GLOBALIZATION AS EVOLUTIONARY PROCESS

Modeling global change

Edited by
George Modelski, Tessaleno Devezas, and William R. Thompson

RETHINKING *Globalizations*

Globalization as Evolutionary Process

The term globalization has gained widespread popularity; yet most treatments are either descriptive and/or focused on changes in economic interconnectivity. In this volume the concept is seen in broader terms as leading international experts from a range of disciplines develop a long-term analysis to address the problems of globalization.

The editors and contributors develop a framework for understanding the origins and trajectory of contemporary world trends, constructing testable and verifiable models of globalization. They demonstrate how the evolutionary approach allows us to view globalization as an enterprise of the human species as a whole focusing on the analytical problem of global change and the rules governing those changes. The emphasis is not on broad-based accounts of the course of world affairs but, selectively, on processes that reshape the social of the human species, the making of world opinion and the innovations that animate these developments.

Chapters are clustered into four foci. One emphasizes the interpretation of globalization as an explicitly evolutionary process. A second looks at historical sequences of such phenomena as population growth or imperial rise and decline as processes that can be modeled and not purely described. The third cluster examines ongoing changes in economic processes, especially information technology. A final cluster takes on some of the challenges associated with forecasting and simulating the complexities of globalization processes.

This innovative and important volume will be of interest to students and scholars across the social sciences concerned with the phenomenon of globalization.

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This series is designed to break new ground in the literature on globalization and its academic and popular understanding. Rather than perpetuating or simply reacting to the economic understanding of globalization, this series seeks to capture the term and broaden its meaning to encompass a wide range of issues and disciplines and convey a sense of alternative possibilities for the future.

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We are grateful to the International Institute for Applied System Analysis (IIASA), Laxenburg, Austria, for co-sponsoring our meeting and for providing such a wonderful setting for our discussions. Professor Nebojsa Nakicenovic, leader of the "Transition to New Technologies" Project at the Institute, welcomed us, and Dr Arnulf Grübler contributed a presentation to our deliberations. Ms Katalin David, the secretary of the TNT Project, made sure that the conference ran smoothly.

The University of Beira Interior (Portugal), also sponsored our endeavor. Humberto Santos constructed the conference website ("Globalization as Evolutionary Process": http://www.tfit-wg.ubi.pt/globalization/), which displays the draft papers, a list of the participants, and the program. During the meeting, he maintained a video-conferencing facility with links to California and Japan. The website also carries a video record of conference presentations.

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The Editors

Foreword

Nebojsa Nakicenovic

Globalization is associated with a range of seemingly conflicting notions, from the integration of economic, political, and cultural systems across the globe, and from being a major force of human development and prosperity, to environmental devastation, exploitation of the developing world, and suppression of human rights. Consequently, globalization has been one of the most studied and hotly debated topics for many decades now. The encyclopedia Wikipedia defines globalization as "a process of increasing global connectivity and integration" and as "an umbrella term referring to increased interdependence in the economic, social, technological, cultural, political, and ecological spheres." The Encyclopedia Britannica provides a somewhat narrower definition of globalization as the "process by which the experience of everyday life ... is becoming standardized around the world." Both imply a deeper evolutionary nature for the globalization process. Like the notion of global change, globalization deals with the fundamental driving forces of human development and well-being. This book bridges the two intertwined processes of globalization and global change from an evolutionary perspective. It provides an integrated and more holistic treatment of human evolution characterized through increasing globalization and dynamic change. In a deeper sense it addresses the two grand questions of our civilization: how did we evolve and where might we be heading?

We at the International Institute for Applied System Analysis (IIASA) in Austria (http://www.iiasa.ac.at) were delighted to host and contribute to the conference on "Globalization as Evolutionary Process," funded by the Calouste Gulbenkian Foundation. The conference was organized jointly with Professors George Modelski, of the University of Washington, and Tessaleno Devezas, of the University of Beira Interior in Portugal. This book is based on the work of this conference held on 6–7 April 2006.

Since its inception 35 years ago, IIASA has worked on global change in its various manifestations: from population and society, energy and technology, to environment and natural resources. An integral part of these research activities is modeling and development of global change scenarios that integrate major driving forces of human development – such as population, urbanization, food and energy, economic and social development – with their environmental and planetary consequences ranging from land-use to climate change. Alternative development paths in these scenarios pursue the different ways that globalization can evolve from stronger homogenization to greater diversity; from an emphasis on economic development to leapfrogging by less-developed parts of the world; from an increasing emphasis on preservation of the environment to more sustainable development patterns. These alternative scenarios portray futures that may evolve and explore different manifestations of global change.

What is common to many of the long-term scenarios developed at IIASA is that various manifestations of globalization result in fundamental changes in space and time – the very fabric of human evaluations. Problems and challenges are transformed from local to global; from immediate to delayed; and from those that affect some parts of the world to those that are truly planetary in nature. This can be interpreted as an acceleration of change, or at least as a dramatic increase in many interrelated changes, and as a compression of geographic distance through unprecedented increases in mobility and communication rendering the world smaller in terms of human perceptions.

Current decisions and actions project a long shadow on our common future. In other words, the planetary space and temporal changes are shrinking. The Nobel Laureate Paul Crutzen has suggested that we should call the current phase in Earth's history the Anthropocene, so as to denote the unprecedented influence of a single species, *Homo sapiens*, on the planetary processes and Earth's future. In some sense, this is indeed the ultimate manifestation of true globalization in all of its positive and negative facets. Students of globalization disagree about the precise sources of shifts in the spatial and temporal contours of human life, but this book presents an important contribution to better understanding the evolutionary nature of globalization, ways to model such complex processes, and how to assess policy implications. In this sense it is complementary to the modeling and scenario analysis performed at IIASA.

Foreword

In the second half of the 1980s, the Calouste Gulbenkian Foundation initiated what became a series of interesting and fruitful studies about our collective future. The first was the project "Portugal 2000," which generated valuable reflections about the framework and the main issues concerning the possible trajectories of the Portuguese nation at the dawn of the twenty-first century. These investigations have been published, in Portuguese and partly in French, in the series *Portugal – the next twenty years*.

As this initiative unfolded, the Foundation sought to support further reflections and endeavors on issues of a global nature and on problems whose consideration and solutions are deemed crucial to the search for a better future. Studies were sponsored for their relevance and fresh approach, which, in the following decades, led to the publication of *Limits to competition* by the Group of Lisbon; *Open the social science*s by the Gulbenkian Commission on the Restructuring of the Social Sciences; and *Enquête sur le concept de modèle* (in French only) by a group of international scholars connected to a research project of the University Paris VII–Denis Diderot.

In this context, a review of current models of globalization, discussing how the use of evolutionary concepts might add value to existing theories, seemed very appropriate. The great intellectual achievements of the past 30 to 40 years, leading to the modern study of living beings and to the science of complexity; the need for contextualization of universalisms; and the emergence of very effective science-based technologies and innovations, have all strongly influenced the impending opportunities for and threats to contemporary societies. In the present state of our knowledge about world affairs, shouldn't the feasibility of simulating globalization as a long-term and multidimensional process be envisaged as a central investigation deserving thorough exploration?

Thus, when Professor George Modelski made a proposal to this effect, it was welcomed by the Gulbenkian Foundation. Moroever, the discussions held during the seminar at IIASA, in Laxenburg, were very stimulating. They showed the extent to which biological contexts and concepts have pervaded current scientific thinking. Both demography and the bulk of social sciences have been profoundly influenced by ideas whose origin and models are found in the life sciences. More precisely, the notion of an "ecological" (or social) niche is now associated with any system or set of social interactions displayed by a population. Diffusion mechanisms thus appear everywhere. Moreover, cycles emerge as a result of the varying rate of change of the diffusion processes.

In this light, globalization can also be conceived as a configuration propelled by trade, technology, and specialization. If so, its impetus will probably be abated by 2030/40, roughly half a century after its inception in the aftermath of the oil crises of the 1970s. What will happen to the present constellation of nations and states as the world evolves and reaches further into the twenty-first century?

This book is a serious, generous and provocative attempt to illuminate change on a global scale. It is the outcome of a group of distinguished and engaged researchers. But the overall achievement would not have been possible without the enthusiasm and determination of Professor Tessaleno Devezas and the intellectual leadership of Professor George Modelski, which we gratefully acknowledge here.

João Caraça
Director, Science Department
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1 Introduction

A new approach to globalization

George Modelski, Tessaleno Devezas, and William R. Thompson

Focus and purpose

The seminar that led to this book was held at the International Institute of Applied Systems Analysis in Laxenburg, Austria, in April 2006, and was sponsored by the Calouste Gulbenkian Foundation of Lisbon. The seminar focused on the long-term process of globalization. The meeting showed several distinct features, including its wide scope and the participation of scientists from many different countries and areas of expertise: political science, anthropology, history, physics and engineering.

One can think of many reasons why it is important to understand the mechanisms and forces behind the phenomenon of globalization. One obvious reason is the use that decision-makers in public policy and industry can make of improved methods of forecasting. All of the participants in our meeting agreed on the fact that this phenomenon represents a worldwide transformational long-term process. As such, it is very difficult to describe globalization using a unifying model embracing all of its characteristics and peculiarities that have changed over time and created the modern world system as we now see it. Participants felt that, in spite of unresolved theoretical questions, we have to focus more on the applied side if any attempt at modeling global change is to prove of some utility to decision-makers in order to put the world on the road towards sustainable development.

In this book we assemble a selection of 17 papers prepared for the seminar, reflecting the wide range of disciplines represented by the authors, as well as the different perspectives shaped by their residence in a number of different countries. The papers, here presented as chapters, are grouped in four parts, in an attempt to replicate a number of sub-foci that emerged from the seminar. One cluster looks at globalization as an explicitly evolutionary process. A second group advances different interpretations developed for analyzing history as a set of processes, as opposed to history as description. The third cluster focuses on more contemporary affairs, with a special emphasis on changes associated with information technology. The last substantive section examines the prospects for forecasting and simulating globalization processes with the help of complex models. All four groups of papers are sandwiched between an introduction and a conclusion, which are designed to make sense of what these chapters represent in the aggregate. In brief, the collected papers constitute a multi-faceted scientific assault on modeling long-term globalization processes.

We are by no means the first to attempt such an effort.[1] However, the attempt here is distinguished by its explicit reliance upon evolutionary conceptualization in a number of the papers and/or the sophisticated empirical analysis underlying some of the contributions.

In the remainder of this chapter, we make a reasoned case for our collective approach to globalization and the processes associated with it.

The approach

Globalization is currently a preferred term for describing the post-cold war era in world affairs. It is the currency of contemporary economic and political debates and, at the start of the new millennium, it is a fashionable concept in the social sciences. A survey of recent library acquisitions shows that books published in the past few years and whose titles include "globalization" number in the hundreds. On the Internet, a Google search showed millions of results in response to that term. Globalization has taken hold rapidly in the first decade of the twenty-first century, because it evidently taps into the widespread feeling that far-reaching change is under way, and that such change needs to be better understood – if only because its effects are not just global but also national and local.

What is globalization?

One authoritative survey of recent debates declares: "no single universally accepted definition of globalization exists" (Held and McGrew 2000: 3). Given the wide-ranging nature of these debates, that is hardly surprising. But there is also widespread consensus on certain essential features that might be attributed to this phenomenon. For one, it is universally referred to as a *process*, that is as a sequence of events over time. Despite a strong showing in its economic aspects (economists tend to adopt a narrow concept, concerned basically with markets; see, for example, Bordo 2003 or Garrett 2000), it is also widely viewed as multi-dimensional; it is moreover held to be long-term in character, with a strong historical component; and finally, it is seen as clearly transformational.

For present purposes it suffices to define "globalization" as (the process of) "emergence of institutions of planetary scope." By institutions, we also mean networks, so that in respect of global economic change we would focus on the rise of world (commodity, labor, and financial) markets as well as on the activities of transnational enterprises. In political restructuring we would trace the rise of nation-states, as well as the role of coalitions, and international organizations. Democratization and the impact of social movements might be viewed as establishing the potential for global community formation. The increasing salience of learning, knowledge, and information networks is laying the foundations for an informed world opinion (cf. Modelski 1999, 2000: 34). This makes it plain that globalization is a process of emergence that is multi-dimensional, and historically significant, and a term obviously basic to understanding global change.

Can we explain globalization?

While the literature on globalization is wide-ranging and profuse, much of it describes the characteristics and the consequences of that process. The problem of *explaining* globalization, on the other hand, is far from being resolved. What is more, an explanatory lag also makes it more difficult to forecast the future course of that process.

One line of explanation, associated with an early argument of Anthony Giddens, maintains that "modernity is inherently globalizing" (in Held and McGrew 2000: 92). This amounts to saying that "modernization causes globalization." Seeing that we live in the modern age, the emergence of planetary arrangements would therefore seem to be basically unsurprising. Such a position might appear reassuring, and gratifying to supporters of this process, and those who regard it basically as "Westernization," but its analytical power is limited and does not tell us much about "modernization" either. We need to know more about the conditions and mechanisms of these processes.

The other line of explanation privileges economic factors. It is more explicit about conditions and mechanisms and it is linked to world-systems analysis associated with the writings of Immanuel Wallerstein. It proposes that the modern "globalizing" world-system is the product of the "capitalist world economy" that arose in Europe in the sixteenth century and has now spread worldwide. In effect, "capitalism causes globalization." That position sits more comfortably with the critics of globalization, and those who fear the workings of unfettered markets or the power of multi-national corporations and who advocate "alternative" world orderings. But it, too, posits a strong association between globalization and "Westernization."

Both lines of explanation ask to be strengthened by way of modeling, testing, and/or simulation, and by being embedded in a larger framework. As one recent critic, Jan N. Pieterse (in Lechner and Boli 2000: 100–101; see also Hopkins 2002) pointed out that, in either conceptualization, be it centered on modernity or on capitalism, globalization emanates from Europe, and the West, and raises problems associated with Eurocentrism, and a "narrow window on the world." In other words, it is associated with an approach that is historically "shallow." If, as some view it, globalization is "an intensification of worldwide social relations," then it also presumes the prior existence of such relations "so that globalization is a conceptualization of a phase following an existing condition of globality" and part of an ongoing process of the formation of world-spanning social connectivity. In Pieterse's (2000) words: "The recognition of historical depth brings globalization back to world history."

What we need for a better understanding of globalization is a deconstruction of the complex mechanisms that produce modernity (and/or capitalism), because we do not subscribe to the notion that these are unimportant questions that are better left concealed in the mists of time. We need to identify the processes of which globalization would be considered a phase.

An evolutionary approach

Given the plethora of books and articles currently being written, and having been persuaded that we are asking questions about a long-lasting shift in cultural orientations rather than a passing fad, what novel and valuable insights can we offer?

One promising line of inquiry, outlined in a recent paper by Devezas and Modelski (2003), relies upon evolutionary epistemology. It implies a vision of globalization as a manifestation (or phasing) of a multi-dimensional cascade of worldwide evolutionary processes. What might be the chief characteristics of such an approach?

1 The unit of analysis for the evolutionary study of globalization is the human species viewed diachronically, since the dawn of history (*c*.3500 BC), as a complex adaptive system, but also as a community of common fate that in the past millennium generated the process of globalization.
2 The metric of evolutionary time is the generation (or generational turnover-time) that computes the rate of global change. The emergence of the world system is the product of fewer than 300 generations.
3 The basic conjecture proposes that global evolutionary change is in form a nested and synchronized set of (logistic-type) learning processes composed of successive ("bolero"-like) iterations of a Darwinian-type algorithm (variation, selection, cooperation, amplification). These universal learning sequences are inherent in the shaping and reshaping of the social organization of the human species (this Dawkins/Plotkin "universal Darwinism" is distinct from, and must not be confused with, biological determinism).
4 Guiding such an inquiry is the "minimalist" insight that complex systems obey simple rules, and that learning algorithms might constitute a set of such rules because they involve both repetition and nesting.
5 A program composed of simple rules is fully compatible with a multi-dimensional view of world-system evolution, and of globalization in particular, as products of a cascade of evolutionary processes.
6 Predictions made on the basis of these conjectures need to be tested against real world evidence drawn from world history of the past 5,000 years

(for instances of such testing, see Devezas and Modelski 2003; Modelski 2003b, and Devezas and Modelski, 2007, Part I of this book).

Please note two important implications of this evolutionary approach: first, there is reason to believe that an analysis drawing on evolutionary theory lends itself to modeling, simulation, and forecasting. Secondly, such an approach allows us to view globalization as an enterprise of the human species as a whole. This "big picture" approach to analysis highlights long-term perspectives; draws upon the history of the humanity; and selects, for analysis, certain identified processes, but it does not purport to depict, model, or simulate all of world history. It focuses on the analytical problem of global change and asks about the rules governing those changes. The emphasis is *not* on broad-based accounts of the course of world affairs but, selectively, on processes that reshape the social (including economic, political, and cultural) organization of the human species; processes such as urbanization, economic growth, political reform and world organization, and the making of world opinion; and the *innovations* that animate these developments.

More specifically, we believe that we can contribute to this burgeoning field in the following ways:

1 by encouraging the construction of models of globalization that aim at higher analytical power, depth in time, and working in the context of the study of complex systems;
2 by exploring the possibilities for simulation of these basic processes;
3 by essaying methods of forecasting global change.

Modeling, simulating and forecasting global processes

Modeling

As far as we can judge from our survey of the extensive literature, modeling global processes is not among the principal interests of recent scholarship on globalization. More familiar is the construction of dynamic accounts of, for example, the rise and fall of empires (most recently, the multi-dimensional model of Turchin, 2003). Most accounts of globalization are descriptions of recently observed phenomena, and the evaluation of their effects, favoring the narrow conception of this phenomenon (as in Garrett, 2000).

Simulating

There are two possible approaches to simulating global processes. The systems-dynamics approach is "top-down" in character (so-called because it views the system from above, as a whole) and uses differential and/or difference equations. Its dynamics (that is the study of the world system over time, or diachronically) is defined via the change in its organization (or "state") as described by the system's equations. Such top-down analyses are suitable for describing systemic regularities (such as four-phase collective behavior in Devezas and Modelski, 2003), or the system's emergent properties.

The other approach (not so far used in global analysis) forms the new subfield of "computational sociology" (also known as "artificial life") that uses so-called "soft computing" models of complex systems that encompass several methods of simulation, and is best characterized as a "bottom-up" approach. Theoretically and methodologically, this makes possible the construction of models from the level of processes that are immediately and empirically observable, namely the local interactions of single units governed by local rules. Some experts view such models as better suited for modeling social change, but others argue that they need to work in combination with "top-down" models capable of capturing the emerging properties of systems of interacting units.

Formal mathematical models developed in the past two decades and most often used, are: cellular automata (CA), Boolean nets (BN), artificial neural nets (NN), evolutionary algorithms (such as the genetic algorithm, GA), and network analysis. We also have some recent models of multi-agent systems, using, for instance, replicator equations to simulate the dynamics of learning (Hofbauer and Sigmund, 1990; Sato and Crutchfield, 2002). In the present state of our knowledge, no one can be sure which method is best suited to the purpose of global analysis. We need to bear in mind that simulation analysis is performed at several levels, at the minimum, "top-down," and "bottom-up." However, we do have the example of climate models that employ both local data and that document trends that extend for thousands of years.

Forecasting

Satisfactory global models could of course help to forecast the trajectory of selected processes. The one extant instance is the "Limits to Growth" family of world models sponsored by the Club of Rome in the 1970s. Focused on the interaction of population and resources, it raised awareness of the "global *problematique*," and especially of the need for sustainable development. While they constituted a landmark in futures studies, their analyses were criticized by economists as excessively technocratic, and their predictions of early resource exhaustion seemed premature. An evolutionary model would, of course, be oriented more directly to a more rounded set of social science (including economic) variables.

Significance

Most generally, our collective undertaking highlights the fact that, as a concept of considerable generality, globalization is multi-disciplinary in character and extends to forms of global change that concern all of the social sciences. What is more, a social evolutionary analysis brings into focus a cascade that spans the social sciences and brings under observation an entire range of social evolutionary processes. The study of globalization is therefore a practical example of the necessity to keep in view the big picture of human society. In effect it implements the recommendations of the *Gulbenkian Commission Report on Restructuring the Social Sciences* ("*Open the Social Sciences*," 1995) by promoting multi-disciplinarity, and by adopting a holistic view of global social organization, and of the changes that it is subject to. As the report also noted: "the conceptual framework offered by evolutionary complex systems as developed by the natural sciences presents to the social sciences a coherent set of ideas that matches long-standing views of students of society" (1995: 64).

In recent years, the concept of a "clash of civilizations" has come to be closely linked to that of globalization. That is a concept that highlights the role of cultural and in particular religious factors in sparking conflict in world affairs. An evolutionary approach to globalization would contrast it with the idea of the human species as a "community of common fate," obviously subject to tensions and clashes but also demonstrably composed of individuals capable of learning to live and work together. (Modelski, 2003a). Globalization denies that civilizations are "the largest aggregate of identity" (in Mozaffari, 2002: 1 – humankind is) and it traces the trajectory of this community over time; asks about, and elucidates, its origins; and raises questions about its future – questions that are the task of all the social sciences.

The value of a testable and therefore verifiable long-term account of the contemporary world trends would be to provide an acceptable framework for the understanding of their origins and trajectory. Convincingly mapping the evolution of the "community of common fate" that is the human species is a worthy goal of major significance. It could serve as a framework for world history, and possibly also as a teaching tool in a globalizing age.

Note

1 See, for example, Denemark *et al.* (2000) and Gills and Thompson (2006). Both of these earlier volumes represent kindred emphases on long-term processes from social science perspectives.

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Part I

Evolutionary models

2 Globalization as evolutionary process

George Modelski

An institutional approach to globalization

The view to be advanced here is an institutional one: it seeks to explain globalization as the emergence of planetary institutions such as world-wide free trade and transnational enterprises; the position of global leadership; and the role of global governance, world social movements and ideologies, and contemporary forms of world opinion, that jointly compose elements of change in an evolving global system.

An institutional approach might best be contrasted with a "connectivist" one in which globalization is seen primarily as a condition of interdependence. For instance, in a recent report, globalization is described as the "growing interconnectedness reflected in the extended flows of information, technology, capital, goods, services, and people throughout the world" (NIC, 2004). Thomas Friedman (2000) defines it as the "inexorable integration of markets, nation-states, and technologies." These views highlight connectivity.

Another facet of globalization viewed as connectivity is "openness." Openness is a property of national systems, and nations can be ranked according to the degree to which they participate in world flows.[1] To operate freely, connections require open societies, because connections thrive most in the absence of barriers – barriers to trade, to capital movements, to migrants, or to the diffusion of ideas and practices. That is why another way to look at globalization is to search for country indices of openness – the degree to which nations accommodate to the world system.

The measurement and analysis of connectivity via global interactions yields much of the substance of the phenomenon of globalization. Trade flows, capital movements, travel and migrations do indeed make the world more – and at times less – interdependent. Scholars judge the progress of that process on the basis of such empirical observations. The mapping of connectivity tends to uncover a variety of networks – trade, financial, social – which are structural features of the world system. Yet these developments also fluctuate, and sometimes even collapse utterly. It is widely noted, for instance, that the hopes for world peace aroused by the expansion of world trade in the latter part of the nineteenth century were to be rudely dashed in 1914, and what followed was a substantial reduction, if not derailment, of an apparent trend toward globalization. And yet we are not entitled to say that the process as such had then come to a complete halt, only a pause. In other words, globalization cannot be viewed as a steadily and linearly ascending process. More likely it is a set of long-term processes that experience local surges and then also flatten out. In any event, a mere ascertainment of trends is no answer to the question: why and how do we globalize?

The approach developed by David Held and his collaborators (1999) that has been described as "transformationalist" goes beyond the "connectivist" view and treats globalization as a historical process ("a process or set of processes rather than a singular condition") that brings about connectivity and openness but one that also has an institutional grounding, and can therefore be depicted in two dimensions, spatio-temporal, and organizational, respectively. That model of globalization combines an interest in the intensity, extensity, velocity, and impact propensity of the flows that animate the world system, with an analysis of the organizational dimension that describes the infrastructure, and the institutionalization, of global interdependence ("a new architecture of world order").

The present view leans strongly toward this second, institutional, dimension of global change as one more suited to an evolutionary analysis, even while recognizing the importance of having good reliable measurements of the multitude of interactions that are of interest. Notice that both connectivity and openness are the product of a set of organizational and institutional arrangements. They derive from the organizations that originate and manage these flows; the regimes that facilitate and govern them; the matrices of mutual trust that sustain them; and the systems of knowledge that guide them. For instance, and briefly stated, political globalization tracks the evolution of world order architecture, from the classical imperial form, through global leadership, to global organization.

At this point we draw a distinction between types of global change. As just noted, we view globalization as the construction (and/or emergence) of institutions of planetary scope. These are global-level social arrangements for the organization of the human species on earth, and their appearance is one obvious instance of global change. But there is of course more to global change than the evolution of the global (social) system. For instance, in and of itself, world population growth, or urbanization, might also be regarded in this way.

As well as the above-mentioned usage, there is another way of using the term "global change" (one that has been gathering strength over the last few decades), that refers to world-wide changes in the natural system. In the *Encyclopedia of Global Change* (Goudie, 2002) "the term 'global change' is synonymous with 'global environmental change.'" These are geocentric movements in the physical world that humans inhabit, and these might be either the workings of the forces of nature pure and simple (natural environmental change) or else anthropogenic (human-induced, as climate change might be the result of globalization, in a form of world system: earth system interaction). They too give rise to problems that land on the global agenda. The mutual influence of these several kinds of global change is worth investigating, but the topic is outside our scope here.

The institutional approach to globalization focuses not just on the facts of transformation (and is therefore also "transformationalist"), but also reaches out for explanation of these global changes. It bases such an explanation on the "learning" axiom – according to which humans are a species capable of learning, and that learning occurs in favorable conditions, and as a programmed species process. Fundamentally, it represents a problem-solving approach, but it does reside in humans' stubborn search for a better world, a journey with many detours and false promises, but one that has so far taken us a long way. A learning process can also be modeled, simulated, and projected into the future.

The NIC report cited earlier raises globalization to the status of a "mega-trend," a trend that can be visualized with the aid of aggregate data on world flows, "a force so ubiquitous that it will substantially reshape all of the other major trends in the world of 2020" But the approach adopted here views it as not just a trend but as a sequence of events exhibiting a "universal law" (for which see below); in other words, a "process" (or, more precisely, as a set of processes), that can be not just mapped (and projected) but also understood: analyzed, theorized about, and – subject to testing – located in a larger explanatory framework as well as used in forecasting.

Process is a key term of this analysis that privileges change over stasis, and "flux" over structure. It is a distinct way of perceiving reality, in that it highlights problem-solving event-sequences. More than a mere trend (a drift, tendency, or general movement), it is a "series of connected developments unfolding in programmatic coordination." Four (self-similar, relatively autonomous) global (institutional) processes – economic, political, social, cultural – arrayed in a cybernetic hierarchy, make up globalization.

Is globalization an evolutionary process?

Globalization is sometimes described as the defining feature of our current era. Some call it a process of the world "getting smaller." Others emphasize those features that increase connectivity. As stipulated, for our purposes it is the process of "emergence of institutions of planetary scope." That is a definition that obviously follows the institutional approach, but sees "connectivity," and "openness," both as causes, and as consequences.

In some discussions, globalization is treated as solely economic in character. Others view it as essentially a contemporary phenomenon and an obvious consequence of technological advances, and yet others treat it as a condition of life today, without inquiring greatly into its provenance. In this discussion, globalization is seen as a process that is historical, transformational, and also four-dimensional, as well as one facet of world-system evolution.[2]

Globalization is a process in time (i.e. diachronic), and therefore also it is a historical process in that its understanding requires tracing it back into its past, if not precisely to its origins. Roughly speaking, we postulate that the onset of globalization coincides with the start of the modern era of the world system, and is therefore to be placed at about the year 1000.[3] These beginnings are linked, for instance, with the experience of the Silk Roads across Eurasia, and to the projects of world conquest, most prominently pursued by Genghis Khan and his Mongol successors in the thirteenth century, but more clearly seen in the ocean-based enterprises of succeeding centuries. Similarly, we cannot expect globalization to assume its final form for possibly another millennium. It is also a historical project, in that there is only one instance of it in the experience of humankind. We cannot generalize about it (in the sense of summing up a number of instances) except by trying to trace the one instance of it that we know through time, or by reducing it to a set of constituent processes and elements.

Globalization is transformational–institutional, because it traces successive steps in what we might call the development of a planetary constitutional design. Whereas, one millennium ago, the human species was recognizably organized in some four or five regional ensembles, with basically minimal knowledge, low mutual contact, and no organization or common rules, since then the information has become more abundant and low-cost, contacts have multiplied, and organization and rules dealing with collective problems are no longer exceptional. The institutions whereby humans relate to each other have been undergoing a transformation at the planetary level, but also at local, national, and regional levels.

Globalization, finally, is also multidimensional, or more precisely, four-dimensional. That is, it has no simple recipe for identifying "stages of world history," such as slavery or capitalism. As generally recognized, it comprises not just the spectacular expansion, under the banner of free trade, of world commerce and of capital movements, with the large array of transnational enterprises, and the elaborate body of rules and regulations that govern all of these. Most certainly, globalization also has a political dimension, and it further concerns the rise of global social movements, and world-wide cultural trends, and the emergence of world opinion as a conception of common interest based on a common pool of knowledge.

As is appropriate for the process of globalization, the approach adopted here employs the human species as the basic unit of analysis, and is therefore planetary (as long as humans remain confined to earth). It therefore is not primarily about inter-species competition but is confined to intra-species processes. A variety of agents partake in those processes, with varying success, and therein lies the story.

If, as argued, globalization is a set of processes that are historical, transformative, and multidimensional, it is easy to see why it is also evolutionary. The evolution of *Homo sapiens* is a long historical process, but it is now increasingly capable of being traced, in respect of biological evolution, with the help of genetic information – the genetic endowment being steadily rearranged via sexual selection and environmental pressures.

Our own interest here is with social-system evolution: changes in human-species behavior over time. More specifically, the processes that we are interested in, the global transformations in politics, economics, society, and culture – such as are reviewed at some length in Held *et al.* (1999) – cry out to be explicated in terms of an evolutionary framework. Outlines of such a framework have been presented in Modelski (2000), and Devezas and Modelski (2003).

The major premise of such an approach is the idea of a program that actuates social evolution via an extended process of group selection, because the human species tends toward self-organization at multiple levels over time in a cascade of learning algorithms. Programmatic coordination (basically a learning algorithm) by definition is inherent in the notion of process. Global processes are evolutionary sequences, and are conjectured to be programmed accordingly by a Darwinian algorithm of search and selection. A program is implied in the notion of self-organization. Search and selection respond to priority problems, and the result is periodic institutional innovation – each period being closely associated with a bunch of innovations responding to major global problems. The first responders to these problems enjoy the support of evolutionary potential: initial conditions that favor innovation (such as an open society). In that way, the key ideas: choice (as in selection, or election), and innovation (as in variation, or mutation) are hardly novel in the social sciences, but they are brought together in regular sequences over specified periods (that are units of these processes and are reckoned in generations). In propitious conditions, each innovation sets in motion an S-shaped learning process. We shall shortly lend substance to these propositions below, on pp. 20 ff. But first, let us review some theoretical problems attendant on an evolutionary approach (see also Thompson, 2001).

The requisites of an evolutionary theory: Giddens

An evolutionary analysis of long-range social processes has a long pedigree, shows several varieties, and has also been subject to criticism, much of it in the recent past too. One of the most cogent recent critics, Anthony Giddens (1984) maintains that "for 'evolutionary theory' in the social sciences to have a distinctive meaning" it should display the following characteristics – it must:

1. Show "at least some presumed conceptual continuity with biological evolution;"
2. Specify something more than progressive change, that is "a mechanism of change;"
3. Trace "a sequence of stages of development," in which the mechanism of change is linked to the "displacement" of certain types of social organization; and
4. Demonstrate that "a mechanism of social change" means "explaining change in some way that applies to the whole spectrum of human history."

Examining these criteria in some more detail, and finding "evolutionism" wanting – in part because world history is not "a world-growth story" – he concludes: "I do not think it possible to repair the shortcomings of either evolutionary theory in general or historical materialism in particular."

Of interest to our discussion is Giddens' argument (1984: 238–9) that "history is not a 'world-growth story'." He writes:

> The history of *Homo sapiens* is more accurately portrayed as follows. No one can be sure when *Homo sapiens* first appeared, but what is certain is that for the vast bulk of the period during which human beings have existed they have lived in small hunting – gathering societies. Over most of this period there is little discernible progression in respect of either social or technological change: a "stable state" would be a more accurate description. For reasons that remain highly controversial, at a certain point class-divided "civilizations" came into being, first of all in Mesopotamia, then elsewhere. But the relatively short period of history since then is not one marked by the continuing ascent of civilization; it conforms more to Toynbee's picture of the rise and fall of civilizations and their conflictual relations with tribal chiefdoms. This pattern is ended by the rise to global prominence of the West, which gives to "history" quite a different stamp from anything that has gone before, truncated into a tiny period of some two or three centuries. … The modern world is borne out of discontinuity with what went before rather than continuity with it.

An evolutionary account of globalization is, of course, *not* "world history," although it is an exercise that engages the social sciences in the recent experience of the world system and in the construction and functioning of global organization in particular. But we do take note of Giddens' "requisites," especially because more recently he has also been among the more significant writers on globalization. He now argues that "modernity is inherently globalizing" (in Held and McGrew, 2000: 60), meaning that globalization is to be understood as a discontinuity with what went before, in and of itself, and certainly not as a product of an evolutionary process.

Answering the first of Giddens' requisites, we observe that the unit of analysis employed here is the human *species*, specifically *Homo sapiens*, in its evolutionary trajectory. That choice contrasts sharply with most of social evolutionary thinking that takes individual human *societies* (such as nations) as the primary object of study, and to which Giddens' critique might in fact be applicable. The emphasis in the present account is on (species-wide) processes of (generational) change that are then analyzed with the universal Darwinian concept set that hinges on variety and selection, but with additional attention being paid to cooperation and symbiosis.

Key to an effective explanation of evolutionary processes is the mechanism of change. In the present analysis it is not "adaptation" (that Giddens also criticizes) but *evolutionary learning*, for we hold that "evolution, at least in the domain of the living, is essentially a learning process" (Jantsch, 1980).[4] Each period of the processes considered here, including the envelope one of globalization, is a phased, evolutionary, learning process (or possibly an "ultra-cycle," in Jantsch's terms: cf. p. 195) and has a programmed time-structure: an event sequence that consists of four phases whose generic names are variation, cooperation, selection, and amplification (the first two phases also being "preparatory," and the other two, "decisive"). "Time structure" means that the process exhibits, over time, *variety*, hence also complexity, of behavior.

All that also means that all our evolutionary processes are *self-similar* (have the same, phased, time-structure, but different periodicities). Each period of the four processes of globalization (shown in Table 2.1 on p. 21) consists of four phases, each phase constituting one period of the respective agent-level process that nests within it). The decisive phase of each process is always the third (selectional) or decisional phase (e.g. Britain I in "global leadership"). Nested learning processes are the mechanisms of evolutionary change.

Our account of globalization represents it as marking stages in development in which evolutionary learning – the mechanism of change – accounts for the time-structure of the process, and for the displacement of certain types of social organization. Prominently, for instance, the course of democratization may be seen as a substitution process that displaces non-democratic forms. Each of the processes in Table 2.1 (and 2.2 too) tells a story of the unfolding of evolutionary learning; important parts of that story have been subject to successful empirical tests.

Fourth, the type of analysis and the mechanisms of change proposed for the study of globalization are potentially applicable across the entire spectrum of human history (Modelski, 2000) and have been so applied (for a summary cf. Devezas and Modelski, 2003). These are the principal mechanisms of social change; they do not by themselves amount to an account of human history in all its richness, but they do make it possible to tell a coherent "world growth story" (as for instance in the account of world urbanization presented in *World Cities: –3000 to 2000* (Modelski, 2003), of which globalization is the most recent part. World-system evolution is a world growth story that shows both discontinuities – for instance those produced by Dark Ages – and continuity – including a common genetic endowment; and a sequence of system-building innovations both in the time span that Giddens labeled "steady state" (that included inter-continental migrations, and ice ages), and in that of world-system organization.

Note, finally that Giddens regards the evolutionary analysis of "history" as carrying all the liabilities of "historical materialism" and its "world growth story," and he also rejects the idea that globalization primarily concerns the working of the world economy. But the view that privileges economic factors does, of course, have wide currency. It is linked to world-systems analysis and proposes that the modern "globalizing" world system is the product of the "capitalist world economy" that arose in Western

Europe in the sixteenth century and has now spread world-wide. That view therefore maintains in effect that "capitalism caused globalization." That proposition sits comfortably with the critics of globalization, and of free-trade regimes more generally, and of all those who fear unfettered markets or the power of transnational corporations, and who advocate alternative world orderings. But, not unlike Giddens' "modernization," the "capitalist world economy" perspective also posits a unique association between globalization and "Westernization."

An institutional theory of progress: Popper

Early evolutionary theory is associated, in many minds (and not just in Giddens' account), with historical materialism. Friedrich Engels famously claimed (in 1883) that "just as Darwin discovered the law of evolution in organic matter, so Marx discovered the law of evolution in human history." That was the materialist version of history in which the prevailing mode of economic production and exchange (such as feudalism, or capitalism) constituted the basis from which alone social organization, and political and intellectual history, could be explained with the help of "laws of history." To this day, that is the conception that undergirds both "evolutionism," and many a critique of globalization.

Giddens' cool appraisal of evolutionary theory just reviewed was part of a debate with historical materialism, and so were important portions of the writings of Karl Popper, and it is in *The poverty of historicism* (1957) that we find a rigorous methodological examination of that philosophy as a form of historicism, and as entertaining evolutionary "laws of history." Popper's main contention that "it is impossible ... to predict the future course of history" *on the basis of such laws* is well known and some take it as a complete dismissal of the possibility of prediction. Less noticed has been the project of "The Institutional Theory of Progress" (1957) that he proposed in the closing pages of that book, one that is entirely compatible with a systematic approach to large-scale change, and in particular with the evolutionary approach to globalization advanced here.

Popper asked: "can there be a law of evolution?" (1957), and answered: No, because "the evolution of life on earth, or of human society, is a unique historical process" and being unique cannot be tested in the light of a universal hypothesis. He gave as an example Darwin's assumption of the common ancestry of life forms that he found to be a descriptive device but not implying a universal law.[5] More broadly, he drew a sharp distinction between *trends*, knowledge of which (generally) does not allow for scientific prediction, and (universal) *laws*, that, combined with knowledge of initial conditions, do make such predictions possible. "A statement asserting the existence of a trend is existential, not universal. ... A universal law, on the other hand, does not assert existence; on the contrary ... it asserts the impossibility of something or other." (1957) However, trends *may* embody universal laws.

The explanation of a *regularity*, described by a universal law embedded in a trend, Popper argued, differs from that of a singular event. It consists of the deduction of a law, containing the conditions under which the essential regularity holds, from a set of more general laws which have been tested and confirmed independently (1957).

In explaining evolutionary trends, we therefore have to resort to general laws of evolution and more specifically to the universal Darwinian principles centered on "search and selection" – well known, tested, and independently confirmed. From these we deduce and hypothesize a set of global evolutionary processes that characterize the human species (but not individual societies) in certain specified conditions, and over time. For global political evolution, the necessary conditions for the success of these processes would include, the existence of an "active zone" – a seedbed of innovation – comprising, at various times, communities characterized by openness and awareness of global problems, i.e. those that are leading in economic innovation, and capable of deploying political influence of global reach. Parallel conditions promote global economic and other types of evolution, and overall, globalization.

In the light of Popper's criteria, what is the status of the present analysis? First, we view the evolution of human society, and more precisely, in our case, that of its global layer of interactions and institutions, not as a single and unique process but rather as a cascade of processes that are analytically distinguishable but are also related, being nested (e.g. long cycles as embedded in global political evolution), and self-similar (all global processes exhibit the same basic algorithm, albeit in several flavors). Second, the four-phase learning algorithm (that is in fact a restatement of key Darwinian concepts) has the status of universal law rather than that of a descriptive device. It is a law that determines the succession of a dynamic series of events. In Popperian terms, it might be reformulated as follows: evolutionary change cannot occur unless the relevant system passes through a "prescribed" sequence of phases. That means that this analysis, subject to testing, is capable of yielding scientific prediction.

In any event, Popper's own argument was not as negative as it might have been represented. In the closing sections of his book, he went on to propose a "theory of scientific and industrial progress" that he called "The Institutional Theory of Progress." Countering Mill's *Logic*, he denied that such "progress" was due to psychological propensities of human nature, and suggested in its place "an institutional (and technological) analysis." That would postulate that evolutionary change will be likely to occur first in conditions of evolutionary potential associated with certain periods/areas; only upon a successful take-off in favorable circumstances will it diffuse throughout the system. That means that a full explanation (and prediction) of evolutionary processes consists of the determination of both their initial conditions (do they show evolutionary potential?), and the relevant learning algorithm.

In brief, how does the present approach differ from "historicist" or "evolutionist" theories that have appeared in the last century? It deploys: (1) a cascade of processes of several kinds, (2) at levels of resolution down to one generation, (3) specifying a universal mechanism of change, and (4) operating at the human species level. Historicist–evolutionist theories, by contrast, identify one basic process, frequently materialist, of a resolution extending over several centuries (e.g. feudalism to capitalism), operating according to laws of one particular epoch (e.g. laws of capitalism) that describe change in individual national societies.

Processes of globalization

The institutional level

So much for theoretical considerations – in line with the institutional conception, we shall now delve into "reality," and depict globalization as a set of four closely related institution-(or system-) building processes. Table 2.1 shows the array of four processes that jointly constitute globalization as an evolutionary phenomenon. As one feature of their relatedness, observe that the characteristic periods of these processes stand in a determinate relationship, showing a doubling of periods as we go from right to left in Table 2.1, such that, at each point in time, the global system experiences four innovative system-building processes at different phases of their paths.

The four institutional processes are: the evolution of the global economy; global political evolution; the rise of the global community; and globalization viewed as a summary (envelope) process also defining the principal problems of the evolving system. Each process searches, explores, and then selects and amplifies (and culminates in) a major institutional innovation: the global economy is refashioned towards enhanced specialization and division of labor via successive stages of a commercial and industrial order, and is currently in the (computer–internet-based) Information Age (that accounts for major features of contemporary globalization). The global political system, as shown below, passes through the learning stages of imperial experiments, via global leadership, and nucleation, to essays in global governance, toward increased capacity for dealing with global problems. Moreover, the rise of the global community is based on the emergence of a democratic base, and its slogan might well be "no globalization without democratization," because no enduring community is conceivable without a democratic foundation. The processes are synchronized, and mutually supportive.

The capstone of all this system-building is globalization viewed as an envelope that holds them together, and lends them coherence. In itself, globalization, too, is an innovation as compared with what we have known in past eras of the world system, but also as called for by a rising population. In fact it is an epochal innovation whose progress might be charted as moving through elements of evolutionary learning. We might measure the progression of globalization as each of its several necessary elements falls into place. Because it is epochal, this cluster of innovations takes time to take root, and the process

Table 2.1 Global institutional processes (globalization) (930 to 2300 AD)

Globalization *Period: 2000 years (phases)*	*Rise of the global community* *Period: 1000 years*	*Global political evolution* *Period: 500 years (selection)*	*Evolution of the global economy* *Period: 250 years*
930 Emergence of global system (recovery)	**Preconditions**	**Imperial experiments:**	**Song (China) Breakthrough**
		(Failed world empire)	**Commercial–nautical revolution**
1430 (mapping the global system)		**Global leadership:**	**Framework of global trade**
		(Global nucleus)	**Industrial take-off**
1850 (global social organization)	**Democratic world**	**Global organization**	**Information age**
		(2080: global governance)	
2300		**Consolidation**	

Columns show process; rows show four-generation periods.
periods in boldface, phases in parentheses.

Table 2.2 Agent-level global processes (1850–2080)

	Global system process (Period: 500 years)	*Global social movements (250 years)*	*Long cycles of global politics (120 years)*	*K-waves* *(60 years)*
1850	**World opinion** Global *problematique*	**Democratization** Early adopters	**LC9 – USA** Agenda-setting	**K17 – Electric–steel** Take-off
1878			Coalition-building	High growth
1914		Democratic nucleus	Macro-decision: World Wars I and II	**K18 – Electronic–auto–aero** Take-off
1945			Execution	High growth
1975	Global connectivity	Democratic transition	**LC10** Agenda-setting	**K19-Computer Internet** Take-off
2000			Coalition-building	High growth
2026		Consolidation	Macro-decision	**K20 – Collective intelligence?**
2050			Execution	
2080	Global organization	**Democratic community**	**LC11** Agenda-setting	

Periods in boldface; phases in smaller print.
Each column shows one process; each row shows one generation.

is a long-term one. In Table 2.1, its period is measured as 2,000 years, and we might be just over halfway through it.

A case study: political globalization

To lend substance to this discussion, let us take a closer look at one of the set of processes that make up globalization, namely the evolution of global politics (or political globalization).[6] The unit of this process (as of the others) is a period (world-system time is not continuous or flowing but discrete or grainy, reckoned in generations, and unfolding in distinct periods). Political globalization has a characteristic period of some 16 generations (about 500 years). Each period is definable by a set of priority global problems, and by the launching and diffusion of institutional innovation. In the third column of Table 2.1, the successive institutional innovations shown are imperial experiments, global leadership, and global organization.

The focus of this analysis is global-level organization that is a necessary condition of an ordered world society but cannot spring into being all at once, in an instant, but only via a prolonged process of political globalization. In this section, we ask: why and how can political globalization be viewed analytically in an evolutionary perspective? Political globalization is just another way of referring to global political evolution. That term describes changes in the collective organization of the human species, with regard to finding solutions to global problems and devising institutions for dealing with them. It traces the operation of the Darwinian learning algorithm of search and selection in the context of humankind as a learning system.

Political globalization therefore shares with global political evolution all the primary characteristics, of process, time, change, and multidimensionality. But an evolutionary approach gives it, as it were, one additional yet essential, feature: it supplies an internal motor of change, and makes it law-like. It brings out the mechanisms that make for global political change, without invoking the *deus ex machina* of technology, while also paying prompt attention to concurrent and antecedent developments in the economy, society, and culture.

Table 2.1 depicts i.e. a summary outline of the course of global political evolution over one millennium. It is also a timetable of political globalization, as well as a forecast of its future course. That is of course very much a "big picture" representation. In reaching back one whole millennium, it does take globalization somewhat further than some would (although it is difficult to imagine how such a change could occur without printing, the compass, and also gunpowder, that the Mongols brought to Europe), but in its main lines conforms to the now increasingly familiar "history of globalization," that took hold promptly over the long haul of the sixteenth century. But, in looking forward to the future, it also suggests that the critical (decisive) period for political globalization might be our own century.

In the main, Table 2.1 presents the evolution of global politics as a higher-order, institutional-level process, animating the search for new forms of collective organization and the transformation of world-wide structures away from the traditional form of empire inherited from the classical era, via the institution of global leadership, and toward global governance. Noteworthy is the fact that global political evolution is paced by the long cycle of global politics, such that the four long cycles that composed each period of political globalization might also be viewed as its phases. (Britain I marked the decisive phase of that period of "global leadership").

The evolution of global politics is a higher-order learning process than the long cycle. It is a process of globalization because it creates of political institutions of world-wide scope – albeit in periods spanning half a millennium. It is one of political globalization, because it accounts for the formation of political structures that weave together several strands of relationships and collective enterprises. Earlier, in the ancient and classical eras, political interaction was either local or regional. It is only about the year 1000 AD that interactors (conquerors, traders, explorers) began to emerge at the planetary level and launched a global layer of interactions. Driving that process at the agent level are long cycles of political competition, but at the higher, institutional, level they add up to global political evolution.

Since the start of the modern era, about 1000 AD, global political evolution has established, in the course of "imperial experiments," the technical preconditions of global order, in part by defeating the project of the Mongol world empire. In the period that fashioned the institution of global leadership (say 1430–1850 AD) an (oceanic) nucleus of global organization emerged in the defeat of (continental) imperial challengers. The two British cycles were the mature form of that structure as it moved from selection to amplification. The contemporary period, that of "global organization" from 1850 onward (and shown in more detail in Table 2.2) is expected to be completed in about two to three centuries. If the first period (of global political evolution) was one of no organization (or failed organization), and the second one of minimal organization, the current, third, is one of selecting an adequate structure (to be completed in the fourth period). By "adequate" we mean one that has the capacity to respond effectively to problems of human survival, especially those posed by threats that are nuclear and environmental. That contemporary, third, period ("global organization") is sure to be critical. It is critical because it is programmed to be the one "selecting" new forms of institutional innovation. That contemporary period is currently in the second of its preparatory (community-building) phases, and it imparts an agenda to global politics that centers on building a democratic base for global governance that will lay the ground – the sub-structure of solidarity – for significant institutional change in the next (selectional) phase of that process, a century from now.

Agent-level processes

Globalization is a set of institutional processes whose one important characteristic is their long reach. These processes cover grand sequences that are reckoned in centuries and not just generations. But their long periods create difficulties for observers and raise the question as to how they actually relate to day-to-day developments.

The set of four institutional processes just reviewed may, however, also be seen as having nested in each of them a shorter-range, albeit self-similar, actor-driven sequences that animate and propel them in a catalytic fashion. Thus, the evolution of the global economy appears propelled by the successive surges (or blossomings) of new leading industrial sectors, in more recent memory from steam-powered railway and shipping routes to computer-animated telecommunication networks. Global political evolution has been catalyzed in the past half-millennium by the competition of great powers for global leadership. The possibility of a global community is based upon the premise of the rise of a global-level cooperative network framed by democratic practices. The organizing norms of a global system are animated by the rise of world opinion powered by complex new information and learning networks.

Table 2.2 represents these four global agent-level processes that have operated since 1850. All four of them are learning sequences: experiments accounting for the *rise* of new leading industries in the global economy, and of world powers with new designs for world politics, of social movements and clusters of world opinion. Each such learning process comprises two preliminary phases that prepare the ground for, and lead up to, the third one that activates the selectional mechanisms of collective decision and, in the fourth, the completion, and "full closure" is achieved. Each period of the learning process has the time structure of the learning algorithm, but the location of each depends on a set of favorable initial conditions.

We reckon the US (learning) long cycle to have extended from 1850 to 1975, with its preparatory phases lasting up to the period 1914–45, laying down the foundations for global leadership that was fully established only after 1940. But the United States' (lightly institutionalized) "term of office," then started, extends beyond 1975, until another selection is achieved (on our timetable, after 2026). Thus, in respect of that US cycle, the first learning sequence ends in 1975, but the "term of office" lasts longer, on this accounting, until 2026, but might also appear as a "lame duck" season, in which the global political system (as though in an election campaign mode), sets up the conditions for a new round of competition.

All four are actor-level processes that can potentially be represented by S-shaped logistics. Empirical analysis of the Portuguese cycle of global leadership demonstrates that it had precisely that shape, showing that Portugal learned by building the first elements of a global system (see Chapter 3 of this volume). Studies of the rise and fall of leading industrial sectors in the modern age demonstrate the same point, and strongly support the notion of a succession of S-shaped surges of globally significant activity shaping the global economy in synchrony with the global political process (see also Modelski and Thompson, 1996). The same argument holds for the spread of democratic practices, via democratization, that provide the grounding for a global democratic community. (Modelski and Perry, 1991). In other words, viewed closely, globalization re-appears as a cascade of multiple (S-shaped, logistic) shorter-term learning cycles that drive globalization at the ground level but are steered by higher-level evolutionary processes.

Democratization, global economy, world opinion

In addition to the global political process centered on long cycles, Table 2.2 shows three related and co-evolving processes: those bearing on community, economy and world opinion. They make up globalization at the agent level, but catalyze developments at the institutional level. Let us briefly comment on each of these.

Democratization is the global social process propelled by a competition between democratic movements and anti-democratic forces. It has a period of one-quarter of a millennium; disseminates democratic practices on a global scale; and is now in the (decisive, or selectional) stage of "democratic transition," that is just past the tipping point of establishing a world-wide majority of democracies, and building a base for future democratic governance. This global evolutionary process of the human species acquiring the elements of democratic practice may be represented by a learning curve that shows how an increasing portion of the world's population has come to live in democratic countries.

The first phase, one of early adopters, unfolded in the decades prior to World War I (at about the 10 percent level); by 1975, a nucleus of over 40 democracies had emerged, which, at the close of the twentieth century, moved to a majority position in the world's population.

Since 1850, democratization has encountered a series of militant and competing movements. These were anarchist–nihilist groups prior to World War I; fascist and communist forces through much of the twentieth century, and, since the late 1970s, possibly the developments in the Arab and Moslem worlds. These may be viewed as successive negative responses to democracy, and resistance to the spread of democratic values and practices. The earlier attempts demonstrably failed to garner sustained global support. Recently prominent has been the challenge presented by radical Islamist movements, even raising the call for a new "caliphate" that harks back to Islam's classical empire. In a longer perspective, democratization lays the ground for an "Age of Reorganization" (Modelski, 2006).

The rise and decline of world powers (the long cycles that drive global political evolution) has run in tandem with *K-waves*, the rise and decline of leading industrial sectors – the driving forces of economic globalization. Both are evolutionary processes in that they exhibit, as a minimum, variation (innovation) and selection (power or market competition). They are self-similar, synchronized, and nested, in that K-waves are initially located in world powers.

The computer–internet K-wave (or K19, Table 2.2; see also Chapter 14) took off in the United States, and more precisely in California's Silicon Valley in the 1970s. Around the year 2000, after experiencing a (selectional) shake-out, it entered a high-growth phase likely to last some two to three decades. While shaping and reshaping the global economy and boosting the forces of globalization, it launched a burst of innovative energy that renewed the American economy's bid for "lead" status (*contra* those, in the 1980s, who viewed it as "declining"). While K17 and K18 provided the pillars of American power in World Wars I and II, K19 induced a "military revolution," enhancing the US capacity for global reach and equipping its forces with high-precision guided weapons before its rivals. However, post-2000, K19 is experiencing high growth, and the advantage is now increasingly shifting from early to late adopters. The relative advantage of the US is declining, competition is rising, and new productive centers, as in China, India, or Brazil, emerge, while older centers, in Europe or Japan, have to retool.

The fourth agent-level global process is the rise, since 1850, of world opinion, a product of opinion-leaders, the media, and the world of learning. Its antecedents can be traced back to the Renaissance, and the Enlightenment, and early in the twenty-first century it lies in the phase of global connectivity that promotes the discovery, definition, and institutionalization of global solidarity (1975–2080). That is a process that moves ahead, on the basis of shared knowledge, with the recognition of common interests in global security and human survival. World opinion lays down the intellectual basis of globalization; it clarifies global problems and helps to set the global agenda; and it also contrives to make the process more predictable.[7]

Is it determinism?

Globalization has been depicted here as a "process structure": a set of processes creating a new level of world organization. The approach has been evolutionary, aiming at portraying it all as a product of self-organization viewed as the "scientific foundation of the evolutionary vision" (Jantsch, 1980).

The processes – dissected in this chapter – that make up globalization hold up well against historical evidence, and their predictions are confirmed *post hoc* in novel and surprising ways. For example, the K-waves of leading sectors have been shown to generate spurts of economic activity basically as predicted, over an extended period spanning up to one millennium. The rise and decline of world powers (long cycles) closely match fluctuations in the concentration of oceanic sea power. Even urbanization demonstrates a step-wise rise in intensity in each of the three major eras of world system evolution. But does this form of evolution make sense only *post hoc* (as some maintain, because evolution is "open-ended"), or does it also give us a degree of guidance for the future?

One feature of the institutional approach is that it concerns processes of long duration and requires a learned faculty for the long vision, but focuses only on one aspect of temporal development (obviously the institutional). The four processes displayed in Table 2.1 show periods ranging from 250 to 2,000 years. Is that not enough to warrant rejection by social scientists whose time horizons rarely extend beyond one generation? Are the social sciences capable of handling such long perspectives? Many would turn away from such bold and as yet to be more fully documented propositions, claiming that at such distances change is hardly observable in the present, even though it might be demonstrated, *post hoc*, in historical conditions. Even in agent-driven processes, the minimum "resolution" is one generation – that might be reckoned as some 25 to 30 years – and is still often beyond the customary range of social investigation.

One other criticism laid at the door of an institutional–evolutionary approach to long-range social change is the claim that it might entail determinism, and that is wrong. Determinism, in the helpful formulation of Auyang (1998), a global doctrine "about the conditions of the world at large," is one that we do not entertain. It is a metaphysical doctrine about "The Future," about free will, and the world as made up of deterministic systems, in which the future of that world is wholly determined by its present configuration. Auyang usefully contrasts determinism with determinacy and that concerns local characteristics attributed to individual systems or processes that may or may not evince dynamic properties. We reject determinism as a philosophical position, but conjecture that the processes under investigation may well be subject to deterministic dynamic rules. We also observe that a majority-description that depicts globalization as "inexorable" (some call it the "inexorabilist" view) does indeed suggest local determination.

On the other hand, the network of concepts for an evolutionary vision presented here meets demanding criteria, as, for example, those set out by Anthony Giddens or Karl Popper. It shows continuity with biological evolution; proposes a clear mechanism of change; shows how that mechanism accounts for the phasing of evolutionary processes; and even suggests the applicability of that mechanism to the wider context of world history. It does not, of course, account for world history as such, and neither does it offer a blueprint for the future, but it does clarify the make-up of certain critical processes, and clarifies the rules underlying large-scale change.

More specifically, why not conceive of our task as one of devising aids in thinking about the future? The future may be full of uncertainties, but it also harbors elements of continuity and stability that lend themselves to prediction. For instance, in democratic countries it is possible to assert that elections will be held with predictable regularity. That makes sense, because a democratic political system will have institutionalized these matters to a satisfactory degree. In similar manner, the rise of global institutions makes the global political environment more predictable.

That is why it is important and productive to view globalization as a cluster of local and co-evolving dynamic processes whose behavior may be observed, charted, and analyzed, and whose product is enhanced institutionalization (without necessarily precluding instability, randomness, or indeterminacy). They may be deterministic processes whose dynamic rules, initial conditions, and time-paths may be specified so as to allow for coarse-grained description, or they may be arrays of probabilistic processes. What about globalization as a set of global (logistic) learning processes (for an example see next chapter)? To the degree that they are well specified, they will offer good material for prediction. One as yet unsolved problem is how to measure globalization as global-system property, in a way that would capture all four of its processes.

Notes

1 Since 2000, the *Foreign Policy* magazine has published annually the A. T. Kearney–Foreign Policy "Globalization Index" (http://www.atkearney.com) that employs a variety of data to measure the global entanglement of 62 countries that account for over 80 percent of the world population. In 2005, Singapore ranked first on that index, followed by the Republic of Ireland, Switzerland, and the United States. China was placed 54th, and Iran held the last place – the 62nd. For each country, the index measures economic integration, personal contacts, technological connectivity, and political engagement. Apparently, as yet there exists no common global measure of globalization (but see Hughes Chapter 16 of this volume).
2 Globalization is placed in the context of world-system evolution in the modern era in Modelski (2000), and this is elaborated in Devezas and Modelski (2003).
3 That would also imply that the *Homo sapiens* process started at about 70,000 years BP, and the world-system process, at 5,000 years BP.
4 Worth exploring is the relationship between "evolutionary learning" and Norbert Elias's concept of the "civilizing process" (cf. Linklater, 2006).
5 Now represented by the "Tree of Life," but originally presented and illustrated by a diagram in chapter IV of *The Origin of species*. Since Popper's writing, this has, of course, been confirmed by the discovery that all life has a common genetic basis – a condition that does imply a universal law.
6 Each period of global political evolution is an instance of the working of a learning algorithm (that is, of the enhanced Lewontin–Campbell heuristic: g–c–t–r: generate–cooperate–test–regenerate. In turn, each such period is driven (in a nested, self-similar process at the agency level) by four long cycles, each of which represents one phase of that algorithm. It is not a "general theory" of world politics, but an account of certain critical processes of transformation. The long cycle is a pattern of regularity in global politics, but as an evolutionary process it charts change rather than a circular process of repetition. See, for instance, *The Evolutionary World Politics Home Page* at http://faculty.washington.edu/modelski/.
7 Karl Popper (1957) maintained, in the preface of his "refutation" of historicism, that the future of human history cannot be predicted because the growth of scientific knowledge is inherently unknowable.

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3 The Portuguese as system-builders

Technological innovation in early globalization

Tessaleno Devezas and George Modelski

Setting out the problem

Devezas and Modelski (2003) demonstrated recently that world system evolution may be viewed as a cascade of multilevel, nested, and self-similar, Darwinian-type processes that exhibit power-law behavior, also known as self-organized criticality. World social organization, poised on the boundary between order and chaos (Devezas and Corredine, 2001, 2002; Kauffmann, 1995), is neither sub-critical nor supercritical, and that allows for flexibility (innovation), which is a necessary condition of evolution and learning. The framework proposed by Devezas and Modelski opens the door to conceptualizing the emergence of world organization and, more recently, of globalization, as a process of systemic learning, which leads in turn to the umbrella concept of a learning civilization.

Pondering about the meaning of a power-law function describing the main lines of human social change over the past five millennia, the authors state that the events underlying this ranking of world evolutionary processes and exhibiting such scale-free behavior are essentially innovations. The broad spectrum of evolutionary processes analyzed in their work is the result of major innovations in their respective spheres, namely in the layers of movement, that, following a cybernetic hierarchy (with increasing informational content), may be ordered as economic, political, social, and cultural processes. Innovation in the world system is a continuum across generations, it being evident that such huge and revolutionary events are much less common than smaller ones. At the lower end of the cascade of processes lie the fairly energetic technological innovations implicated in the formation of the socio-economic long (or K-) waves, and the long cycles of global politics. With decreasing energy content and increasing informational content follow the innovations responsible for radical changes in social organization, and in beliefs and ideologies. Underlying the whole is a power law asserting that the frequency of evolutionary innovations (assuming one major innovation, or cluster of innovations, per each characteristic period) is inversely related to their importance, as indicated by their respective temporal reach (or length).

In this study we propose to focus in on two components of this cascade: K-waves, and long cycles, with the related innovations that set the stage for the Atlantic phase of the West European leadership of the world system. In fact, the evolution of global politics is rarely analyzed in terms of innovations, and students of "hegemonic succession" seldom if ever accord Portugal a leading role in it. On the other hand, most theorists of K-waves agree on a neo-Schumpeterian evolutionary view that K-waves are basically driven by technological innovations. Radical technological innovations tend toward clustering "quasi"-periodically during some historical time corresponding with the downswing of a K-wave. It is relatively easy to see the swarming of radical innovations during the period of contraction (recession) of the world economy along with the unfolding of the last four K-waves (since the Industrial Revolution), as recently discussed by Devezas *et al.* (2005). It is also widely understood that globalization that is itself an epochal innovation has its roots in early modern developments. But consensus is lacking on at least two points regarding the onset of the Iberian leadership of the world economy, and that may be summarized below as two questions:

1 How do we interpret the close relationship between technological innovations, K-waves, and long cycles, in the period preceding the Industrial Revolution?
2 Does empirical evidence from that period support the notion of K-waves and long cycles as evolutionary learning processes related by a power law?

The answers to these questions are somehow interconnected, and we shall discuss them as foundations for understanding the processes that make up globalization, viewed as institution- (or system-) building process as depicted by the Modelski–Thompson concepts of leading sectors and world powers (Modelski and Thompson, 1996).

Modelski–Thompson's "leading sectors and world powers"

According to Modelski and Thompson (1996), the precise nature of innovations conducive to reshaping the world economy has changed over the last millennium. In their enlarged time frame, the analysis of global economics and politics begins with the inception of the market economy in Sung China at about AD 930, evolves gradually through the formation of a national market and the entrenchment of a fiscal/administration framework, and leads to the expansion of the maritime trade (i.e. first employing the compass) by the southern Sung. In the thirteenth century, the locus of innovation shifted to the Mediterranean, led first by Genoa and soon followed by Venice. The Venetians, using their great galley fleets, quickly developed a strong trade network all over the Mediterranean space, also reaching the Black Sea and the North Atlantic Ocean.

At this point the international trade among European and Asian countries was already an energetic and fervent activity, with the leading sectors clearly commercial in nature. For the period between *c*. AD 1200 and AD 1400, which corresponds with the onset of the European leadership of the world system, Modelski and Thompson identified four K-waves – two led by the Genoese (the Champagne Fairs and the Black Sea trade respectively) and two led by Venice (based on the creation of a network of galley fleets, and the organization of the pepper trade with the Orient, respectively). These four cycles peaked in 1250, 1300, 1355, and 1420, respectively and considered together they represent two Italian long learning cycles of global politics. Yet, according to the authors, the predominantly commercial nature of the leading industries endured all from the fifteenth through to the eighteenth centuries, embracing the Portuguese, the Dutch and the first British eras. Only by the end of the eighteenth century did the emphasis in the character of innovations shift to industrial production, developed during the second British era (cotton textiles, iron, and railways), that has remained so up until present day and throughout the US era (steel, chemicals, electricity, motor vehicles, aerospace, computers).

In order to accommodate the changing nature of innovations along with the history of the world system, within just one embracing concept, Modelski and Thompson employed the term "leading sectors." Routine innovation and incremental change may be more or less continuous processes in economic activities. But, as we have seen, radical innovations are not continuous, instead they swarm during some historical periods, more or less corresponding to the declining period of a given K-wave, or, we might also say, during the declining period of a preceding leading sector. Yet, once spurts of radical innovation begin, there is some probability that they will continue because other players will perceive new opportunities and/or new necessities as the payoffs from the previous spurts decline. Modelski and Thompson paired this concept of leading sector with that of "world power," that nation-state most actively contributing to the evolution of global politics, and they identified the relationship between these two phenomena as co-evolution, seeing two K-waves matching each period of a leading power cycle.

During the historical period preceding the Industrial Revolution, the commercial nature of radical innovations has meant the development of new trade routes; the opening of new markets; trade in new products; and the introduction of new modes of transportation. After the onset of the Industrial Revolution, the industrial nature of radical innovation has meant, first, the introduction into the market of a completely new product (technological innovation, which followed some scientific discovery or invention), and, second, the massive production of these goods, using new ways of creating products by improving productivity and performing tasks that could not be done as efficiently and quickly as before. In other words, only after the Industrial Revolution can the Schumpeterian rule of invention → radical (technological) innovation → economic expansion be applied. A question then arises: which was the dominant rule in the epoch preceding the

Industrial Revolution when the commercial nature of innovations was the driving force of the economy?

We turn now to the analysis of our first question: how to interpret the close relationship between innovations, K-waves, and long cycles, in the period preceding the Industrial Revolution?

System building as a learning process

The answer to this question lies in the realm of evolutionary system-building and its relationship with technology. Social scientists have long discussed the best approach to understanding the emergence and stabilization of artifacts that humans use for their immediate purposes. There is a dispute between social constructivism (an outgrowth of the sociology of science) and system (systems)-building (an outgrowth of the history of technology), each filling books and articles with empirical examples of their processes.

Devotees of the former assume that artifacts and practices are underdetermined by the natural world and argue that they are best seen as constructions made by individuals or collectivities that belong to social groups. Social groups have different interests and resources, and consequently they have different views of the proper structure of artifacts. The stabilization of artifacts is then explained by referring to social interests that are imputed to the groups concerned and their differential capacity to mobilize resources in the course of debate and controversy. According to this view, artifacts are forged during controversy and achieve their final form when a social group imposes its solutions on other interested groups by one means or another. Social constructivism works on the assumption that the social lies immediately behind and directs the outgrowth and stabilization of artifacts.

On the other hand, the system-building approach proceeds on the assumption that the social is not especially privileged. Those who build artifacts do not concern themselves with artifacts alone, but must also consider the way in which the artifacts relate to social, economic, political, and scientific factors. All these factors are interrelated and potentially malleable. In other words, according to this approach, innovators are best seen as system-builders who juggle a wide range of variables as they attempt to relate the variables in an enduring whole. Going a step further Law (1989) declares that:

> the stability and form of artifacts should be seen as a function of the interaction of heterogeneous elements as these are shaped and assimilated in a network. In this view, then, an explanation of technological form rests on a study of both the conditions and tactics of systems building.

Law calls this activity "heterogeneous engineering," suggesting that the product can be seen as a network of juxtaposed components, and he uses as empirical verification of his model the case of the Portuguese expansion. Our proposal in this chapter is to contribute with a deeper insight to

Law's systems building–heterogeneous engineering approach, pointing out some missing elements in his analysis, while also contributing to studying the case of the Portuguese expansion.

Such missing points are, not necessarily in order of importance, the absence of an evolutionary perspective; the precise distinction between technique and technology; a clear conceptualization of innovation; and the view of system building as a learning process.

A more thorough discussion of these points would be out of place here, and has already been undertaken by Devezas (2005) in a recent work. Let us recall first that Portuguese expansion was just one of the initial phases of the building of the world system, which is an evolutionary and systemic learning process, involving a cascade of multilevel, nested, and self-similar, Darwinian-type processes, and extending over a number of periods (varying in length from one to over 250 generations) (see also Devezas and Modelski, 2003). While the scope of the present chapter appears narrow, its subject is one of outstanding importance, because it highlights the Portuguese role in at least two very important transitions in the formation of the world system: the creation of a global network together with instruments of global reach (the debut in the rush toward a more globalized world, and hence the onset of globalization), and the emergence of some scientific commitment in system-building endeavor.

To gain a full understanding of the second point mentioned above, we need to review briefly the distinction between technique and technology. To begin with, we should bear in mind that techniques precede technology, not only in human history, but also according to a purely evolutionary point of view. Techniques did not need a brain or mind to come into existence in the course of biological evolution: very primitive life forms have developed skilled techniques of gathering food, of attracting partners for mating, of disguise to avoid predators, and of capturing prey. Some primitive underwater animals were and still are very successful killing machines. More concretely, techniques came to life in the course of biological evolution as a form of searching for a shortcut to reach a goal, because it makes it easier to pursue this goal through such a shortcut. This seems to be a clear manifestation of the *principle* of least action in practice, which has worked as the underlying driving force for better and better search procedures, amplified by the development of learning capabilities.

Following this reasoning, we can state then that humans, when dealing with techniques, do in a conscious way what nature always does unconsciously. In other words we can say that human technical skills are the continuation of this natural search for shortcuts by the application of intelligence. As pointed out by Devezas (2005), technology is a recent human achievement that flourished conceptually in the eighteenth century, when techniques were no longer seen as skilled handiwork, but were recognized as the object of systematic human knowledge and a new "*Weltanschaun*" (at that time purely mechanistic). This term was first proposed in 1777 by the German economist Johannes Beckman (in his opus *Einleitung zur Technologie oder zur Kenntnis der Handwerke, Fabriken und Manufakturen*), as the science of technique, or the "*Lehre*" of people performing something (technical) at their best.

The several early K-waves that we mentioned were systemic learning processes involving commercial innovations strongly based on empirical technical progress, drawing remarkably little support or inspiration from science. But the Portuguese saga in the Atlantic and Indian oceans, while rooted strongly in empiricism, does show a certain scientific commitment in at least three instances. First, the initiatives were set in motion by Prince Henry during the first quarter of the fifteenth century, initiating a dialogue with experts, scholars, and scientists from other parts of the world, and in this way creating for the first time a kind of think-tank (some call it the School of Sagres, although its real existence is in dispute). Second, in the early 1480s, King John II convened a scientific commission to seek improved methods for measuring the "*altura*" (the height above the horizon of the sun or a star) that resulted in a written text called the *Regimento do Astrolábio e do Quadrante* and led to expeditions in the Atlantic Ocean and down the African coast, with the sole intention of elaborating precise tables to convert the *altura* into latitude, as well as to ascertain the exact latitudes of important coastal features. Third, with the issue of the first technical publications on Portuguese shipbuilding (*Ars Nautica*, *c*.1570; *Livro da Fábrica das Naus*, *c*.1580), then, for the first time in recorded history, creating the science of naval engineering (Domingues, 2004). This scientific commitment itself represents an innovation in system building undertaken by the Portuguese in the fifteenth and sixteenth centuries, which will help us in the quest for the answer to our first question. Here is how the historian Boorstin (1986), in *The Discoverers*, assessed the quality of that effort: "As an organized long-term enterprise of discovery, the Portuguese achievement was more modern, more revolutionary, than the widely celebrated exploits of Columbus."

To build a system means to undertake structural change within the world system, with ripple effects on constituent subsystems (which means that globalization is system-building). As already pondered by Devezas and Corredine (2002), the system being built is an evolving macrostructure that is socio-technical, techno-economic, and macro-psychological (collective–cognitive). This evolving process is the wearing out and exhaustion of existing macrostructures and their replacement by new ones that are better fitted to the new evolutionary situation. Evolving systems show feedback between macroscopic (collective) structures and events of individual interactions at the micro-level. Macrostructures emergent from the micro-level in turn modify the individual interactions at each stage of irreversible evolution, which means that we are dealing with a dissipative process. An order parameter is such an outgrowth of micro–macro interactions; it is a macrostructure or macrovariable that emerges along with a reduction in the degrees of freedom of the system. The evolving leading sector, or a leading global power, are our order parameters. An order parameter implies a new "collective design" embracing a set of novelties. The long wave and the long cycle are our perception of it, functioning as a pattern recognition process. In our case study, the order parameters are the onset of the Portuguese global-reaching project and the two innovative commercial routes induced by it (to be analyzed in the next section).

In the framework of complex systems, the behavior of human collectivities is explained by the evolution of macroscopic order parameters, which are caused by non-linear microscopic interactions of humans or human subgroups (firms, nations, states, institutions, etc.) (Devezas and Corredine, 2002). Social or economic orders may be interpreted as attractors of structural change. Using the language of synergetics, we may say that at the microscopic level the stable modes of the old states are dominated by new unstable modes (the "slaving principle"). New structures emerge when the nucleating unstable modes can serve as an order parameter determining ("enslaving") the macroscopic behavior of the system. The rate of change from old to new is co-determined by control parameters related to the type and intensity of interactions involved. In other words, the control parameters are related to the rate of learning with which humans learn to deal with the new environment imposed by the dominant order parameter.

System building is then an evolutionary process through which the system self-organizes and learns, configuring and reconfiguring itself toward greater and greater efficiency, and in this manner, performs some activities better with each iteration. Each stage corresponds with a given structure that encompasses previous self-organization, learning and the current limitations. This is to say that self-organization and learning are embodied in system structure. The learning rate is the control parameter determining the timing of the entrenchment of the new system.

Now we shall see how the Portuguese helped to launch globalization by the dawn of the fifteenth century, in a process that endured for some 150 years. For the first time in history, they built a system of global reach, far more complex than anything that went before, involving the network of basic technical–technological innovations, that in turn synergistically effected its quick entrenching.

The Portuguese as system-builders

The technical environment: historical analysis

In Table 3.1 we attempt a summary of the order parameters (leading sectors, world powers) and the technical–technological innovations (that in turn involve the basic learning rates controlling the timing of these processes) that were responsible for the entrenchment of Portugal in a position of global leadership in the fifteenth century, launching Europe upon a new role on the world ocean.

Table 3.1 Leading sectors and technical–technological innovations of the Portuguese cycle (LC5)

Global leadership	*Leading sectors*	*Technical–technological innovations*
(World powers)		
Political innovations at the global level	**Commercial innovations for the global economy**	**(Involving the basic learning rates and the timing for building the system)**
Order parameters	***Order parameters***	***Control parameters***
1430 (beginning) Portuguese cycle LC5 (preparatory phases)	Guinea Gold (K9) – 1430 (Commercial route to West African coast)	The caravel – 1420 The "*volta da Mina*" – 1440s The quadrant (and the "*Balestilha*") – 1440s Caravel artillery – 1473
1494 (continued) Portuguese cycle LC5 (decision phases) (decisive battle: Diu, 1509)	Indian Spices (K10) – 1494 (Commercial route to India and control over Indian Ocean trade)	The "*altura*" (the *Regimento*) – 1480s The Nau (great ship) – 1490s Cast bronze ship cannons – 1490s The galleon – 1510s Network of bases – 1460–1540

We do not intend at this time to analyze all of the innovations (leading sectors and technical–technological innovations) involved, for this has already been undertaken in previous works, such as those of Modelski and Thompson (1996) and Law (1989). Along with the text below, we intend to call attention to some relationships not yet well explored by previous authors, and to present a collection of new graphs that show a good fit to the model of the Portuguese expansion as an evolutionary and systemic learning process. The numbering of K9 and K10 refer to the ninth and tenth K-waves respectively, and LC5, to the Portuguese long cycle, in accord with the Modelski and Thompson (1996) usage.

We know that earlier innovations, too, such as the compass (famously Chinese in origin), the astrolabe, *portolano* charts, or the sandglass, etc., were of fundamental importance for the navigation capacity of these times. The Portuguese did not develop them, but we do know that Portuguese artisans contributed much to their further development. This is the case, for instance, with the quadrant. The quadrant (like the astrolabe), had been a standard research instrument of astronomy and astrology since the fourteenth century, and carried a great deal of information about the movement of planets, about the seasons, and the hours of the day. However, such information was both unnecessary to the calculation of the latitude and simply incomprehensible to the layperson. The Portuguese developed simpler versions of the quadrant, shorn of all but its essentials for the measurement of the "*altura*," in this way contributing to its further development and introducing innovation into its design. Of the remaining *c*.80 of these instruments preserved in museums all over the world, nearly half are of Portuguese origin, carrying the names of their makers, such as Agostinho de Goes Raposo, Francisco Gois and João Dias (Albuquerque, 1988).

With Table 3.1 we wish to show how important each set of innovations was for the entrenchment of each related phase (LC5, and K9 and K10) of the Portuguese expansion. Note that the first set of technical–technological innovations was also of paramount importance to the second phase, but did not act properly as control parameters, for the involved collectivity of agents (people) have already learned to deal with them.

Regarding the first set of technical–technological innovations detailed in Table 3.1, we know a great deal about the decisive contribution of the caravel to Portuguese endeavors in the South Atlantic and exploration along the coast of West Africa. The caravel is a descendant of traditional Arab fishing-boats used by the Moslems in the south of Portugal (Algarve). The first written reference to it appears in the *Foral de Vila Nova de Gaia*, privileged in 1255 by King Afonso III, but most authors agree that the ship started its true career around 1420 (Domingues, 2004; Albuquerque, 1985; Cortesão, 1975). Weighing less than 100 tons and being 70 to 80 feet from stem to stern (with a length-to-breadth of about 3.5:1), it was carvel-built, quite light and fine in lines, and drew little water, having a flat bottom. These characteristics make it well adapted to offshore exploration – a task for which one needs vessels that do not blunder on to reefs. Maneuvering along the West African coast required a great deal of sailing obliquely into the wind or even against the wind ("*bolinar*"), a task at which the lateen-rigged caravel with two or three masts excelled.

The caravel did not require a large crew, and its robust deck was strong enough to carry deck-mounted guns, a process that started in earnest in 1472–73. In 1479, during a war with Spain, and using this newly acquired armament, the caravels of Portugal captured a Spanish fleet of 35 ships returning from Guinea with a cargo of gold. In the treaty (1480–81) which ended that war, Spain conceded to Portugal the exclusive right to navigate to Guinea (*Mare Clausum*), a precedent that in turn led to the Treaty of Tordesilhas (1494) that brought about a similar allocation of access to ocean spaces on a global scale. In the view of Monteiro (1989), the naval victory of 1479, that he locates off Cape St Vincent, opened a new (cannon-dominated) chapter in the history of naval warfare, and established Portugal as the dominant sea power in the Atlantic (Diffie and Winius, 1977; Monteiro, 1989).

Later in the fifteenth century, larger and longer caravels (about 100 ft long) were developed for long ocean voyages, with four masts, square sails on the fore and main masts, and lateen sails on the stem masts. The squared sails filled like parachutes and propelled the ship with maximum efficiency.

The caravel supplied the necessary instrument of innovation that enabled the Portuguese to have access to the Gold Coast, and prepared the way for even bolder explorations later, both in the economic and in the political context.

But another innovation – this time in operating procedures – was necessary for the successful working of the caravel in its southwesterly enterprises along the Atlantic coast of Africa. The major problem that Portuguese sailors faced at those times after rounding Cape Bojador, the classic point of no return, was how to come back to Lisbon or the Algarve, sailing against the winds and the strong Canaries current, or, in other words, how to come back home using the same route along the coast. At some unrecorded point, Portuguese sailors developed a technical navigation trick (Diffie and Winius, 1977; Albuquerque, 1985; Law, 1989), that consisted of putting the adverse Atlantic winds and currents to good use by pointing their caravels seaward, away from the Moroccan coast, heading first northwesterly and then taking a more northerly course until the westerlies and North Atlantic drift were encountered, making it possible to head east in the direction of the Portuguese coast. The more southerly the route along the Atlantic African coast, the bigger the circle (the *volta* in Portuguese) necessary to come back to Lisbon or Algarve. In some history books this *volta* is sometimes referred as the *volta da Mina* or *volta da Guine*, but the last seems to have been developed later as a route sailing round the Cape Verde Islands (Albuquerque, 1985).

We have already noted the development of the quadrant. If, on the one hand, the quadrant was not a native technical innovation, then the *balestilha* (cross-staff, see Figure 3.1), another instrument for the measurement of

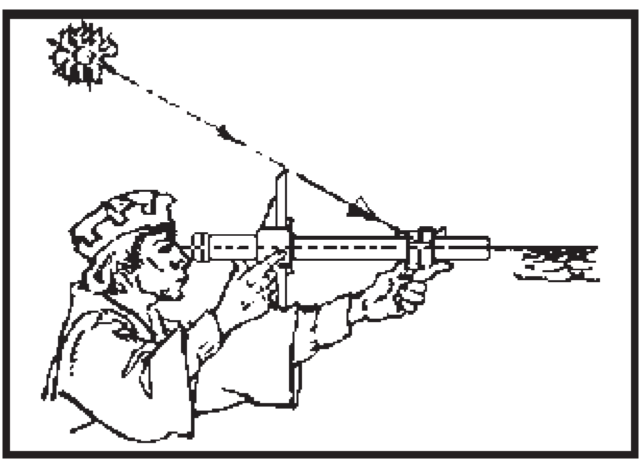

Figure 3.1 Picture representing the *balestilha* (cross-staff), another instrument for the measurement of the *altura*; this was an authentic Portuguese invention, probably from the earlier sixteenth century.
Source: (from http://www.museutec.org.br/previewmuseologico/a.balestilha.htm).

the *altura*, was an authentic Portuguese invention, although it may have been developed later in the K10 period (Albuquerque, 1985, 1988), since the first written reference to the *balestilha* appears in the *Livro de Marinharia de João de Lisboa* (issued in 1514). But the production of locally made, simplified quadrants was already routine by the 1440s.

Our point is that this set of at least four basic innovations made up the control parameter that set the stage for the entrenchment of the Guinea Gold order parameter, and was also the basis for concurrent political developments. The rate at which the Portuguese acquired the skills to deal with this new technical–technological environment lent a rhythm to the unfolding of the whole of the K9, and also the LC5, process, as we shall see in the next section.

The same might be said about the set of innovations related to Indian spices – the K10 chapter of Portugal's economic enterprise. As noted, King John II's initiative of convening a scientific commission to devise improved methods for measuring the *altura* (that resulted in a written text called the *Regimento do Astrolábio e do Quadrante*) and also the decision to send expeditions to the Atlantic and the African coast with the sole intention of elaborating precise tables to convert the *altura* to latitude, resulted not only in important improvements in the existing technological environment but also represented an important scientific commitment at a time when developments were basically empirical.

The Portuguese enterprise in the Indian Ocean was implemented by introducing other types of innovations, not only physical–technical but also socio-technical in character – those bearing on the construction of the rudiments of a global political structure. Prior to the arrival of the Portuguese in the Indian Ocean in 1498, Egypt (with the backing of Venice) monopolized access to the seas east of Suez, and controlled the sea-lanes that connected its ports with the Indian subcontinent, Southeast Asia and China. European traders were absolutely prevented from passing through Egypt (Abu-Lughod, 1989). In the Indian Ocean, peaceful trade was the norm but was carried on largely among Moslem merchants. Although there were periods when coastal rulers of the Malabar coast and Southern India were powerful enough to demand toll taxes from passing ships, there had not been any systematic attempt by any single power to enforce overall command of the sea.

The basis of the Portuguese project was sea power: fleets, and bases, supplemented by alliances with local rulers, and for more than a century it gave Portugal command of the ocean. Sea power was founded on two types of newly developed ships: the Great Nau, initiated in the late 1480s when it became clear that caravels were not sturdy enough for the route around the Cape of Good Hope, and the galleon, built from the 1510s onward in response to specific needs to patrol the coasts of both the Atlantic and the Indian oceans. The armed Nau, which weighed 350 to 600 tons, was the backbone of the cargo fleets that started sailing regularly to India, and returned with spices and other Oriental goods. The galleon was of similar design, but smaller and faster; capable of dual (military and commercial) uses; and well armed.

Portuguese naval engineers produced very robust decks able to support a large amount of heavy artillery. Out of it evolved the great Ships-of-the-Line of the seventeenth and eighteenth centuries.

As soon as the Portuguese were sure of their new route to India, they decided (in a design attributed to Affonso d'Albuquerque) to seize the most profitable ports of South Asia, the Persian Gulf, and Southeast Asia, claiming a right to exclusive control of navigation, and in effect substituting a Portuguese monopoly (modeled on the Guinea system) for the Egyptian system. They used the strategy of divide and conquer – first concentrating on isolating Moslem traders from the Hindu ruler of Calicut and then demonstrating their fire-power by launching a two-day bombardment of the vital port city of Calicut (the largest spice market of the Indian Ocean in those days). Command of the Indian Ocean was established by the decisive naval victory at Diu (1509) over an Egyptian–Gujerati fleet. This led to the control of other key trading destinations, including Goa (1510), Malacca (1511) and Ormuz (1515). Some historical analysts (Modelski and Thompson, 1996; Diffie and Winius, 1977) argue that the Portuguese were fortunate to arrive in the Indian subcontinent at a time when many of the ports were outside of the political control of any powerful local ruler, and when the great Asian economies were essentially land-based and self-reliant. But the fact is that the Portuguese success had come about mainly because – unlike the trading ships of their predecessors – the Portuguese ships were extremely well armed for their times. In the last few decades of the fifteenth century, Portuguese artisans mastered the art of bronze-casting large cannons, from six to ten feet in length and weighing well over 500 pounds (Toussaint, 1981). But much of the armament also came from elsewhere: "most of the gunners aboard Portuguese ships in the fifteenth, sixteenth, and seventeenth centuries were Flemish or German" (Cipolla, 1965), a reflection of the close alliance with the Habsburgs and commercial links with the Low Countries.

Finalizing the set of innovations that made up the control parameters that set the stage for the entrenching of the Indian Spices order parameter, we have the fact that Portugal's sea power was also a function of the network of fortresses (bases) that were in turn backed by regular naval patrols. The Venetians had developed a similar network on the regional scale of the Mediterranean, but the Portuguese put their predecessors to shame with the almost planetary reach of their own creation, with each fortified post equipped with a greatly superior fire capacity.

As we shall see in the next section, the Portuguese cycle and the two spurts of the Portuguese K-wave expansion fit logistic learning curves and form well-defined system-building learning processes.

Portuguese discoveries and expansion: A quantitative analysis

In order to quantify the concepts of "discoveries and expansion," we have chosen to enumerate the Portuguese expeditions and campaigns, first considering them discretely, and then cumulatively as a time-series. A total of 159 expeditions/campaigns are recorded (see the Appendix), from the data given by Albuquerque (1985), Cortesão (1975) and Diffie and Winius (1977), and covering the period between 1415 and 1615. This is in effect an extended record of the entire Portuguese long cycle (LC5).

Figure 3.2 presents a discrete curve of the number of expeditions/campaigns at five-year intervals. By expeditions, we mean primarily exploratory and preparatory undertakings; campaigns, by contrast, refer to military, primarily naval, operations that include the capture of cities. We avoid the term "conquests" because that connotes large territorial ambitions; in fact the entire genius of the deliberate Portuguese design lay in network control, in establishing and controlling a global network.

In Figure 3.2 we can observe two clear spurts of what we can refer to as the "intensity of activity." Beginning with 1415 (the conquest of Ceuta) the counting proceeds in five-year intervals. The first part of the graph (before 1500), has a "see-saw" profile, indicating that during the K9 phase the Portuguese accomplished their expansion endeavors at more or less five-year intervals. This aspect disappears after 1500 during the K10 phase, signaling a much greater intensity of activity.

Figure 3.3 shows the logistic fit of the cumulative count, also considered in five-year intervals. The fit is good and suggests that Portuguese expansion was a powerful collective learning process – one of learning to construct and

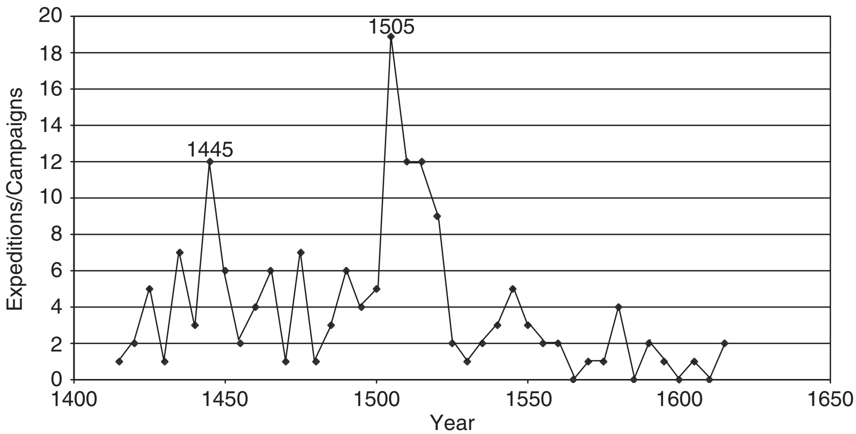

Figure 3.2 Discrete curve showing the number of Portuguese expeditions/campaigns at five-year intervals. Two clear peaks of intensity of activity can be observed. A total of 159 expeditions/campaigns were considered, embracing the period between 1415 and 1615. Observe the seesaw aspect of the first part of the graph (before 1500), indicating that during the K9 phase the Portuguese accomplished their goals more or less at five-year intervals.

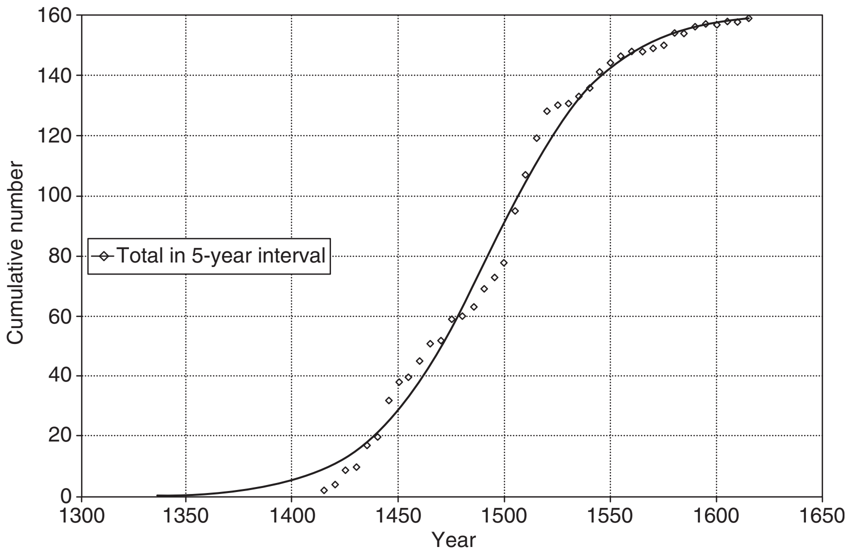

Figure 3.3 Logistic fit of the cumulative count, also considered for five-year intervals. The fit parameters are: t_0 (year of reaching 50 percent of the ceiling) = 1492; Δt (period of time to go from 10 percent to 90 percent of the whole process) = 122 years; δ (growth parameter) = 0.036.

operate a global-level network system. The process went through the standard phases over a period of just over a century: initial preparation in terms of agenda-formation, complemented by exploration and mobilization of resources including allies, followed by campaigns into the Indian Ocean that launched the decision-phase that "selected" (sealed the success) of the Portuguese project, and led to its consolidation. Boorstin (1986) wrote that "… the Portuguese had undertaken a collaborative national adventure based on long-term planning." Planning was certainly in evidence in this effort, but we can also discern the workings of a systemic evolutionary design.

Figure 3.4 documents another aspect of that process. Using the data from Albuquerque (1985) and Modelski (1999), it shows the diffusion of Portuguese fortresses world-wide, from 1415 onward, including the completion of the bulk of the project by about 1540. The number considered for that period is 26 units. The cumulative curve resulting from the count at ten-year intervals is shown in a logistic fit.

In order to obtain the full richness of information contained in these three graphs and its meaning for the study of the Portuguese chapter of world system evolution, we should look at the detail shown by the succession of points in the graphs. Although we can indeed fit a logistic curve, the graph in Figure 3.3 suggests that what we have here are two succeeding

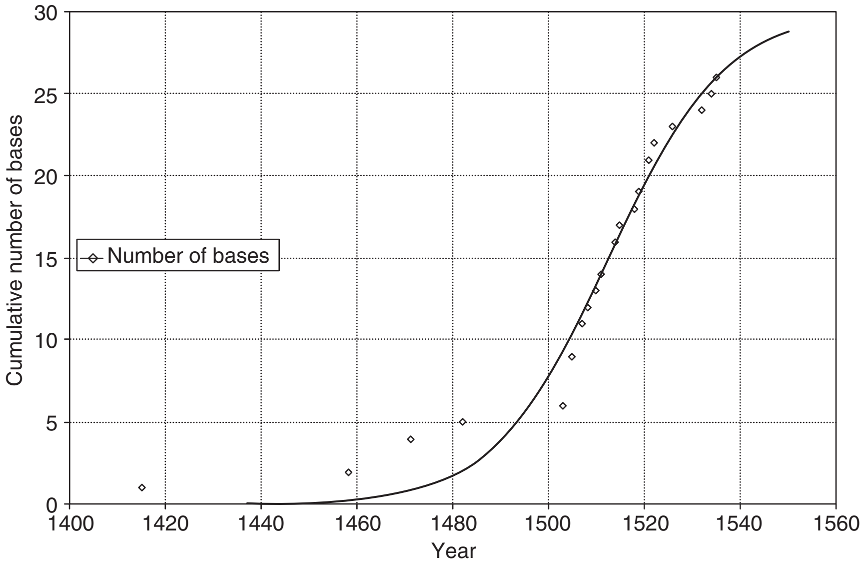

Figure 3.4 Logistic fit of data for the establishment of the global network of Portuguese bases. The fit parameters are: t_0 (year of reaching 50 percent of the ceiling) = 1513; Δt (period of time to go from 10 percent to 90 percent of the whole process) = 52 years; δ (growth parameter) = 0.085.

logistic spurts, in this way matching the two peaks presented in Figure 3.2. We can then apply the bi-logistic fit using the method developed by Meyer (1994), which consists of fitting the sum of two logistic equations instead of a single one. The result is shown in Figure 3.5 in the form of fitted Fisher–Pry straight lines. We have three striking aspects to consider in this graph. The first one is related to the fact that the straight lines are almost parallel, meaning that both spurts followed very similar learning rates: $\delta = 0.092$ for the first spurt and $\delta = 0.083$ for the second spurt. These learning rates imply take-over times Δt (time to go from 10 percent to 90 percent completion of the process) of 48 years and 53 years respectively, which correspond with the duration of K-waves (usually of the order of a half century, sometimes shorter, sometimes a bit longer). The second aspect is related to the coincidence of the middle points of both logistic growth curves (1446 and 1512 respectively) with the peaks shown in Figure 3.2. This reveals the precision and validity of the bi-logistic fit. And finally, the third aspect is related with the separation of about 66 years between the two spurts, once more indicating the validity of the K-wave approach first proposed by Modelski and Thompson (1996).

Regarding Figure 3.4, although the succession of points seems to suggest a bi-logistic growth, the bi-logistic fit has not worked in this case, probably

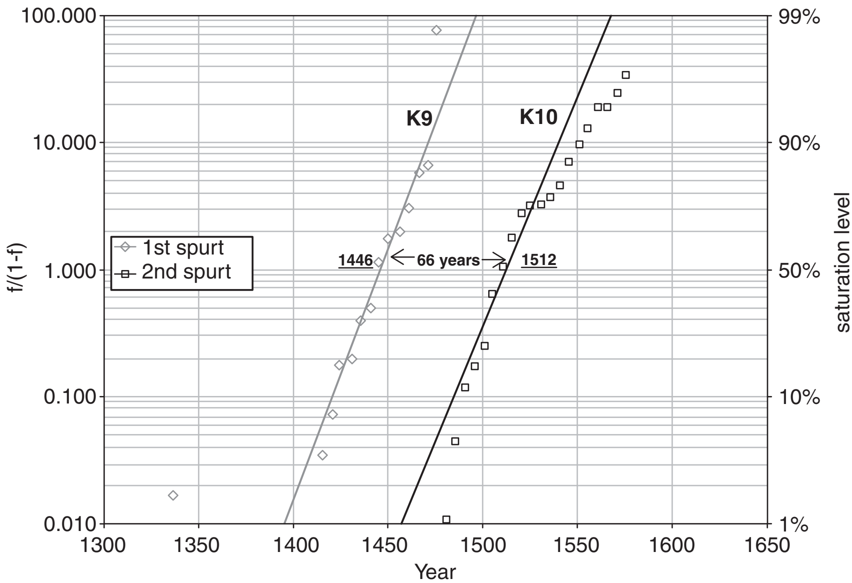

Figure 3.5 Bi-logistic fit in the form of Fisher-Pry straight lines of the data for the Portuguese expeditions/campaigns, using the method developed by Meyer (1994). The points are the same as in Figure 3.3. The two peaks of Portuguese expansion are separated by a time span of 66 years, and they reveal very similar learning rates.

due to the small number of bases constructed before 1500. That means that the construction of the global network of bases corresponds with a single learning curve strongly representative of the second spurt of progress, with a take-over time $\Delta t = 52$ years at a learning rate $\delta = 0.083$, with the middle point at 1513, matching very well the second intensity peak of Figure 3.2 and the unfolding of the second logistic growth curve (K10) as well (shown in Figure 3.5).

The two spurts observed in Figure 3.5 correspond closely with the two K-waves co-evolving with the Portuguese cycle. These spurts are alternatively represented in Figure 3.6 (logistic fit) and Figure 3.7 (Fisher–Pry version), based on data in Modelski and Thompson (1996), each based on only a few data points. The fit is less good than for the earlier graphs, but it is not incompatible with the suggestion of two successive learning curves, flattening after the 1490s and the 1540s respectively. In the first case we see that the influx of Guinea gold was a brief and restricted boom, as already pointed out by Modelski and Thompson (1996). But, in the second case, corresponding with the boom in Indian spices, we see a process perfectly in phase with the unfolding of the second K-wave (K10) presented in Figure 3.5.

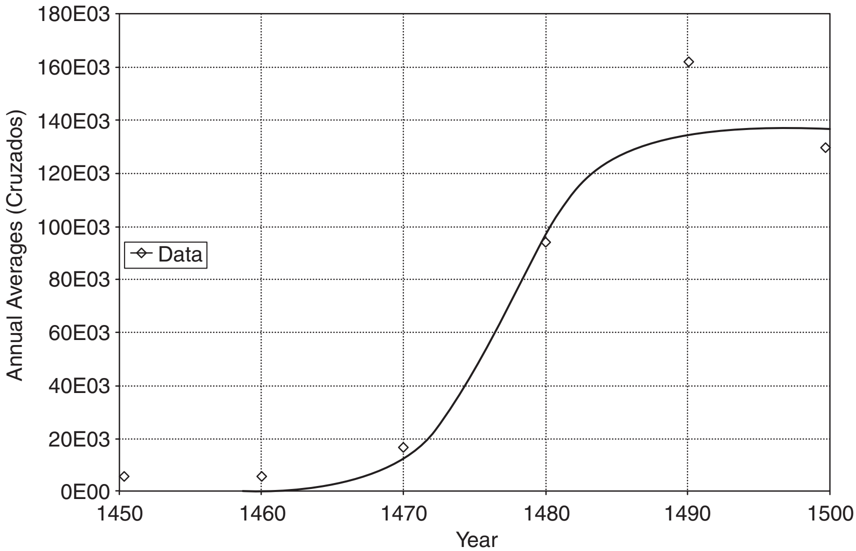

Figure 3.6 Logistic fit based on data in Modelski and Thompson (1996, p. 78, Table 6.2) for Guinea Gold (estimated annual averages in cruzados). The fit parameters are: t_0 (year of reaching 50 percent of the ceiling) = 1477; Δt (period of time to go from 10 percent to 90 percent of the whole process) = 14 years; δ (growth parameter) = 0.324. (The curve is the result of the best fit to a logistic curve using the Levenberg–Marquardt's method. If there had been no fit, then the program would have rejected the data as not belonging to a logistic trend, because the data would not have converged.).

We close this empirical testing stage with a brief comment on the light that it sheds on the role of Spain. Modelski and Thompson wrote in an endnote (1996) that:

> The dispute over whether Portugal or Spain should provide the center of sixteenth century attention often neglects Portugal's global economy lead in the first half of that century (before 1540) and lays stress on Spanish gains in the second half.

In view of the evidence that we present, an attempt to claim global leadership for Spain during the sixteenth century cannot be maintained and should be resisted. Columbus did discover America for the Spanish crown, but Spaniards did not lead in technical innovation or build a global network. Soon after Portugal's effort reached a plateau in the mid-sixteenth century, the Dutch (initially working with the Spaniards, and then fighting them) launched what soon became the Dutch cycle (LC6). World system evolution

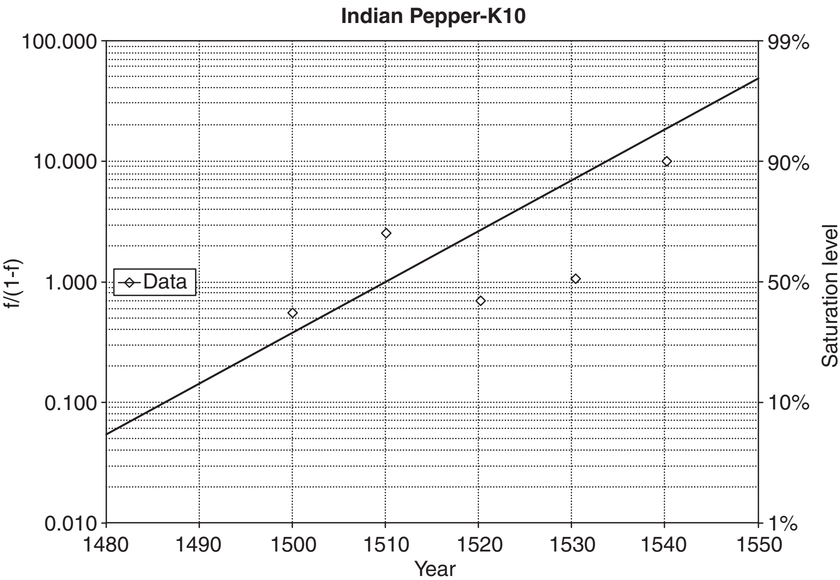

Figure 3.7 Fisher–Pry fit based on data in Modelski and Thompson (1996, p. 78, Table 6.2) for pepper imports (estimated annual averages in quintals). The fit parameters are: t_0 (year of reaching 50 percent of the ceiling) = 1510; Δt (period of time to go from 10 percent to 90 percent of the whole process) = 46 years; δ (growth parameter) = 0.098.

(Modelski, 2000) continued, with new products, new commercial routes, new forms of business organization, and new forms of international cooperation, but now in the Dutch cycle, also corresponding with the order parameters of the Baltic trade (K11) and the Asian trade (K12) (Modelski and Thompson, 1996).

Conclusions

Portuguese expansion of the fifteenth and sixteenth centuries consisted of two quite well-defined system-building learning processes that set the stage for the enterprise of globalization. Each of these spurts of progress, corresponding with the entrenching of the order parameters (global politics, and leading sectors) Portugal, Guinea Gold and Indian Spices respectively, were well grounded in a set of technical–technological innovations, that set the pace of the course (via learning rates) of each of these processes. That is why the answer to our first question (how should we interpret the close relationship between technological innovations and K-waves in the period preceding the Industrial Revolution?) lies in the realm of evolutionary analysis. Even when the commercial nature of innovations was the driving force of the economy, technical–technological innovations (empirically developed or not) were behind (working as a kind of supporting stratum) both the apparently purely commercial nature of the leading sector, and the ambitions of the Portuguese world project.

This case study of the Portuguese expansion supplies the evidence for this argument, and makes it more plausible that the same process was at work in the preceding K-waves and long cycles, and those that followed, as claimed by Devezas and Modelski (2003). Before the Industrial Revolution the Schumpeterian rule: invention → radical (technological) innovation → economic expansion (that carried with it the scientific commitment of most of the inventions and the industrial production of basic innovations) should be simply rewritten as technical innovation (mostly empirical) → commercial leading sector → economic expansion and/or political innovation → technological change → structural change at the global level. The evolutionary principle of least action inducing a continuum of technical "trickery" and amplified by enhanced learning capabilities, has been the underlying driving force. Techniques in early times, and technology in the modern era, were necessary to overcome the laws of nature. System-builders work under Francis Bacon's dictum "*Natura non nisi parendo vincitur*" ("Only by obeying Nature can we conquer it.").

Regarding our second question, we have contributed empirical material, demonstrating that two of the global processes that drive globalization: K-waves and the long cycle, exhibit the properties of systemic learning. Our quantitative analysis does lend support to important segments of our overall conception of a cascade of processes governed by a power law, shaping world system evolution in general, and early globalization in particular. Both the Portuguese cycle and the two K-waves suggest concrete examples of that process, and the close match between the two K-waves and one long (Portuguese) cycle is strong evidence of the working of the power law. Finally, we also show how the two K-waves nest within one long cycle, and how the two processes, while multilevel, are also self-similar. This is new evidence that globalization is an evolutionary learning process.

Acknowledgments

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Appendix: Portuguese expeditions/campaigns data set

The methodology: Selection criteria

This data set is a list of Portuguese events with an explorative mode (or in other words, those that led to discoveries and unexplored lands); these events are counted as expeditions and others as campaigns to seize a position or capture a city, as well as those expeditions (involving the departure of a fleet) with the goal of constructing a fortress or establishing a settlement. All such events in the list that follows are marked by an asterisk (*). Certain other dates and events were included in this list only because they mark important events in the history of Portugal and the history of the Portuguese expansion (e.g. the Treaty of Tordesilhas), but they were not included in the count of events on which the figures are based.

More generally, the methodology was that of recording the events that indicate the intensity of activity as shown in Figure 3.2. Also, for the sake of consistency, the event of 1336 (the arrival of the Portuguese in the Canaries) was not considered. With regard to the intense movement of ships or fleets heading to India, a movement that continued in a regular manner after 1500, all of the most important sailings to India before 1509 were counted because they were representative of the beginning of the effort to establish a new route to India. After that point, the preparation of fleets sailing to India became part of everyday life in Lisbon, and so is not counted as "new."

The English spelling of place names follows the usage adopted in Diffie and Winius (1977) *Foundations of the Portuguese Empire*.

1307	– D. Dinis promotes the organization of a Portuguese navy. Nicknamed the "grower of the ships (*naus*) to be," he orders the planting of the Leiria pine forest.
1317	– D. Dinis appoints Manuel Pessanha of Genoa as the Admiral of Portugal.
1336	– First Portuguese expedition arrives in the Canaries.
1413	– Prior do Hospital scouts Ceuta, collecting information, and advises Joao I to seize the area.
*1415	– (21 August) D. João I captures Ceuta with a fleet of 200 ships and some 20,000 men.
*1416	– Expeditions to the Canaries.
*1419	– Discovery of the island of Madeira.
1420	– Probable date of the introduction of the caravel in the Portuguese fleet.
*1421	– Beginning of reconnaissance expeditions to the lands beyond Cape Nun.
**1423	– Two expeditions to explore the West African coast to Cape Bojador.

*1424	– Attempt to seize the island of Grand Canaria.
*1425	– Renewed expedition to the Canaries.
*1427	– Discovery of the Azores.
*1431	– Discovery of Santa Maria Island in the Azores.
*1432	– Another expedition to Santa Maria, designed to settle it.
**1433	– Discovery of the S. Miguel Island in the Azores.
	– Gil Eanes' first attempt to sail beyond Cape Bojador.
***1434	– New expedition to the Canaries.
	– Gil Eanes sails beyond Cape Bojador.
	– Inland expedition to Senegal, in search of Prester John.
*1435	– Gil Eanes reaches Angra (bay) dos Ruivos, *c.*180 miles beyond Cape Bojador.
*1436	– Afonso Gonçalves Baldaia reaches Pedra da Galé and explores the mouth of the Rio do Ouro.
*1437	– Expedition to Tangier.
*1440	– Expedition to the Canary Islands.
**1441	– Nuno Tristão reaches Cape Blanco.
	– Antão Gonçalves explores Rio do Ouro.
	– (date known for the first use of the caravel in the "enterprise of the discoveries").
**1443	– New expedition led by Adão Gonçalves to Rio do Ouro.
	– Nuno Tristão discovers and explores the islands Gente, Gracas, and Arguim in the Bay of Arguim.
****1444	– A fleet with six Caravels departs for the Bay of Arguim.
	– Nuno Tristão reaches Terra Dos Negros, near the mouth of Senegal River.
	– Dinis Dias reaches the rocky cape of Cape Verde and Das Palmas Island.
	– New expedition of Adão Gonçalves to Rio do Ouro.
****1445	– Álvaro Fernandes reaches Cape dos Mastros.
	– João Fernandes goes up the Rio do Ouro looking for Prester John.
	– Gonçalo Sintra discovers Angra.
	– Expedition against the Moors in island of Tider.
****1446	– Estevão Afonso reaches the Rio Gambia.
	– Alvaro Fernandes reaches the Rio Casamansa.
	– João Infante discovers the Rio Grande (or Rio Geba).
	– Nuno Tristão reaches the Rio Nuno.
*1447	– Expedition of Álvaro Fernandes reaches Dos Bancos Island.
*1449	– Expedition for the construction of the fortress of Arguim.
*1452	– Exploratory expedition results in the discovery of Flores and Corvo islands.
*1453	– Expedition of Cid de Sousa reaches Cape of Masts (Cabo dos Mastos).

**1456	– Discovery of the islands Boavista, Santiago, Maio, and Sal;
	– Diogo Gomes explores the mouth of the Geba river, and the Bissagos islands.
1457–58	– Interruption of the exploratory expeditions in order to prepare for the attack on Alcacer–Seguer.
*1458	– Capture of Alcacer–Sequer.
**1460	– Diogo Gomes and António de Noli discover the five eastern islands of the Cape Verde archipelago.
**1461	– Pedro de Sintra reaches Cape de Santana.
	– Discovery of the islands of Santa Luzia and São Nicolau.
**1462	– Expedition to establish a settlement on the island of Santiago.
	– Discovery of the islands Santo Antão and São Vicente.
*1463	– Expedition led by D. Afonso V to the coasts of North Africa.
*1464	– Failed attempt to take Tangier.
*1470	– Soeiro da Costa explores the western African coast between Cape Mesurado and Cape Three Points (Cabo das tres Pontas).
***1471	– Expedition to Morocco led by D. Afonso V.
	– Capture of Arzila.
	– Capture of Tangier.
*1472	– Discovery of the islands of São Tome and Príncipe
*1473	– Fernando Pó explores the coasts of the Cameroons (Camaroes) and discovers Formosa island.
*1474	– Discovery of Rio Gabão and of Cape Lopo Goncalves.
*1475	– Discovery of Cape Santa Catharina. (closes the cycle of discoveries during the reign of D. Afonso V)
1479	– Treaty of Alcacovas gives the Canary Islands to Spain, and the African coast to Portugal.
*1481	– Diogo de Azambuja sails from Lisbon with the task of starting the construction of the fortress of São Jorge da Mina.
1480–1485	– Preparation of the first written guides for the navigation by latitude ("*altura*" and *Regimento*)
*1482	– Construction of the fortress of São Jorge da Mina on the Guinea coast.
*1483	– Expedition of Diogo Cão reaches Cape Lobo.
*1485	– Diogo Cão reaches Serra Parda.
*1486	– On a royal initiative, João Afonso Aveiro travels to the Kingdom of Benin.
***1487	– Bartolomeu Dias rounds the Cape of Good Hope.
	– Pêro de Évora and Gonçalo Eanes reach Timbuktu and Tucural.
	– Pêro da Covilhã and Afonso de Paiva explore the African interior in search of Prester John.

*1488	– Bartolomeu Dias, after anchoring in the Bahia dos Vaqueiros, reaches the Great Fish River (Rio do Infante).
1489	– King Bemoin (in the Senegal region) donates part of his territory to the King of Portugal.
*1490	– Expedition to the Congo, led by Gonçalo de Sousa.
**1491–94	– Expeditions to North America led by Pêro de Barcelos and João Labrador.
**1491	– Land voyage of Martins Lopes to Asia.
	– Arrival of the embassy of D. João II in Zaïre–Congo.
*1493	– Settlement established on São Tome Island.
1494	– Treaty of Tordesilhas between Portugal and Spain.
*1495	– João Labrador reaches Greenland.
	– (end of the cycle of discoveries in the reign of D. João II)
*1497–98	– Vasco da Gama sails for India and arrives at Calicut.
*1498	– Duarte Pacheco Pereira leads a secret expedition beyond the line of Tordesillas.
***1500	– Pedro Álvaro Cabral arrives in Brazil.
	– Expedition of Diogo Dias to the Gulf of Adem.
	– Cabral's fleet reaches India, when it anchors in Cochin.
****1501	– Terra Nova (Newfoundland) discovered by Gaspar Côrte-Real (fleet departed in 1500).
	– Third armed fleet sails to India, again led by Vasco da Gama.
	– Fleet sails from Lisbon with the purpose of verifying the real extension of Brazil.
	– Gaspar Côrte-Real returns to Terra Nova (and dies).
*****1502	– Discovery of the islands of Ascenção and Santa Helena;
	– António de Campos discovers the Patta Islands.
	– Capture of Calecut; *feitoria* established in Cochin.
	– Capture of Sofala.
	– Establishment of a *feitoria* in Mozambique.
****1503	– Fernando de Noronha discovers the islands near the Brazilian north coast, which today bear his name.
	– Start of the voyage to India by the fleet led by D. Francisco de Almeida.
	– Transformation of the *feitoria* in Cochin into a fortress and seat of the State of India.
	– Gonçalo Coelho leads an expedition to Brazil.
*1504	– Lopo Soares sailes for India leading an important fleet.
***1505	– Construction of the fortress of Santa Cruz (Cape Guir).
	– Construction of the fortress of Mazagan (Morroco).
	– Capture of Quiloa and Mombasa.
***1506	– Expedition of D. Lourenço de Almeida to the NW of Ceylon (Sri Lanka).
	– Discovery of the island of Tristão da Cunha.

******1507	– Capture of: Calaicate, Curiate, Mascate, Soar, Orçafão and Ormuz.
	– Construction of a fortress at Ormuz.
*1508	– Capture of Safi (Moroco).
*1509	– A new armed fleet sails for India.
*1510	– Definitive capture of Goa.
******1511	– Discovery of the island of Timor.
	– Conquest of Malacca.
	– First official expedition to the Pacific Ocean, starting from Malacca.
	– Discovery of the island of Ternate (Moluccas).
	– Expeditions inland, from Sofala.
	– Expedition (embassy) to the kingdom of Pegu.
*1512	– Capture of the fortress of Benasterim.
**1513	– Expedition from Malacca to China.
	– Capture of Azemmour.
*1514	– The Portuguese take Tednest (Morroco) from the Moors.
**1515	– Expedition from Sofala to the region of Monomotapa and Butua.
	– Recapture of Ormuz.
****1516	– Construction of the fortresses of Santa Cruz de Agadir and Chaul.
	– Expedition of João Coelho to the Gulf of Bengal.
	– Lopo Soares starts from Goa to explore the Red Sea.
*1517	– The Portuguese arrive in Canton.
**1518	– Simão da Silva's land expedition to the Congo.
	– Establishment of a fortress and *feitoria* in Colombo (Sri Lanka).
*1519	– Submission of the King of Pacem (in India) to the Portuguese.
*1520	– Expedition of Diogo Lopes de Sequeira to Massawa and Arquico.
*1523	– Mozambique expedition sets out for the island of Querimba.
1524	– The Portuguese leave the fortress of Pacem.
1525	– Moslem attack on Malacca.
1526	– English ships begin to frequent the coast of Guinea.
1527	– First French ships appear off the coast of Mozambique.
**1530	– Expedition of Martim Afonso to the Rio da Prata (South America).
	– D. Nuno da Cunha occupies island of Beth (Portugal adopts a plan to colonize Brazil).
*1531	– Capture of the city of Bassein.
*1535	– Fortress of Diu acquired by the Portuguese.

**1536 – Expedition to the interior of the Congo. Fernão Mendes Pinto sets off for India.
*1539 – *Feitoria* established in Nagasaki.
– French fleet explores the coast of Guinea.
**1541 – Cristóvão da Gama leads an expedition to the aid of the King of Ethiopia.
– Estevão da Gama begins exploration of the African coast of the Red Sea.
– The Portuguese lose the fortress of Santa Cruz de Guer.
*1542 – The Portuguese leave Safi and Azemmour.
*1544 – Definitive incorporation of Bardez and Salsete into the Estado da India.
*1545 – Construction of the fortress of São Sebastião in Mozambique.
1549 – The Portuguese leave Alcacer–Sequer.
***1550 – Expedition to Macau.
– Expedition of Miguel Henriques to the Rio San Francisco (Brazil).
– Establishment of a *feitoria* in Sanchuang.
– The Portuguese leave Arzila.
*1552 – Gaspar da Veiga discovers the river of Quama.
1553 – The Turks capture Ormuz.
*1555 – Establishment of a *feitoria* in Macau.
*1559 – Paulo Dias de Novais leads an armed fleet to Angola.
*1560 – Paulo Dias de Novais explores the rivers Quanza and Pungo–Andongo.
*1569 – A strong fleet leaves Lisbon for Onor (the objective was also to punish its inhabitants).
*1574 – First failed expedition of D. Sebastião to North Africa.
*1576 – Expedition to explore Paraiba in NE Brazil.
*1577 – D. Sebastião retakes Arzila.
*1578 – Duarte Lopes begins a long expedition to the lakes of Nyassa, Alberto Nianza, Victoria Nianza, and Tanganika.
– D. Sebastião's Moroccan expedition ends with the defeat at Alcacer-Kebir , and the King's death.
1580 – The Spanish army invades Portugal.
1583 – First actions of Francis Drake along the east coast of Brazil.
**1587 – Martim Afonso de Melo takes Ampaza and Mombasa.
1589 – Arzila is returned to the Sultan Almançor.
*1594 – The Portuguese occupy Rio Grande Do Norte (NE Brazil).
1598 – The Dutch occupy several places in Southeast Asia.
1599 – The Dutch take the island of Banda.
1600 – The Portuguese leave the Moluccas.
*1603 – Expedition of Pêro Coelho de Sousa to Ceará (North Brazil) to establish settlements.

1605	– The Dutch conquer the island of Amboina.
1609	– The Dutch conquer Ceylon (Sri Lanka).
*1613	– Filipe de Brito dies in Pegu.
*1615	– The Portuguese expel the French from Maranhão (North Brazil).
1617	– The Portuguese are expelled from Japan and replaced by the Dutch.

4 Measuring long-term processes of political globalization

William R. Thompson

Measuring and modeling long-term, political globalization is not a novelty. We have been doing it for some time. We simply have not called it political globalization. Rather, some of us have referred to it as processes of long-term structural change, systemic leadership and global war, with the presumption being that some of the behavior is relatively new – in the sense that it has emerged only within the past 500 years in readily recognizable form.[1]

Indeed, two of the reasons that we lack a strong consensus on the nature of modern systemic leadership are that the behavior is both relatively new and has taken five centuries or more to give it a shape that almost everyone can identify, even if it still remains elusive. It is the earlier, evolving shape(s) over which observers tend to disagree the most.

No doubt, we will also disagree about where trends in political globalization are heading. Yet much of the analysis associated with systemic leadership, global war, and kindred processes has been placed on making cases for either delineating the processes or attempting to validate their existence, impact, and significance. That may be another reason for not readily acknowledging these processes as processes of political globalization.

No effort will be made herein to pin down where exactly political globalization processes might be heading. That is probably a task for forecasting, perhaps simulation, and certainly speculation and theory building. A crystal ball, of course, would also help. The focus in this chapter is instead placed on describing what measurements are already available for such modeling purposes. The bottom line is that there is more data already available than one might imagine. We have a number of pertinent series of 500 years' duration – at least ten, as well as others of shorter duration. Whether they are exactly what any modeler might desire is a different question that probably depends more on theoretical preferences than anything else. In this respect, however, we have a specific set of theoretical preferences on modern political globalization outlined in Modelski (2007, Chapter 2 of this volume). The obvious question is whether they are likely to serve the operational needs of this particular project. The short answer is that they help, but more needs to be done. After a few more words about political globalization, each series is given some attention below, and sketched in plot form, before returning to the question of measuring and modeling political globalization as an evolutionary process.

Political globalization

Globalization has become extremely popular as a concept and process denoting increased connectivity and heightened sensitivity to the implications of greater connectivity at any level. Yet Held *et al.* (1999: 16) make the excellent point that there are five different levels within which more connected activity, among other behaviors, can take place. We are fairly familiar with localization, nationalization, regionalization, and internationalization (all defined in Table 4.1). The lion's share of our analyses takes place within these less-than-global spatial parameters. Much less common are analyses focusing on inter-regional or genuinely global institutionalization and behavior. While the five levels are often fused together indistinguishably, our understanding of political globalization is likely to progress only if we pay some attention to spatial distinctions. Accordingly, political globalization refers only to Held *et al.*'s (1999) "inter-regional" or global phenomena in this chapter.[2]

Nonetheless, there is more to globalization than spatial scope. Held *et al.* (1999), Modelski (2007, Chapter 2 of this volume) and Devezas and Modelski (2007, Chapter 3 of this volume) argue that the processes of spatial–temporal interdependence take place within an institutional or organizational framework. If trade, for instance, is one of the premier agents of increasing connectivity, then few would deny that commodities are exchanged within some type of political–economic regime. Political globalization, therefore, is about the expansion of a global political system, and its institutions, in which inter-regional transactions (including, but certainly not restricted to, trade) are managed. While interdependencies have been in flux since at least the beginning of movements of *Homo sapiens* out of East Africa some 60,000 to 100,000 years ago, the globalization processes that are currently in play are largely a more recent phenomenon that began to become more apparent only

Table 4.1 Types of interconnection processes

Type	*Generation and consolidation of flows and networks of activity, interaction, and the exercise of power*
Localization	Within a specific locale
Nationalization	Within fixed territorial borders
Regionalization	Within functional or geographic groups of states and societies
Internationalization	Between two or more nation-states irrespective of their specific geographic location
Globalization	Between and among major regions in the world economy

Source: based on discussion in Held *et al.* (1999: 16).

in the last 500–1,000 years. This observation does not preclude prototypical behavior prior to 1494/1500, but it can be argued that the global institutions with which we are most familiar today began to emerge most visibly around the middle of the second millennium CE.

To be sure, there are alternative ways of viewing this process. Modelski (Chapter 2 of this volume) begins his modern globalization period at CE 1000, reflecting a combination of Sung economic advances; the general suppression/diffusion of the Chinese technological changes by the Mongols; and what he views as an early Mongol failed experiment in world-order creation. I have no dispute with the great significance of Sung creativity and Mongol destructiveness and the subsequent diffusion of Chinese innovations from East to West. These processes are undoubtedly linked to post-1500 developments. But I do have some problems viewing the Mongol Empire as a failed experiment in a world-order project.

Pre-1500 globalization (or Afro-Eurasianization) proceeded within (and outside of) imperial institutions often limited in their tendency (or ability) to span multiple regions. Empires of expanding scope – Akkadian, Egyptian, Assyrian, Persian, Macedonian, Roman in the ancient, western Old World, and Xia, Shang, Chou, Han, Sui-Tang, Sung in the eastern Old World – were important agents in the globalization (or continentalization) of eastern and western Eurasia.[3] A major evolutionary shift in globalization took place with the development of the Silk Roads in the Han–Roman era after about 200 BCE.[4] Another such shift was associated with the Mongol expansion in the thirteenth century CE. Iberian empire-building in the fifteenth and sixteenth centuries was responsible for a third major escalation in globalization, linking the Old and New Worlds. Obviously, empires did not cease to exist after 1500. Neither did they cease to play a role in globalization. Yet, in retrospect, imperial organizations have become increasingly obsolete in the last half-millennium. Modelski (Chapter 2 of this volume) is correct to suggest that they represent failed experiments in creating territorial orders of expanding scope, but it is not clear to me that the Mongol order was any more world-like than the Akkadian or Macedonian empires.

That difference of opinion, nonetheless, does not really detract from the virtues of viewing globalization processes as overlapping learning processes in which activities pursued in earlier phases are still manifested in later periods. Whether the modern "clock" needs to be started for all three types of globalization processes – community formation, political, and economic – at the same time (CE 1000) remains debatable. An alternative perspective would suggest that "modern" economic globalization processes began around CE 1000 with Sung innovations. Political innovations began to be more discernible later on (and closer to CE 1494). Community formation has been even slower to emerge. If democratization is the hallmark of community formation processes, one begins to see some reluctant and halting republican sentiments voiced in the mid-seventeenth century (Cromwellian England and the Netherlands) but real headway becomes more discernible only in the first half of the twentieth century. Thus, a rival and conceivably testable hypothesis is a staggered initiation of modern globalization processes, with developments in economic change making political change more possible, and changes in economics and politics making community formation more possible.

Yet should one mention the concept of global institutions, we tend to think most readily of the alphabet soup of the UN, IMF, GATT/WTO, or ICJ organizations. They certainly are part of the contemporary institutional package or infrastructure. They reflect choices made at the end of World War II about how best to create a postwar world order. Yet they do not represent the whole of the institutional package. Neither are they even the most important institutional manifestations. They are simply the most visible among the recent changes. Less visible but certainly not less significant are older institutions that emerged to provide some semblance of global governance early on and well before the rather recent emergence of contemporary international organizations.

The institutions of global systemic leadership and global war began to emerge in 1494. Unlike the emphasis on the command and control of territory in traditional empire, global systemic leadership is predicated on innovations in commerce and industry, economic pre-eminence, and a commanding lead in the development of capabilities of global reach. Maritime orientations were critical to the emergence of global system leaders. Such an orientation had been seen before 1494. Dilmun in the third millennium BCE; the Minoans in the second millennium BCE; and the Phoenicians/Carthaginians in the first millennium BCE, all represented ancient prototypes of maritime-oriented system leaders emphasizing trade over military conquest. As in the case of subsequent prototypes – Genoa and Venice – these actors possessed limited capabilities; operated on an essentially regional scale and ultimately succumbed to adjacent empires.

Various things changed after 1494. Small states with maritime orientations, located on the Atlantic rim of Eurasia, developed leading commercial roles in linking eastern and western Eurasia (Thompson, 2000). These states were no more secure against predatory European land empires than their Mediterranean predecessors, but balance-of-power strategies, in conjunction with a intensively competitive regional system, were developed that not only thwarted the unification of Western Europe under one empire but also enabled the small trading states to survive longer than usual. Coalitions were built in which the trading states provided coordination, financing, and sea power. But the coalitions also required the participation of land powers that were rivals of the aspiring regional hegemon, and could be expected to provide armies and second fronts. These coalitions rarely worked smoothly, but they managed to prevail in repeated iterations through the recent cold war.

The coordination, financing, and sea power could be provided by one state because of the tendency for technological innovations in trade and industry to be monopolized by one state for a finite period of time. The innovations made these states the lead economies of the world economy, spearheading economic growth and introducing new routines and products that radically transformed the way that economic processes worked. Leading positions in trade and industry encouraged the development of global-reach capabilities that were predominantly naval over the past 500 years. Lead economies also developed impressive financial surpluses that gradually made them the primary source of investment and lending.

Another institution was crucial to the emergence of systemic leadership. This second institution, global war, also began to emerge only after 1494. Global wars are intermittent periods of intensive conflict that last roughly the length of a generation and establish environments conducive to the exercise of systemic leadership in setting policy and rules for global transactions. They also serve to thwart the territorial ambitions of aspiring European regional hegemons. Defeating the main threat to the survival of states with systemic leadership potential is one outcome. Another is the exhaustion of most of the participating major powers, with the exception of the lead economy, which latter actually profits from the global war. Prior to the initiation of the global war, a spurt of technological innovation propels one economy into the global lead. While this advantage will prove invaluable in the ensuing competition among the major political–military and economic contenders, it is also destabilizing and seems to make global warfare more likely. But the process of engaging in global warfare while increasingly insulated from the battlefields creates the strong probability of a second technological spurt that becomes most evident in the postwar period. The collective edges of the system's lead economy are thereby further enhanced, particularly in an era characterized by rivals that have been defeated recently or exhausted in the coercive balancing process.

In this fashion, the global war enhances and solidifies the system leader's relative position. The postwar commanding lead of the system leader is neither artificial nor an artifact of the global war. But it is subject to a life cycle that reflects basically the life cycles of the technological change upon which it is built and the impact and half-life of the global war. At the end of the war, the system leader has its best opportunity to make policy and create rules for global transactions. It is also when other global institutions are most likely to be created – as demonstrated most evidently in the case of the previously mentioned Bretton Woods institutions (UN, IMF, IBRD, ICJ, GATT/WTO) and the subsequently formed NATO. The postwar environment in which these contemporary institutions have been created helps to explain their waning efficacy with the passage of time since the last global war.

As a consequence, the main institutions for "modern" political globalization have been systemic leadership, global war, and international organizations. The rhythm of intermittent spurts of radical technological change and global community formation has also proceeded in conjunction with these developments. Their interaction, in conjunction with related processes, generates the complex

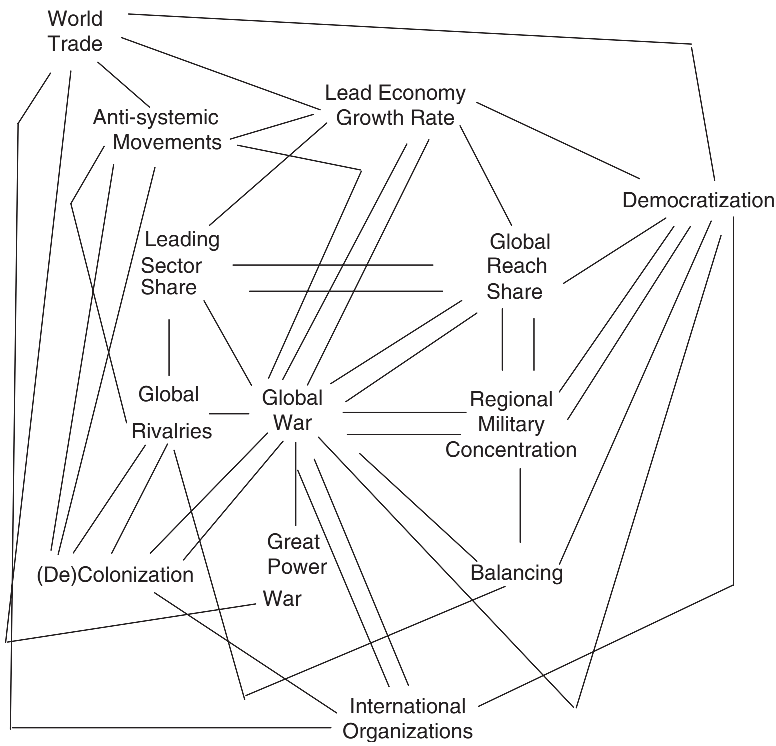

Figure 4.1 A baker's dozen processes related to political globalization.

field of activity summarized in Figure 4.1. The relationships among the 13 variables depicted can be compartmentalized into four sub-complexes:

1 the systemic leadership resource platform (lead economy growth rate, leading-sector share, and global-reach share);
2 global war and its associated processes (balancing, rivalry, great-power war and the dis-synchronization of global and regional power concentration);
3 World economic growth (limited to world trade in Figure 4.1); and
4 A mixed assortment of other processes, including international organizations, anti-systemic movements, democratization, and (de)colonization.

Most of these variables can be measured over the past 500 years in various ways. The only exceptions are the processes that possess histories of less than 500 years in duration. Two of these exceptions (democratization and anti-systemic movements), for the most part, began to emerge just before or during the French Revolutionary/Napoleonic Wars – or only a couple of hundred years ago. Another one, international organizations, has an even shorter history. Thus, there are very good reasons for not having longer series for them.

Figure 4.1 is both messy and incomplete. Not every possible linkage, either in terms of theoretical speculation or empirical verification, has been made. Too many arrows and the figure would simply become unreadable. Yet the arrows that are delineated suggest that the inter-relationships among these dozen processes are complex. This complexity will assuredly prove to be a problem for comprehensive modeling of their interactions. But, for present concerns, the emphasis here will be on simply describing the processes and their respective measurement.

A number of processes and their measurement

Systemic leadership resource platform

Systemic leadership is based primarily on three "legs." At the very core is the monopolization of clusters of new, radical technology that generate 40–60-year long waves of economic growth. As pioneers of innovation, system leaders revolutionize their own economies before the new ways of doing things are diffused to some other economies. Head-start and monopoly, however temporary, generate a considerable surplus for tax revenues, general affluence, and investment purposes at home and abroad. They also generate a respectable share of the world market in cutting-edge commodities, either in terms of trade and/or industrial production. To protect the lead economy's predominant position in the world economy, the development of global-reach capabilities are necessary. Historically, global reach was most likely to be achieved by making use of naval power – whether to protect maritime trade routes; to transport armies and weapons at great distances; or to secure homeland security from maritime attacks. In the twentieth century, sea power, of course, has been supplemented by first air and then space power, but it has not yet been replaced altogether. Moreover, it did not suffice to simply have global reach. The system leader has to be predominant in global-reach capabilities, which suggests that the system leader's share of global-reach capabilities must also be fairly monopolistic to be optimally effective. Thus, the core foundation for the systemic leadership institution includes the lead economy growth rate–leading-sector share–global-reach share triangle.[5] Perhaps less central to this triangle, but certainly of some importance, is the system leader's share of investment capital.

Figure 4.2 plots Modelski and Thompson's (1996) data on the timing of K-wave spurts in serial form. In order to create a long series for the first time, some changes have been made to the original data. Stricter rules for how long to regard an industry as leading have been imposed. The values for each decade have been normalized in terms of the highest value observed for each system leader. Thus, each highest value per leader becomes 1.0, and all other values are adjusted proportionally. Finally, in three cases (the 1560s for the Netherlands and the 1870s/1880s for the United States), it is misleading to begin the next leader's growth rates as early as suggested in Modelski and Thompson (1996).[6]

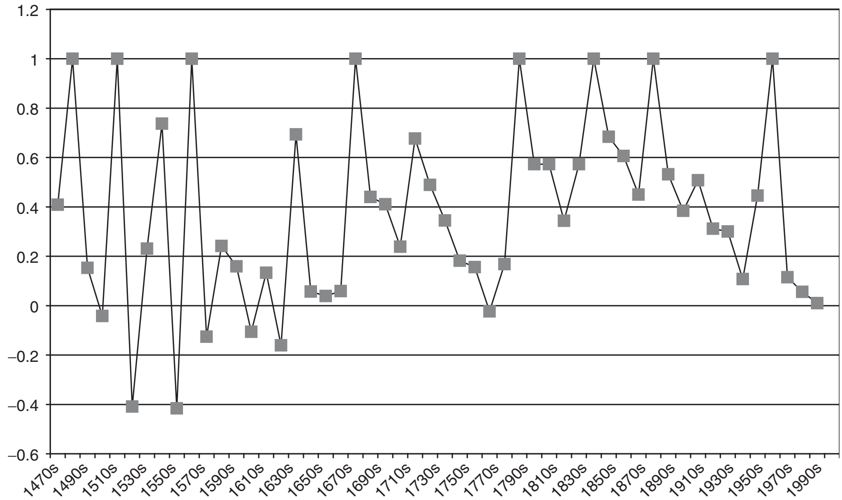

Figure 4.2 Kondratieff growth rates.

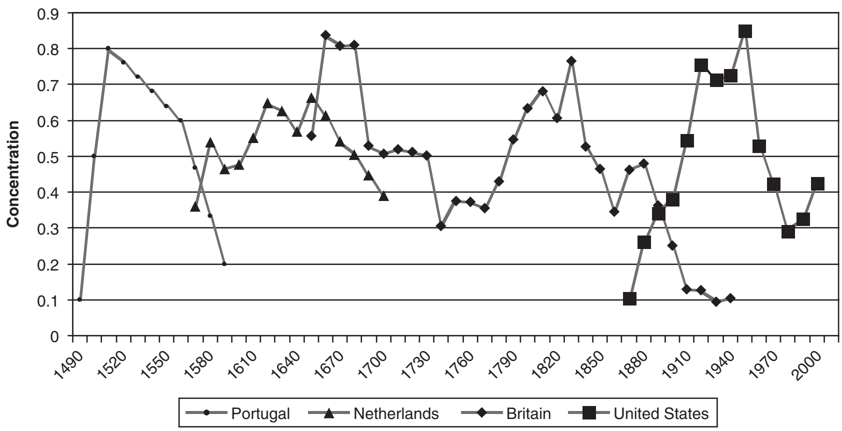

Figure 4.3 System-leader leading-sector concentration.

In each of the three cases, observations for the preceding system leader are used instead. While Figure 4.2 focuses on the lead economy's growth rate, Figure 4.3 tracks their respective leading-sector shares over time. Figure 4.4 demonstrates the fluctuations in system-leader global-reach capabilities (naval power) updated through to the year 2000. Figure 4.5 suggests one way to capture the timing of systemic leadership in world capital investment, albeit for less than a half-millennium period.

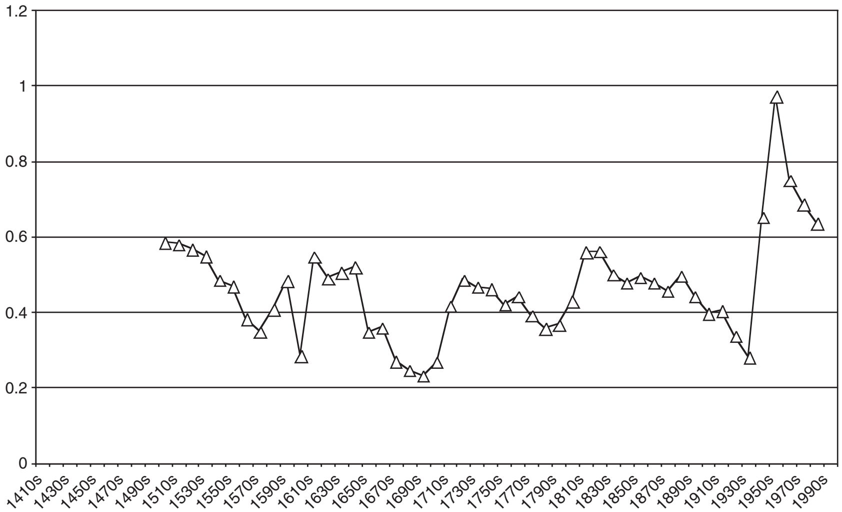

Figure 4.4 Global-reach capabilities concentration.

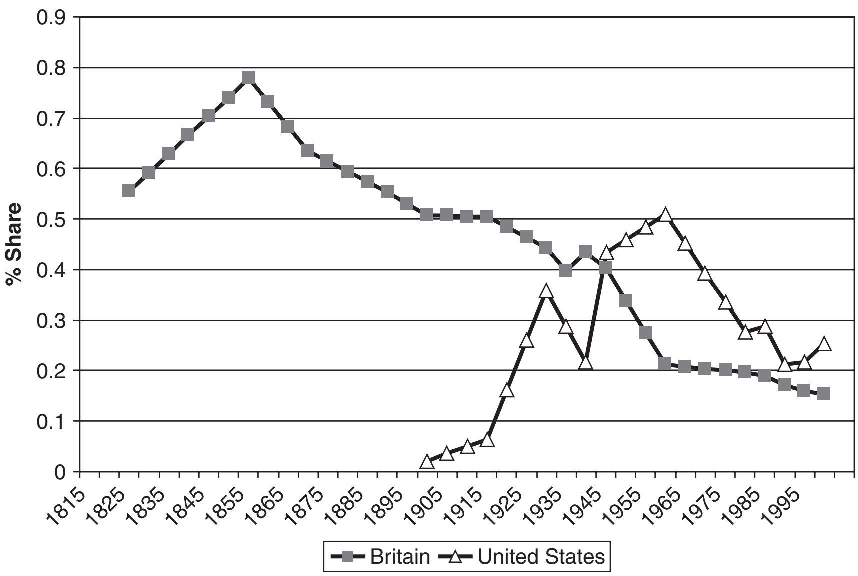

Figure 4.5 Systemic leadership share of gross foreign investment.

Global war and associated processes

By definition, global wars are the intensive struggles which initiate new intervals of systemic leadership. In the leadership long cycle convention, these wars were fought in 1494–1516, 1580–1608, 1688–1713, 1792–1815, and 1914–45. There are several major causal processes that tend to overlap considerably. One is the "Twin Peaks" argument (Modelski and Thompson, 1996) that stipulates that there is a high probability that each system leader will benefit from at least two consecutive spurts of technological innovation that bracket the global war. The first spurt precedes the outbreak of global war and encourages the consequent fighting by destabilizing the economic pecking order and, in some cases, hastening the relative decline of the incumbent system leader. The second spurt follows the period of global war and is predicated in part on technological development accelerated by war participation and preparations. Table 4.2 demonstrates this pattern over the past 500 years.

States with advanced economies are encouraged to contest for the position of system leader, but they do not do so in an all-against-all fashion. One reason is supplied by a second major causal process that concerns the timing or mistiming of power concentration at the global and principal regional levels. When a New World power or system leader emerges in the immediate post-global-war era, regional concentration tends to be low, because the major land powers of Europe have often exhausted themselves in global conflict. As the relative position of the global system leader decays, states in the principal region (historically Western Europe) are encouraged to improve their regional positions and to plan for seizing regional hegemony. A rising concentration of power then encourages re-concentration at the global level in order to head off the implications of a Spain, France, Germany, or Soviet Union achieving regional supremacy. Not only would control of the principal region increase

Table 4.2 The timing of K-wave growth spurts and global war

Lead economy	*Observed high growth*	*Global war*	*Observed high growth*
Portugal	Guinea gold 1480s	1494–1516	Indian pepper 1510s
Netherlands	Baltic/Atlantic trade 1560s	1580–1608	Eastern trade 1630s
Britain I	Amerasian trade 1670s	1688–1713	Amerasian trade 1710s
Britain II	Cotton, iron 1780s	1792–1815	Railroads, steam 1830s
United States	Steel, chemicals, electronics 1870s and 1900s	1914–1945	Motor vehicles, aviation, electronics 1950s

Based on information reported in Modelski and Thompson (1996).

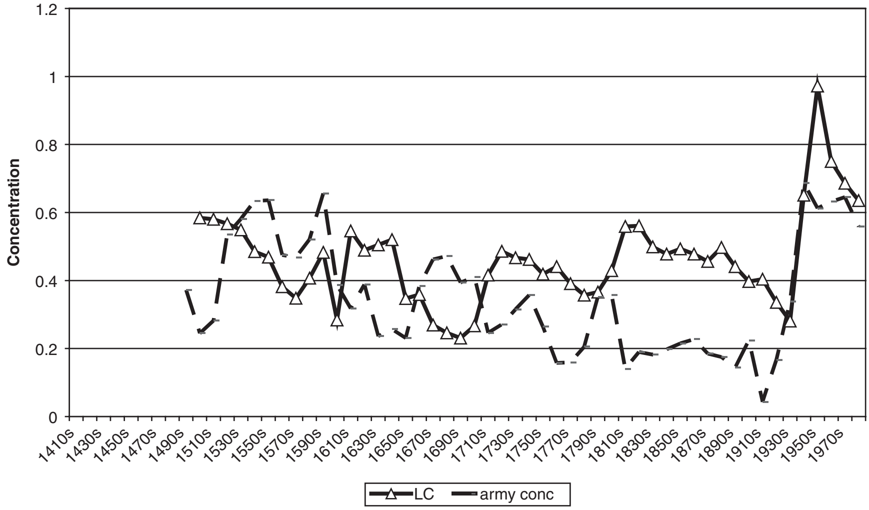

Figure 4.6 Global and regional concentration.

the resource base of the regional hegemon, it would also provide an excellent platform for gaining hegemony at the global level as well. Global wars are thus fought in part to suppress these threats emanating from aspiring regional hegemons *and* challengers for the global lead (Dehio, 1962; Thompson, 1992; Rasler and Thompson, 1994; Rasler and Thompson, 2001). Figure 4.6 shows the global and European regional oscillations in relative military power concentration since 1494. Global military concentration is indexed in terms of global reach or naval capabilities. Regional military concentration is measured in terms of concentration in army sizes as measured by the leading land power's share.[7]

A third causal process that has yet to be fully investigated is the tendency for pre-global-war tensions to activate and escalate a large number of rivalries between the major players especially. The upshot of this propensity is that decision-makers have been encouraged to focus overly on a rivalry (or rivalries) which is most critical to their own perceptions of security, without full appreciating that other states are also engaged in exactly the same process. The conventional explanation is that tight alliances "force" decision-makers to join ongoing conflicts. But we know that decision-makers sometimes choose to ignore their alliance commitments. It seems more plausible to assume that something more than alliances are involved in conflicts that become wider. Multiple "ripe" or "ripening" rivalries is one possibility, and one that at least appears to fit 1914 reasonably well (Thompson, 2003). Global wars, as a consequence and given the appropriate structural conditions, can break out without anyone fully premeditating a conflict of wide scope. Global wars assume a wide scope as complex networks of multiple rivalries are drawn into the systemic crisis.[8]

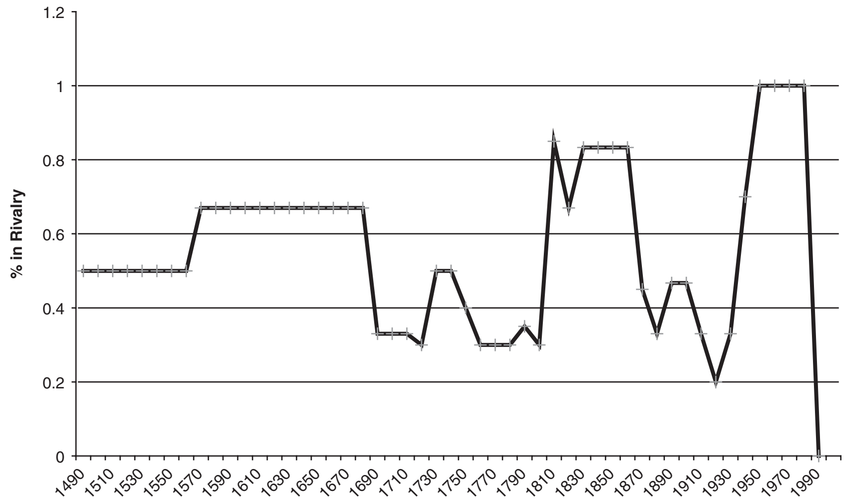

Figure 4.7 Global rivalry propensities.

Rivalry information is available for major powers back to 1494. The instability of multiple rivalries heating up more or less simultaneously is not something that is easily measured at this point in time. We lack long serial information on the intensity of rivalry conflict and instead simply have duration information. However, the structural propensity toward rivalry in the global political system can be measured by calculating the proportion of observed rivalries in comparison to the maximal number possible in any given period due to changes in major power *N*. Figure 4.7 plots this calculation for a half-millennium. Note the non-linear but clear trend towards less rather than more rivalry as one moves toward the current era.

Of course, the trend towards less rivalry in the global political system is mirrored at the larger world level. Interstate strategic rivalries still exist, but they have definitely become less common in most parts of the world. One byproduct of decreased rivalry is the declining onset of interstate warfare. Figure 4.8 portrays this decline, controlling for the number of dyads that might possibly be at war.

The traditional antidote to regional hegemony in Europe, and global war for that matter, is the balance-of-power process. In this distinctively European tradition of the past 500 years or so, the logic is that it is unlikely that any single state can stop the territorial expansion of Europe's strongest land power. Other land powers, individually, are too weak. Sea powers can try to contain territorial expansion within the region, but they usually lack the resources to do much away from their favored strategic medium – the sea. Thus the logical thing to do is to create coalitions to thwart regional conquest. Balancing against aspiring regional hegemons is far from automatic, but it has occurred with some regularity – aided as it is by rivalry patterns (Levy and Thompson,

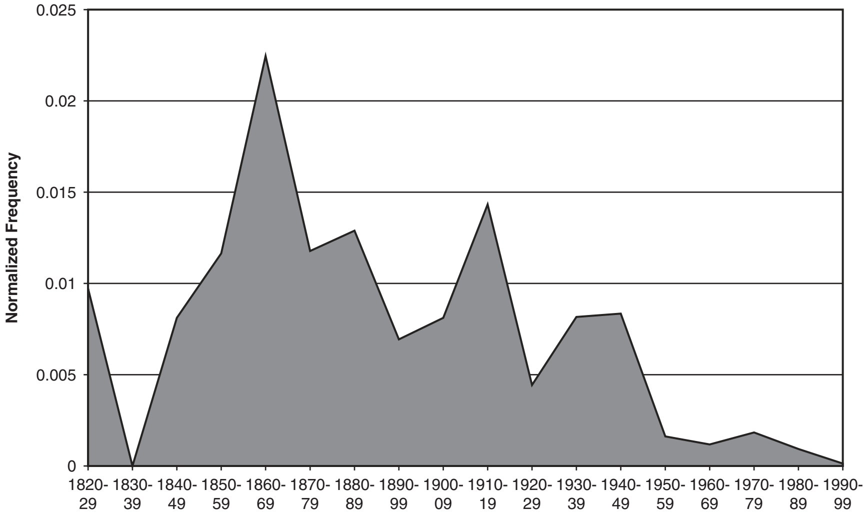

Figure 4.8 Normalized interstate warfare ongoing.

2004; Levy and Thompson, 2005b). That is, rivals are more likely to balance against their rivals than against non-rivals. Yet balancing rarely seems to have suppressed regional hegemonic bids without the balancers also going to war with the state seen as a mutual threat. Hence, balancing neither precludes nor prevents warfare. On the contrary, it makes it more likely, not less likely (Levy and Thompson, 2005a).

It is possible to serialize the information on European balancing over the long term. One might protest that this is a regional process, but the main point of the balancing exercises has been to contain regional hegemony in Western Europe. From global powers' points of view, a European regional hegemon would have an impressive resource base to make a coercive bid for global hegemony. In this respect, one might call global wars pre-emptive. Not surprisingly, global powers, and especially system leaders, are therefore prominent in the annals and coordination of balancing coalitions. Figure 4.9 indexes balancing activity in terms of the proportion of major powers in a balancing coalition against the leading European land power in any given decade.[9]

World economic growth

The lead economy's spurts in radical technological change have been shown to be one of the drivers of its national economic growth. In turn, the lead economy's national growth and the technological spurts are positive drivers of world economic growth. But, as world economic growth proceeds, there are negative feedback influences on the lead economy's growth. At the least,

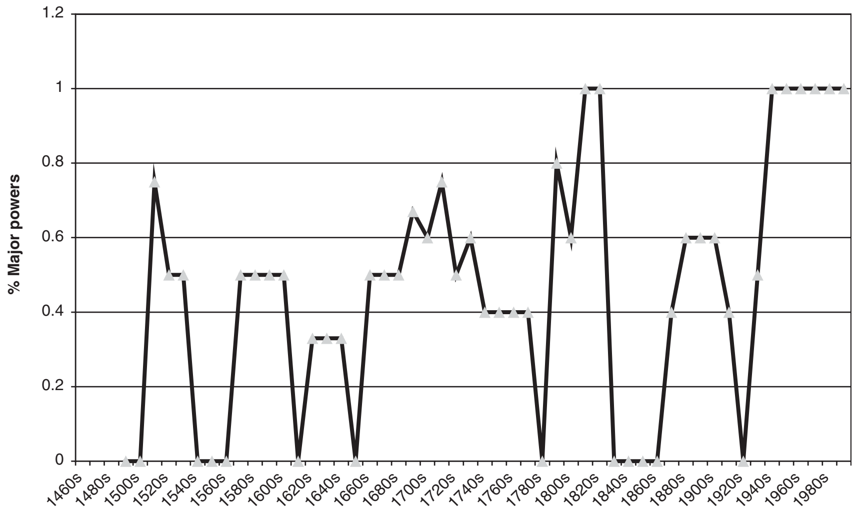

Figure 4.9 Balancing behavior.

these relationships characterize the last 125 years or so of world economic growth (Reuveny and Thompson, 2004). Presumably, similar relationships, albeit undoubtedly weaker in form, also characterize earlier centuries. Since no one has yet developed a 500-year series of world economic growth, the claim that late-nineteenth- and twentieth-century relationships should be observed earlier in time remains speculative. However, we do have a 500-year series of world trade based on O'Rourke and Williamson's (2001) series of 50-year observations on a large number of commodity movements since 1500. Rasler and Thompson (2005b) used their numerous cited sources to "fill in" the half-century observations to create decadal observations.[10] World trade, as tracked in Figure 4.10, is found to respond to renewed systemic leadership and the diminishment of great-power war.[11]

Related processes

There is no intention here to try to mention all of the possible processes "related" to the other processes depicted in Figure 4.1.[12] Only four are identified in the figure: international organizations, democratization, (de)colonization, and anti-systemic movements. They are singled out because some analysts find them important and some empirical work has been done on them already. Of the four, (de)colonization is the one with the longest history. It is possible to crudely capture the timing of European colonization and decolonization activities by making careful use of Henige's (1970) data on the coming and going of colonial governors.[13] Colonization information is useful in part because one dimension of the struggle between challengers and system

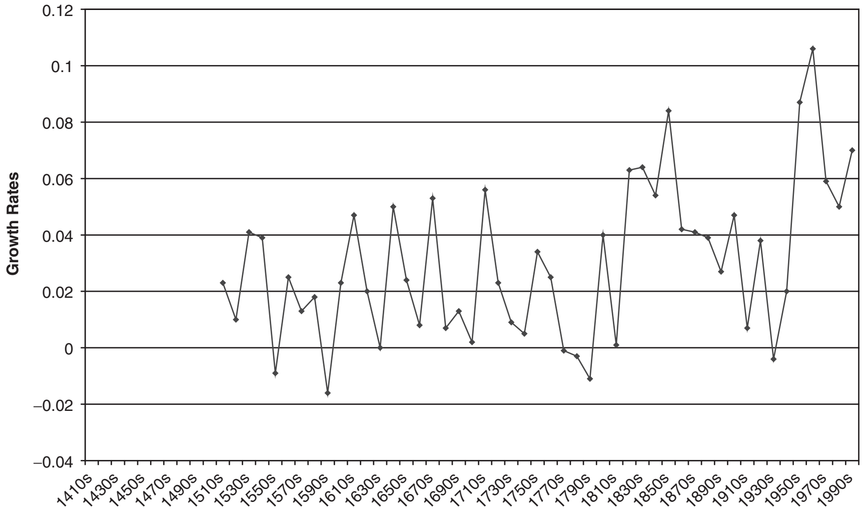

Figure 4.10 World trade growth.

leaders has been over the possession of colonies. Some states have preferred private resource preserves, while others have demanded trading access to these private preserves. That dichotomy has hardly kept trading states from falling back into colonial modes when it suited them but, overall, system leaders have tended increasingly to lead decolonization efforts for the purposes of creating more open trading systems. The development of systemic norms and world public opinion have also worked increasingly against the control of alien populations and territories. Figure 4.11 suggests that European colonization is largely obsolete in the current system, but its disappearance has not been without a struggle.[14]

The dynamics of early strong growth subject to some plateauing and then decline, which is found in other global power behavior such as economic innovation activity, is also difficult to miss. The two-wave formation (primarily Portuguese–Spanish versus Dutch–French–British), may also be linked to a form of "generational" behavior in global politics.[15] Imperial expansion and contraction, without doubt, is linked closely to the expansion and obsolescence of imperial warfare – the tail end of which is captured in Figure 4.12.[16]

Another linkage to decolonization is suggested by Hironaka's (2005) argument that the propensity toward civil war is largely but not exclusively a function of the number of new states in the system.[17] Figure 4.13 depicts the relationship between changes in this number and the amount of civil war ongoing for nearly the past 200 years.[18] One might object that these data take us away from the global political system per se, but the rejoinder is that they appear to be an artifact of normative developments within the global system that discourage colonization. They also reflect, of course, the

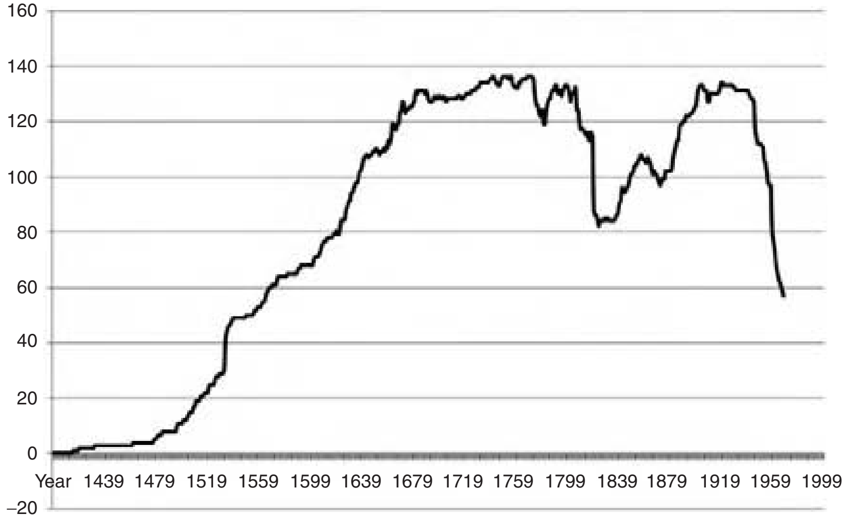

Figure 4.11 European colonies.

Figure 4.12 The decline of imperial warfare.

exhaustion of the former colonial powers in global warfare, as well as the more recent emergence (post-1945) of systemic leadership that has been consistently antagonistic toward the maintenance of colonial territories.

International organizations are obvious institutional manifestations of world order. As such, they are important not only to order maintenance or governance, but also to decolonization and democratization among other processes.

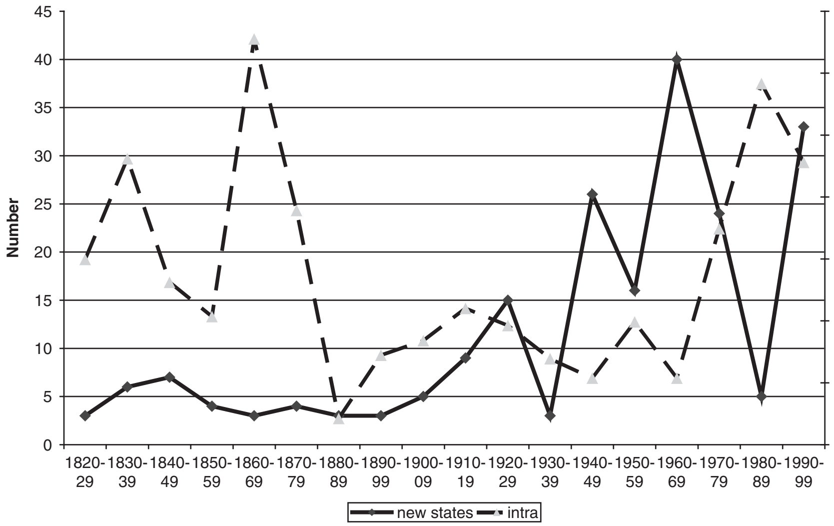

Figure 4.13 New states and internal warfare.

They also provide an intermittent focus for anti-systemic movements. Ideally, we would like to have information on the proportional expenditures on local, national, and international governance. The questions would be which of the three levels is experiencing growth in comparison with its past and in relation to the other layers. Assembling that data might sound like a simple task but, in fact, would be a major undertaking in its own right. Local- and national-level information might be the easiest to acquire, but it still might involve considerable labor in manipulating United Nations data on governmental expenditures. Estimating international-level expenditures would probably have to proceed on a sampling basis.

In the interim, information on United Nations expenditure may be suggestive. While UN information is not as accessible as one might think, Figure 4.14 focuses on the United Nations regular budget, controlling for inflation. The impression that the figure generates is that, not too surprisingly, international organizational activity is trending upward, with some discernible acceleration after the early 1970s. But Figure 4.15, which adds partial information on the total spending of the United Nations, suggests in contrast that this organization's spending has peaked and is in discernible decline. The decline may prove temporary, but it may also be suggestive of a Bretton Woods life cycle, with the regime developed in 1945 demonstrating considerable erosion. Figure 4.16 which plots the growth of intergovernmental organizations (IGOs) and non-governmental organizations (NGOs) adds another dimension to this speculation.[19] The growth of both IGOs and NGOs slowed in the depressed 1980s, with the difference that

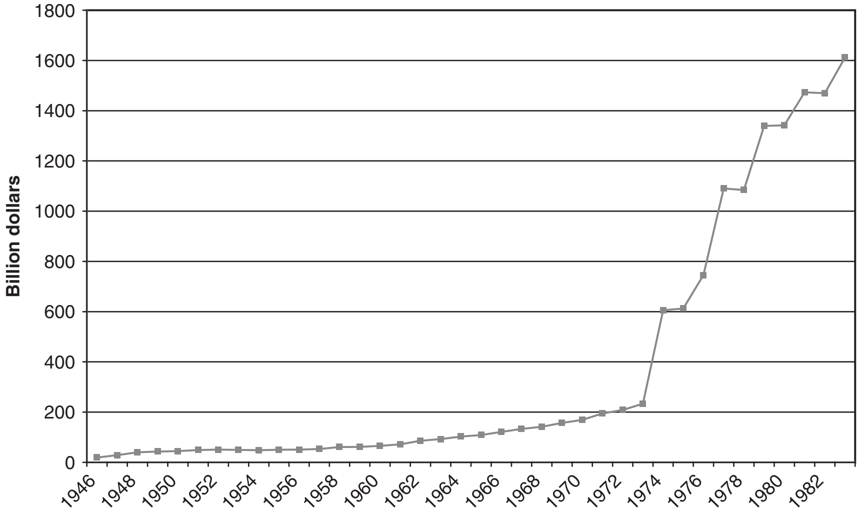

Figure 4.14 United Nations' regular budget.

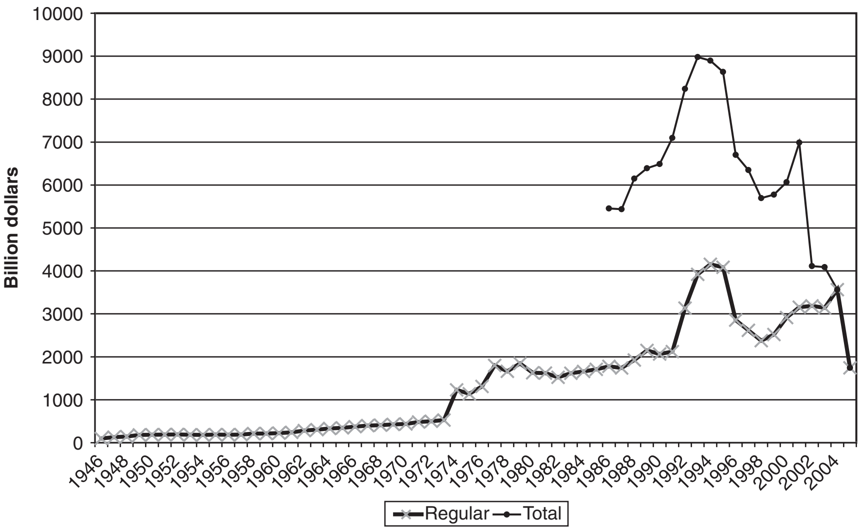

Figure 4.15 Regular and total spending of the United Nations.

NGO growth resumed in the 1990s while IGO growth did not. Whether IGO growth peaked in the mid-1980s remains to be seen.

Modelski (2007, Chapter 2 of this volume) identifies democratization as the most significant social movement in the global system. He sees it as creating a possibility for fundamentally altering the way in which the global political system operates – an evolutionary shift in standard operating procedures, led

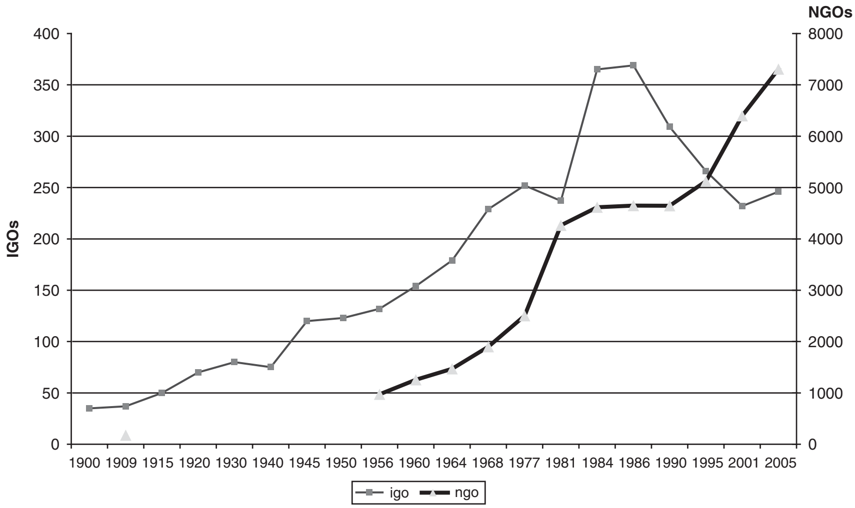

Figure 4.16 The growth of IGOs and NGOs.

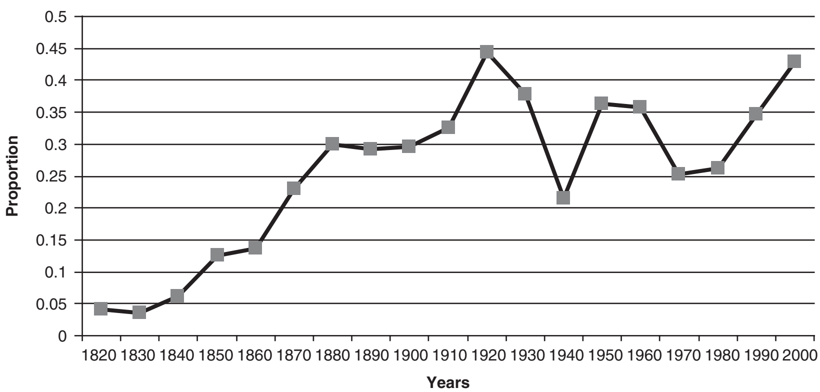

Figure 4.17 Proportion of democratic states.

in part (and sometimes less than consistently) by the past two system-leaders. If this argument is valid, democratization presumably would represent a basic parameter governing other processes in the global political system.[20] One way to capture this propensity toward increased democratization is to simply calculate the number of states in the world system considered to be relatively democratic – as is done in Figure 4.17. This calculation provides one possible index of the pace of democratization, but it is certainly not the only possibility. Alternatively, one might instead calculate the number of people living in democratic systems as a proportion of world population.

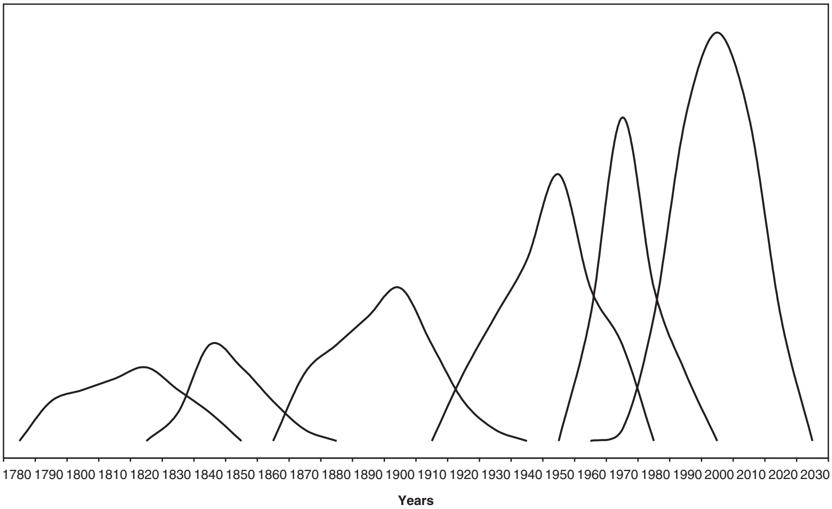

Figure 4.18 Waves of modern terrorism.

The third process relegated to the "other" category is anti-systemic movements.[21] This activity is manifested very strongly in terrorism behavior.[22] One argument is that there have been as many as six waves of terrorism since the French Revolutionary/Napoleonic Wars.[23] Each wave tends to have different foci (e.g. opposition to imperial/colonial rule; opposition to aristocratic rule; opposition to government *per se*; opposition to capitalism; or, most recently, militancy on behalf of the spread of fundamentalist Islam). Each wave also tends to vary with respect to terrorist tactics, lethality, and the types of targets focused upon. At this time, we do not have a long-term series of terroristic anti-systemic activities, but one could be developed. If we did have such data, its longitudinal shape might resemble Figure 4.18.

Conclusion

No argument has been advanced in this chapter that we have any reason to be complacent about the adequacy of data available for modeling political globalization. More always needs to be done. Still, we have a decent starting point. We also have some strong hints in the trends in the data described above. Take for instance, systemic leadership as measured by the concentration of global naval reach. Its mean levels are trending upward, while, at the same time, the means of the global rivalries index – in some respects, a measure of the resistance to central leadership, are clearly trending downwards towards zero. Does that imply that the global political system is becoming more centralized and more orderly? The answer is probably "yes," even if that interpretation does not seem to correlate very well with the emphasis on turmoil in short-term journalistic descriptions of international politics. But we must keep in mind the context in which the observation of greater centralization and order is advanced. No one is saying that the global political events of 2006 or 2007 are increasingly subject to centralization and order. What is being said is that, over the sweep of the past five centuries, global politics appears to be becoming more centralized and orderly.

One might project the rate of change into the next century, but that assumes that the rate of change will proceed as it has historically. It also assumes that many of the cyclical processes depicted in Figures 4.2 through 4.18 and Table 4.2 will continue as before as well. Maybe they will, but perhaps they will not. One wonders what might have been forecast in, say 1450, by hypothetical quantitative modelers operating with data encompassing 1000–1450? Would the emergence of a clear, albeit temporary, hierarchy in global naval reach have been predictable? Would global wars be something that could have been forecast? More to the point, how does one capture the potential for evolutionary shifts in parameters that lead to entirely different, or at least partially different, forms of behavior?

One way to address this question is to link the various data series to Modelski's (2007, Chapter 2 of this volume) framework for globalization? Table 4.3 is based on Table 2.1 of Modelski (2007, Chapter 2 of this volume). The reason for repeating part of the table is to focus attention on some of the salient (and some implicit) features that are most pertinent for measurement and modeling purposes.

In brief, Modelski views globalization as an enveloping concept, encompassing multiple processes concerning community formation as well as political and economic evolution. Different generations recognize problems, rank order them, and search for solutions. Periodically, new solutions are institutionalized as innovations. Each institution is likely to be characterized by an S-shaped learning process which means that the pace of change is initially fairly rapid, before leveling off. The macro-evolutionary pattern, therefore, should resemble a sequence of S-shaped institutional growth curves.

The first column in Table 4.3 lists a hypothesized periodicity based on the assumption that each successive era encompasses four generations. Since this chapter focuses primarily on political evolution, for the moment we can ignore columns two and four, and zero in on column three. The third column has a tripartite division: imperial experiments, global leadership, and global organization. The three periods of time are seen as a macro-succession of overlapping phases, with each one also anticipated to take the form of an S-shaped learning curve.

In some respects, columns two and four are easier to operationalize. We have data on democratization and economic innovation. Some earlier work on measuring these processes (Modelski and Perry, 1991, 2001; Modelski and Thompson, 1996) have already been published. Political evolution has also received some earlier attention, but primarily in terms of the infrastructure or

Table 4.3 Globalization and global political evolution

Globalization	*Global community*	*Global political evolution*	*Global economic evolution*
930 **Global System Emergence** (N. Sung)	**Preconditions**	**Imperial Experiments**	**Sung Break-through**
1060 (S. Sung)			
1190 (Genoa)		Failed Mongol world empire	Commercial–nautical revolution
1300 (Venice)			
1430 **Global System Mapping** (Portugal)		**Global Leadership**	**Framework of Global Trade**
1540 (Netherlands)			
1640 (England)			Industrial take-off
1740 (Britain)			
1850 **Global Social Organization** (United States)	**Democratic World**	**Global Organization**	**Information Age**
1975 (United States)			
2080			

Source: based on Table 2.1 in Modelski (Chapter 2 of this volume). States in parentheses in the first column are the principal (but not the sole) agents in stimulating the globalization processes.

foundations for leadership activities. That is, we have information on the lead economy's leading-sector growth rates; the extent to which the lead economy dominates in the production of leading sectors; and its development of global reach (primarily sea power), for the Portuguese, Dutch, English/British, and US global system leaders, as well as others. We also have some data on Venice, but little in the way of concrete series prior to that time.

While these data have yet to be subjected to formal logistic curve analysis, the nature of their growth (and decline) is highly suggestive of the anticipated S-shape. Figures 4.19 and 4.20 provide two illustrations. Figure 4.19 focuses on the buildup of Portuguese naval power in the sixteenth century. Figure 4.20 focuses on the similarly rapid, British dreadnought battleship buildup prior to 1939. Each series has a slightly different shape but, in general, the behavior demonstrated by both the Portuguese and British is one of initially accelerated growth, peaking, and then slowing/declining growth.[24] As noted earlier, more infrastructural information is also being developed on system-leader basing strategies but still more work needs to be done on the specific timing of base establishment. Still, it appears quite likely that the development and duration

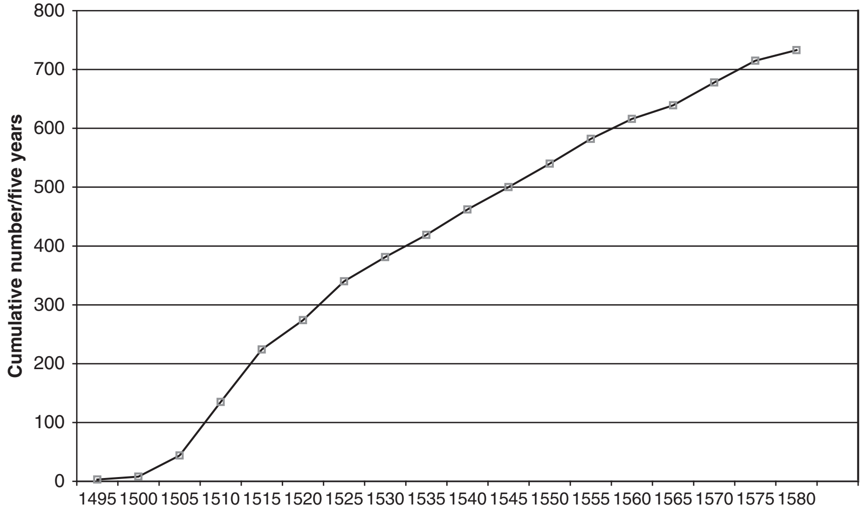

Figure 4.19 Portuguese ship cumulation/five-year intervals.

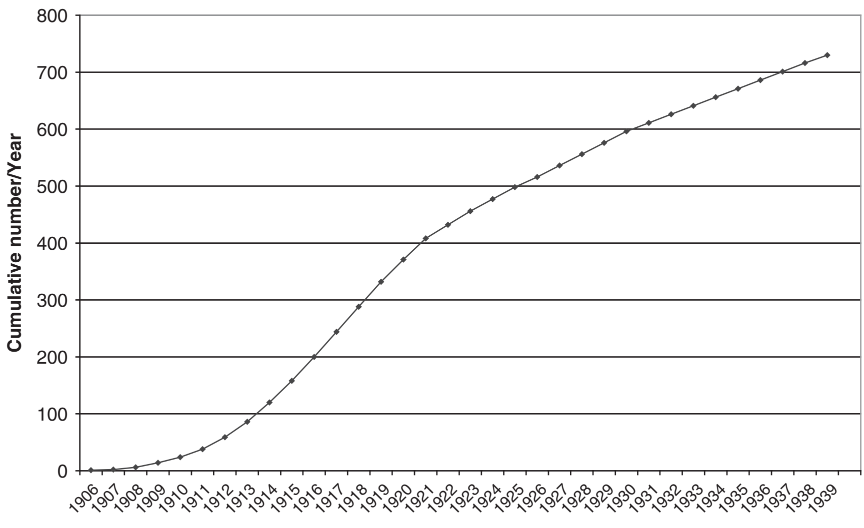

Figure 4.20 Cumulative British dreadnoughts/year.

of system-leader bases will also resemble a sequence of S-shaped growth curves in the Venetian to US intervals.

Since decolonization and imperial disintegration continues as an activity through all three of the macro-political phases, imperial experimentation is clearly not restricted to the pre-1430 era. But that is where the observation that these macro-phases overlap comes in. Most, if not all, of these modern experiments in empire construction can be measured fairly readily. The growth of the Mongol Empire could be estimated without too much trouble. Some indicators for the European experimentation along these lines were described earlier in this chapter. Without exception, they can be depicted as a sequence of S-shaped growth curves.

Global leadership behavior, going beyond the infrastructure for this behavior, is not an area that has received much empirical attention. A major exception to this generalization is Devezas and Modelski's (Chapter 3, this volume) work that analyzes the logistical shape of Portuguese exploration activities. Their successors also engaged in exploration, and that may be worth further examination. Another area that deserves further exploration, however, is Dutch and British leadership in containing and suppressing aspiring European regional hegemons – another manifestation of imperial experimentation at the regional level. Yet if any of aspiring conquerors of Western Europe had been ultimately successful, they would have created a formidable base for global imperialization. That is one of the reasons why they were opposed by early modern maritime powers. Exactly how one captures anti-regional hegemony activity in a satisfactory metric is something that has proved elusive so far. Some initial, exploratory attempts to capture the shape of Dutch and British resistance to Spanish and French expansion has stumbled over the issue of just what should be measured. Do we focus on alliance-making (as in the balancing series described earlier in this chapter), physical conflict, arms races, or some combination of the three? Much more measurement experimentation needs to be done in this area before we will be ready to test its shape over time.

Resistance to regional hegemony, of course has continued into the third phase of global organization. It may be that whatever metrics are developed for the global leadership phase can be pursued through at least the nineteenth and twentieth centuries (and perhaps into the twenty-first?). But it is also clear that new dimensions of institutional development need to be examined. We have some sense of the rapid expansion of public and non-governmental international organizations since the mid-19th century, but more specific annual or even decadal growth rates are less commonly available and could be computed. In addition to paying attention to the types of activities that they are intended to regulate, we might also go beyond the frequency of organizational birth and death to estimate the relative proportion of global wealth associated with their spending records. Estimates of membership densities in organizational networks might also be worth calculating. A more demanding accounting scheme would also distinguish between the less-than-global versus global scope of international organizational domains.

The final measurement challenge, assuming that we are able to handle the measurement challenges at the four-generation-interval level, would be to develop a protocol for combining the interval-level measurements into the larger-phase period measurements. As long as the measurement task is focused on similar activities, such as imperial expansion or organizational expenditures, the more macro undertaking is not difficult to imagine. Combining different types of behavior – such as Portuguese exploration and Dutch resistance to regional hegemony – may prove to be another matter. Similarly, it may take some time to become more familiar with the expectations of logistic modeling – which combines both different approaches to modeling in which we have engaged in the past, and a new way to interpret the type of activities upon which we are focusing.

It should be clear that we have not heard the last word on how to measure modern political globalization. Until we do, we might do well to concentrate on exploring the logistic characteristics of globalization behavior and institutions, as well as modeling the complexities of interactions among the numerous processes that seem to be significant to political globalization operations. There is certainly enough to do to keep us busy for a while. One thing, moreover, seems highly probable. Analyzing the multiple processes on which we currently have serial information will lead to the identification of other relevant processes and measurement solutions, with or without a great deal of a priori theoretical construction. For better or worse, that is pretty much how we ended up with the series that we possess currently. Perhaps it should not be surprising that attempting to model the evolution of political globalization must proceed along the same experimental fumbling tracks that political evolution itself follows.

Notes

1 "Readily recognizable form" does not mean that all analysts agree on the form. Scholars disagree, for instance, over what to do about Portugal versus Spain versus the Habsburgs; whether the Netherlands was the first or second modern system leader (or not one at all); and whether Britain had one or two strikes at bat. The point here, however, is that students of international political hierarchy disagree about the candidates of the past 500 years. Few, if any, make claims about system leaders prior to 1494, unless one wishes to count a variety of rather loose and dubious comparisons between modern leaders and the Roman Empire. At the same time, the conceptualization of political globalization is evolving as well. Modelski (2007, Chapter 2 of this volume), for instance, advances a new way of interpreting the last 1000 years of evolving globalization. It will take some time to absorb and evaluate the implications of this interpretation.

2 Cioffi-Revilla (2006) makes a distinction between endogenous and exogenous globalization. Endogenous globalization is about greater interconnections within regions prior to the time when all continents had become linked, however minimally (*c.* CE 1500). Exogenous globalization refers to inter-regional increases in connections. The question that probably deserves more consideration is the distinction between regions and continents. If Afro-Eurasia encompassed multiple regions, then the increased interactions among the multiple regions would count as globalization even if people in the Old World had not yet become linked to the New World. Do we gain by making further distinctions about endogenous and exogenous globalization within Afro-Eurasia?

3 Modelski has suggested (pers.comm.) that we employ the following vocabulary for "globalization" processes in different eras: regionalization in the ancient world (up to about 1000 BCE), continentalization in the classical era (between 1000 BCE and CE 1000), and globalization in the modern era (after CE 1000). This suggestion is

a very appealing protocol. The only problem that I see is that some activities in the classical and modern eras seem more like regionalization than they do either continentalization or globalization. Thus the scale may prove more useful than tying the type of activities to specific points in time.

4 In evolutionary shifts, the parameters within which processes work change abruptly, as opposed to more normal incremental changes. In observations such as these I am departing from the script specified in Tables 2.1 and 2.2 in Modelski (2007, Chapter 2 of this volume). Those tables are focused on the most recent (or latest millennium) of globalization, while I prefer maintaining closer links to developments prior to the last thousand years.

5 Robert Harkavy is developing a database on global bases going back to the fifteenth century that could also be utilized to measure another dimension of the systemic leadership infrastructure.

6 By misleading, I mean that there can be problems in looking at the growth rates of new industries prematurely. Any industry that is initially starting up is apt to demonstrate high growth rates, due to the small numbers involved. If the objective is to capture the timing to peaks in the growth spurts, then one must be wary of outliers created by premature changes in the counting mechanism.

7 Thompson and Rasler (1999) suggest another use for army data in terms of examining the impact of global war on army expansion, as opposed to asserted military revolutions.

8 Another related possibility is that deterrence is unlikely to work optimally in global war settings. Challengers envision more limited conflicts, while system leaders are often at relatively weak points in their relative power life cycles. Moreover, there is often ambiguity about who might fight whom and when. See, for instance, Thompson (1997/98).

9 These data are based on information on great-power alliances and the distribution of armies within Europe for the past 500 years.

10 Unfortunately, listing the many commodities and sources involved in this effort would take more space than is desirable at present.

11 This is warfare measured in terms of severity or battle deaths (see Goldstein, 1988).

12 Another process is highlighted by the recent work on hierarchy in city size distributions that White *et al.* (2006) find to be closely related to K-wave activity as specified by leadership long-cycle analyses. At some point, we might do well to develop a generational protocol in order to test a growing number of hypotheses about the generational rhythm of long-term political–economic changes. The question remains, however, where to begin. Long-cycle phases suggest one possibility.

13 See, for instance, the analyses of Bergesen and Schoenberg (1980); Boswell (1989); and Boswell and Chase-Dunn (2000). Henige's information has to be used very carefully to avoid distortion. There are sometimes long pauses between the seizure of a territory and the appointment of a colonial governor. Another problem is that large territories are sometimes partitioned into smaller colonies at a later point. If these sub-partitions are counted as new colonies, then it would suggest revived dynamics of territorial expansion when all that is going on is some administrative reshuffling. In Figure 4.11, colonial control is counted from the date of seizure or occupation, and subsequent partitioning of colonial territory is ignored. Finally, there is also the problem that small islands are given the same weight as colonies with large territory and populations. Some control for area encompassed by colonial control certainly would be preferable, but it would not be easy to generate, particularly in those cases in which European control was largely restricted to coastal areas for decades if not centuries. Note as well that these colonial series have not been calculated beyond Henige's stopping point. Otherwise, more decline would be in evidence.

14 Some empirical connections are missing from Figure 4.1 in order to avoid overwhelming it with too many arrows. One missing arrow is that systemic leadership, as measured by global-reach concentration, has been found to be linked significantly to decolonization efforts (Reuveny and Thompson, 2002). See also the argument and analysis done by Pollins and Murrin (1999).
15 On this issue, see Devezas and Modelski (2002, 2007, Chapter 3 of this volume).
16 As in other cases, it should be possible to push back the measurement of "imperial" warfare to earlier centuries. In Figure 4.12, it is measured in terms of a moderately tweaked version of the Correlates of War "extra-systemic" warfare.
17 For instance, she also stresses Cold War rivalry as a factor in prolonging the duration of civil wars in new states.
18 The state frequency count measures the number of states per year considered to be new to the international system in that year.
19 The data on IGOs and NGOs are taken from multiple volumes generated by the Union of International Associations (1995/96, 2001/02, 2005/06). Keep in mind that not all IGOs operate with inter-regional scope. Only about 25–30 percent of the numbers reported in Figure 4.16 are inter-regional organizations. In 1981, 82 IGOS were inter-regional, thereby qualifying as global entities. In 2005, 67 organizations qualified. The decay in IGO numbers, thus, applies to both political globalization and regionalization.
20 Of course, one of the awkwardnesses associated with democratization is that analysts have found conflict to increase with increased democratization. Initially, democratization expands the number of mixed dyads (i.e. democratic and non-democratic states) that have been found to possess the greatest propensity for conflict among the various regime dyadic types (e.g. in comparison with authoritarian or democratic dyads). There is also some debate continuing on whether we bestow too much faith on the ability of regime-type changes to transform world politics. See, for instance, Rasler and Thompson (2005).
21 Yet, as Christopher Chase-Dunn argues, colonial rebellions and insurgencies are also anti-systemic in nature.
22 Another and not unrelated vein is the ideological struggle over prevailing ideologies (aristocratic privilege, fascism, communism, liberalism) that was so pronounced in the twentieth century. The contest of ideas, however, is not easy to capture quantitatively.
23 The six-wave argument is found in Thompson (2006). Rapoport (2004) argues for four. Bergesen and Lizardo (2004) also argue for multiple waves, but their identification is based on a different conceptualization.
24 One problem in converting sea-power indices to logistic curve formats is that naval technology has evolved considerably in the past half-millennium. This propensity makes it very difficult to simply count ships over time without introducing increasing thresholds on what types of ships are considered competitive at different time periods. For instance, in the early part of one century, a 50-gun ship-of-the-line might be considered quite formidable – only to be relegated to frigate or scouting duties later in the same century because the minimal firepower for front-line duty had escalated to 100 guns. As a consequence, each technological intervention in the ship count makes it difficult to calculate serial growth when the precise unit of analysis changes from one era to the next.

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5 Is globalization self-organizing?[1]

Joachim Karl Rennstich

Globalization as a complex system?

Although in recent years the importance of world-historical trajectories for the development of modern-day "globalization" has been increasingly acknowledged, a number of important theoretical questions remain. The scholarship on globalization often sharply diverges over the issue of its developmental logic, in the sense of what "drives" the long-term development of world-systems, a world system, or even a global (meta) system[2] (that goes beyond the social world).

Different explanations for this logic, ranging from random chance to the dialectical nature of capitalism, have been offered. Yet, the observance of a relatively stable pattern of global system development has been criticized either for its linear nature or for the lack of theoretical underpinnings for its pulsating behavior. Its critics argue that either such models are based on a technological or economic determinism that has proven to be a poor predictor of global system development, or they are missing the central element creating the observed rhythm of a dynamic world-system development, and thus provide a poor theoretical tool for analysis.

This "central element" is the object of this chapter. The arguments developed here rest on the assumption that thinking of the global system as a complex, self-organizing (mostly) social system allows us to step outside the constraints of the study of the institutions and processes that "produce" globalization[3] and instead enables us to analyze the underlying logic that drives, curtails, and reinforces these processes. Here we offer a framework that combines complex system analysis with an evolutionary theory of global system development.

Complex systems analysis offers us insights into the way that systems establish "order" without a singular or initial ordering entity. Yet an order – or developmental logic – does emerge in such systems, based on systems of trial and error, adaptation, and system-wide learning, resulting in a system that features "self-organization" (for a good summary of the relevant literature, see Devezas and Corredine 2001; Devezas and Corredine 2002).[4]

Here we argue that globalization understood as a long-term social system (involving economic, political, and cultural processes) forming a global social world resembles such an emerging ordered system without a single orderer. No single power, whether an empire, state, or any other unit, has transformed the human social world over the last 500 or 1,000 years (or any other period) into the state we experience it today. Rather, globalization thus understood has been the result of a number of recurring processes of trial and error, adaptation, system-wide learning, and thus a complex system based on the principle of self-organization.

Employing the general lessons derived from the study of complex systems, it is possible to identify the general (or meta) developmental logic of the long-term globalization process, while at the same time leaving room for divergent schools of explanations on the factors that influence important order-structuring factors such as learning or adaptation in the system.

One critical component in this process of order-structuring is the introduction of generational cohorts as a key sub-system of collective learning, which includes not only the capacity for adaptation, but also for innovation. Based on innovations originating in new forms of socio-technological behavior of the first generation of innovators, the following second generation, groomed in this new environment, transforms these innovations into a coherent socio-technological paradigm. The third generation, while still enjoying the spoils of the high returns on the leadership in this increasingly adapted socio-technological paradigm, remains "stuck" in it, unable to adapt to emerging new alternative socio-technological innovations, and allowing new socio-economic innovations to arise in alternative and geographically separate clusters. This leaves the fourth generation witnessing the rise of challengers to this established order, and eventually the emergence of a new socio-technological paradigm – often outside of its domain of control.

While the argument developed here is not necessarily tied to a specific school of long-term globalization, we use a long-wave model to demonstrate the application of the generational argument developed here. The pattern of roughly 100-year-long waves (or long cycles) of alternating leadership clusters – characterized by their innovative development of a coherent socio-technological paradigm – can be empirically traced and analyzed through the observance of a four-step generational cohort pattern, and referred to here as the "Buddenbrook cycle."

Global system development: An evolutionary approach

Evolutionary models are characterized by a focus on change, dynamics, and selection. Change in this view is constant, but never linear in its unfolding – it changes pace, intensity, and impact, depending on the environment in which this change unfolds. In doing so, changes are affecting the development of environments that in turn affect them (feedback effects). The global system constitutes such an environment of dynamic change. In its development, it follows an "evolutionary logic" that explains the creation of "possibility space," or, in other words, the potential options for change open to the systems and its parts (Clark *et al.* 1995). This evolutionary logic driving the global-system process is based on the following set of epistemological assumptions of evolutionary economics (Andersen 1994), that also build the basis of the model presented here:

- agents (e.g. individuals, groups, organizations, etc.) can never be "perfectly informed" and thus have to optimize (at best) locally, rather than globally;
- an agent's decision-making is (normally) bound to rules, norms, and institutions;
- agents are to some extent able to imitate the rules of other agents (imitation), to learn for themselves, and are able to create novelty (innovation);
- the processes of imitation and innovation are characterized by significant degrees of cumulativeness and path-dependency (but may be interrupted by occasional discontinuities);
- the interactions between the agents take place in situations of disequilibria, and result in either successes or failures of commodity variants and method variants as well as of agents; and
- these processes of change are non-deterministic, open-ended, and irreversible (creating a path of choices).

Thus, socio-political and ultimately global system change seen in this light is always a historical, dynamic process involving the use as well as the creation of resources (as diverse as simple objects, techniques, and knowledge; or even entire social organizations). The evolutionary logic is the result of social interaction, and thus human agency. This agency, however, takes place and is embedded in an institutional and technological context. In other words, whereas the driving logic (human agency) of this process remains the same, its context changes, constituting a "social learning algorithm" of evolutionary change that is at work at all levels of the global-system process (from the individual to the change of the global system as a whole). Within the framework presented here, the four mechanisms driving the evolutionary globalization process and constituting a "social learning algorithm" are: (1) variety creation (very broadly: cultural process); (2) cooperation or segregation (social process); (3) selection (political process); and (4) preservation and transmission (economic process).

Since such a synthesis has to be an ordered one, all world-system processes have a time structure that allows for successive optimizations of these mechanisms in a formal–logical "learning sequence" (following the numbered sequence above). Global-system processes in this view, then, are seen as nested and synchronized (i.e. coevolving) four-phase temporal learning experiments driven by common "evolutionary logic" inherent in all these processes.

Evolutionary logic, system complexity, and world-system evolution

From an evolutionary perspective, the development of the global system as we experience it today has been characterized by what McNeill and

McNeill (2003) describe as a process of intensifying connections of human "webs." These webs are rather diverse in their form, strength of connections, and the areas and peoples that they cover. Through the gradual amalgamation of many smaller webs into a single world web, the global system emerges in the form of the "Old World Web," spanning most of Eurasia and North Africa and forming about 2,000 years ago. With the expansion of oceanic navigation, a more complex and extended (both in depth and width) single "cosmopolitan web" emerged out of existing metropolitan (and the few remaining local) webs, creating a truly global, single human web.

Descriptions of the development of a global system abound (as discussed above). The analysis of McNeill and McNeill has been used here in order to highlight two of the most important aspects of the global-system formation, often only implicitly acknowledged in the respective analyses: the evolutionary character of its development and the complexity of its connection. The long-wave approach employed in this work is based on and extends the analysis of the development of the modern era system (i.e. the current global organization phase in the global or world-system process) as put forward by Modelski and Thompson (1996) and Rennstich (2003a). The model developed there takes into account the dynamic processes of the evolutionary drive of the global world-system process and the resulting change in the overall network structure of the nested, coevolving cultural, social, political, and economic processes.

To readers familiar with existing long-wave narratives of world-system development, it is important to note the inclusion of the element of system complexity in the model presented here. In this view, a crucial aspect in terms of its evolution from a set of previously loosely related webs or sub-systems into the far more interconnected global system of today – the "weaving of the global web" as a developmental or system-ordering process – is the recognition of the relationship between these systems as a complex meta-system. The advantage of employing such a meta-evolutionary model (a model that assumes that the global-system formation follows the features of a complex system) to the analysis of long-term global-system formation, is that it allows us to draw on the important insights of other research traditions, employing findings from seemingly unrelated subject matters, that nonetheless contribute significant theoretical and empirical findings for our study of global-system evolution. The meta-narrative (of innovation, adaption, and system-wide learning) remains the same, whereas we can employ alternative explanations for the social factors that structure the relationship of the social agents (and thus have a direct impact on the capacity for innovation, adaptation, and learning).

Change in complex systems, whether in the direction of greater or lesser complexity, produces a trajectory or "historical path," limiting future options and thus becoming path-dependent in this way.[5] The logic of the development of these systems is based on trial-and-error. Configuration (adaptation), and reconfiguration (i.e. learning) become an part of the entire system as well as the various sub-systems (or "web" in the terminology of McNeill). The path as such is therefore not determined towards a specific goal. With each step, a new structure (or environment) is created that encompasses previous self-organization, learning and the current limitations, and to which the units have to correspond, shaping yet another new structure in the process. Therefore, complex systems such as the nested global economic, political, social, and cultural processes under study here exhibit a tendency to "self-organization," that is, the endogenous ordering into hierarchies gives them a system-wide form.[6]

The way the interrelationships between parts of the systems are established – i.e. the weaving of the webs or, put differently, the structure of the networks making up the global system – thus becomes crucial for our understanding of the dynamics of these coevolving structures.

Network structures

The middle of the eighteenth century in this view, to use the image employed by McNeill and McNeill, marks a change in the "spinning" of the global system web, or, in complex systems terms, the punctuation of the complex global system. Up to this point, webs had been extended and newly formed, mostly in the form of the establishment of linkages between pre-existing (metropolitan) webs, and, in turn, creating a larger, single web – a process that we could describe as "external network" or web extension. What changes during this time is the increasing tendency of "internal web weaving," i.e. the attempt to extend pre-existing large webs internally to create rival alternative rather than complementing webs or networks.[7]

Table 5.1 lists the development of the network structure, in addition to the coevolution of the economic and political process of globalization, describing the leading sectors of each economic Kondratiev- or K-wave and the lead economy of each political long wave of global world-system leadership.[8] The roots of the three main network systems in existence so far can be found in the evolutionary "trials" (as part of the evolutionary development of variety creation) during the two Chinese-dominated periods emerging in *c*.900 CE.[9] In particular, the Southern Sung period during the eleventh and twelfth centuries provides many elements that are similar to those present in the following maritime network system. Given their lineage and the larger evolutionary pattern of development, however, it is analytically more sensible to regard them as evolutionary trials, rather than part of the first external network system.

Observing this process, we are able to mark three distinct network phases during the evolution of the modern world system: a maritime commercial phase (Genoa, Venice, Portugal, Dutch, England I), an industrial phase (England II, US I), and the emerging digital commercial phase (US II). All three phases can be divided into two meta-systems of internal and external network phases (as a result of leading sectors and the different technological styles, see Table 5.1).[10]

Table 5.1 Drivers of evolutionary system development and network structures

Starting (approx. year)	*Global system process*	*Global community process*	*Global political evolution (long cycles)*	*Global economic evolution (K-waves)*	*Network structure*
930	Preconditions	**Experiments**	**Eurasian transition**	**Sung breakthrough**	Build-up, transition external
		Reforming	North Sung		
			South Sung		
1190		Republican	Genoa	**Commercial/nautical revolution**	External
			Venice		
1430	Global nucleus	Calvinist	**Atlantic Europe**	**Oceanic trade**	External
			Portugal		
			Dutch Republic		
1640		Liberal	Britain I	**Industrial take-off**	Transition
			Britain II		Internal
1850	Global organization	**Democracy**	**Atlantic–Pacific**	**Information**	
		Democratic groundwork	USA	K17 – Electric, steel	Internal
				K18 – Electronics	Transition
				Digital	
				K19 – Informational industries	External
				K20 – Digital network (?)	External
2080			China (?)	K21 (?)	

Source: Based on Modelski (2000) and own additions. All years CE.

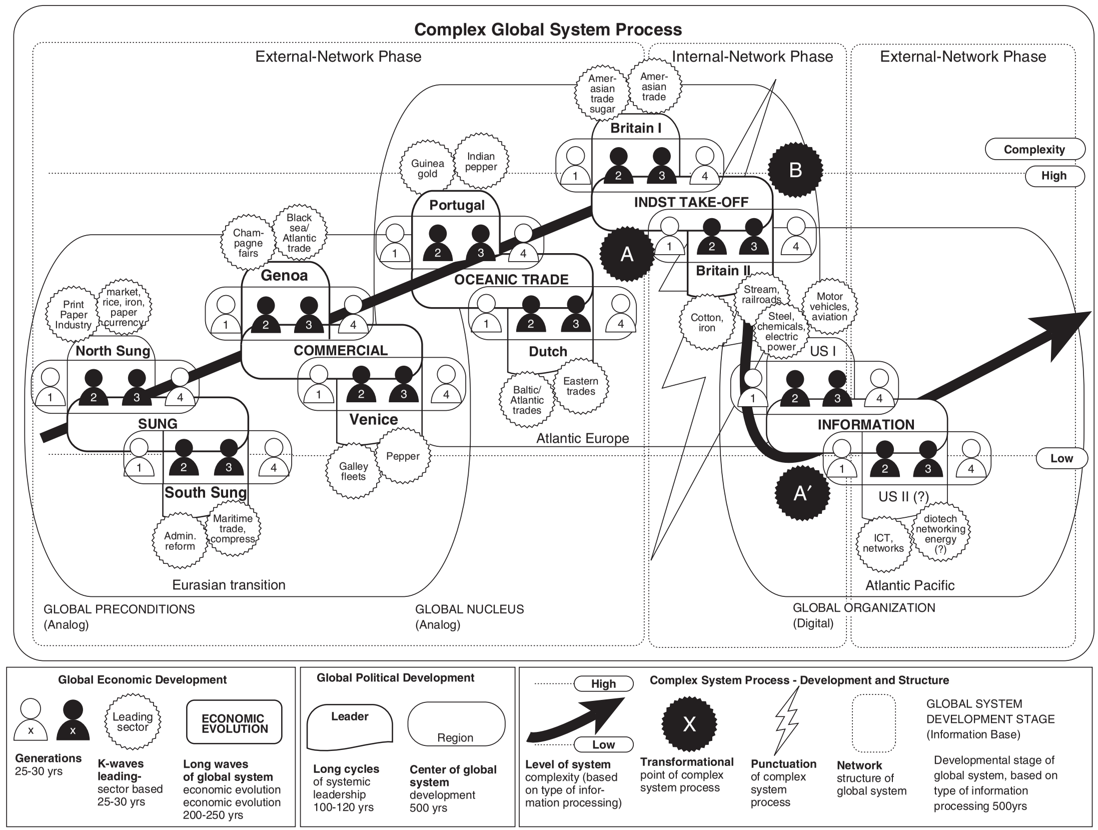

Figure 5.1 Complex global system process.

In sum, the global-system process during the time of the punctuation (from roughly the 1740s to the 1970s, see Figure 5.1) changes from a process marked by external structure connections to one marked by internalizing webs, manifesting the selected organizational and institutional structures, until a new phase of evolutionary dynamics sets in during the late twentieth century.[11]

One of the main characteristics of systemic leadership transitions in most treatments of the subject seems to be the inability of the existing leader to establish a similar leadership position in a newly emerging and structurally different commercial and organizational arrangement. This shift in the geographic and political location of power has been explained as the outcome of the leader's experience of success in the current setting, creating an entrenched institutional setting (in a broader sense) that proves adaptive in defending its turf but less so in fostering the rise of new leading sectors. However, the case of Britain's continued leadership over an extended period of time (and separate long waves) has shown that this is not always the case.

In the previous occurrence of a switch from one network system to another – as a result of the change in the type of capitalist mode of "global web weaving" (commercial maritime, industrial, and digital commercial) dominating the global system to a new one – we have witnessed a phenomenon here referred to as the "phoenix cycle."[12] In instances where the systemic chaos is not only driven by the "normal" process of hegemonic crisis and breakdown (see Figure 5.1), but also coincides with a systemic crisis (emerging out of the rising complexity of the system), the existing leader can defend its leadership position in the transforming world system. This shift is triggered by a change in the major socio-economic interaction mode of the system, leading to a shift in the system meta-structure (the "web-weaving"). Only if the parallel development of a new cluster of innovations and the rise of new leading sectors can occur within its domain, is the existing leader able to extend its leadership position (see Figure 5.1).

As shown by a number of authors[13] from various research traditions, past success often contains the very ingredients for future demise. Whereas continued endogenous innovation still takes place within the space of the existing leader, adaptation to a newly emerging, changed environment (as a result of the rise of new leading sectors elsewhere) proves very hard for a society that can (and usually does) become locked into economic practices and institutions that in the past proved so successful. Powerful vested interests resist change, especially in circumstances when a nation is so powerful as to institutionalize its commercial and organizational arrangement on a global level, a change sorely needed, however, to maintain its leadership. Gilpin (1996) thus concludes that "a national system of political economy most 'fit' and efficient in one era of technology and market demand is very likely to be 'unfit' in a succeeding age of new technologies and new demands." The creation of these national systems and their respective fitness is the direct result of the social contextualization of inventions, technologies, and their resulting innovations, developing into leading sectors in the case of the emerging new systemic leader.

Transitions of systemic leadership usually involve the shift from one leader to another, due to what Boswell (1999) calls the "advantage of backwardness." If we view the emergence of new commercial and organizational arrangements as a largely endogenous process, its emergence also causes an environmental shift that can be understood as an exogenous factor as well. However, the response of the existing leader to this change is largely driven by endogenous factors again – a process that results in a unique social contextualization of technologies.

Figure 5.1 illustrates graphically the relationship between the rate of change, rising system complexity, and prevalent system network structure or "mode of web-weaving" earlier discussed on the basis of the development in Table 5.1.[14]

The bold black wave-like arrow in Figure 5.1 represents the rate of complexity that rises over time. This graphical representation does not aim to portray any "exact" representation from which the global system formation has emerged. The illustration marks instead the first emergence of a specific system-weaving mode (or *modus operandus*) that characterizes global-system development as it seems to continue into the present day. "A" indicates the point at which growth in complexity will begin to slow, as hypercoherence takes effect and the possibilities for change (i.e. possibility space) begin to decrease rapidly. Since complex socio-political systems (like all complex systems) will inhibit an internal dynamic which leads them to increase in complexity, the rate of decision-making must, necessarily, keep pace with this increased complexity (see Devezas and Corredine 2002; Devezas and Corredine 2001; Devezas and Modelski 2003).

This system increases in reach and overall complexity until (during the nineteenth century) it reaches a state in which the path-dependent system eventually runs out of future possible choices – a state also referred to as "hypercoherence"[15] that regularly occurs in any complex system.[16] In other words, the global system experiences a systemic punctuation (also referred to as "catastrophic change") around 1850, resulting in the end of the experimental phase in the global community process and starting with the democratic phase as the set-up that seems the most fit and efficient in the global social system.[17]

Decision-making (and thus the process of agency) does not take place in an isolated environment, but rather a strongly contextual one, marked by high levels of feedback effects: agency affects the environment in which it unfolds, but also is formed by it. Thus, it is important not only to focus on the agents (in the context of this work, defined as states aiming for systemic leadership or hegemony), but also to identify the contextual environment in which this agency takes place.

This structure is mainly the result of the need to cope with a rise in complex decision-making through externalization of the decision-making process.[18]

However, the more complex the system becomes – that is, the wider the possibility space extends – the more liable it is to collapse. This collapse takes place in the form of a selection of best-adapted organizational and institutional variance, as the possibility space for change begins to close and the system becomes hypercoherent.

Surrounding the time of this "punctuation" (starting around the middle of the eighteenth century), the global-system process is marked by an important change in the form of its "web-weaving" or network formation. Rather than seeking to manage the extension between webs, large metropolitan webs aim to turn into single, large "mono-structures" with control over the entire web rather than mainly the external connections to other webs, manifesting the selected organizational and institutional structures. This network-system mode remains largely in place, until a new phase of evolutionary dynamics begins in the late twentieth century (in the second half of the twentieth century, see Figure 5.1), bringing back the main focus on the organizational control of the connections between existing webs or networks.

Point B in Figure 5.1 represents the point at which catastrophic change into a decline mode occurs. The network structure of the global system during its initial unfolding remains external in nature, bringing with it ever-higher levels of complexity as the webs deepen in both depth and width. During point A, the point of hypercoherence, the network structure becomes internally oriented, leading to a point, B, of "catastrophic change" or punctuation (i.e. the selection of a macro-organizational and institutional model in the global community process).[19]

New innovations and technologies and their accompanying institutional arrangements or paradigms[20] made it possible to extend the management of entire webs rather than just the external network of relationships between existing webs. As a result, the major units of the global web – large, metropolitan webs with their respective hinterlands – could now viably seek to extend those hinterlands and incorporate large chunks of previously connected but largely independent webs into their own domain. As a result, the major mode of network structure creation and control switched from an external network-oriented one, to a mode focused on the control of internal networks that remained connected with other webs (forming a large global web) but shifted their focus on to the internal networks rather than the external ones.

Ultimately, however, the control of these systems proved too complex, resulting in a state of hypercoherence of the global web (as described above). Since the middle of the twentieth century, the global system – again as a result of new technologies shifting the focus again on control of external network connections rather than control over entire webs – has begun a new stage of global-system formation that now incorporates not only the physical domain of human interaction but also the "virtual" one that can be captured in a binary (or "digital") code.

Social contextualization of technology

As pointed out at the beginning of this chapter, the crucial question of what drives the pulsation or rhythm of these processes remains an important matter for debate. The connection between the agents involved; their interactions with each other; and also the institutional arrangements that these interactions foster, are all in need for closer scrutiny. It is useful here to return back to the parameters affecting the rate of learning and adaptation in complex social systems such as the global-system one. While social systems include more than individual agents, the duration of long waves are largely determined by two biological control parameters (Devezas and Corredine 2002) as a result of human agency. Those two parameters include (1) cognitive factors (driving the rate of exchanging and processing information at the microlevel), as well as (2) generational cohorts (constraining the rate of transfer of knowledge).

A criticism that is often leveled at evolutionary models such as the one described here, involves the alleged technological determinism that supposedly drives the socio-economic processes that make up the global-system development. Such criticism needs to be taken seriously. If indeed, technological development alone would be the key driver of these processes, then the theory would serve us poorly. As we know from many accounts, technology in itself is very social (Basalla 1988). China had the technological skills, the necessary infrastructure, and the resources in place to develop a steel industry at the level of production that hundreds of years later would enable the rise of industrialism in England. Yet this "preconditioning" did not automatically lead toward the path of industrialization.

This points to an embedding of technology into a larger context, that is part social, part economic, part political, and in its combination institutional – a point that is highlighted in another example of the need to view technology and innovation as an element embedded in a larger social[21] context, as described by Brews and Tucci (2003). Their study of the need to embed information and communication technologies (ICTs) into a larger social context to create the desired outcomes, demonstrates that the social contextualization of technology exists independently of the complexity of the technologies and innovations involved, but rather is a general attribute of the role of technology in the processes that shape the formation of the global system as described here.

This formation is striking in its (relative) regularity, at least since the emergence of the trajectories emanating in Sung China in the CE 900s – a regularity that is even more perplexing, given the significant differences in their social contextuality, if one compares the Sung systems with those of the Venetian city states, Portugal, the Netherlands, Britain, and the current US systems (see Table 5.1). If the pattern does not necessarily derive from a direct, determinant connection between technologies and the socio-technological systems that they enable, then what else can explain this pattern?

Cognitive factors

Cognitive factors which directly impact the capacity to process information are important to the argument developed here. For millennia, humans have employed technologies to aid them in this task: some of the earliest uses of records were directly related to the storage of economic data and later to contractual arrangements. As pointed out earlier, one feature of complex systems is their initial relative simplicity. A global system process, even though unfolding over millennia, can therefore only be made possible through the increasing ability of technology to aid human agents and their collective units in processing information, as the biological human capacity to process information has developed much more slowly.

The complexity, as explained earlier, of a given complex system does not develop in a linear fashion, but tends to grow in a non-linear and exponential manner. Therefore, the very fact that technology and its socialization in terms of information-capacity widening has increased in an exponential manner, made the regular pattern of long waves possible in the first place. Otherwise the increasing complexity of a broadening global system would have overburdened the human cognitive capacity process and forced the development of the system to slow-down (as it did in pre-modern times).

This interrelationship between human-biological and technologically aided cognitive processing capacity also explains the moment of "catastrophic change" and the punctuation of the system process (see the earlier discussion of Figure 5.1). The technologies of the pre-industrial age were simply not sufficient to add the cognitive capacity necessary for a further weaving of a now global web. It is during this phase that critical technologies for the shift from analog to digital information processing occurs (these are long-term transformations, after all).[22]

The cognitive challenges posed are daunting, as not only social, but increasingly biological information gets coded in the same basic binary code of 0 and 1 (as reflected in the rise of sectors such as biotechnology and bio-informatics). Yet it seems that the necessary technological tools have been developed to aid social agents in the cognitive processing capacity needed to continue the evolutionary developmental path of global-system formation.

Figure 5.2 uses the Buddenbrook cycle to trace the regular pattern of trial and error, adaptation and learning (see also Table 5.1), and places it right at the heart of the development of long cycles and long waves, and ultimately the development of the center of global system development. It is the "human element" at the heart of this entire process that explains the relative regularity of its development independently of increasing technological capabilities (which might point to an increase in the speed of this process); the extension of the system; and the broadening of its demographic, geographic, and institutional breadth (which might point to a slow-down or alternatively again an increase in speed, as more variety-creation could take place and faster rates

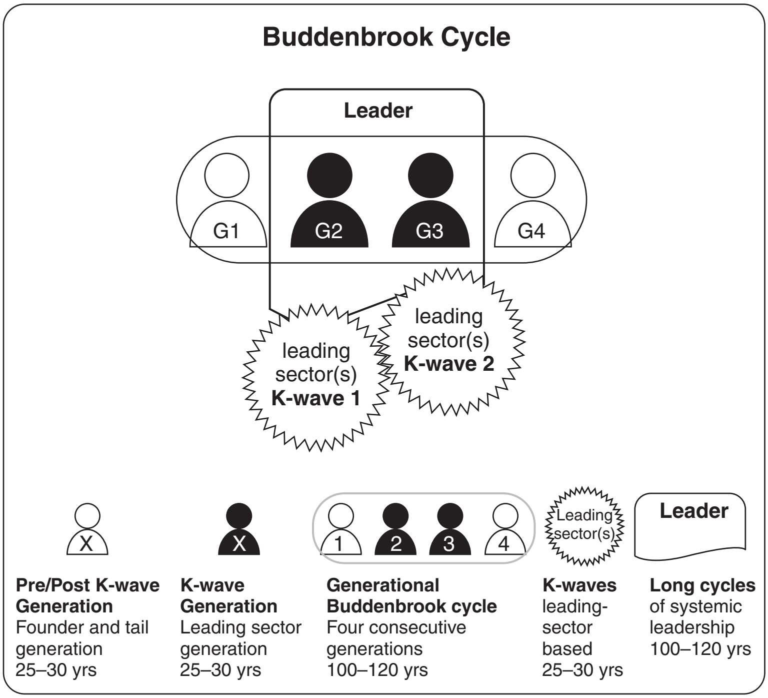

Figure 5.2 The Buddenbrook cycle as part of a leadership-long cycle.

of learning and adaptation) or the increase in the destructive capabilities of the actors during the decision-making and selection phases. Rather than a change in the dynamics of the learning and/or adaptation process, we do see a relative constancy.

We argue here that it is the social embedding of leading-sector technologies that provides the crucial key to a better understanding of the regularity of this process. This embedding is captured in what we summarize here as the Buddenbrook cycle.

The buddenbrook cycle

This cycle (graphically depicted as part of a leadership long-cycle in Figure 5.2) derives its name from the novel by Thomas Mann, in which he describes the rise and decline of four generations of a trading family-firm in Lübeck, Germany (and the parallel rise of a new alternative generational family-firm-set). Mann's description captures the very essence of the theory developed here:

> The first generation (X_1 of Unit X) establishes the foundation of a new set of innovations (or "innovational frame") through a new, alternative "way of doing things." We term this the "founder generation."

It is during this phase that certain key inventions, that often occurred many years earlier, are formed into major innovations and their resulting technologies. This transformation is the result of a unique combination of the social context in which these technologies are embedded and the feedback that these technologies evoke in turn in this social context. However, the impact of these new ways of doing things is not yet large enough to allow the unit to take a leadership role in the system.

> The second generation (X_2), brought up in an emerging new socio-economic environment (i.e. the innovational frame), and thus socialized in a certain use of the involved innovations and technologies, adds to the first set of innovations and brings it to a second new height. We term this the first "K-wave generation."

This phase is critical in terms of the socialization of technology and broadening of the innovational frame. The second generation takes up the cues from the first "choice-maker" generational cohort, following the paths taken up (for better or worse) by their previous generational peers. They are taking the emerging new socio-technological paradigm for granted and, through the application of chosen technologies, fully socialize these technologies beyond the level of the choice-maker generation. It is during this generation that the leading sectors fully develop as a result of their completed embedding in the social context of a given unit (a family in the case of the Buddenbrooks; a state in the case of the global-system formation). These leading sectors in turn become the basis of the Kondratiev waves that are the basis of the leadership long-cycles discussed earlier (see Figure 5.1).

> The third generation (X_3), immersed in this "winning set" and aiming to continue its way of doing things, is unable to adapt to a changing environment, which itself is created and fostered by a new set of alternative clusters and thus is forced to witness the decline of its own innovational frame. We also term this generation a "K-wave generation" as it also marks the development of a second set of leading sectors that provide the basis for a second unit-based K-wave.

This third generation is mainly reaping the benefits of the earlier success of the first two generational cohorts. During this phase, former innovations (and the associated benefits of systemic control and rent-extraction) become more widely adopted in the wider social context, and form a new norm. This increasingly leaves room for new inventions to transform into innovations outside this specific social context (the way that "things are being done" in family A) and eventually leads to the rise of alternative sets of innovations (in family Y_1, Z_1, etc.).

> The fourth generation (A_4) finds itself in the middle of a process of transition and transformation. The very innovations that once proved critical in the development of systemic control and leadership have by now become the norm. At the same time, a new generation cohort (the first generation of Family B) outside of the generational lineage of Family A establishes the foundation of a new set of innovations (or innovational frame) through a new, alternative way of doing things. The center of innovation (and the associated transformations) shifts from Family A to Family B. We thus call this generation a "tail generation."

Whereas the completion of the social embedding of technology has been crucial for the success of the previous generation, leading to the successful development of leading sectors within its domain, and enabling it to obtain a position of systemic leadership, this embedding has now been manifested in the institutionalization of this "winning set" – most beautifully illustrated in the novel *Buddenbrooks*, when the newly crowned Consul Buddenbrook (taking over the post from his father), decides against his own better judgment (as he senses the threat emanating from the outside) to display the status of the family and the family business through the purchase of a very grand house in the town of Lübeck. Although the decline is already discernible, the family (and their key decision-makers) seems unable to adapt to the changes in the environment that they sense, but rather aim to manifest its still strong standing in the established system through a focus on symbols demonstrating its institutional control. In the end, however, just as Tom Buddenbrook in the novel, the system leader is relegated to the sidelines, respected in the system, but clearly not in control of it.

The non-determinate nature of self-organization is largely the result of the constant need to adapt to new environments that are in turn affected by those adaptations and the biological constraints (discussed earlier) that frame the learning (and thus adaptive process), namely cognitive ability and generational constraints. Even though some actors (depicted in the leadership long-cycles) are able to obtain some limited systemic leadership position within the global-system development, no actor is able to maintain this position beyond the four-generation Buddenbrook cycle.

This model of a four-generational human (generational) cycle of social trial-and-error, learning and adaptation is tested against the empirically measured unfolding of long cycles and long waves as part of our earlier-discussed global-system development model. Figure 5.3[23] plots (with a bold line) the distribution of the actual length of the leadership long-cycles and long-waves as identified in the modern era globalization model discussed above and graphically represented in Figure 5.1, against a random distribution of generation-based long waves. (The length of a generation is assumed to be between 25 and 30 years, and the composition of a Buddenbrook cycle is assumed to be four generations making up one long wave, as discussed below, taking into account the mean length of the assumed length of generational

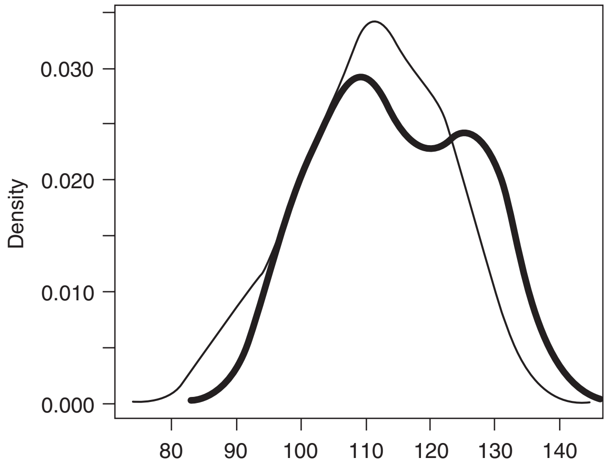

Figure 5.3 Distribution of length of generational waves, kernel density estimation distribution of actual long wavelengths (thin line) v. random wavelengths (mean = 110 years, SD = 12 years, bold line).

long-waves in the model (110 years) and a standard deviation of 12 years in length.[24])

The graph indicates a normal distribution in terms of the length of both the generational Buddenbrook model (thin line) and the actual long-waves of the past 1,000 years. A Shapiro–Wilk normality test results in $W = 0.91$ (p-value $= 0.3$), indicating[25] that we cannot dismiss the normal distribution of the generational wavelengths. In other words, if we expect either an increase or decrease in the speed of global-system formation, then we need to identify a trend in the distribution of the length of the waves (in the respective direction, depending on an increase or decrease in speed expectation). The results instead indicate that the modeled Buddenbrook cycle (which argues for a consistent length for the trial-and-error, learning, and adaptation process) is mirrored in the empirically measured length of the actual long waves that mark the global-system process. The increased need of human generations for cognitive processing capacity is satisfied by the increase in technological capacity to aid humans in this task – up until the point of punctuation of the global system (during the time of industrialization). The end of this phase, marked by a shift from production-oriented leading sectors and internal network domination to external network-focused, information-based leading sectors, also marks the "restart" of the self-organizing principle that guides global-system development. This time, however, it is based on a new information principle: digital, binary code, versus the analog, word/paper-based principle that was the information principle since the rise of revolutionary information-processing technologies in northern Sung China in the CE 900s).

New technologies, old agent: The continuation of self-organizational logic

This chapter has demonstrated in theoretical terms that the observed regular pulse of global-system development is not necessarily the result of a technological determinant. Rather, it is the outcome of a crucial element in the transformation of inventions and innovations as an enabler of choices (or "possibility space" in the language of evolutionary models) and technologies that, once fully embedded in their social context, turn into technologies, resulting in the development of leading sectors, which in turn enable some units to emerge as powerful leaders in a transforming global system. It is important to notice that the social context covers both the domestic and national (endogenous in evolutionary terms) systems, as well as the larger world systemic one. This "double socialization" is mirroring the feedback that takes place in the socialization process during the transition from the first (choice-maker) to the second generation, and the feedback effects that the new leading sectors (that resulted from the domestic socialization) have on the development of the global system as a whole. As in many social transformations, these processes are rarely a one-way, cause-and-effect affair. The interactions that take place in these processes shape the environments into new forms, but, at the same time, those environments have an impact on the form of socialization that emerges. Also, we hope to provide some common ground for various long-term approaches of the study of the globalization. The meta-framework presented here in the form of an evolutionary model, in our view allows seemingly divergent narratives of global web-weaving to add to our understanding of the globalization process as it unfolds over millennia, bridging not only analytical approaches within political science, but also across the social – and even biological – sciences.

Notes

1 The author would like to especially thank George Modelski, Tessalino Devezas, and William R. Thompson, as well as the group of participants at the conference in Vienna, for their support and helpful suggestions. The contribution of Michael Colaresi in sharing his skills and invaluable insights regarding earlier drafts of this paper is also greatly appreciated.

2 One of the aims of this chapter is to provide a common analytical ground for the divergent schools of long-term globalization. Therefore, while acknowledging the respective importance and distinctive meanings of world(-)system(s) and the term global, we will use the term "global system" as a description of the meta-process of globalization.

3 For an interesting discussion of this "endogeneity trap," see Sassen (2006).

4 For examples of the application of a similar approach, see also Allen *et al.* (1992); Scott and Lane (2000); Shaw (2000); and Ziman (2000).

5 This is the result of the structure of complex systems. Whereas in systems theory all sub-systems relate to each other, complex systems consist of networks of links of various types between all parts of the system, but each part is not necessarily linked with all the others in the same way.

6 As a result, these complex systems exhibit "morphogenesis" (i.e. the development of an organism or of some part of one, as it changes as a species), based on processes that are partly independent of agency, although they require agents to both initiate them and enact them (Dark 1998).
7 By no means do we intend to deny a continuing connection between these webs – a prerequisite for the argument of a continued development of a single, extending global system. What is important in this context is the shift of emphasis from control of web connections to one of control over larger sub-webs as a whole. This process has often included the usurpation of smaller, existing webs into a larger "imperial" web, with the aim of extending the sphere of control of a web, rather than extending the web through external connections only through the focus on the control of the connections rather than the other webs themselves.
8 Kondratiev or K-waves describe the emergence and subsequent decline of long-term economic cycles (roughly 50 years in length) that are superimposed on shorter – and better-known – business cycles, describing the "capitalist pulse" of the economic global-system process. For a discussion of the concept of K-waves in the context of the model employed here, see Rennstich (2003a). For a more general discussion on K-waves, see, for example, Duijn (1983); Goldstein (1988); Berry (1991); and Freeman and Louçã (2001).
9 This work follows the increasing use of CE (Common Era) and BCE (before the Common Era), which replaces the traditional dating system employing AD and BC respectively for the same periods.
10 For a full discussion of these phases, see Rennstich (2003b).
11 The change in the dominant mode of the weaving of the global web is crucial for a full understanding of the meaning of "domination" and "control" of the global system, but is beyond the scope of the discussion here. As pointed out earlier, one of the major advantages of the evolutionary approach as presented above is the ability to separate the selection criteria (or systemic fitness) from the identification of the general developmental logic of the system (self-organization). For this discussion, see, for example, Rennstich (2005).
12 For a discussion on the effect of these types of rivalries between great powers, see Rennstich (2003b, 2004). For a similar account, see Cantwell (1989); Levathes (1996); and Pomeranz (2000). For an alternative account, see Frank (1998), who distinguishes between "merchant capitalism" (pre-1770s), "industrial capitalism" (1770s to 1940s), and "global capitalism" (post-1940s).
13 See for, example, Nelson and Winter (1982); Freeman and Soete (1990); Porter (1990); Christensen (1997); Freeman and Louçã (1997); Gilpin (2001); and Perez (2002).
14 See Rennstich (2003a) for a more thorough discussion of this argument.
15 The terms "hypercoherence" or "catastrophic change" refer not to the overall breakdown of the global system process, but rather to the terminology used in chaos- and catastrophe-theory. They represent an "option-narrowing" as the result of the selection of a new organizational and institutional setting in the global community process. After a relatively short period of internal network structure dominance, the system reverts to an external system structure, setting in motion a new rise in complexity, bringing with it a new phase of externally open systems, and, consequently, in the end leading to a new stage of hypercoherence.
16 For a discussion of complex-systems theories, see Auyang (1998).
17 For a more detailed account, see Rennstich (2003a).
18 A good example might be the difference in organization of the decision-making process in a small four-person firm, in contrast to the hierarchical structure found in much larger enterprises. The sheer complexity of the need for individual decisions renders it impossible for a single person to make all the necessary decisions.

Rather, these organizations develop mechanisms of delegating decision-making – connecting several agents over a number of hierarchies in a joint decision-making network. The world as whole also resembles such a joint decision-making network. It permeates from the global-system process to the nested social and political processes and the inner core of the economic process. During this "search phase" of expanding possibility space, the dynamics of the system develop best in a relatively (externally) open environment.

19 It is important to note that "catastrophic change" here refers not to a breakdown of the global-system process, but rather refers to the terminology used in chaos- and catastrophe-theory and represents an "option-narrowing" as the result of the selection of a new organizational and institutional setting in the global community process. After a relatively short period of internal network structure dominance, the system reverts to an external system structure, setting in motion a new rise in complexity, bringing with it a new phase of externally open systems and consequently in the end leading to a new stage of hypercoherence.

20 See Perez (2002) for an excellent discussion on the relationship between technology, capital, and socio-economic and techno-economic paradigms that determine what in evolutionary models is referred to as "possibility space."

21 The use of the word "social," especially in a work such as this that crosses disciplinary boundaries, is laden with dangers. If not specified otherwise, it is meant to capture inter-agent process, whether they can be characterized as economic, political, or otherwise.

22 For a more detailed account, see, for example, Hobart and Schiffman (1998) and Robertson (1998).

23 The author is indebted to and would like to extend his gratitude to Michael Colaresi for bringing this approach to our attention.

24 The assumption of a range of 25–30 years as the length of a generation tries to reflect the uncertainty and general disagreement about the "common" or "general" length of a generation in the literature. Most observations that we are aware of are reflective of this range (see, for example, from a wide range of approaches: Berger 1960; Jaeger 1985; Strauss and Howe 1991; Griffin 2004; Fenner 2005). The mean of this range is taken to be 27.5 years, together with a standard deviation in length of 12 years (of a long-wave consisting of four consecutive generations).

25 *W* is a measure of the straightness of the normal probability plot, and small values indicate departures from normality (Shapiro and Wilk 1965). Rather than "proving" a normal distribution, the test merely shows whether it is possible to dismiss the normality of a given distribution, which in this case we cannot.

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6 Theories of long-term change and the future of world political institutions

Fulvio Attinà

The large majority of political scientists working in the field of institutional change have a preference for short-term and contextual analysis rather than long-term and process/structure analysis. By contrast, this chapter relies on long-term analyses of global processes, structures and mechanisms in order to understand the formation of and past changes in the world's political institutions, and to work out how to model future change. In the four sections of this chapter, the nature and origins of these institutions, and the causes and direction of their non-casual change, are explored. On the assumption that the formation of and changes in these institutions are long processes, moved forward by human communities' aptitude for learning, three propositions are discussed hereafter, i.e.:

1 The global system, which encompasses all regional international systems, came into existence a thousand years ago. Political globalization also started about a thousand years ago, and has been developing for at least ten centuries.
2 In the continuous reproduction of the global political system, social mechanisms of learning and innovation have produced a coherent network of institutions of government that, in the second half of the twentieth century, turned decisively towards a preference for formal structures.
3 Change in global political institutions is neither casual nor without direction, and its destination can be predicted fairly accurately.

Knowledge about the past processes of change in the world system is important for anticipating the direction of current change in the world's political institutions, but analytical and interpretive models are also relevant to the accomplishment of this endeavor. In particular, George Modelski's evolutionist approach to the analysis of global politics is here recognized as an appropriate strategy for the analysis and modeling of institutional change. Aspects of this approach are examined here in dialog with three other long-term change theories and studies, namely Gunder Frank's economic structure approach; the "common perspective" approach largely represented by the English School; and Alexander Wendt's organizational/teleological approach. Definition of global political institutions is the first step of this study, in terms of recognizing the differences that exist among political scientists with regard to the very nature of these institutions.

Defining the political institutions of the global system

In the traditional study of international politics, as distinct from the long-term study of global politics, scholars concentrate on institutions like diplomacy, international law and war, institutions that serve the primary interest that states have in having ordered and predictable relations. Diplomacy developed to communicate and negotiate in conditions that were fair and certain; international law developed to avoid conflicts of interest, by referring to shared principles and norms; war evolved to solve serious conflicts by agreed forms of violence when agreement on shared norms is lacking, and violence is taken as the ultimate instrument.[1] These institutions have not been created by someone in particular, but have emerged from the continuous interaction of states, and, on occasion, have been transformed and adapted to new circumstances. According to the terminology of the English School, which is particularly concerned with the study of this type of institutions (see especially Buzan, 2004; Holsti, 2004) it is common to refer to them as primary or constitutive institutions.

In the study of global politics, as explained thoroughly by the authors in this book (see especially Chapter 2 by Modelski, and Chapter 4 by Thompson), the existence of a different type of institution, i.e. global-reach institutions, is brought to our attention. Like the previous ones, they are informal, but nevertheless effective, institutions for the constitution, operation and reproduction of the global political system. Global leadership is the institution that gives uniform direction to the system by selecting and executing coherent programs and strategies of government with regard to world problems and relations between state-actors. Global war is (maybe, has been) the macro-decision institution for the change of authority in the system. As such, global wars have been key turning points in world history with regard to institutional change because, besides introducing new leadership, they have reformed the political structure of the whole world. Besides these two strictly political institutions, other institutions of global reach, which belong to the economic and social sectors, like leading industries and social movements, have important functions in the operation and reproduction of the global political system. On the whole, institutions of global reach emerge from world-wide processes and the action of the state- and non-state-actors that are able to perform on a global scale. They persist over time and across subsequent historical world systems. However, their characteristics change over time to adapt to new conditions, and by interacting with organization-institutions, which are presented here below. With regard to such knowledge, it is possible that global war will, in future, give way to a different form of macro-decision-making institution that will fulfill the function of change in the authority of the system; and that global leadership shifts from the one-state form that dominated the past 500 years, to the different form that scholars see as consisting of either one formal organization or a uniform network of international organizations. In Modelski's analysis, for instance, global leadership is one of the historical forms of authority-bearing institution within the process of evolution of global politics. More precisely, around 500 years ago, the one-state form of global leadership replaced the classical imperial form that lasted from about AD 1000 to AD 1430, and it is now in the process of being replaced by the global organization form (see Devezas and Modelski, 2007, Chapter 3 of this volume). Other scientific studies (see, for example, the discussion of Wendt's analysis later in this chapter) also recognize that the current process of change in the inter-state system leads to the centralization, into a world organization, of the power to act in the interests of security.

Besides the two above-mentioned informal types of institution, a third type has been created by states in order to deal with collective issues and problems. They confer organization to the global system over periods of time shorter than that of the global-reach institutions with which they partially overlap. They are formed at the time of the establishment of historical – either regional or world level – international systems on the initiative of many states, but especially the most powerful ones and those possessing resources specifically relevant to crucial, common problems. The label "organization and government institution" is appropriate to such institutions, because they are instrumental in the formation of the political organization of the system and government that deal with distinct issues and problem areas. On the succession of systems to one another, not all organization and government institutions are replaced with new ones. Some of them preserve their main features over time; others are reformed and adapted to new conditions; and brand-new ones are created. On occasion, these institutions can also be reformed during the lifetime of a historical system, under the pressure of coalitions of states, in order to respond to new emerging problems. The great-power "concert" is an example of an organization and government institution of the eighteenth and nineteenth centuries. Initially an institution of the European international system, it also served as a global leadership institution. The League of Nations and the United Nations are examples of institutions formed to cope with the global problems of the twentieth century. Other contemporary institutions, created to deal with the current problems of the global system, are coherent complexes of norms, practices and international organizations, commonly called regimes. They are issue-specific, and regulate currency, trade, the environment and other international problems.

World political institutions, then, can be divided into three types, intimately linked, complementary to, to some extent overlapping with one another, but also divisible from one another, i.e. the primary or constitutive type, the global-reach type, and the organization and government type. Type-one and type-two institutions have a continuous existence, whereas type-three institutions are discontinuous and system-specific. It is an important aspect of the argument of the present study that organization-and-government institutions of the current world political system, at odds with the institutions of the world systems of the past, are more formal, i.e. they have their own statutes, administrative structures, and material and human resources. These characteristics must be preserved in modeling the next stage of evolution of global-reach institutions, especially of global leadership and global war, because of the interdependent development of both global-reach- and organization-institutions. Incidentally, we should remember that the importance of the formal nature of the current organization- and government-institutions is widely recognized in the accepted definition of the present global system as institution-based hegemonic system, and of the United States' institutional hegemonic or leadership role (see, for example, Ikenberry, 1998; Cronin, 2001; Puchala, 2005). These definitions imply that, at the end of the Second World War, the United States sustained the formation of institutions that have adapted to new circumstances and have been the essential instrument of organization and government of the global system that has existed up to the present time. Consequently, as noted in the conclusions of this chapter, the American interpretation of this role merits special attention in the modeling of the next phase of institutional change.

The majority of analysts of international politics are reluctant to use the terms "organization" and "government." It is not my intention here to deal extensively with this issue, but, for the sake of clarity, the use of these terms is defined briefly below, because the definition is useful to the analysis of global politics here presented. The reluctance of international relations scholars to use the "organization" and, especially, "government" concepts is explained by the close relationship that exists between these concepts and those of authority and legitimacy that are believed to be inapplicable to the international political system. This belief is founded upon the notion that the international system, at odds with the state, is lacking in institutions for imposing authoritative decisions on the system members. Within such a concept, only formal–legal institutions have both political authority and legitimacy, and system members will only accept political submission to formal–legal institutions. In opposition to this concept, another concept – empirically demonstrated mainly by anthropological and sociological studies – acknowledges that authority is the legitimate political role founded on practice that system members normally accept as good for the system order, irrespective of the transformation of the practice into legal–formal institutions.

Taking into account that political authority can be both formal–legal authority and practice authority, three kinds of political systems can be distinguished, i.e. those, like states, that rely only on legal–formal-authority institutions; those, like past international systems, that rely only on practice-authority-institutions; and those that rely on both formal–legal- and practice-authority institutions, like the contemporary global system, as it is demonstrated here later. It is worth remarking, however, that the formal and informal base of authority-institutions is not taken by political scientists as being important in explaining the structure and dynamics of political systems. In fact, analysts take the relationship between the concentration of power/authority and the level of legitimacy of political authority into account much more. For example, on the base of this relationship, the typologies of domestic political regimes are arranged in order to differentiate the various democratic and authoritarian forms. Also, international political systems can be classified in relation to power concentration and the legitimacy of authority, and various forms of institutional political organization can be differentiated from one another. It must be added here that the term "political organization" in international political analysis is homologous to the term "regime" in the analysis of domestic politics, but, to avoid confusion, it cannot be used in international political analysis with the meaning it has in domestic politics analysis, because "regime," in the international relations field, has the consolidated meaning of a complex of norms, practices and international organizations for the control and management of issue-specific problems.

In order to demonstrate the importance of the relationship between power concentration and authority legitimacy in distinguishing between different types of international political organization, it is worth noting Adam Watson's comparative study of the international systems of three historical periods, i.e. ancient state systems; European international society after the fifteenth century; and the later global international society. Watson (1992) distinguishes four types of political organization – i.e. independence, hegemony, dominion and empire – according to the increasing level of both power centralization and legitimacy of authority.[2] Watson's study makes explicit that all political organizations – even those characterized by high power concentration – are stable as far as the system members consider the authority of one or few of them as legitimate. His analysis demonstrates that strong propensity toward hegemony and empire types prevailed in ancient international systems. By contrast, European international society, was characterized by anti-hegemonic attraction, although hegemonic tendencies prevailed to a large extent. An anti-hegemonic push has pervaded the global international society, but independence organization has not existed so far. However, Watson emphasizes the importance of system's cultural traits in explaining the dominance of different forms of organization in the three periods that he examined, but he overlooked the role of institutions as instruments of government of the leading state(s).

Unlike Watson, Modelski explicitly deals with the institutional dimension of the world political system. In his analysis, global political institutions are defined as behavioral and policy patterns, and also as operational and routine rules giving stability to international relations that are reproduced through socialization processes. In his analysis, the institutions of government of the global political system are the institutions of global reach that sustain the vertical structures of the system, giving a global power the tools needed to set in action strategies for the control of collective problems. Modelski defines global leadership as "an informal structure of global political authority ... [for] the management of global problems" (2000b). Global leadership, then, is a practice (i.e. not a formal) institution of government, based on both concentration of forces of global reach, i.e. military, economic, and cultural resources of power, and output legitimacy, i.e. good management of global problems. It can be said that, Modelski, unlike many contemporary students of international hegemony, has turned to a preference for the term "leadership" rather than "hegemony" in referring to this institution, because the latter term has normally been used to indicate coercive power, while organizational capabilities and participatory decision-making are important components of global-reach institutions. However, especially since Gramsci and the Gramscian School (see, for example, Arrighi, 1982; Cox, 1987; Murphy, 1994) defined the concept of hegemony by stressing the importance of consent in the relationship between the hegemonic actor and its partners, the two terms can be considered as interchangeable in political discourse.

Another important point to make regarding global leadership is that, as Modelski remarks, it is not an omnipotent and unlimited institution of government of the global system. This aspect deserves comment. Political systems differ from one another in the scope of the legal capacity and legitimate action of the government institutions, i.e. the number and range of issues that belong to the political or public sphere. The areas of values, interests and problems that the system members reserve for the private sphere, i.e. the areas that political authority cannot enter, and the areas of values, interests and problems that the system members agree to process as "public sphere" matters, i.e. the areas of collective discussion and authoritative decisions, are neither the same across space, i.e. in all political systems, nor over time, i.e. in the history of a single political system. Generally speaking, in the last few centuries, state political systems have enormously increased the number of areas pertaining to the political sphere, especially in advanced countries. However, by contrast, the global political system has only moderately, and in recent times, increased the number of matters that can be said to be covered by the political sphere.[3] As Ikenberry (1998) remarks, at the time that a new international system comes into existence, states agree on the limits of the political sphere of the system, and, in the constitution (which is not a formal, written document) of the new system, scientists can find an indication about the enlargement of the scope of the political sphere of the previous international system. Modelski defines the world's public sphere as consisting of critical world problems, comprehending problems brought in by various segments of world opinion, and the challengers to the global leader – either single countries or coalitions of countries. Analyzing the development of the current world system, Ruggie (2004) also demonstrates that non-state-actors are autonomously capable of fomenting, and are responsible for, the current enlargement of the world public sphere. The competence of the state that is in the global leadership role, then, is fairly definable as far as the public sphere of the present global system is itself defined, and also the public sphere of the future system can be forecast by an accurate analysis of current social and political trends.

Origins of the political institutions of the global system

The question of the origins of the global political institutions is intimately linked to the question of the formation of the global system. The view of the recent formation of the world system, which is commonly portrayed as the recent incorporation of regional international systems into the European system, has been challenged by both the view of the pristine unity of the world system, and the view of the inception of the formation of the global system as early as the end of the first millennium.

Pristine unity has been defined and defended by André G. Frank, who considers the world as the all-inclusive unit of social reality. At odds with the social scientists that concentrate on the study of parts of the world on the assumption that only the parts are coherent units, Frank defended the scientific need to also recognize the world as a coherent unit in order to explain the difference between the parts. As he loved to say, the world system existed not for the last 500 years, but for 5,000 years, i.e. since the first system of states was formed in Mesopotamia (Frank and Gills, 1993). In Frank's view, capitalist accumulation, which has been active world-wide in the last five thousand years, made all the parts of the world members of a coherent unit. This interpretation is at odds with the "common perspective" on the forms of the economy that places the origin of capitalist accumulation in sixteenth-century Europe. In particular, Frank developed his discourse in direct opposition to Immanuel Wallerstein (1974), and demonstrated that capitalist production and the interdependence of capitalist systems are much older than Wallerstein and also the "common perspective" take for granted. In particular, Wallerstein was wrong in underestimating interdependence and division of labor among different (sub)systems, because he undervalued the effect of luxury-goods exchange and trade. When the state overtook hunter/gatherer groups and chiefdoms,[4] the ruling classes immediately started to exchange luxury goods, and produced an interdependent world economic system in which only one division of labor emerged. In other terms, both the introduction of capitalist production and the formation of states and international systems are placed in the fourth millennium BC.[5] The world system, i.e. the interdependence of regional state systems, by contrast, started in 2700–2400 BC, when the economies of Eurasia (Mesopotamia, Egypt and the Indus Valley) joined together in a single economy whose motive force was capitalist accumulation. In addition, the same cycles of growth and decline of capital accumulation united the parts of that economy in a single process of change. This aspect concerns the causes of global change, and is discussed in the next section of this chapter. Here, the issue of interest is the time that political institutions appeared in the world system that had already become integrated by the same economic institutions and processes.

At odds with the perspective of the pristine origin of the world system, the majority of social scientists view the formation of the global system and worldwide political institutions as a process of very recent origin. More exactly, the formation of the world system is believed to be concomitant with the late stage of the expansion of the European state system. According to this perspective, which has been thoroughly investigated by the English School (see, for instance, Bull and Watson, 1984; Buzan, 2004), during the last five centuries, international systems, existing separately in different regions of the world, progressively came into a unified system, because, in the first place, the European expansion produced the economic and technological unification of the planet and, in the late eighteenth and the nineteenth century, the political unification of the world founded upon primary institutions such as state sovereignty, international law and diplomatic conventions. To give conceptual foundations to this perspective, the English School distinguishes two types of state system: the type in which international relations depend only on the fact that each state takes account of the other states' behavior, and the type in which international relations are stably organized by rules and institutions agreed on and commonly respected by the states, in their own interests. Hedley Bull (1977), the founder of the English School, named the former type the international system, and the latter type the international society. Accordingly, the world political system as an international society, i.e. as the system founded on institutions shared by all the states of the planet, came into existence in the recent process that started with the inclusion of the Ottoman Empire in the European state system, and finished with the decolonization of non-European countries in the second half of the twentieth century.

Two objections are raised here against this view of the recent formation of the world political system. First, the distinction between an international (institution-empty) system and an international (institution-laden) system/society is abstract and not factual, as some English School writers also admit (see below). Second, attention is only paid to institutions as practices of ordered relations normally respected by the states, i.e. primary institutions. Institutions as means of government and strategic political action are ignored.

Regarding the first issue, Adam Watson, who, in association with Bull, made a study of the expansion of the European international society (Bull and Watson, 1984), remarks that the states of Europe and Asia always respected trade agreements between merchants and companies. Therefore, they were members of the same international society, because *ab initio* they shared the same obligation to the *pacta sunt servanda* (treaties must be respected) norm (Bull and Watson, 1984). Economic and strategic pressures, as Watson remarks in a later study (1992), put states of different cultures and civilizations into the same system of rules and institutions of a practical and regulatory nature. It is worth noting that other English School authors, namely Buzan and Little (2000), in a study of world history and politics, also amended the English

School analysis of the formation of the world system by demonstrating that regional international systems have normally been mutually connected as parts of wider economic international systems.[6] Moreover, in conclusion, authors with the same "common perspective" directly or indirectly admit that the world political system was already in place at the time of the first colonial expansion of the European monarchies in the fifteenth and sixteenth centuries, the so-called era of the first expansion of the European state system.

Regarding the second issue – i.e. overlooking global government institutions – it is noted here that the "common perspective" admits that the world political system came into existence thanks to the standardization strategies of the centre of the system (see Buzan and Little, 2000). The European powers exercised coercive and persuasive pressures on the peripheral countries in order to impose on them the economic and cultural standards of the centre. Apparently, then, also in the "common perspective" view, the dominant state-actors of the world system had explicit strategies of government, but the analysts of this perspective have overlooked the analysis of the institutions used by the central states to enforce standardization – i.e. government – strategies on the world system.

The analysis of the formation of institutions for selecting and executing strategies of government in the global system is, instead, the main interest of George Modelski. He is explicit on the question of the temporal origin of the global process of formation of political institutions. Assuming that the world system is a construction founded upon a long learning process that started several millennia ago, and has been strengthened with nuclei of cooperation since 1200 BC, he demonstrates that the process of construction of world-wide institutions was initiated about a millennium ago, and "crystallized" during the last half millennium. In particular, institutions with world impact came into being with the projects of the Chinese Sung dynasty in the tenth century; the Mongolian attempt to build a world empire in *c*.1250; the creation of the network of Portuguese naval and commercial bases all over the world after 1515; and, lastly, by the late nineteenth century, the creation of international organizations. Accordingly, Modelski's analysis demonstrates that the subsuming of all regional systems into one world system came about with the progressive formation of a collective organization and also the constitution of institutions aimed at implementing strategies for the solution (i.e. government) of collective problems. In international political analysis, the term "globalization" should be reserved for this process of the last millennium that has been patterned by evolutionary mechanisms of social change, as examined later in this chapter (Modelski, 2000a).[7]

Summarizing this section, we can note that Frank has demonstrated that, in the last five millennia, the whole world has been characterized by capitalist accumulation structures and cycles that held together the parts inside the same unit, as also echoed by Buzan and Little's analysis. Expressly founded upon the universality of the economic practice of capitalist accumulation and the world cycles of economic growth and decline, Frank's perspective neglects the presence of world-wide political institutions of government. On the other hand, the authors of the "common perspective" have demonstrated the existence of primary political institutions, and, more precisely, of practices that make international relations ordered and predictable to state rulers, but fail to single out global-reach and organization- and government-institutions as different kinds of global political institutions, while underlying the importance of standardization practices in forming a single world political system. Lastly, Modelski, unlike the other political scientists, has revealed the process of formation of global reach and also organization- and government-institutions, by studying the projects and actions of the states that, during the last millennium, have been carrying out strategies of organization around the world and have been solving global problems.

Causes of long-term change

In this section, the causes of long-term change in the political institutions of the global system are dealt with. The "common perspective" is silent on this matter, therefore, only the analyses of Frank, Modelski, and Wendt are examined here. In Frank's analysis, change is caused by economic structures. In Modelski's analysis, change is explained by evolutionary processes and mechanisms. In the analysis of Wendt (2003), the driving factors of important transformations in the area of security-institutions are the social structures and mechanisms understood in the context of the self-organization and teleological theories.

Frank explains long-term change in the world system as resulting from the effects of three structures, i.e. the structure of the economic cycle; the centre–periphery structure; and the hegemony/rivalry structure. In short, these structures have three main consequences for the world system, i.e.:

1 regularity of change, because the ascending and descending phases of capitalist accumulation succeed each other in a cycle at a fairly regular pace (more exactly, a 400-year-long cycle is divided into phases of growth and decline – each about 200 years long);
2 the transfer of the accumulation of a surplus from the peripheral to the central zones;
3 concentration of an important fraction of the economic surplus and the related political–economic hegemonic power in the hands of the owner/ruling classes of the centre (Gills and Frank, 1993).

Under these structural conditions, change in the world system is associated with the long cycles of capitalist accumulation, and consists of the movement of the central zone within the centre–periphery structure, and the succession of hegemonies in the hegemonic/rivalry structure. In particular, the centralization of power with regard to accumulation and political organization, i.e. hegemony, always triggers the formation of opposing alliances, which causes conflict and, consequently, a different country comes to occupy the hegemonic position. It is worth noting that, in Frank's view the process of capital accumulation and transfer of economic surplus is inter-regional and inter-social, not international. Therefore, the world system consists of interdependent, hegemonic zones, and is dominated by a network of hegemonies. However, Frank admitted that one hegemonic zone has privileged position in the world system, and, consequently, the ruling class of the great-power state of that zone is endowed with the benefits that accrue from the status of super-hegemony. For that reason, without going into further analysis, Frank did not rule out the fact that great wars between opposing alliances of competing great powers – as maintained by the political science theory of hegemonic cycles – can be the succession mechanism of the hegemony/rivalry structure.

It is also worth noting that in contrast to critics of the cycle explanation, Frank emphasized that transition does not produce a repetition of the preceding cycle, because new conditions make the forms of accumulation, hegemonic power, and world order of a cycle different from those of the past one. Frank also did not rule out the fact that the economic cycles that he analyzed and the other technological and socio-political cycles that he did not analyze, are encompassed within the same evolution process of the world system (Gills and Frank, 1993). In this regard, it is noted here that the analysis of social evolution aims to answer the question of why different socio-political organizations coexist in a historical period, and why all of them disappear except the one that overcomes the others. The same methodology, therefore, is applied by social evolutionists to the study of the past, in order to explain past change, and to the present in order to discern the conditions that have the greatest chance of occurring in the times ahead. The answer to the question of how the diffusion of one social organization and disappearance of others occurs lies in the relationship between actors and the environment. In brief terms, it consists of the changes in social organization that the actors make in order to solve the problems and challenges of new environmental factors. This answer is given, taking into account the aptitude of the human race to react to the environment by learning and producing innovation. For this reason, researchers into social evolution are interested in the conditions that favor innovation, and they adopt a specific methodology to explain the conditions that reinforce new configurations – in general, association and cooperation – and the conditions that expand selected configurations – in general, imitation and emulation. According to the orthodox evolutionist interpretation, the process of change shows a pattern, because it depends on mechanisms that always produce the same chain of action and reaction in response to environmental problems. However, the less-orthodox evolutionary analysts regard patterns of change as being inapplicable to social systems.

Using evolutionist methodology, George Modelski demonstrates that interaction between world problems and world politics propels the formation of and changes in global political institutions. This interaction has the form of a "patterned" process comprising four phases and mechanisms, commonly referred to as variation, cooperation, selection, and amplification. In the variation (or innovation) phase, actors propose contending strategies for coping with common problems. In the cooperation phase, the actors that agree on the same strategy of problem solution gather in one group. In world politics, this mechanism is the formation of coalitions, alliances and special relationships. In the selection phase, the winning strategy is settled on. In Darwinian biology, which initiated evolution studies, this is a natural mechanism, i.e. it is imposed by the forces of nature. In social systems, selection should be the result of rational cost/benefit calculation with regard to the available options, but is made, by and large, by trial and error, and without fixed preferences. All social sciences have their own preferred approaches to the study of this mechanism. Economics mainly focuses on market competition between enterprises; political science concentrates on the study of electoral competition between parties and candidates; and the science of international politics analyzes great-power competition for world leadership. The fourth phase, amplification,consists of the consolidation and diffusion of the selected innovation strategy throughout the whole system.

Using evolutionist methodology in the analysis of the process of globalization during the past millennium, Modelski is able to explain the formation and change of the political institutions of the global system. Passing through three periods – the Eurasian Transition (930–1430), the Western European or Atlantic (1430–1850), and the Western Post-European or Atlantic–Pacific period (1850–) – the world system moved from conditions of loose structure and low connections among its parts to conditions of high connection and organization, and the increasing actions of government institutions. Each period corresponds with an evolutionary mechanism. The first one corresponds with innovation, i.e. the creation of the preconditions for collective organization;[8] the second with cooperation, i.e. the formation of the nucleus;[9] and the third one to the selection of the global organization.[10] The fourth phase of consolidation of the organization will occur in the distant future. In the three past phases of the process, the active zone of the world system contained the most populated countries, the greatest cities, the strongest centers of production, and was also the location of the state in charge of the system leadership.[11] During the three phases, the active zone moved from Asia to Western Europe–the Atlantic and, later, to the Atlantic–Pacific zone. The zone of the global leader and its challenger moved accordingly. This last aspect concerns the issue of the global-leader succession, which is intimately linked to the issue of the development of global political institutions that Modelski also analyzes by means of the four-phase cycle. In particular, each cycle of global leadership encompasses the agenda-setting phase, during which the problems of the system are defined, and new solution strategies proposed; the coalition-building phase, during which groups of states are created in competition with one another according to different agendas and strategies; the macro-decision phase, during which two main coalitions fight one another, normally up to the level of and including global war; at the end of this phase, the major power of the winning coalition acquires the leader role, and, with the support of allied countries, starts the execution phase of the program of solving world problems.[12] It is worth signaling here that, unlike the authors of the hegemonic school – who explain hegemony succession according to the theory that the consumption of the power of the hegemonic state is caused by an overload of engagements and challenges – Modelski connects global leadership to the long-term evolution of the global system, and explains the succession of leadership and also the changes in global political institutions as being dependent on evolutionary mechanisms. Taking into account these mechanisms, one is also able to recognize the direction and destination of the changes in the institutions of the system. This aspect is treated later in this chapter, after presenting Alexander Wendt's explanation of world political change.

Wendt's analysis is anchored in self-organization theory, but does not make use of instruments like that of organization growth and collapse that other self-organization researchers apply to the study of long-term change (see, for instance, Dark, 1998; Rennstich, 2007, Chapter 5 of this volume). Wendt instead applies teleology to self-organization theory to explain long-term changes in the organization of the world system. In Wendt's theory, change in social systems (and the formation of order in the natural world) emerges spontaneously from the boundary conditions that drive a system toward its final state. Wendt wants to demonstrate that the final state of the world system is the disappearance of the boundary conditions that cause the struggle of states and individuals for mutual recognition and security. Wendt terms this final state the world state, meaning that all the states, without ceasing to exist, will create an organization and grant it with the function and power of ensuring security to all the states and human beings.

Wendt makes clear that his teleological explanation of world politics is founded on the interaction between the ascending process of non-deliberate self-organization of the members of the system, and the descending process of the structural development of system constitution. In other terms, for the self-organization theory, order is the non-deliberate result of the interaction of the actors that adopt "local" rules of behavior (such as, for instance, balance of power rules). At the same time, system development is explained by methodological holism, which maintains that systems, as irreducible totalities with structural integrity, choose – so to speak – the characters and behaviors of their actors. In fact, social systems are characterized by fundamental organizational principles, or boundary conditions, that separate them from their environment and impose a closure on their internal processes. However, the interaction of the ascending and descending processes does not give a complete explanation because ascending, self-organizational causality is not linear, and knowing the direction of the change does not help, while the descending causality is homeostatic and is unsuitable for explaining change. In order to complete explanation, the role of the final state as attractor is needed. The final, attractor state is knowable by taking into account the boundary conditions of the system that keep it under conditions of instability. The movement of the system, then, is not caused by the final state, but by the boundary or structural conditions.

This section has hinted at a variety of processes, structures and mechanisms that cause long-term changes in the global system. In particular, in Frank's view, the system is under the influence of economic structures that also have political importance, like the hegemony–rivalry structure. However, Frank remarked that evolutionist mechanisms meddle with those structures in causing change in the world system. Studying social evolutionary mechanisms, Modelski is able to single out the long-term process of formation of political institutions for dealing with crucial problems of global range. Adopting a non-historical perspective and a different kind of structural factor, i.e. the boundary conditions of the state systems, Wendt maintains, instead, that international change is the inevitable succession of system stages towards a stable attractor state. In this section, it has also been signaled that processes, structures and mechanisms can give regularity and direction to change, but in this respect the researchers are not in agreement with one another. Wendt excludes regularity but recognizes the existence of a direction that leads towards the destination of the final state. According to Frank and Modelski, regularity is an intrinsic character of the explanatory model that each of them adopts, and direction depends on the continuous innovative reproduction of the system. In Frank's theory, however, reproduction is without a final state. Instead, in Modelski's theory, the end product of the process of change is known as the conclusive stage of the current evolution period, and will be followed by a further period that cannot be predicted at this moment. In this section, causes relevant to understanding changes in the political institutions of the global system have been examined. In the next section, attention is drawn to the direction of change and the destination of the system.

Direction of change and destination

Change interpreted as the introduction of some corrections to and innovation with regard to the choices made by the states in the process of institution development, is examined here. In particular, our attention is drawn to the teleological movement examined by Wendt, and the evolution movement examined by Modelski, because only these authors deal with these issues. The former is a succession of five system stages, each one possessing new institutional solutions to the problem of security. The latter is the "patterned" evolutionary process that, through learning and innovation, upgrades the institutions created to deal with critical problems. The destination of change is rather similar in the two studies, as will be discussed later in this chapter.

In the Wendt model, human beings are organized in various autonomous political communities that struggle for recognition and security. The dominant form of political community, i.e. the sovereign state, creates a system organization founded on boundary conditions that make necessary to resort to war for the sake of the system unit's security. Wendt, however, puts forward the common view that overcoming such organization based on perennial conflict for security is an impossible event.[13] He signals that technology makes the costs of enforcing security by resorting to war unbearable, and for that reason it can be expected that states will make the same choice that individuals have made, that is, they will form a world state to which to surrender the task of ensuring security to all. Wendt's argument, however, is that this transformation is not the mere result of cost calculation, but of a change at the level of the ideas. More precisely, change will consist of a process of construction of new individual and collective identities that ensure the mutual recognition of all human communities and states. Since the individuals want to be recognized as members of a group, and the state is the most important group struggling for such recognition, the formation of the world state is inevitable. In brief terms, Wendt explains this inevitable formation with a five-stage process that the states pass through in search of security and recognition. The five stages are also termed the system of states; a society of states; the world society; the collective security system; and the world state.[14] On the one hand, the culture of anarchy of each stage makes the struggle for recognition a violent one; on the other hand, the development of military technology makes violence increasingly intolerable and ineffective in terms of security.

Wendt concentrates on change in the institutions of international security, and does not give a historical description of the system stages, but rather gives a theoretical explanation of the mechanisms that produce change. However, it is not difficult to locate stages on the time line of past world history. It is also clear that the fourth stage of the movement is now under development. Therefore, the great question of today is about the inevitable – in the Wendtian sense – institutional choices needed to bring about the world state.[15] Wendt believes that the world system will undergo three important transformations in order to form an organization with the Weberian characters of the state, i.e. the monopoly of force, legitimacy, sovereignty and collective identity. First, it will become a security community, that is a community in which nobody feels threatened by others, and everybody is sure that any conflict is solved by peaceful means, even if the risk of violent actions by criminals cannot be eliminated. Second, a system of collective security will be created, so that any "criminal" action will provoke the reaction of all the system members. After these changes are made, the third change will be the creation of a global organization capable of making decisions on security affairs, using binding legitimate procedures. Such an organization will not necessarily have its own armed forces, because the execution of its decisions can be made by the armed forces of the territorial states. Moreover, since the world public sphere will consist only of security deliberations, the world state will not have a formal structure of government, i.e. a unitary body under a leader. Nevertheless, the territorial states, deprived of sovereignty in security affairs, will be different from what they are today.

Unlike Wendt's final state, the future of the world political system as seen by Modelski, using the analysis of the long-term process of political globalization, is not defined only in terms of security problems and institutions. As mentioned above, Modelski distinguishes three periods within the globalization process, i.e. the Euro–Asian Transition; the Western European or Atlantic; and the current Western Post-European or Atlantic–Pacific period. In the last one, intergovernmental organizations, functional regimes, and non-governmental world-wide organizations came into existence, and created pervasive networks that have raised the participation of a variety of actors in world politics. As a consequence of this evolution, Modelski believes that, after a phase of democratic transition, the problem of the consensual base of the world order will be solved, and in the twenty-first century a fuller political framework will emerge. Rather than the interconnection of sovereignty, recognition and security on which Wendt focuses, Modelski (2000a) attributes the potentialities of innovative change to the agents of globalization, i.e. the individuals and organizations that propagate the level of global interactions like multinational enterprises; world financial markets; non-governmental organizations for humanitarian purposes; leaders of social movements; and also states in a global leadership position. In other terms, the globalization process is fomented by the interaction of the global leadership process (i.e. the world government institution-building process) and other processes, namely the economic processes that influence trade regimes and the world market; the process of democratization and formation of a democratic world community; and the process of formation of world public opinion in which the media have an important role. At the end of the twenty-first century, all these processes will bring to an end the current phase of global politics, which is dominated by long cycles of hegemonic succession. At that time, in harmony with the Kantian vision and in broad agreement with Wendt, Modelski believes that a global democratic community with a federal-type organization will absorb the current role of global leader and will organize the global political system.

Concluding remarks about the future of global political institutions

The main aspects of the four perspectives on the long-term change of global political institutions reviewed here are summarized in Table 6.1. Some similarities notwithstanding, the differences in theory, methods and substantive matters are quite considerable. According to researcher preferences, the four perspectives will be of different utility to the task of modeling and forecasting global political institutions. In general, the long-term economic perspective helps to deal with the influence of economic processes on the construction and development of global political institutions. The "common perspective" has no orientation towards causative factors like structure, process and mechanism, but is worth taking into account in modeling the integration role that primary institutions have on the system actors. The evolution and

Table 6.1 Synopsis of four scientific approaches to the study of world political institutions

	Frank	*Common perspective*	*Modelski*	*Wendt*
Origin (locus and time) of institution building	The world system of capital accumulation in *c*.2700 BC	The enlarged European state system in around the sixteenth century	The Eurasian system in around the tenth century	The European state system in around the seventeenth century
Actors of institution-building	Social actors	Nation-states	Great powers, leading industrial sectors and, at the current time, IGOs, media and social movements	Individuals, political communities, and states
Authority institution	Superhegemony	The great-power "concert"	Imperial power Global leadership Global organization	World-wide organization (not yet existent) in security matters
Political/public sphere	Economy	General	World-wide problems	Security
Power base in institution-building	Economic	Economic and military	Economic, military and institutional	Military
Method of government	Surplus transfer and accumulation; political order	Standardization	Problem-solving	Force concentration
Causes of institution change	Economic cycles; centre/periphery structure; hegemony/rivalry structure	Contingent circumstances	Evolutionary mechanisms	Social structures (boundary conditions) and social mechanisms (self-organization and teleological causation)
Direction of change	Unknown	Unknown	Known from the study of path-dependent evolution	Attractor states
End state	None	None	Fuller democratic community of states	World state

the self-organization/teleological perspectives, instead, offer many valuable suggestions and instruments to future studies. The latter admittedly helps to model the effects of security and mutual recognition as driving factors in the behavior of the states as formal actors of global politics, and also of the individuals and other communities and groups as informal actors within the global system. The power of the evolutionary approach of George Modelski is demonstrated by the high correlation between the historical development of global politics in the last millennium, and the "patterned" phases of change summarized in the well-known "Matrix of Evolutionary World Politics" that synthesizes Modelski's explicative design for world dynamics.

In his recent analysis of the Global Organization period, Modelski concentrates on the issue of the rise of the global democratic community. His analysis takes into consideration various factors and trends involved in this process. This chapter's main aim has been to call particular attention to one of them – the emergence and strengthening of formal institutions of organization and government during the past *c*.80 years. Since intergovernmental organizations and economic regimes have introduced formal procedures in the government of the global political system, this innovation is key to further development for the well-known relationship existing between legal–formal institutions and political legitimacy and democracy. It is worth noting here that the democratization of the state during the nineteenth and twentieth centuries has been a complex process that included trial-and-error experimentation with formal democratic procedures of policy-making. The legitimacy of democratic regimes increased as long as experimentation overcame errors, and agreed procedures of collective decision-making were adopted by political actors to bring legitimacy to government institutions. While Modelski (see, for example, Devezas and Modelski, Chapter 3 of this volume) concentrates on macro-level change in the current long cycle (LC10), modeling the future global government institutions also requires attention being paid to the micro-level change, i.e. the democratic reform, of the procedures of existing world political institutions.

The political organization of the present global system is an institution-based leadership organization, as noted in the introductory section of this chapter. Therefore, the good news for analysts and people concerned with non-violent change in the global government structure is that agreed procedures for collective decision-making have been introduced at world level with the above-mentioned evolutionary innovation that has brought formal institutions of government to the global political system. In the present world system, then, institutional power is increasingly important, as Modelski remarks (see Devezas and Modelski, 2007, Chapter 3 of this volume). The bad news is that the reform of democratic procedures, which normally is also hard to attain when reform norms exist, such as at the level of the state political system, is very difficult at the level of the world political system, where reform norms do not exist. The most important reason for this state of affairs is that the global leader is also the veto player in the reform process of the institutions of the world government structure. However, the present global system has issue-differentiated institutions, i.e. different regimes for different issues (plus, of course, the United Nations, which is here counted as the security institution of the world system), but their agencies are considered as belonging to different issue regimes. This institutional differentiation can be counted as a positive choice with regard to changes in global politics, because it raises the level of international democracy by giving states different institutional arenas in which they can use various resources to negotiate positive-sum accords. In this regard, the development of the environment (see, for example, Falkner, 2005; Vogler and Bretherton, 2006) and human rights (see, for example, Cardenas, 2004) regimes are worth examining. However, the United States is the most important actor (or one of the most important actors) out of all the major regimes – either thanks to the resources that it has or the coalitions that it is able to form. This makes the United States extremely able to obstruct the approval of unwanted reforms by using its "resource power," and by influencing negotiation by exercising pressure across different institutions. As Wendt remarks concerning security matters, world institution change is possible when the great powers recognize the advantage in supporting reform, i.e. they recognize the unbearable costs of no reform. It can be sustained that in the security sector, as well as in other sectors, this condition is more possible when the United States loses its ability to form coalitions, i.e. when the de-concentration of power grows and political multipolarity emerges, as in the current phase of coalition reconfiguration signaled by Modelski, and also because new powers are created by the growth of opportunities opened up by the globalization process. However, the decline in American institutional power may also lead to a crisis in the existing global institutions, rather than the relocation of the institutional power to other states and coalitions of states. Briefly, reforming the world government institutions might cause conflict and confrontation, with human suffering and resource-wastage in the next macro-decison phase. However, as Modelski has remarked in recent writings, modeling global change also has to take into account the alternative reform process that world public opinion may trigger by consolidating the negotiation and mediation power of transnational non-governmental organizations and civil-society movements that have emerged on the scene of the global political system.

Notes

1 It is correct to add that some authors also consider balance of power to be an institution that gives order to the whole set of relations of an international political system.

2 In *independence*, states are free to make domestic and external decisions, but international relations and their voluntary respect for reciprocal agreements impose limits on their external behavior. In *hegemony*, states are independent in domestic affairs, but hegemonic authority conditions their external relations because they consent to the need for authority to ensure order in the system. In the third type,

dominion, the authority of one state on the others covers the domestic sphere, even if states maintain their identity and structures of government and administration. In the fourth type, *empire*, all the states are directly administered by the centre of the empire.

3 Existing regional international systems have a public sphere of different scope. Over the last 50 years, Europe has been enlarging the range of the matters considered to be in the public sphere; extending the number of states sharing it; and also substituting practice-based institutions with formal–legal institutions of government, thanks to the integration process of the European Union.

4 According to anthropologists and archaeologists, in 3000–4000 BC there emerged political organizations that had the three characteristics of a state, i.e. a legitimate monopoly of force, a centralized bureaucratic government, and a network of urban centres. However, Cioffi-Revilla (2005) demonstrates that the transition from chiefdom to state happened in different eras in different places, i.e. between 8000 and 3000 BC in West Asia, between 6500 and 1045 BC in East Asia, between 2500 and 100 BC in Andean America, and between 1200 and 100 BC in Mesoamerica.

5 Cioffi-Revilla (1996) puts the formation of the first state system in West Asia at *c.*3700 BC, but *c.*2000 BC in East Asia.

6 Assuming the interconnection of five social sectors (the military, political, economic, socio-cultural, and environmental), Buzan and Little (2000) distinguish three types of systems, i.e. complete international systems, characterized by the interconnection of all the sectors; economic international systems, characterized by economic and socio-cultural exchange in the absence of political–military interaction; and pre-international systems, which latter precedd the development of cities and civilization, and are characterized by socio-cultural interaction and no commercial exchange. Bringing the economic sector into the picture, Buzan and Little (2000) affirm that in the last 6,000 years complete international systems existed independently from one another and were part of economic international systems that led them to mutual connections. The two types of system were characterized by the same tendency to increase in size growth until the global economic system appeared 500 years ago and, a few centuries later, the present complete international system, the global international system, started to exist.

7 Also, Frank (1998) believes that the view of globalization as the process now creating a single world system is misleading, because it wrongly supposes that originally distinct societies are now constructing a global system.

8 In the Eurasian Transition period, in which Mongols aimed at creating a Euro-Asian world order, the printing press, the compass and gunpowder constituted the various preconditions of modernity that produced technical development.

9 In the Atlantic period, the global political system came into existence thanks to a world network of fortresses, commercial posts, colonies and missions. Originally created by the maritime power of Portugal in cooperation with Spain, this network consolidated thanks to three factors: national states in Atlantic and Iberian Europe, the notion of sovereignty conceived in Westfalia in 1648, and the balance of power defined in Utrecht in 1713–14.

10 In the Atlantic–Pacific period, intergovernmental organizations, international regimes and non-governmental international organizations came into existence and created a dense network of various actors in world politics.

11 It can be noted here that the global-power state must have military, economic–financial, technological, and industrial resources in order to control the regimes, rules and institutions of global interdependence, and also cultural and ideological capabilities in order to receive the consent of the system members about the organizational principles by respecting the individuality of those system members.

12 Modelski and Thompson (1988, 1996) illustrate the alignments, power concentration, and world wars of the cycles of global politics of the last five centuries in which Portugal (first cycle: 1516–1609), Holland (second cycle: 1609–1714), Great Britain (third and fourth cycle: 1714–1815 and 1815–1945) and the United States from 1945, have been selected as global powers. Each cycle has an approximate duration of a century, and each phase is about 25 years long, i.e. the approximate duration of a generation.

13 In particular, Wendt (2003) mentions the Kantian and Hegelian position. According to Kant, the state of conflict of the international system produces republican states, and these, selfish and jealous of their sovereignty, will never go beyond the constitution of a world federation of states. According to Hegel, the states, unlike the individuals, do not have enough motivation to abandon the state of anarchy and the search for mutual recognition that guarantees security to each of them. Therefore, they have the tendency to perpetuate their character of self-sufficient totalities. As we will see later in this chapter, Wendt disagrees with Hegel, and broadly agrees with Kant.

14 In "stage one" – the system of states, there is no mutual recognition and collective identity. A state that is stronger than another state can conquer it, and confront another state in order to gain mutual recognition or conquer it; and so on. The system is unstable and moves toward a non-Hobbesian attractor. In "stage two," the society of states, an anarchic culture of the Lockian type is established; states recognize each other's legal sovereignty, and cease to be the victims of mutual conquest, but do not recognize the citizens of the other states as subjects that cannot be conquered. In other words, states exclude the legitimacy of war for the total conquest of another state, but not for earning their own positions. The increase in the destructiveness of military technology, however, also makes position wars (as opposed to conquest wars) unbearable, and the increasing number of human deaths makes it inevitable that the right to existence for every individual will be accepted. Therefore this stage is also unstable. In "stage three" – the world society – instability is overcome by the international obligation to solve conflicts by non-violent means, so that the security of the individuals is recognized, as well as that of the states. However, since such an obligation does not include collective protection from aggression, and "criminal" states can act violently, instability is not eliminated. In "stage four," the collective security system, states agree on mutual defence. Although a world state is not created, this stage realizes the security of states and individuals, and could be a stable one. Every sovereign state, however, may defect, withdraw the recognition of another state's autonomy, and make it a target of aggression. Such instability can be overcome only by entering into a stage in which mutual recognition takes a stronger form. Individuals and small powers that have little to lose by transferring the responsibility of mutual recognition to a world state will promote this change. Also the great powers will accept this stage as soon as they become aware of the disadvantage of preserving a system in which they bear high costs in order to get other states to respect their power and privileges. In "stage five," the world state, the recognition of individuals is not mediated by state governments and borders, even though states continue to be important because they organize particularism and defend themselves from universalism. Since the world state is able to react to any aggression and therefore discourages defection, this stage is a stable one unless it is confronted by shocks of external origin that cannot be defined at the present day.

15 According to Wendt, the world state will come into existence in 100–200 years from now. The coincidence with the end-time of the next phase of Modelski's calendar is worth noting here.

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Part II

Models of long-term change

7 Compact mathematical models of world-system development

How they can help us to clarify our understanding of globalization processes[1]

Andrey Korotayev

Introduction

In 1960, in the journal *Science*, von Foerster *et al.* published a striking discovery. They showed that between CE 1 and 1958, the world's population (N) dynamics can be described in an extremely accurate way, with an astonishingly simple equation:[2]

$$N_t = \frac{C}{t_0 - t}, \tag{1}$$

where N_t is the world population at time t, and C and t_0 are constants, with t_0 corresponding with an absolute limit ("singularity" point) at which N would become infinite.

Parameter t_0 was estimated by von Foerster and his colleagues as 2026.87, which corresponds with 13 November 2006; this made it possible for them to give their article the attention-grabbing title – "Doomsday: Friday, 13 November, A.D. 2026."[3]

Note that the graphic representation of this equation is just a hyperbola; thus, the growth pattern described is denoted as "hyperbolic."

The basic hyperbolic equation is:

$$y = \frac{k}{x}. \tag{2}$$

A graphic representation of this equation is shown in Figure 7.1 (if k equals, e.g. 5).

The hyperbolic equation can also be written in the following way:

$$y = \frac{k}{x_0 - x} \tag{3}$$

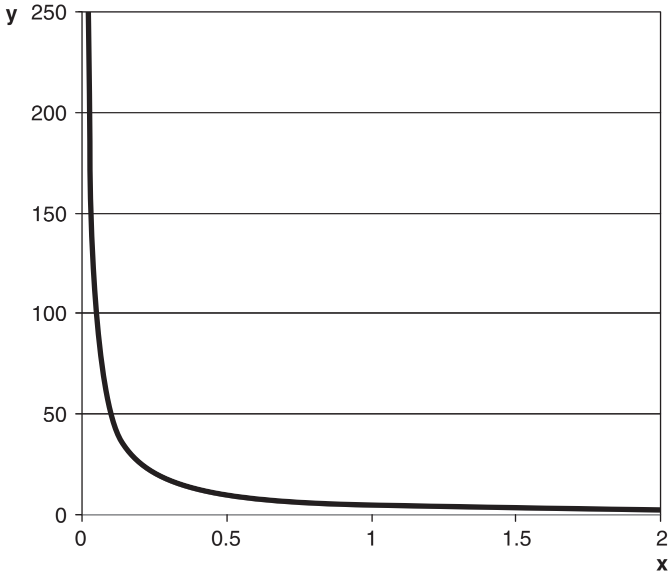


Figure 7.1 Hyperbolic curve produced by equation $y = 5/x$.

With $x_0 = 2$ (and k still equal to 5) this equation will produce the following curve (see Figure 7.2):

As can be seen, the curve produced by equation (3) in Figure 7.2 is a precise mirror image of the hyperbolic curve produced by equation (2) in Figure 7.1. Now let us interpret the X-axis as the axis of time (t-axis); the Y-axis as the axis of the world's population (counted in millions); replace x_0 with 2027 (that is the result of just rounding von Foerster's number, 2026.87); and replace k with 215,000.[4] This gives us a version of von Foerster's equation with certain parameters:

$$N_t = \frac{215{,}000}{2027 - t} \tag{4}$$

In fact, von Foerster's equation suggests a rather unlikely scenario. It indicates that if you want to know the world population (in millions) for a certain year, then you should just subtract this year from 2027 and then divide 215,000 by the difference. At first glance, such an algorithm seems most unlikely to work; however, let us check whether it does. Let us start with 1970. To estimate the world population in 1970 using von Foerster's equation, we first subtract 1970 from 2027, obtaining 57. Now the only remaining task is to divide 215,000 by the figure just obtained (that is, 57), and we should arrive at the figure for the world population in 1970 (in millions): $215{,}000 \div 57 = 3{,}771.9$. According to the US Bureau of the Census database

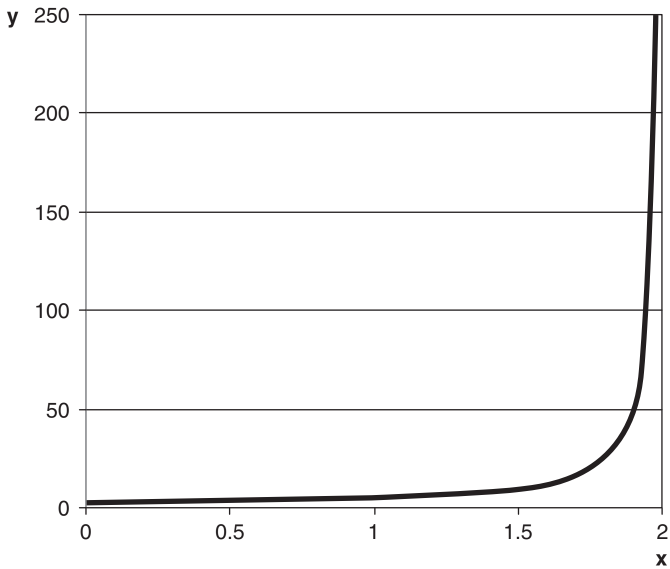


Figure 7.2 Hyperbolic curve produced by equation $y = 5/2 - x$.

(2006), the world population in 1970 was 3,708.1 million. Of course, none of the US Bureau of the Census experts would insist that the world population in 1970 was precisely 3,708.1 million. After all, the census data are absent or unreliable for this year for many countries; in fact, the result produced by von Foerster's equation falls well within the error margins for empirical estimates.

Now let us calculate the world population in 1900. It is clear that in order to do this we should simply divide 215,000 million by 127; this gives 1,693 million, which turns out to be precisely within the range of the extant empirical estimates (1600–1710 million).[5]

Let us perform the same operation for the year 1800: $2027 - 1800 = 227$; $215{,}000 \div 227 = 947.1$ (million). According to empirical estimates, the world population for 1800 was indeed between 900 and 980 million.[6] Let us repeat the operation for 1700: $2027 - 1700 = 337$; $215{,}000 \div 337 = 640$ (million). Once again, we find ourselves within the margins of available empirical estimates (600–679 million).[7] Let us repeat the algorithm once more, for the year 1400: $2027 - 1400 = 627$; $215{,}000 \div 627 = 343$ (million). Yet again, we see that the result falls within the error margins of available world population estimates for this date.[8] The overall correlation between the curve generated by von Foerster's equation and the most detailed series of empirical estimates is as follows (see Figure 7.3):

The formal characteristics are as follows: $R = 0.998$; $R^2 = 0.996$; $p = 9.4 \times 10^{-17} \approx 1 \times 10^{-16}$. For readers unfamiliar with mathematical

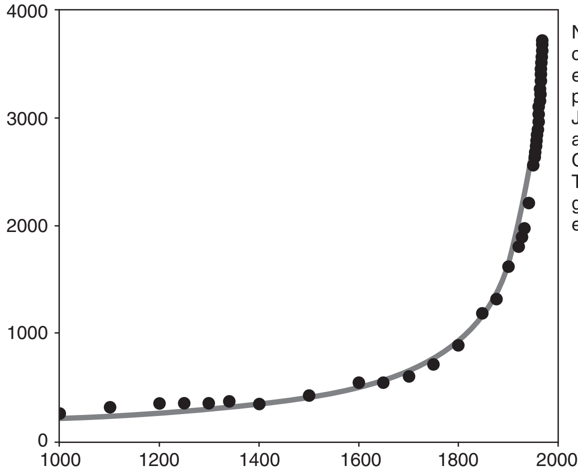


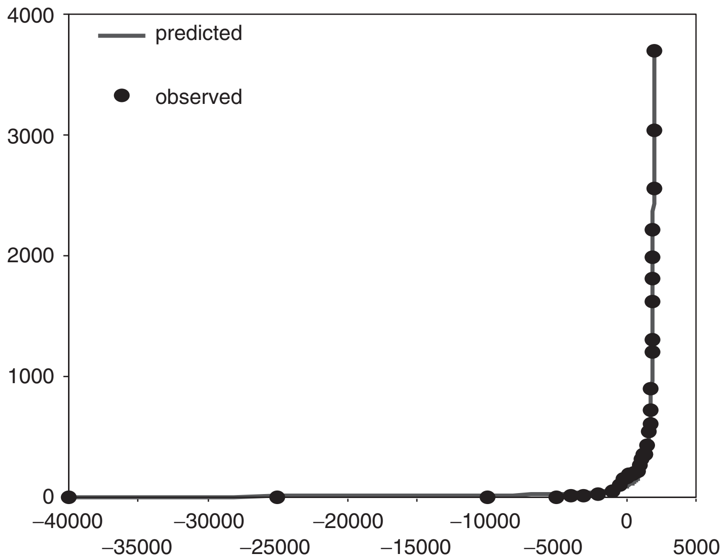
Figure 7.3 Correlations between empirical estimates of world population (in millions, 1000–1970) and the curve generated by von Foerster's equation.

statistics: R^2 can be regarded as a measure of the fit between the dynamics generated by a mathematical model and the empirically observed situation, and can be interpreted as the proportion of the variation accounted for by the respective equation. Note that 0.996 also can be expressed as 99.6 percent.[9] Thus, von Foerster's equation accounts for an astonishing 99.6 percent of all the macro-variation in world population, from CE 1000 through to 1970, as estimated by McEvedy and Jones (1978) and the US Bureau of the Census (2006).[10]

Note also that the empirical estimates of world population find themselves aligned in an extremely neat way along the hyperbolic curve, which convincingly justifies the designation of the pre-1970s world population growth pattern as "hyperbolic."

Von Foerster and his colleagues had detected the hyperbolic pattern of world population growth for CE 1 to CE 1958. Later it was shown that this pattern continued for a few years after 1958,[11] and also that it can be traced for many millennia BCE (Kapitza 1992, 1999; Kremer 1993).[12] Indeed, the McEvedy and Jones (1978) estimates for world population for the period 5000–500 BCE are described rather accurately by a hyperbolic equation ($R^2 = 0.996$); and this fit remains rather high for 40,000–200 BCE ($R^2 = 0.990$) (see Korotayev *et al.* 2006b: 150). The overall shape of the world's population dynamics in 40,000 BCE to CE 1970 also follows the hyperbolic pattern quite well (see Figure 7.4):

A usual objection (e.g. Shishkov 2005) to the statement that the overall pattern of world population growth until the 1970s was hyperbolic,



NOTE: $R = 0.998$, $R^2 = 0.996$, $p \ll 0.0001$. Black markers correspond to empirical estimates of the world population by McEvedy and Jones (1978) and Kremer (1993) for 1000–1950, as well as the U.S. Bureau of the Census (2006) data for 1950–1970. The solid line has been generated by the following version of von Foerster's equation:

$$N_t = \frac{189{,}648.7}{2022 - t}$$

Figure 7.4 World population dynamics, 40,000 BCE to CE 1970 (in millions): the fit between predictions of a hyperbolic model and the observed data.

is as follows. Since we simply do not know the exact population of the world for most of human history (and especially, before the Common Era), we do not have enough information to detect the general shape of the world population dynamics through most of human history. Thus, there are insufficient grounds to accept the statement that the overall shape of the world population dynamics in 40,000 BCE to CE 1970 was hyperbolic.

At first glance, this objection looks very convincing. For example, for 1 CE the world population estimates range from 170 million (McEvedy and Jones 1978) to 330 million (Durand 1977), whereas for 10,000 BCE the estimate range becomes even more dramatic: 1–10 million (Thomlinson 1975). Indeed, it seems evident that with such uncertain empirical data, we are simply unable to identify the long-term trend of world population macro-dynamics.

However, notwithstanding the apparent persuasiveness of this objection, we cannot accept it. Let us demonstrate why.

Let us start with 10,000 CE. As was mentioned above, we have only a rather vague idea about how many people lived on the Earth that time. However, we can be reasonably confident that it was more than one million, and less than 10 million. Note that this is not even a guesstimate. Indeed, we know which parts of the world were populated by that time (most of it, in fact), what kind of subsistence economies were practiced[13] (see, for example, Peregrine and Ember 2001), and what the maximum number of people 100 square kilometers could support with any of these subsistence economies (see, for example, Korotayev 1991). Thus, we know that with foraging technologies practiced by human populations in 10,000 BCE, the Earth could not have supported more than 10 million people (and the actual world population is very likely to have been substantially smaller). Regarding world population in 40,000 BCE, we can be sure only that it was somewhat smaller than in 10,000 BCE. We do not know what exactly the difference was, but as we shall see below, this is not important for us in the context of this discussion.

The available estimates of world population between 10,000 BCE and CE 1 can, of course, be regarded as educated guesstimates. However, in CE 2 the situation changes substantially, because this is the year of the "earliest preserved census in the world" (Bielenstein 1987: 14). Note also that this census was performed in China, one of the countries that is most important for us in this context. This census recorded 59 million taxable inhabitants of China (e.g. Bielenstein 1947: 126; Durand 1960: 216; Bielenstein 1986: 240; Loewe 1986: 206), or 57.671 million according to a later re-evaluation by Bielenstein (1987: 14).[14] Up to the eighteenth century, the Chinese counts tended to underestimate the population, since before this they were not real censuses, but rather registrations for taxation purposes; in any country a large number of people would do their best to escape such a registration in order to avoid paying taxes, and it is quite clear that some part of the Chinese population normally succeeded in doing this (see, for example, Durand 1960). Hence, at least we can be confident that in CE 2 the world population was no less than 57.671 million. It is also quite clear that the world population was substantially more than that. For this time we also have data from a census of the Roman citizenry (for CE 14), which, together with information on Roman social structure and data from narrative and archeological sources, makes it possible to identify with a rather high degree of confidence the order of magnitude of the population of the Roman Empire (with available estimates in the range of 45–80 million – see Durand 1977: 274). Textual sources and archeological data also make it possible to identify the order of magnitude of the population of the Parthian Empire (10–20 million), and of India (50–100 million) (Durand 1977). Data on the population for other regions inspire less confidence, but it is still quite clear that their total population was much smaller than that of the four above-mentioned regions (which in CE 2 comprised most of the world population). Archaeological evidence suggests that population density for the rest of the world would have been considerably lower than in the "Four Regions" themselves. In general, then, we can be quite sure that the world population in CE 2 could scarcely have been less than 150 million; it is very unlikely that it was more than 350 million.

Let us now move to CE 1800. For this time we have much better population data than ever before for most of Europe, the United States, China,[15] Egypt,[16] India, Japan, and so on (Durand 1977). Hence, for this year we can be quite confident that world population could scarcely have been less than 850 million and more than one billion. The situation with population statistics further improves by 1900;[17] there is not much doubt that that the world population in that year was within the range 1,600–1,750 million. Finally, by 1960 the population statistics had improved dramatically, and we can be quite confident that the world population then was within the range 2,900–3,100 million.

Now let us plot the mid-points of the above-mentioned estimate ranges and connect the respective points. We obtain the graph shown in Figure 7.5.

As we can see, the resulting pattern of world population dynamics has an unmistakably hyperbolic shape. Now you can experiment and move any points within the estimate ranges, as much as you like. You will see that the overall hyperbolic shape of the long-term world population dynamics will remain intact. What is more, you can fill the space between the points with any estimates that you find. You will see that the overall shape of the world population dynamics will always remain distinctly hyperbolic. For example, you can replace the estimates of McEvedy and Jones (1978) used by us earlier

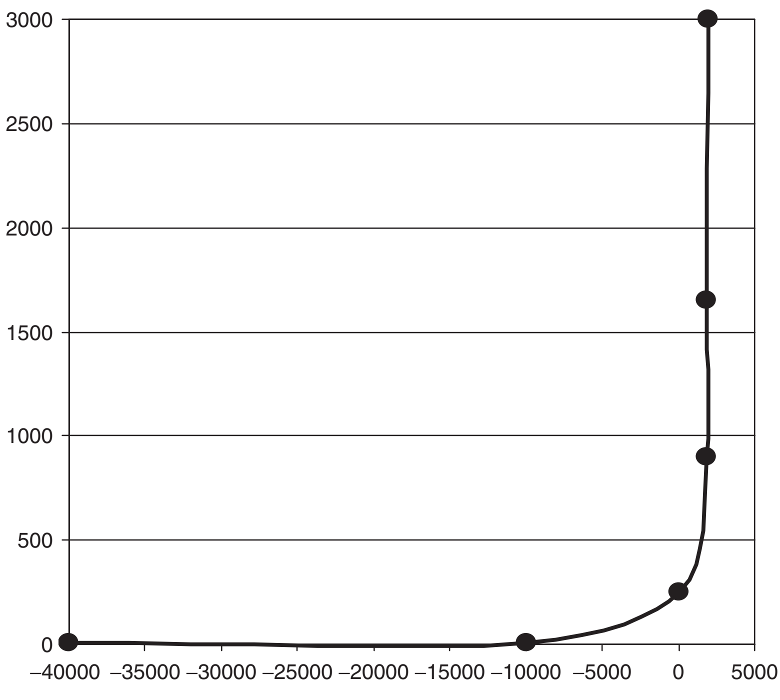


Figure 7.5 Graph resulting from plotting the mid-points of the above-mentioned estimate ranges and connecting the respective points.

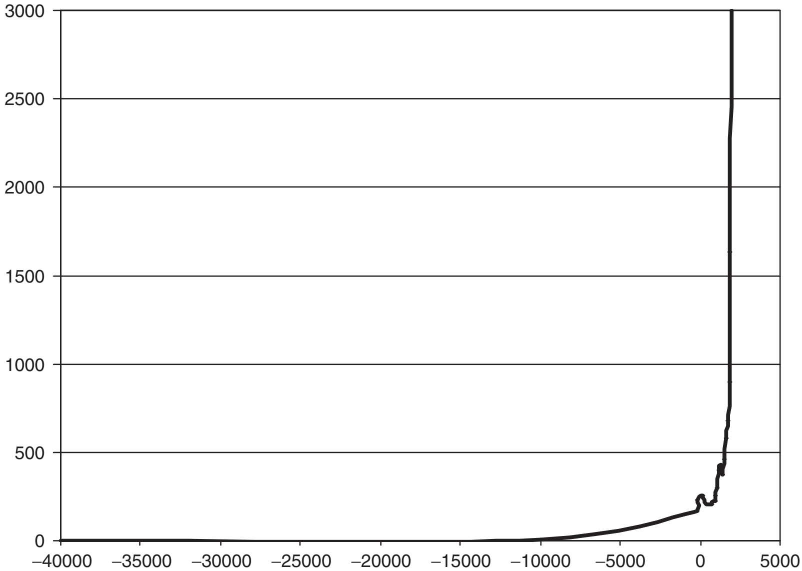


Figure 7.6 World Population dynamics, 40,000 BCE–CE 1960, according to Biraben (1980).

for Figure 7.4 in the range between 10,000 BCE and CE 1900, with the ones of Biraben (1980) (note that generally Biraben's estimates are situated on the opposite side of the estimate range in relation to those of McEvedy and Jones). You will obtain the graph shown in Figure 7.6.

As we can see, the overall shape of the world population dynamics remains unmistakably hyperbolic.

So what is the explanation for this apparent paradox? Why, although world population estimates are evidently uncertain for most of human history, can we be sure that the long-term world population dynamics pattern was hyperbolic?

The answer is simple, for, in the period in question the world population grew by orders of magnitude. It is true that for most of human history we cannot be at all confident of the exact value within a given order of magnitude. But, with respect to any time-point within any period in question, we can be already perfectly confident about the order of magnitude of the world population. Hence, it is clear that whatever discoveries are made in the future, whatever re-evaluations are performed, the probability that they will show that the overall world population-growth pattern for 40,000 BCE to CE 1970 was not hyperbolic (but, say, exponential or linear) is very close to zero indeed.

"Economic Doomsday": Saturday 23 July AD 2005

Note that if, in addition to world population data, von Foerster, Mora, and Amiot also had at their disposal data on the world GDP dynamics for

CE 1–1973 (published, however, only in 2001 by Maddison), they could have made another striking "prediction" – that on Saturday, 23 July, AD 2005 an "economic doomsday" would take place; that is, on that day the world GDP would become infinite if the economic growth trend observed in CE 1–1973 continued. They also would have found that in CE 1–1973 the world GDP growth followed a quadratic–hyperbolic rather than a simple hyperbolic pattern.

Indeed, Maddison's estimates of the world GDP dynamics for CE 1–1973 are almost perfectly approximated by the following equation:

$$G_t = \frac{C}{(t_0 - t)^2}, \tag{5}$$

where G_t is the world GDP (in billions of 1990 international dollars, in purchasing power parity (PPP)) in year t, $C = 17,355,487.3$ and $t_0 = 2,005.56$ (see Figure 7.7).

The only difference between the simple and quadratic hyperbolas is that the simple hyperbola is described mathematically with equation (2):

$$y = \frac{k}{x}, \tag{2}$$

whereas the quadratic hyperbolic equation has x^2 instead of just x:

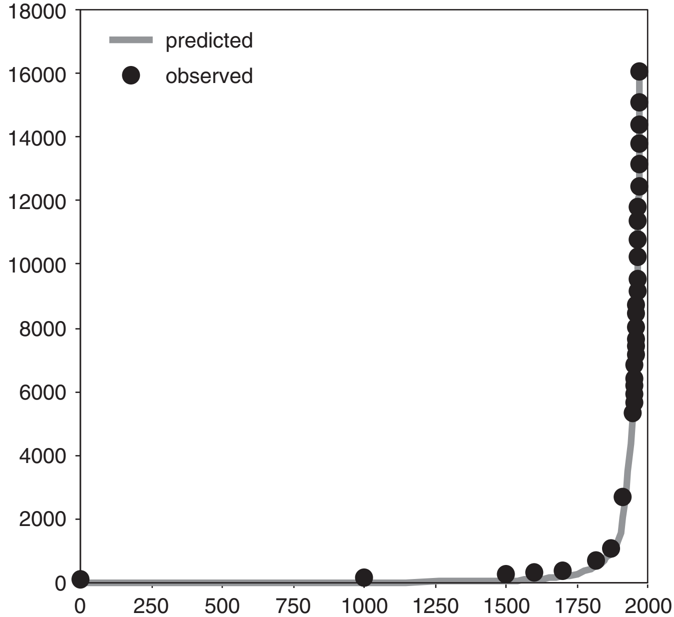
$$y = \frac{k}{x^2}. \tag{6}$$

Of course, this equation can also be written as follows:

$$y = \frac{k}{(x_0 - x)^2} \tag{7}$$

It is this equation that was used above to describe the world economic dynamics between CE 1 and 1973. The algorithm for calculating the world GDP still remains very simple. For example, to calculate the world GDP in 1905 (in billions of 1990 international dollars, PPP), one should first subtract 1905 from 2005, but then divide C (17,355,487.3) not by the resultant difference (100), but by its square ($100^2 = 10,000$).

Those readers who are not familiar with mathematical models of population hyperbolic growth should have a lot of questions at this point.[18] How could the long-term macro-dynamics of the most complex social system be described so accurately with such simple equations? Why do these equations look so strange? Why, indeed, can we estimate the world population in year x so accurately just by subtracting x from the "Doomsday" year and dividing some constant by the resultant difference? And why, if we want to know the



NOTE: $R = 0.9993$, $R^2 = 0.9986$, $p << 0.0001$. The black markers correspond to Maddison's (2001) estimates (Maddison's estimates of the world per capita GDP for 1000 CE has been corrected on the basis of Meliantsev (1996, 2003, 2004a, 2004b). The grey solid line has been generated by the following equation:

$$G = \frac{17{,}749{,}573.1}{(2006 - t)^2}.$$

Actually, as was mentioned above, the best fit is achieved with C = 17,355,487.3 and t0 = 2005.56 (which gives just the "doomsday Saturday, 23 July, 2005"), but we have decided to keep hereafter to integer numbered years.

Figure 7.7 World GDP dynamics, CE 1–1973 (in billions of 1990 international dollars, PPP): the fit between predictions of a quadratic–hyperbolic model and the observed data.

world GDP in this year, should we square the difference prior to dividing? Why was the hyperbolic growth of the world population accompanied by the quadratic hyperbolic growth of the world GDP? Is this a coincidence? Or are the hyperbolic growth of the world population and the quadratic hyperbolic growth of the world GDP just two sides of one coin, i.e. two logically connected aspects of the same process?

In this article we shall try to provide answers to these questions. However, before starting this, we would like to state that our experience shows that most readers who are not familiar with mathematics stop reading books and articles (at least our books and articles) as soon as they come across the words – "differential equation." Thus, we have to ask such readers not to be scared by the presence of these words in the next passage and to read further. You will see that it is not as difficult to understand differential equations (or, at least, some of those equations), as one might think.

Differential equation of the world population growth

To start with, the von Foerster equation:

$$N_t = \frac{C}{t_0 - t},$$

is just a solution of the following differential equation (see, for example, Kapitza 1992, 1999; Korotayev *et al.* 2006a: 119–120):

$$\frac{\mathrm{d}N}{\mathrm{d}t} = \frac{N^2}{C}. \tag{8}$$

This equation can, of course, be written as:

$$\frac{\mathrm{d}N}{\mathrm{d}t} = aN^2, \tag{9}$$

where

$$a = \frac{1}{C}. \tag{10}$$

What is the meaning of this mathematical expression:

$$\frac{\mathrm{d}N}{\mathrm{d}t} = aN^2?$$

In fact, it is very simple. In our context $\mathrm{d}N/\mathrm{d}t$ denotes the absolute population growth rate at some moment of time. Hence, this equation just says that the absolute population growth rate at a certain moment of time should be proportional to the square of population at this moment.

Note that this significantly demystifies the problem of the hyperbolic growth in world population . Now, to explain the hyperbolic pattern of world population growth we should just explain why for many millennia the absolute growth rate of the world population tended to be proportional to the square of the population.

We believe that the most significant progress towards the development of a compact mathematical model that provides a convincing answer to this question has been achieved by Michael Kremer (1993), whose model will be discussed next.

Michael Kremer's model of the world demographic and technological growth

Kremer's model is based on the following assumptions:

First of all he makes "the Malthusian (1978) assumption that population is limited by the available technology, so that the growth rate of population is proportional to the growth rate of technology" (Kremer 1993: 681–2).[19] This statement looks quite convincing. Indeed, throughout most of human history the world population was limited by the technologically determined ceiling of the carrying capacity of land. As was mentioned above, with foraging subsistence technologies, the Earth could not support more than 10 million people, because the amount of naturally available useful biomass on this planet is limited, and the world population could only grow over this limit when people started to apply various means to artificially increase the amount of available biomass, that is with a transition from foraging to food production. However, extensive agriculture also can only support a limited number of people, and further growth of the world population has only become possible with the intensification of agriculture and other technological improvements.

This assumption is modeled by Kremer in the following way. Kremer assumes that overall output produced by the world economy equals:

$$G = rTN^{\alpha}, \tag{11}$$

where G is output, T is the level of technology, N is population, and $0 < \alpha < 1$ and r are parameters.[20] With constant T (that is, without any technological growth) this equation generates Malthusian dynamics. For example, let us assume that $\alpha = 0.5$, and that T is constant. Let us recollect that $N^{0.5}$ is just $\sqrt{N}$. Thus, a fourfold expansion of the population will lead to a twofold increase in output (as $\sqrt{4} = 2$). In fact, here Kremer models Ricardo's law of diminishing returns to labor (1817), which in the absence of technological growth produces just Malthusian dynamics. Indeed, if the population grows fourfold the output grows only twice, this will naturally lead to a twofold decrease of per capita output. How could this affect population dynamics?

Kremer assumes that "population increases above some steady-state equilibrium level of per capita income, m, and decreases below it" (Kremer 1993: 685). Hence, with the decline of per capita income, the population growth will slow down and will become close to zero when the per capita income approaches m. Note that such a dynamic was actually rather typical for agrarian societies, and its mechanisms are known very well – indeed, if per capita incomes declines to close to m, it means a decline in the nutrition and health status of most of the population, which will lead to an increase in mortality and a slowdown in population growth (see, for example, Postan 1950, 1973; Abel 1974, 1980; Malthus 1978 [1798]; Artzrouni and Komlos 1985; Cameron 1989; Usher 1989; Chu and Lee 1994; Komlos and Nefedov 2002; Malkov 2003, 2004; Turchin 2003; Nefedov 2004; Malkov *et al.* 2005; Korotayev *et al.* 2006b, c). Thus, with constant technology, population will not be able to exceed the level at which per capita income ($g = G/N$) becomes equal to m. This implies that for any given level of technological development (T) there is "a unique level of population, $\bar{n}$," that cannot be exceeded with the given level of technology (Kremer 1993: 685). Note that $\bar{n}$ can be also interpreted as the Earth's carrying capacity, that is, the maximum number of people that the Earth can support with the given level of technology.

However, as is well known, the technological level is not a constant, but a variable. And in order to describe its dynamics Kremer employs his second basic assumption: "High population spurs technological change because it increases the number of potential inventors …[21] In a larger population there will be proportionally more people lucky or smart enough to come up with new ideas" (Kremer 1993: 685), thus, "the growth rate of technology is proportional to total population."[22] In fact, here Kremer uses the main assumption of the Endogenous Technological Growth theory (Kuznets 1960; Simon 1977, 1981, 2000; Grossman and Helpman 1991; Aghion and Howitt 1992, 1998; Jones 1995, 2003, 2005; Komlos and Nefedov 2002, etc.). As this supposition, to our knowledge, was first proposed by Simon Kuznets (1960), we shall denote the corresponding type of dynamics as "Kuznetsian,"[23] while the systems in which the "Kuznetsian" population–technological dynamics is combined with the "Malthusian" demographic one will be denoted as "Malthusian–Kuznetsian." In general, we find this assumption rather plausible – in fact, it is quite probable that, other things being equal, within a given period of time, one billion people will make approximately one thousand times more inventions than one million people.

This assumption is expressed by Kremer mathematically in the following way:

$$\frac{\mathrm{d}T}{\mathrm{d}t} = bNT \tag{12}$$

Actually, this equation says just that the absolute technological growth rate at a given moment of time is proportional to the technological level observed at this moment (the wider the technological base, the more inventions could be made on its basis), and, on the other hand, it is proportional to the population (the larger the population, the higher the number of potential inventors).[24]

In his basic model Kremer assumes "that population adjusts instantaneously to $\bar{n}$ (1993: 685); he further combines technology and population determination equations and demonstrates that their interaction produces just the hyperbolic population growth (Kremer 1993: 685–6; see also Podlazov 2000, 2001, 2002, 2004; Tsirel 2004; Korotayev *et al.* 2006a: 21–36).

Kremer's model provides a rather convincing explanation of *why* throughout most of human history the world population followed the hyperbolic pattern with the absolute population growth rate tending to be proportional to N^2. For example, why will the growth of the population from, say, 10 million to 100 million, result in a 100 times growth in the $\mathrm{d}N/\mathrm{d}t$? Kremer's model explains this rather convincingly (although Kremer himself

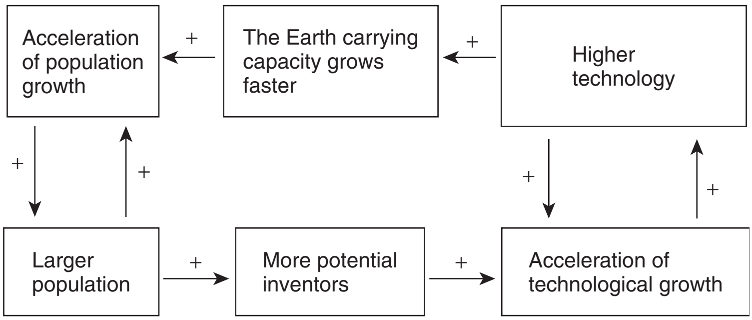


Figure 7.8 Block scheme of the nonlinear second-order positive feedback between technological development and demographic growth (version 1).

does not appear to have spelled this out in a sufficiently clear way). The point is that the growth of world population from 10 million to 100 million implies that human technology also grew approximately ten times (given that it will have proven, after all, to be able to support a population ten times larger). On the other hand, the growth of a population by ten times also implies a tenfold growth of the number of potential inventors, and, hence, a tenfold increase in the relative technological growth rate. Hence, the absolute technological growth rate will grow $10 \times 10 = 100$ times (as, in accordance with equation (12), an order of magnitude higher number of people having at their disposal an order of magnitude wider technological basis would tend to make two orders of magnitude more inventions). And, as N tends towards the technologically determined carrying-capacity ceiling, we have good reason to expect that dN/dt will also grow just by about 100 times.

In fact, Kremer's model suggests that the hyperbolic pattern of the world's population growth could be accounted for by the non-linear second-order positive feedback mechanism that was shown long ago to generate just the hyperbolic growth, known also as the "blow-up regime" (see, for example, Kurdjumov 1999; Knjazeva and Kurdjumov 2005). In our case, this non-linear second-order positive feedback appears as follows: the more people – the more potential inventors – the faster the technological growth – the faster the growth of the Earth's carrying capacity – the faster the population growth – with more people you also have more potential inventors – hence, faster technological growth, and so on (see Figure 7.8).

In fact, this positive feedback can be plotted even more succinctly (see Figure 7.9(a)).

Note that the relationship between technological development and demographic growth cannot be analyzed through any simple cause-and-effect model, as we observe a true dynamic relationship between these two processes – each of them is both the cause and the effect of the other.

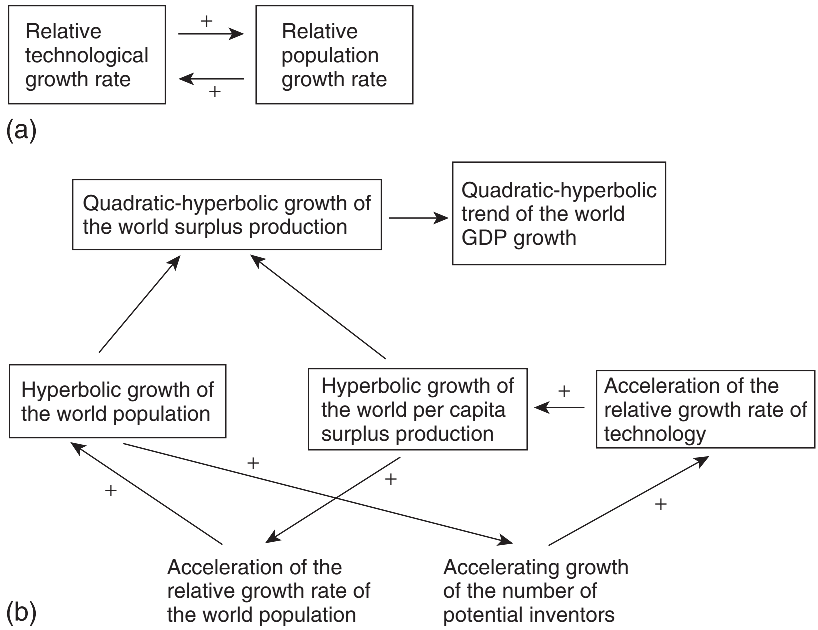


Figure 7.9 (a) Block scheme of the nonlinear second-order positive feedback between technological development and demographic growth (version 2) (b) Block scheme of the nonlinear second-order positive feedback between technological development and demographic growth (version 3).

World dynamics as the World System dynamics

It is remarkable that Kremer's model suggests ways to answer one of the main objections raised against the hyperbolic models of the world's population growth. Indeed, at present, the mathematical models presenting world population growth as being hyperbolic have not been accepted by the academic social science community. (The title of the most recent article by a social scientist discussing Kapitza's model, "Demographic Adventures of a Physicist" (Shishkov 2005), is rather telling in this respect.) We believe that there are substantial reasons for such a position, and that the authors of the respective models are as much to blame for this rejection as the social scientists.

Indeed, all these models are based on an assumption that world population can be treated as having been an integrated system for many centuries, if not millennia, before 1492. Already in 1960, von Foerster *et al.* had spelled out this assumption in a rather explicit way:

> However, what may be true for elements which, because of lack of adequate communication among each other, have to resort to a competitive, (almost) zero-sum multiperson game may be false for elements that

> possess a system of communication which enables them to form coalitions until all elements are so strongly linked that the population as a whole can be considered from a game-theoretical point of view as a single person playing a two-person game with nature as its opponent.
>
> (von Foerster *et al.* 1960: 1292)

However, in CE 1–1500, for example, did the inhabitants of, say, Central Asia, Tasmania, Hawaii, Terra del Fuego, the Kalahari, etc. (that is, just the world population) really have "adequate communication" to make "all elements … so strongly linked that the population as a whole can be considered from a game-theoretical point of view as a single person playing a two-person game with nature as its opponent"? For any historically minded social scientist the answer to this question is perfectly clear and, of course, it is squarely negative. Against this background it is hardly surprising that those social scientists who have happened to come across hyperbolic models for world population growth have tended to treat them merely as "demographic adventures of physicists" (note that indeed, 9 out of 11 currently known authors of such models are physicists); none of the respective authors (von Foerster *et al.* 1960; von Hoerner 1975; Kapitza 1992, 1999; Kremer 1993; Cohen 1995; Podlazov 2000, 2001, 2002, 2004; Johansen and Sornette 2001; Tsirel 2004), after all, has provided any convincing answer to the question above.

However, it is not so difficult to provide such an answer. The hyperbolic trend observed for world population growth after 10,000 BCE does appear to be primarily a product of the growth of quite a real system, a system that seems to have originated in West Asia around that time in direct connection with the Neolithic Revolution. Together with André Gunder Frank (1990, 1993) and Frank and Gills (1994), we denote this system "the World System" (see also, for example, Modelski 2000, 2003; Devezas and Modelski 2003). The presence of the hyperbolic trend itself indicates that the major part of the entity in question had some systemic unity, and the evidence for this unity is readily available. Indeed, we have evidence for the systematic spread of major innovations (domesticated cereals, cattle, sheep, goats, horses, the plow, wheel, copper, bronze, and (later) iron technology, and so on) throughout the whole North African–Eurasian Oikumene for a few millennia BCE (see, for example, Chubarov 1991, or Diamond 1999 for a synthesis of such evidence). As a result, the evolution of societies in this part of the world already at this time cannot be regarded as truly independent. By the end of the first millennium BCE, we observe a belt of cultures, stretching from the Atlantic to the Pacific, with an astonishingly similar level of cultural complexity, characterized by the agricultural production of wheat and other specific cereals; the breeding of cattle, sheep, and goats; the use of the plow, iron metallurgy, and wheeled transport; the development of professional armies and cavalries deploying rather similar weapons; elaborate bureaucracies, and Axial Age ideologies, and so on – this list could be extended for pages). A few millennia before, we would find another belt of societies strikingly similar in level and character of cultural complexity, stretching from the Balkans up to the outskirts of the Indus Valley (Peregrine and Ember 2001: vols. 4 and 8; Peregrine 2003). Note that in both cases, the respective entities included the major part of the contemporary world's population (see, for example, Durand 1977; McEvedy and Jones 1978, etc.). We would interpret this as a tangible result of the World System's functioning. The alternative explanations would involve a sort of miraculous scenario – that these cultures with strikingly similar levels and character of complexity somehow developed independently of one another in a very large but continuous zone, while for some reason nothing comparable with them appeared elsewhere in the other parts of the world that were not parts of the World System. We find such an alternative explanation highly implausible.

Thus, we would tend to treat the world population's hyperbolic growth pattern as reflecting the growth of quite a real entity, the World System.

A few other points seem to be relevant here. Of course there would be no grounds for speaking about a World System stretching from the Atlantic to the Pacific, even at the beginning of the first millennium CE, if we applied the "bulk-good" criterion suggested by Wallerstein (1974, 1987, 2004), as there was no movement of bulk goods at all between, say, China and Europe at this time (as we have no reason to disagree with Wallerstein in his classification of first-century CE Chinese silk reaching Europe as a luxury rather than a bulk good). However, the first century CE (and even the first millennium BCE) World System definitely qualifies as such if we apply the "softer" information-network criterion suggested by Chase-Dunn and Hall (1997). Note that at our level of analysis the presence of an information network covering the whole World System is a perfectly sufficient condition, which makes it possible to consider this system as a single evolving entity. Yes, in the first millennium BCE any bulk goods could hardly penetrate from the Pacific coast of Eurasia to its Atlantic coast. However, by that time the World System had reached such a level of integration that iron metallurgy could spread through the whole of the World System within a few centuries.

Yes, in the millennia preceding the European colonization of Tasmania, its population dynamics – oscillating around the 4,000 level (e.g. Diamond 1999) – were not influenced by World System population dynamics and did not influence it at all. However, such facts just suggest that since the tenth millennium BCE the dynamics of the world population reflect very closely just the dynamics of the World System population.

A compact mathematical model of the economic and demographic development of the World System

On the basis of Kremer's model, we (Korotayev *et al.* 2006a) have developed a mathematical model that describes not only the hyperbolic world population growth, but also the macro-dynamics of the world GDP up to 1973:

$$G = k_1 T N^{\alpha}, \tag{11}$$

$$\frac{dN}{dt} = k_2 S N, \tag{13}$$

$$\frac{dT}{dt} = k_3 N T \tag{12}$$

where G is the world GDP, T is the World System technological level, $N$is population, and S is the surplus produced, per person, over the amount (m) minimally necessary to reproduce the population with a zero growth rate in a Malthusian system (thus, $S = g - m$, where g denotes per capita GDP); k_1, k_2, k_3, and α ($0 < \alpha < 1$) are parameters.

We have also shown (Korotayev *et al.* 2006a) that this model can be further simplified to the following form:

$$\frac{dN}{dt} = aSN \tag{13}$$

$$\frac{dS}{dt} = bNS \tag{14}$$

while the world GDP (G) can be calculated using the following equation:

$$G = mN + SN. \tag{15}$$

Note that the mathematical analysis of the basic model (11)–(13)–(12) suggests that during the "Malthusian–Kuznetsian" macro-period of human history (that is, up to the 1960s) the amount of S (per capita surplus produced at the given level of World System development) should be proportional, in the long run, to the World System's population: $S = kN$. Our statistical analysis of available empirical data has confirmed this theoretical proportionality (Korotayev *et al.* 2006a). Thus, in the right-hand side of equation (13), S can be replaced with kN, and as a result we arrive at the following equation:[25]

$$\frac{dN}{dt} = kaN^2 \tag{9}$$

As we remember, the solution of this type of differential equation is:

$$N_t = \frac{C}{(t_0 - t)} \tag{1}$$

and this simply produces a hyperbolic curve.

As, according to our model, *S* can be approximated as *kN*, its long-term dynamics can be approximated with the following equation:

$$S = \frac{kC}{t_0 - t} \tag{16}$$

Thus, the long-term dynamics of the most dynamic component of the world GDP, *SN*, "the world surplus product," can be approximated as follows:

$$SN = \frac{kC^2}{(t_0 - t)^2} \tag{17}$$

Of course, this suggests that the long-term world GDP dynamics up to the early 1970s must be better approximated by a quadratic hyperbola than by a simple one; and, as we could see above (see Figure 7.7), this approximation works very effectively indeed.

Thus, up to the 1970s the hyperbolic growth of the world population was accompanied by the quadratic–hyperbolic growth of the world GDP, just as is suggested by our model. Note that the hyperbolic growth of the world population and the quadratic hyperbolic growth of the world GDP are very tightly connected processes, actually two sides of the same coin – two dimensions of one process propelled by the non-linear second-order positive feedback loops between the technological development and demographic growth (see Figure 7.9(b)).

Conclusion

Thus, as we have seen, 99.3–99.78 percent of all the variation in demographic, economic and cultural macro-dynamics of the world over the last two millennia can be accounted for by very simple general models.

Actually, this could be regarded as a striking illustration of the fact well known in complexity studies – that chaotic dynamics at the micro-level can generate highly deterministic macro-level behavior (e.g. Chernavskij 2004).

To describe the behavior of a few dozen gas molecules in a closed vessel, we need very complex mathematical models, which will still be unable to predict the long-run dynamics of such a system, due to an inevitable irreducible chaotic component. However, the behavior of trillions of gas molecules can be described with extremely simple sets of equations, which are capable of predicting almost perfectly the macro-dynamics of all the basic parameters (and just because of chaotic behavior at the micro-level).

Our analysis suggests that a similar set of regularities is observed in the human world too. To predict the demographic behavior of a real family we would need extremely complex mathematical models, which would still predict a very small fraction of actual variation, simply because of the presence of inevitable irreducible chaotic components. For systems including orders-of-magnitude higher numbers of people (cities, states, civilizations), we would need simpler mathematical models with a much higher predictive capacity. Against this background, it is hardly surprising to find that the simplest regularities accounting for extremely large proportions of all the macro-variation can be found precisely for the largest possible social system – the human world.

This, of course, suggests a novel approach to the formation of a general theory of social macro-evolution. The approach prevalent in social evolutionism is based on the assumption that evolutionary regularities of simple systems are significantly simpler than the ones characteristic of complex systems. A rather logical outcome of this almost self-evident assumption is that one should first study the evolutionary regularities of simple systems, and only after understanding them should one move to more complex ones.[26] We believe this misguided approach helped lead to an almost total disenchantment with the evolutionary approach in the social sciences as a whole.[27]

We believe that, among other things, the compact macro-model analysis seems to suggest a rather novel approach to World System analysis. It could be suggested that within a new approach the main emphasis would be moved to the generation and diffusion of innovations. If a society borrows systematically important technological innovations, then its evolution already cannot be considered as really independent, but should rather be considered as a part of a larger evolving entity, within which such innovations are systematically produced and diffused. The main idea of the world-system approach was to find the evolving unit. The basic idea was that it is impossible to account for the evolution of a single society without taking into consideration that it was a part of a larger whole. However, traditional world-system analysis has concentrated on bulk-goods movements, and core–periphery exploitation, thoroughly neglecting the above-mentioned dimension. However, the information network turns out to be the oldest mechanism of the World System integration, and has remained extremely important throughout its whole history, remaining so up until to the present. It seems to be even more important than the core–periphery exploitation (for example, without taking this mechanism into consideration, it appears impossible to account for such things as the demographic explosion in the twentieth century, whose proximate cause was the dramatic decline of mortality, but whose main ultimate cause was the diffusion of innovations produced almost exclusively within the World System core). This also suggests a redefinition of the World System (WS) core. The core is not the WS zone, which exploits other zones, but rather the WS core is the zone with the highest innovation donor/recipient (*D*/*R*) ratio, the principal innovation donor.

Note also that the suggested approach throws a new light on our understanding of globalization processes. Against the background of the mathematical models discussed above, the fact that the world population growth followed the hyperbolic pattern in the tenth millennium to the first millennium BCE (see, for example, Korotayev *et al.* 2006b) indicates that the majority of the world population already functioned within a single system in this period. Let us recollect that a few millennia before the Common Era, the World System covered only a small portion of the Earth landmass (stretching from the Balkans up to the western outskirts of the Indus Valley), but already at this time it encompassed the majority (although in no way overwhelming) of the world population. In the third millennium BCE, with the diffusion to East Asia of such major Middle Eastern technological innovations as domesticated wheat, barley, cattle, sheep, goats and many others (which led to a radical growth of the carrying capacity and, hence, population in this part of the world), the World System incorporated East Asia, and by the end of the 1st millennium BCE the overwhelming majority of the world population lived just within the World System.

Thus, most of the world population became "globalized" many millennia before "the century of globalization," although the World System had only encompassed the whole of the Earth landmass in the second millennium of the Common Era.

However, in no way was the spatial expansion of the World System the only dimension of the globalization process in the pre-modern age. Another important dimension of the globalization trends since the tenth millennium BCE was the growing integration of the developing World System. The mathematical models of the World System development clarify our understanding of some other dimensions of the globalization processes. A certain trend can be only detected at a scale at least one order of magnitude wider than the characteristic time of those changes that create the respective trend. Against this background it is hardly surprising to find the following: in the tenth millennium to the first millennium BCE, it typically took major innovation centuries to diffuse throughout the World System, and we can only detect the hyperbolic growth of the world population at the scale of millennia. In the second millennium CE, this time of diffusion decreased to the order of decades, and for this period we are able to detect the hyperbolic growth pattern at the scale of centuries. By the end of the nineteenth century, the time taken by the major technological innovations to diffuse throughout most of the World System decreased further to the order of years, and for 1870–1970 it turns out to be possible to detect the hyperbolic growth pattern at the scale of decades (see, for example, Kremer 1993). Against the background of the above-discussed mathematical models this, of course, suggests orders of magnitude growth of the World System integration during the period under study, specifying another important dimension of the evolutionary globalization processes.

Notes

1 This article is intended for all those interested with the patterns of social evolution and development, including those who are not quite familiar with mathematics. Hence, mathematically sophisticated readers should find some explanations of elementary mathematics in it totally uninteresting, and we would only advise such readers to skip over such explanations.

2 To be exact, the equation proposed by von Foerster and his colleagues is as follows:

$$N_t = \frac{C}{(t_0 - t)^{0.99}}.$$

However, as has been shown by von Hoerner (1975) and Kapitza (1992, 1999), it can be written more succinctly as:

$$N_t = \frac{C}{t_0 - t}.$$

3 Of course, von Foerster and his colleagues did not imply that the world population on that day could actually become infinite. The real implication was that the world population growth pattern that was followed for many centuries prior to 1960 was about to come to an end and be transformed into a radically different pattern. Note that this prediction began to be fulfilled only in a few years after the "Doomsday" paper was published, since 1960 the world population growth began to diverge more and more from the blow-up regime, and now it is not hyperbolic any more (see, for example, Korotayev *et al.* 2006a).

4 Note that the value of coefficient k (equivalent to parameter C in equation (1)) used by us is a bit different from the one used by von Foerster.

5 Thomlinson (1975); Durand (1977); McEvedy and Jones (1978); Biraben (1980); Haub (1995); Modelski (2003); UN Population Division (2006); US Bureau of the Census (2006).

6 Thomlinson (1975); McEvedy and Jones (1978); Biraben (1980); Modelski (2003); UN Population Division (2006); US Bureau of the Census (2006).

7 Thomlinson (1975); McEvedy and Jones (1978); Biraben (1980); Maddison (2001); Modelski (2003); US Bureau of the Census (2006).

8 Some 350 million (McEvedy and Jones 1978), 374 million (Biraben 1980).

9 The second characteristic (p, standing for "probability") is a measure of the correlation's statistical significance. A little counter-intuitively, the lower the value of p, the higher the statistical significance of the respective correlation. This is because p indicates the probability that the observed correlation could be accounted for solely by chance. Thus, $p = 0.99$ indicates an extremely low statistical significance, as it means that there are 99 chances out of 100 that the observed correlation is the result of a coincidence, and, thus, we can be quite confident that there is no systematic relationship (at least, of the kind that we study) between the two respective variables. On the other hand, $p = 1 \times 10^{-16}$ indicates an extremely high statistical significance for the correlation, as it means that there is only one chance out of 10,000,000,000,000,000 that the observed correlation is the result of pure coincidence (in fact, a correlation is usually considered as statistically significant with $p < 0.05$).

10 In fact, with slightly different parameters ($C = 164{,}890.45$; $t_0 = 2{,}014$) the fit (R^2) between the dynamics generated by von Foerster's equation and the macro-variation of world population for CE 1000–1970, as estimated by McEvedy and Jones (1978) and the US Bureau of the Census (2006) reaches 0.9992 (99.92 percent), whereas for 500 BCE to CE 1970 this fit increases to 0.9993 (99.93 percent) (with the following parameters: $c = 171{,}042.78$; $t_0 = 2{,}016$).

11 Note that after the 1960s, world population deviated from the hyperbolic pattern more and more; at present it is definitely no longer hyperbolic (see, for example, Korotayev *et al.* 2006a: 10–20, 67–86, 92–104, 112–14).

12 In fact, Kremer asserts the presence of this pattern since one million BCE; and Kapitza, since four million BCE! We, however, are not prepared to accept these

claims, because it is far from clear even who constituted the "world population" in, say, 1 million BCE, let alone how their number could have been empirically estimated.

13 Note that at that time these economies were exclusively foraging (although quite intensive in a few areas of the world (see, for example, Grinin 2006)).

14 Or 57.671 million according to a later re-evaluation by Bielenstein (1987: 14).

15 Due to the separation of the census registration from the tax assessment conducted in the first half of the eighteenth century, the Chinese population in 1800 had no substantive reason for avoiding the census registration. Therefore, the Chinese census data for this time are particularly reliable (e.g. Durand 1960: 238; see also Korotayev *et al*. 2006b: 47–88).

16 Due to the first scientific estimation of the Egyptian population performed by the members of the scientific mission that accompanied Napoleon to Egypt (Jomard 1818).

17 With a notable exception of China (Durand 1960; see also Korotayev *et al.* 2006b: 47–88).

18 Whereas the answers to the questions regarding the quadratic hyperbolic growth of the world GDP might not be completely clear, even for those readers who know the hyperbolic demographic models.

19 In addition to this, the absolute growth rate is proportional to the population itself – with a given relative growth rate a larger population will increase more in absolute numbers than a smaller one.

20 Kremer uses the following symbols to denote respective variables: Y – output, p – population, A – the level of technology, etc.; while describing Kremer's models we will employ the symbols (closer to Kapitza's 1992, 1999) used in our model, naturally without distorting the sense of Kremer's equations.

21 "This implication flows naturally from the nonrivalry of technology ... The cost of inventing a new technology is independent of the number of people who use it. Thus, holding constant the share of resources devoted to research, an increase in population leads to an increase in technological change" (Kremer 1993: 681).

22 Note that "the growth rate of technology" means here the relative growth rate (i.e. the level to which technology will grow in a given unit of time, in proportion to the level observed at the beginning of this period).

23 In economic anthropology it is usually denoted as "Boserupian" (see, for example, Boserup 1965; Lee 1986).

24 Kremer did not test this hypothesis empirically in a direct way. Note, however, that our own empirical test of this hypothesis has supported it (see Korotayev *et al.* 2006b: 141–146).

25 Thus we arrive, on a theoretical basis, at the differential equation discovered empirically by von Hoerner (1975) and Kapitza (1992, 1999).

26 Of course, the main exception here is constituted just by the world-system approach (e.g. Braudel 1973; Wallerstein 1974, 1987, 2004; Frank 1990, 1993; Frank and Gills 1994; Chase-Dunn and Hall 1997; Denemark *et al.* 2000; Chase-Dunn *et al.* 2003; Devezas and Modelski 2003; Modelski 2003; Chase-Dunn and Anderson 2005, etc.), but the research of world-system theorists has up to now yielded rather limited results, to a significant extent, because they have avoided the use of standard scientific methods and have mostly remained at the level of verbal constructions (with the notable exception of Devezas and Modelski 2003).

27 In fact, a similar fate would have stricken physicists if a few centuries ago they had decided that there is no real thing such as gas, that gas is a mental construction, and that one should start with a "simple" thing such as a mathematical model of a few free-floating molecules in a closed vessel.

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8 Modeling periodic waves of integration in the Afro-Eurasian world-system

Peter Turchin

Introduction

Most people assume that the current period of global connectivity is a unique and unprecedented development in human history. Although the breadth and depth of the globalization that began after World War II is indeed unrivaled, in the past humanity has experienced other periods of heightened long-distance connectivity that resulted in massive long-distance movements of goods, people, ideas, genes, cultivars, and pathogens (Chase-Dunn and Hall 1997; Gills and Thompson 2006). One example of a previous "globalization" is the Age of Discovery of the sixteenth century, during which all major population centers of the world, both in Afro-Eurasia and the Americas, were connected by trade and conquest, which resulted in a massive interchange of cultural elements, genes, and pathogens, known as the Columbian Exchange (Crosby 1972). The globalization of the sixteenth century was followed by the Crisis of the Seventeenth Century, which was also truly global in nature. The wave of state collapse rolled over the whole of Eurasia (with the possible exception of South Asia). Populations declined in such far-flung regions as Spain, Russia, and China. But the demographic catastrophe was even greater in the New World – the Native American population may have declined to perhaps ten percent of the pre-Columbian level. So massive was the world's population collapse that we can detect it in the decline of global emissions of greenhouse gasses (CO_2 and CH_4), which even then were affected by anthropogenic activities. According to at least one theory, this decline in greenhouse gas concentration may have caused the Little Ice Age of the eighteenth century (Ruddiman 2005).

Another "globalization," although on a lesser scale – "merely" continental (a "continentalization"?) – followed the Mongolian conquest of the Eurasian steppe heartland (Abu-Lughod 1989). The expansion of interaction networks during the thirteenth century was also followed by a crisis period during the fourteenth century. One may continue multiplying the examples, but students of world history have long known that long-distance trade/information networks have a tendency to "pulsate" – expand and contract – on the time-scale of centuries. (Chase-Dunn and Hall 1997).

This chapter will discuss the possible mechanisms that may drive these world-system pulsations. First, however, we need to define more precisely the problem to be explained. The main focus of the inquiry is on macro-social systems (also known as "world-systems") – systems of societies that are strongly linked to one another by interaction networks (trade, alliances, warfare, migration and information flows). We know that on a very long temporal scale, since the time when the first archaic states evolved, the density and spatial extent of interaction networks have increased until they have merged into a single world-encompassing web. However, this evolutionary upward trend was not a smooth one; it resulted from a series of upsweeps that were interspersed with slow-downs and even retreats. (Chase-Dunn and Hall 1997). We are interested in explaining these expansions ("integrations") and contractions ("fragmentations") of long-distance interaction networks. One clue to the possible explanation is the observation that the spatial pulsations of macro-social systems appear to be related to another dynamic – the imperial rise and fall.

The explanation that I propose for world-system pulsations runs as follows. Large agrarian states ("empires") experience long-term oscillations in demographic, economic, political, and social structures, known as "secular cycles" (Turchin 2003). The typical length of a secular cycle is between two and three centuries. Secular cycles are driven by endogenous mechanisms (internal to the state and society), but interactions between states, as well as exogenous factors, such as climate, may synchronize state-based oscillations within a macro social system. The secular cycle is a fundamental rhythm that affects, to a greater or lesser degree, all aspects of the functioning of a society, including its capacity to support long-distance exchange networks.

In what follows I will first present the logic of the demographic–structural theory and illustrate it with an outline of secular cycles in western Afro-Eurasia. Second, I will review the synchronizing mechanisms. Third, I will discuss how the phase of the secular cycle may affect the extent and intensity of interaction networks. Finally, I will discuss how the demographic–structural and synchronizing mechanisms interacted, by tracing world-system pulsations in Afro-Eurasia from the Bronze Age onwards.

Because the theory is still in its early stages of development, the exposition is by necessity speculative, and I expect that much of what follows will be modified in the light of new models and data. The geographic focus is on Afro-Eurasia (in conventional terms, North Africa, Europe, and Asia).

Secular cycles and the demographic–structural theory

Social, political, and economic processes within polities (chiefdoms, states, and empires) are often characterized by cycles or waves. Over the last decade it has become apparent that one kind of temporal dynamics, which we have termed secular cycles, is a virtually ubiquitous feature of large-scale agrarian societies. As suggested by the demographic-structural theory.

(Goldstone 1991; Nefedov 1999; Turchin 2003), secular cycles arise as a result of non-linear interactions between demographic, economic, and political components of social systems. During the integrative phase of the cycle, the state and elites maintain social stability and order, which creates favorable conditions for sustained population growth. Population growth in excess of the productivity gains of the land has several effects on social institutions. First, it leads to persistent price inflation, falling real wages, rural misery, urban migration, and increased frequency of food riots and wage protests. Second, the rapid expansion of population results in an increased number of aspirants for elite positions. Increased intra-elite competition leads to the formation of rival patronage networks vying for state rewards. As a result, elites become riven by increasing rivalry and factionalism. Third, population growth leads to expansion of the army and the bureaucracy, and rising real costs for the states. States have no choice but to seek to expand taxation, despite resistance from the elites and the general populace. Yet, attempts to increase revenues cannot offset the spiraling state expenses. Thus, even if the state succeeds in raising taxes, it is still headed for fiscal crisis. As all these trends intensify, the end result is state bankruptcy and consequent loss of the military control; elite movements of regional and national rebellion; and a combination of elite-mobilized and popular uprisings that manifest the breakdown of central authority (Goldstone 1991).

Sociopolitical instability resulting from state collapse feeds back on population growth (Turchin 2003). Most obviously, when the state is weak or absent, the populace will suffer from elevated mortality, due to increased crime, banditry, and internal and external warfare. Additionally, the troubled times cause an increased migration rate, as refugees flee war-affected areas. Migration may lead to emigration (and we can simply add that to mortality) and to the spread of epidemics. Increased vagrancy spreads the disease by connecting areas that would stay isolated during better times. As vagabonds and beggars congregate in towns and cities, increasing their population size, they may tip the density over the epidemiological threshold (a critical density above which a disease spreads). Finally, political instability causes lower reproduction rates, because, during uncertain times, people choose to marry later and to have fewer children.

Instability can also affect the productive capacity of the society. First, the state offers protection. In a stateless society, people can live only in natural strongholds, or places that can be made defensible. Fearful of attack, peasants can cultivate only a small proportion of that productive area, i.e. that which is near fortified settlements. The strong state protects the productive population from external and internal (banditry, civil war) threats, and thus allows the whole cultivable area to be put into production. Second, states often invest in increasing the agricultural productivity by constructing irrigation canals, roads, and flood-control structures. A protracted period of civil war results in a deterioration and outright destruction of this productivity-enhancing infrastructure.

Thus, during the disintegrative phase that follows a crisis, population declines and the numbers and appetites of elites and elite aspirants diminish, which in turn creates conditions for the end of civil wars; the establishment of the strong state; and the start of another cycle.

The characteristic period of the secular cycle varies from two to three centuries in societies with widespread monogamy among the elites, such as the Christian states of Europe; to around a century among societies with polygynous elites, such as the Islamic societies of the Near East. (Since the reproductive ability of human males is primarily determined by the availability of mates, polygynous elites have faster demographic growth rates. The resulting rapid secular oscillations are sometimes known as Ibn Khaldun cycles.) It is important to note that secular cycles are not cycles in the strict mathematical sense. Irregularities arise endogenously as a result of complex non-linear interactions (chaos) and exogenously, as a result of climate fluctuations and catastrophic external invasions of hostile armies or pathogens. For this reason, in smaller polities, where exogenous factors play a more pronounced role, secular cycles tend to be frequently interrupted as a result of actions by stronger neighbors.

The logical coherence of the demographic–structural theory has been tested by constructing a series of mathematical models (Nefedov 1999; Turchin 2003; Korotayev and Khaltourina 2006). The theory has also proved to be very fruitful in applications to several case-studies. Empirical tests so far (reviewed in the forthcoming Turchin and Nefedov 2007 article) suggest that secular oscillations are ubiquitous whenever exogenous factors play a relatively minor role – in larger polities (especially world-empires such as Rome or Han China) and in relatively isolated locations (island states such as England or Japan).

The case-study for which we have the greatest amount of data, allowing us to test various aspects of the demographic–structural theory, is England between 1100 and 1800 (Turchin 2005; Hall and Turchin 2007; Turchin and Nefedov 2007). English population dynamics during the second millennium CE were dominated by two trends (Figure 8.1(a)): a very long-term (millennial) upward tendency that reflects technological evolution, and secular cycles around the long-term trend. It is possible to separate these two dynamics by estimating the long-term trend; using the data on average yields characterizing each epoch; and subtracting this trend from the data. When we detrend data in this way, we are left with the cyclic tendency, depicted in Figure 8.1(b) (for details of calculations, see Turchin 2005). Detrended population, which can be thought of as a measure of the pressure placed by the population on the available resources, is inversely related to the real wage: real wages are low during periods when population pressure is high, and vice versa. This pattern is shown in Figure 8.1(b), where it can be seen that before 1800 the inverse real wage (the "misery index") varies in step with the detrended population. After 1800, the two curves diverge in a very dramatic way, emphasizing the fundamental change in the socioeconomic system associated with the Industrial Revolution.

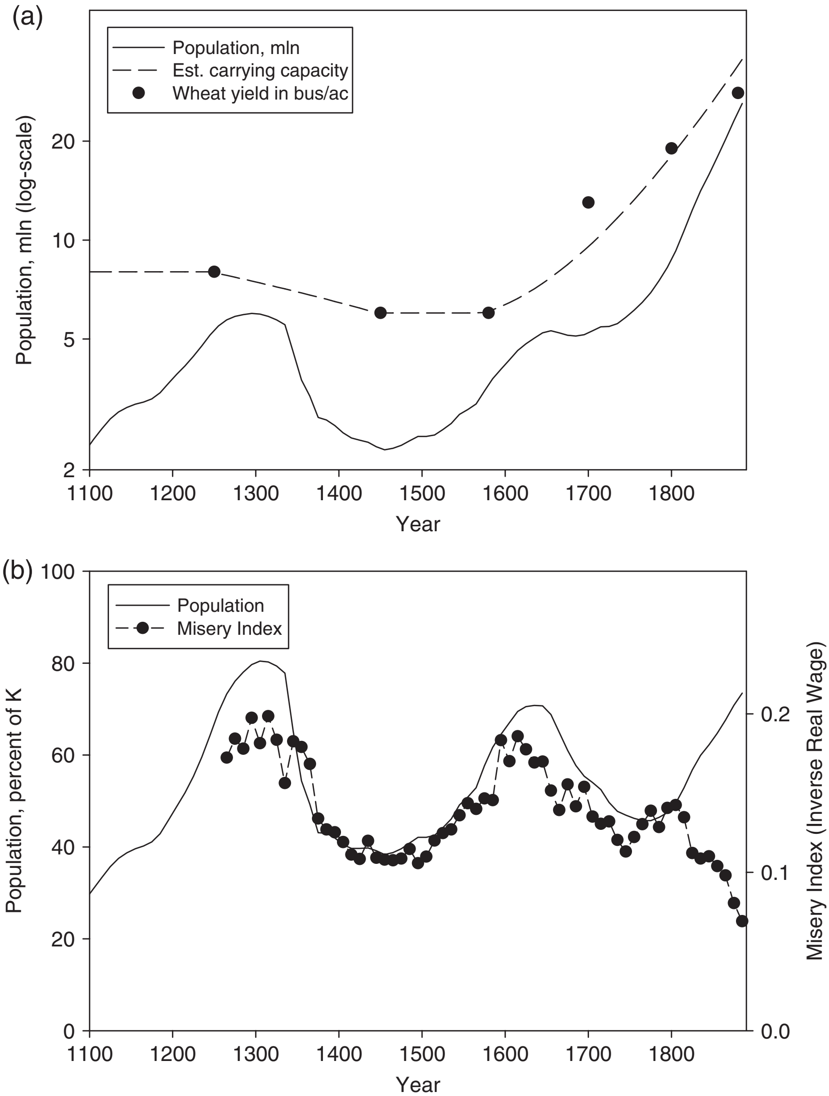

Figure 8.1 (a) Population numbers in England and Wales between 1100 and 1870 (solid line curve), plotted together with the estimated carrying capacity (broken line curve). The data points indicate average yields of wheat (in bushels per acre) for each period, from which the carrying capacity is calculated. (b) Detrended population – population numbers divided by the carrying capacity (solid curve) plotted together with the "misery index" – the inverse real wage (points connected by the broken curve). Data sources are given in Turchin (2005).

Although the case of England is the one in which the existence of population cycles has been most clearly demonstrated, this dataset is by no means unique. Wherever we can construct a long time-series of population counts, we usually observe secular cycles. Figure 8.2 (a) to (c) gives three examples of such cyclic dynamics.

A tentative chronology of secular cycles in Western Europe

As can be seen from Figures 8.1, 8.2(a), and 8.2(c), the western end of Afro-Eurasia was subject to secular cycles, at least since the time of the Roman Empire. Here I provide a synoptic view of the cycle sequence in this region. The account is based on the forthcoming book by Turchin and Nefedov (2007). All dates given below are approximate, because transitions between cycles are not discrete events.

The cycles of the Roman Empire

The first large empire in Western Europe was that of Rome. During the second century BCE, Rome became the hegemonic power in the Mediterranean. Around 130 BCE, however, the integrative tendency reversed itself, and the Republic entered a 100-year-long period of instability, which ended only when Augustus established the Principate in 27 BCE.

The cycle of the Principate lasted three centuries. The reigns of the Julio-Claudian and Flavian emperors were a period of population growth and economic expansion, somewhat marred by political instability at the very top, which, however, affected mostly the ruling class (the most serious period of political instability was the "year of three emperors" that followed the deposing of Nero in 68 CE). The next phase began with the accession of Nerva (96; from this point on, all years are CE) and ended with the arrival of the Antonine Plague (165). This was a period of high political stability, when the empire was governed by the five "good" emperors (Nerva, Trajan, Hadrian, Antonius Pius, and Marcus Aurelius). As is usual during the late stages of the integrative part of the cycle, the elites did very well and their numbers grew. Thus, this period is usually considered as the Golden Age of the Roman Empire. There was, however, increasing popular misery due to overpopulation and inflation. The peak of state power, territorial extent, and economic prosperity (at least for the elites) was achieved during this phase. A number of social and economic indicators, such as the number of inscriptions and documents; building activity; and marble and brick production, peaked towards the end, *c.*130–150. Trade flows also peaked during this period (MacMullen 1988).

The shift from integrative to disintegrative trends can be dated to the first appearance of the Antonine plague (165). The consensus among the elites unraveled, and by the end of the period, when Commodus was overthrown, the situation developed into a full-blown civil war (192–97). The period

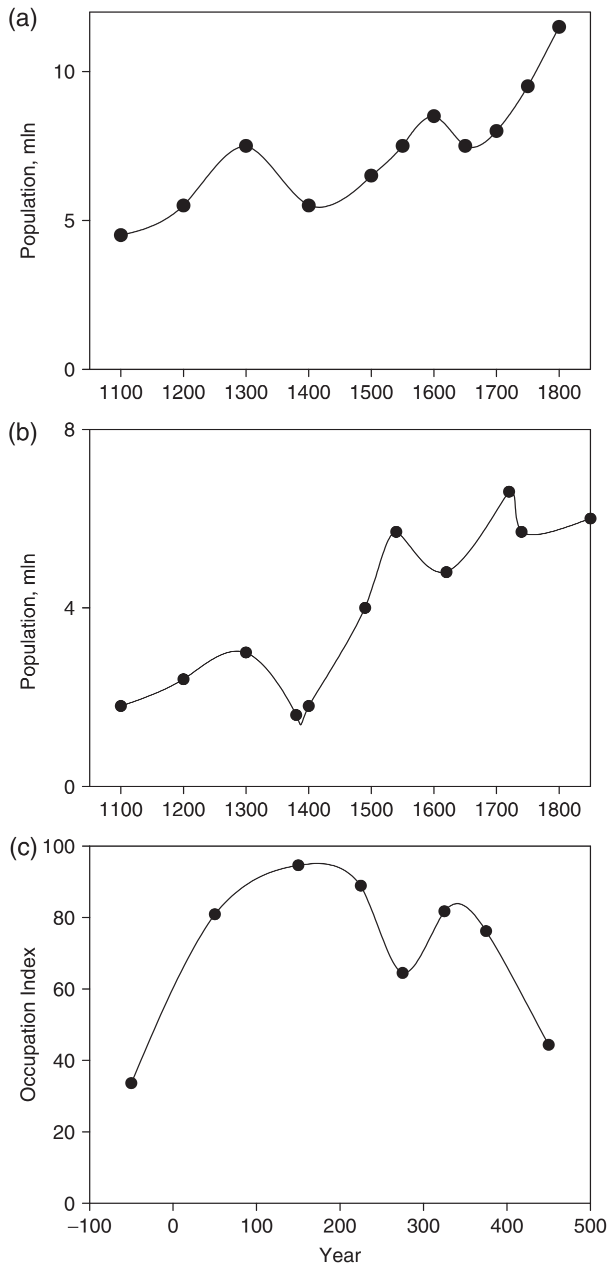

Figure 8.2 (a) Population dynamics of Spain, 1100–1800 (McEvedy and Jones 1978). (b) Population dynamics of northern Vietnam (Lieberman 2003) (c) Proportion of archaeological sites occupied during any given period within the western Roman Empire (Lewit 1991).

from 211 (when Septimius Severus was succeeded by Caracalla) to 285 was characterized by continuing intra-elite conflict, chronic civil war, and further population decline (resulting from the recurring epidemics of the 250s and 260s, among other causes). The disintegrative trend reversed itself when Diocletian defeated his rivals and established the Dominate.

During Late Antiquity, the Roman Empire went through another secular cycle, that of the Dominate. The later Roman Empire, which was governed from Constantinople (after its foundation in 330), was not a particularly cohesive polity – it was racked by periodic civil wars, and during the fifth century most of the western provinces were lost to Germanic invaders. Under Justinian (527–65), Constantinople managed to reconquer North Africa, Italy, and parts of Spain, yet during the second half of his reign the empire entered a crisis phase. The crisis was precipitated by the arrival of what was probably the first pandemic of the bubonic plague, known in the West as the Plague of Justinian (542–46). Internal instability, religious schism, and exhausting wars with Sassanian Persia weakened the empire. In the seventh century, the majority of its remaining possessions were lost to the Arabs.

The cycles of medieval German empires

After the troubled third century, the centers of political power within the Roman Empire shifted away from the old imperial core in Italy to the periphery (Turchin 2006). As discussed above, one of the new centers was Constantinople. Another center developed on the site of the Roman frontier along the Rhine. This was the *Regnum Francorum*, the polity of Germanic peoples (mainly Franks, but also incorporating Alamanni and Burgundi) governed by the Merovingian dynasty. The Frankish Kingdom reached its peak during the sixth century, and then fragmented in the seventh.

The next secular cycle began in the early eighth century. The integrative phase of the Carolingian Empire took place under the able leadership of Charles Martel (714 to 740); Pepin the Short (741 to 768); and Charlemagne (768 to 814). The empire disintegrated under the successors of Charlemagne during the ninth century.

The final cycle was the German Reich under the Ottonian (919–1024) and Salian emperors (1024–1125). In the twelfth century this empire began its disintegration into, ultimately, a hodgepodge of statelets ruled by dukes, counts, and imperial knights; bishops and archbishops; and town councils. Again, the centers of political power shifted to the periphery – the Frankish marches, where the European Great Powers such as France, Spain, and Austria arose.

The cycles of the European Great Powers, with a particular emphasis on France

Although there was a great degree of synchrony between the secular cycles affecting different Western European countries, this synchrony was not perfect.

For example, during the fifteenth century the secular cycle in England started to lag behind that of France by about 50 years, and this shift in phase persisted into the nineteenth century (Turchin 2003). Since I lack the space here to discuss the secular cycles in Europe during the last millennium in all their variations, I will focus on a single polity, France. The medieval, or Capetian (by convention, cycles are named by the dynasty that reigned during the integrative phase) cycle began at *c*.1150. The century between 1150 and 1250 saw rapid population growth and an enormous expansion of the territory controlled by the French kings. After the mid-thirteenth century, population growth slowed down and gradually ceased altogether. The onset of crisis was signaled by the famines of 1315–17 and reached its culmination in the arrival of the Black Death, followed by military defeats, peasant uprisings, and the first civil war. A temporary stabilization was achieved during the 1360s, but it proved to be a very fragile one. High sociopolitical instability and the absence of sustained population growth lasted until the mid-fifteenth century. It was around 1450 that the new integrative trend became obvious, so we take this date as the end of the medieval cycle and the beginning of the early modern one.

The end of the Hundred Years' War thus marked the beginning of a secular integrative trend in France, which lasted until 1570. The crisis of the Wars of Religion was followed by depression and another crisis of the Fronde (a period of political instability in France between 1648 and 1653). As a result, a disintegrative tendency prevailed during the period of 1570–1660. The cycle ended when Louis XIV, "the Sun King," assumed personal control of the government, marking the beginning of the expansionary phase of the next secular cycle.

The integrative trend of the second early modern (Bourbon) cycle was the Age of Enlightenment (Fischer 1996), which was succeeded by the disintegrative trend of the Age of Revolution. Table 8.1 presents a summary of the chronological sequence of secular cycles in Western Europe.

Table 8.1 A summary of the chronological sequence of secular cycles in Western Europe

Secular cycle	*Integrative phase*	*Disintegrative phase*
Republican Rome	350–130 BCE	130–30 BCE
Principate	30 BCE to CE 165	CE 160–285
Dominate/Merovingian	CE 285–540	CE 540–700
Carolingian	CE 700–820	CE 820–920
Ottonian–Salian	CE 920–1050	CE 1050–1150
Capetian	CE 1150–1315	CE 1315–1450
Valois	CE 1450–1560	CE1560–1660
Bourbon	CE 1660–1780	CE 1780–1870

It is worth reminding the reader that the main purpose of this chapter is not to present a definitive and well-supported theory of pre-industrial globalizations (which simply does exist at this point), but rather advance some hypotheses that can be pursued in future research. Accordingly, some parts of the historical reconstruction, from the point of view of the demographic–structural theory, presented in Table 8.1, are fairly speculative and will be refined in the future.

As a preliminary test of the chronology proposed in this section, I turn to the survey of the biological standards of living in Europe, recently published by Koepke *et al.* (2005). The basic idea of the approach is that the population pressure on resources resulted in reduced levels of nutrition. Inadequate nutrition for growing human beings (infants and juveniles) causes stunted adult stature. Thus, it should be possible to observe population fluctuations indirectly by measuring how the average heights of individuals changed with time (Figure 8.3).

There is a remarkable degree of congruence between the chronology of secular cycles, as laid out in this section, and the fluctuations of average heights in Europe. I emphasize that the data in Figure 8.4 represent an independent test of the theory, because they were not used in any way in constructing the chronology of secular cycles. Interestingly, the relative height of peaks in

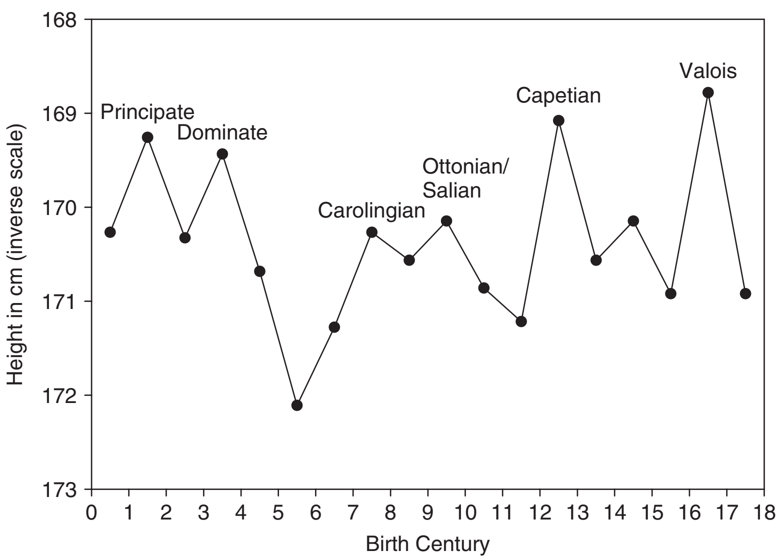

Figure 8.3 Average height of Europeans during the two millennia CE. Data from skeletal material (Koepke and Baten 2005). Note that heights are plotted on an inverse scale, so that the peaks in the graph correspond with population peaks (because periods of high population density should be correlated with low average heights).

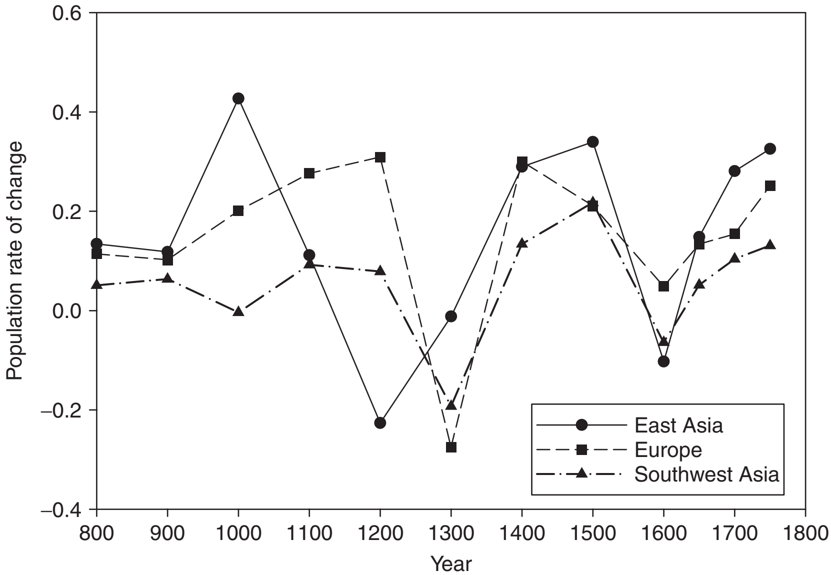

Figure 8.4 Population change in three regions of Afro-Eurasia. Population rate of change is expressed in percent change per year Data from McEvedy and Jones (1978).

the graph corresponds well with what we know about the relative height of population peaks achieved during various secular cycles. Thus, the population peaks during the Roman period were much higher than during the Middle Ages. The drastic population collapse of the sixth century, in particular, is very well reflected in the remarkable increase of average stature. On the other hand, population peaks of the last medieval (Capetian) and the first early modern (Valois) cycles matched and even exceeded those of the Roman times.

Comparison: Secular cycles in Europe and China

Recently Sergey Nefedov (1999) showed that the dynastic cycle in imperial Chinese history was driven by the demographic–structural mechanism. In other words, each major dynasty (see Table 8.2) generally corresponds with a secular cycle. One exception is the Tang dynasty, which experienced two consecutive cycles, separated by the Rebellion of An Lu-shan (CE 755–63). As a comparison between Tables 8.1 and 8.2 shows, there was a great degree of synchrony between the secular cycles in Europe and China during two periods: (1) around the beginning of the Common Era, and (2) during the second millennium. During the first of these periods, there was a rough synchrony between the Roman Republican and the Eastern Han cycles, followed by the essentially concurrent Principate and Western Han cycles. The period from

Table 8.2 Unifying dynasties in the history of China (after Mair 2005)

Dynasty	*Period*
Qin	221–206 BCE
Eastern (Former) Han	202 BCE to CE 9
Western (Later) Han	CE 25–220
Western Jin	CE 265–316
Sui	CE 581–618
Tang	CE 618–907
Northern Song	CE 960–1127
Yuan	CE 1271–1388
Ming	CE 1368–1644
Qing	CE 1644–1911

Table 8.3 Secular cycles in Europe and China during the last millennium, compared with global economy processes as identified by Modelski and Thompson (1996, Table 8.3)

European cycles	*Chinese cycles*	*Global economy processes*
Ottonian-Salian 920–1150	Northern Song 960–1127	Sung* Breakthrough 930–1190
Capetian 1150–1450	Mongol–Yuan 1200–1388	Nautical/Commercial Revolutions 1190–1430
Valois 1450–1660	Ming 1368–1644	Oceanic Trading System 1430–1640
Bourbon 1660–1870	Qing 1644–1911	Industrial Take-off (1640–1850)

*A variant spelling of Song.

the third to tenth century, however, was largely asynchronous. For example, the major Sui-Tang unification (sixth and seventh centuries) occurred during a period of fragmentation in Europe.

As a comparison between the first two columns in Table 8.3 shows, the synchrony was re-established during the tenth century. The third column gives the timing of global economic processes that were identified by Modelski and Thompson (1996). In the scheme proposed by Modelski and Thompson, these processes are comprised of two long cycles, which in turn contain two Kondratieff waves. I believe that we (that is, Modelski and Thompson, on one hand, and secular cycle theorists, on the other) may be looking at the same dynamical phenomenon, but from very different angles of view.

Synchronizing mechanisms

The demographic–structural mechanisms reviewed in the previous sections are *local* in the sense that they act within each polity. Thus, the theory presented so far suggests that states should go through secular cycles independently of one another, each obeying its own internal "clock." Empirical evidence suggests otherwise (Chase-Dunn *et al.* 2000b; Chase-Dunn *et al.* 2007; Hall and Turchin 2007). States separated by thousands of kilometers – even when located at the opposite ends of Afro-Eurasia – often experienced synchronous collapses (Table 8.3). This pattern can be illustrated by looking at population dynamics within three large regions: Europe, Middle East, and the Far East (Chase-Dunn *et al.* 2007). Around 1000 CE, populations in the three regions appear to be moving independently of each other (Figure 8.4). Over the next several centuries, however, population change becomes increasingly synchronized, so that the crisis of the seventeenth century is virtually synchronous across the whole of Eurasia (but with the exception of South Asia).

What may account for such a synchronization? Here we can turn to a body of theory developed by population ecologists in order to explain the broad-scale synchrony often observed in animal population cycles. The most important insight from the theory is that the factors causing synchrony need not be (and usually are not) the same that drive cycles. Two or more dynamical systems oscillating with roughly the same period can be brought into synchrony if they are affected by a shared source of irregular (non-cyclic) exogenous perturbations. One possibility is that a single catastrophic perturbation may "reset" both systems to the same initial conditions, after which they would behave in a similar way until the accumulation of small differences causes their trajectories to diverge. A possible example of such a resetting perturbation is the pandemic of the Black Death, in which case the crisis of the seventeenth century can be thought of as an "echo" of the fourteenth century catastrophe.

An alternative to a single catastrophic event is for many small shared perturbations to cumulatively bring the trajectories closer together, until the systems fluctuate in synchrony (in the ecological literature, this is known as the "Moran effect"). A possible example of such an exogenous driver is the fluctuations in the global climate, perhaps driven by changes in solar activity.

The effect of the secular cycle on the interaction networks

We now have all the necessary ingredients to advance a hypothesis accounting for macro social pulsations, or globalization–deglobalization waves with pre-industrial Afro-Eurasia. The basic assumption is that there were times when different regions within Afro-Eurasia experienced fairly synchronous secular cycles. In order to trace the effect of the demographic–structural mechanisms on interaction networks, we need to dissect the secular cycle a bit more closely.

The integrative secular trend

As was noted above, each secular cycle comprises an integrative trend followed by a disintegrative one. The integrative trend can be further divided into two phases (note that this division does not imply that there are any obvious breaks between the phases; instead each phase gradually evolves into another. The phases are simply a convenient device for labeling different stages of the cycle, the dynamics themselves are smooth and continuous. During the first phase, expansion, the population grows from the minimum and is still far from the ceiling of the carrying capacity (the total number of people that the territory can feed depends on both the amount of arable land and on the current agricultural technology). As a result, real wages are high. Also, because land is plentiful, the labor productivity is high. Part of the resulting surplus is consumed by the producers themselves (so this is the "Golden Age" of the peasant), but it is also easy for the state to collect the taxes. The state is thus able to impose internal order (which further drives expansion). Internal unity and strength enable the state to prosecute successful wars of expansion against weaker neighbors. Imperial expansion brings order and stability to large tracts of land, which is an important precondition for the expansion of long-distance trade that will flower during the next phase.

The second phase, stagflation, is entered when population begins to approach the carrying capacity. Eventually, growth ceases and the population stagnates, while too many mouths to feed means that food prices increase (thus the name of the phase: stagflation = stagnation + inflation). Too many hands means that labor is cheap. As a result, at the same time that one set of prices (food, fuel, shelter) grows, the prices for manufactured goods deflate due to the cheapness of labor. This economic conjunction creates extremely favorable conditions for the landowning elites, because the prices of what they produce on their land (grain, livestock, wood) are at the peak, while the prices of the things that they consume (manufactured goods, services) are at a low level. Stagflation, thus, is the Golden Age of the elites, while the general populace becomes more miserable. This is the period of dramatic growth in the inequality of wealth distribution.

The increasing purchasing power of the elites creates employment opportunities for artisans and merchants. Rural unemployment and underemployment, coupled with urban demand for labor (in crafts and trades, but also as servants for the wealthy) generate a population flow towards the cities, which grow much faster than the general population during this period.

The elite demand for luxury goods ("conspicuous consumption") drives long-distance trade. Because the state is still strong (although beginning to run into fiscal difficulties due to spiraling costs) in this phase of the secular cycle, it is capable of protecting the trade routes. If a number of extensive empires happened to be synchronized in their development during this period, then we may observe the rise of an Afro-Eurasia-wide trading network, which has occurred repeatedly in history: in the Roman–Parthian–Kushan–Han, the Byzantine–Caliphate–Tang, and the Mongol eras. The influence of imperial consolidation on long-distance trade was recently explored using a mathematical model devised by Malkov (2006).

Whereas the expansion phases tend to be relatively disease-free, epidemics are much more likely to occur during the stagflation phases of secular cycles. Several mechanisms are at play. First, and most obviously, population growth may result in the crossing of the epidemiological threshold above which a new disease is able to spread. Second, declining living standards, due to popular immiseration, lead to malnutrition and the weakening of defenses against infection. Third, rampant urbanization means that an increasing proportion of the population inhabits the cities, which were notoriously unhealthy places in pre-industrial times. Fourth, increased migration and vagrancy result in thicker interaction networks, through which disease can spread more easily. Fifth, long-distance trade connects far-flung regions and promotes disease spread.

The historical record supports the contention that recurrent waves of pandemic diseases swept Afro-Eurasia, coinciding with, or following shortly after population peaks. The most famous pandemic in history, the Black Death of the fourteenth century, arrived at the end of a period of unprecedented population growth in Afro-Eurasia. Other pandemics also fit the pattern: the plagues of Antonine and Justinian; the diseases associated with the Columbian interchange; and the cholera pandemics.

The disintegrative secular trend

Stagflation is succeeded by the phase of crisis, which is characterized by population decline and high sociopolitical instability. The arrival of a pandemic is a frequent (although not ubiquitous) contributing factor to population decline (other frequent causes of decline are famine and civil war). Other earmarks of crisis are the bankruptcy and collapse of the state; spiraling intra-elite conflict; and popular rebellions. The end result is often full-blown civil war and anarchy.

The crisis is sometimes the concluding phase of the secular cycle, and is followed by the expansion phase of the next cycle. Whether this occurs depends on the internal characteristics of the society and its geopolitical environment. For example, in the Maghrib societies, studied by Ibn Khaldun, the crisis of the ruling dynasty was rapidly followed with conquest by tribal Bedouin from the nearby "desert" (in the sense of an area occupied by small-scale non-urbanized groups of people), who established the next ruling dynasty. The crisis phases are relatively short (roughly half a century) in societies with non-militarized elites, such as in Chinese empires. Once these elites lose control of the army, they are relatively quickly dispossessed of their elite status and either physically destroyed or demoted to commoner status.

The situation is very different in societies with militarized elites, and where there is no ready source of new elites nearby (unlike in the case of the Maghrib).

In such cases, it may take the elites rather a long time to thin their ranks to the point where the problem of elite overproduction is abated and a new cycle can begin. As a result, the crisis phase is succeeded by a depression phase, such as the one that followed the catastrophe of the Black Death in Western Europe. In England, for example, by the late fourteenth century the population had been halved, yet the return to stability and the beginning of the next cycle occurred only with the establishment of the Tudor dynasty – a full century later. This long depression has puzzled Neomalthusian historians – population was low, real wages and peasant consumption levels were high, yet population stagnated (for a discussion of this problem, see Brenner 1985, and the articles responding to him). The reason for population stagnation was the continuing sociopolitical instability driven by elite overproduction, which was ended only in the bloody decades of the Wars of the Roses.

In summary, disintegrative secular trends may end after a relatively short period of crisis, or drag on for over a century if there is a lengthy depression phase. To make the situation even more complex, continuing fragmentation may cross the point of no return, and last indefinitely, until the society is conquered from the outside. Thus, a new secular cycle may not ever get started, if the society is unable to consolidate to the point of creating a viable state. This is what happened in Italy after the collapse of the Roman Empire, or in the heartland of the medieval German empire, after its fragmentation in the twelfth century. As I emphasized earlier, secular cycles are not cycles in a mathematical sense; at each point there is a possibility that external forces would affect the course of the cycle evolution. The post-crisis phase of the secular cycle, however, is the least-determined one; there are a number of bifurcation points – each capable of taking the society on a very different trajectory.

Returning to the issue of what the disintegrative trend means to interaction networks; most obviously, it reverses the trends that brought about the globalization in the first place. Political fragmentation and continuous instability disrupt long-distance trade. At first, commoners suffer much more from famines, epidemics, and instability. As their numbers decline, the economic conjuncture underlying the well-being of the elites is reversed, and the demand for luxury goods suffers. The trade becomes more local, and the scale of polities becomes smaller due to political fragmentation. The end result of these processes is the contraction of interaction networks involving both trading goods/information and military/diplomatic relations. As a result, long-distance trade flows should cycle with peaks coinciding with population peaks, that is, falling within the pre-crisis (stagflation) phases (Figure 8.5).

Not all variables oscillate synchronously, however. A high degree of urbanization, for example, persists into the crisis and even depression phases. The driving factor now, however, is not rural unemployment (as during stagflation) but the lack of security in the countryside. Walled towns and cities offer protection against armies fighting civil wars; external invaders attracted by the anarchy; and bands of brigands. As a result, urbanization

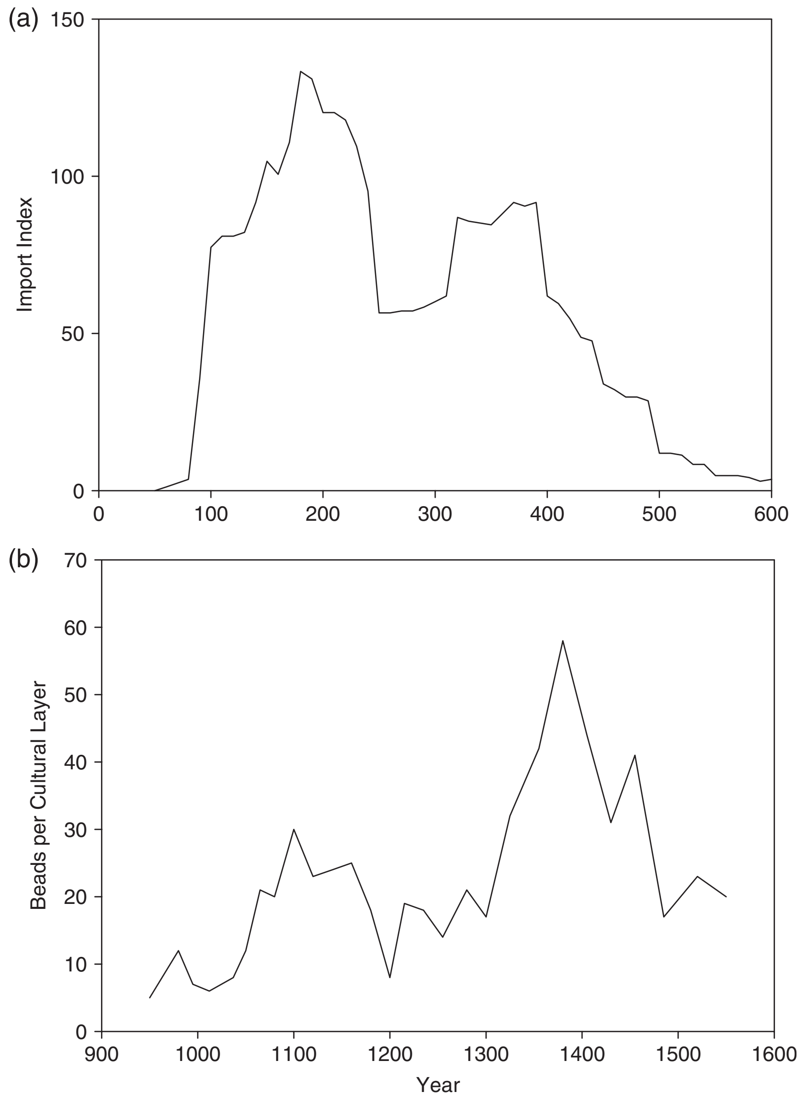

Figure 8.5 Examples of trade cycles reflected in archaeological data. (a) Importation of red African slipware into Central Italy (Bintliff and Sbonias 1999) (b) Import of amber beads into Novgorod (Rybina 1978).

rates follow a secular cycle, but with peaks occurring during the crisis phases; that is, shifted in phase with respect to population peaks (Figure 8.6).

Similarly, we should not expect that the epidemiological situation would get better as soon as population density declines. High levels of urbanization mean that a substantial proportion of the population is crammed into cities,

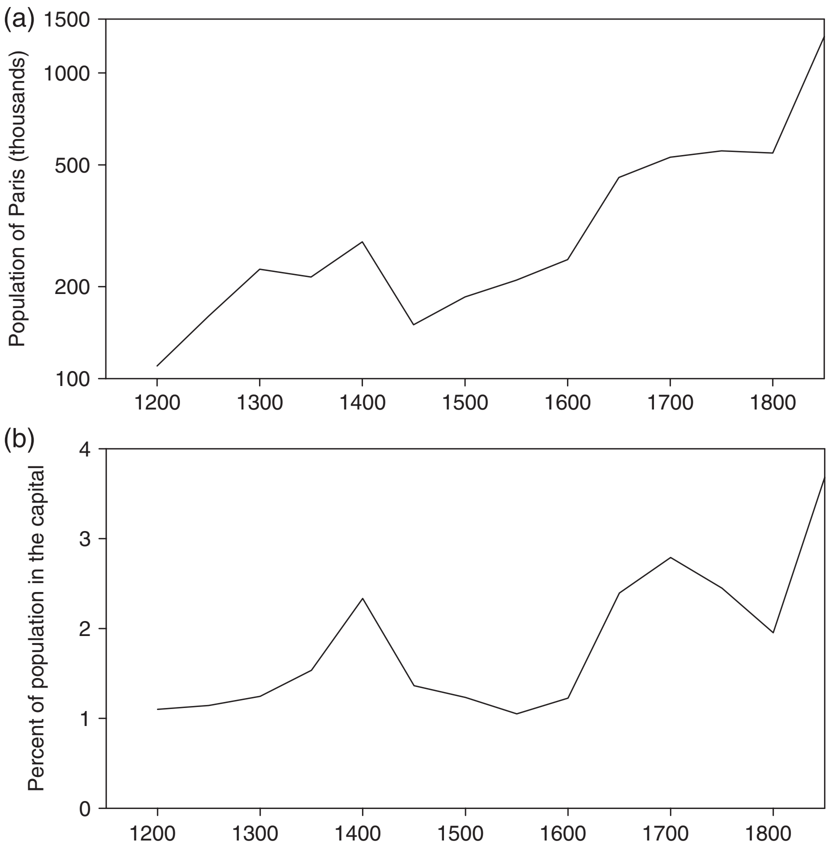

Figure 8.6 Cycles of urbanization in France, 1200–1850. The urbanization index here is defined as the proportion of total population in the national capital. Note that the peaks of urbanization lag behind the population peaks by about a century.

where disease becomes endemic. Continuing instability disrupts food production and distribution, so malnutrition remains a recurrent problem. Finally, epidemics are spread by movements of rival armies during civil wars, and by refugees fleeing war-affected areas.

An example of how epidemics respond to the secular cycle is provided by the dataset, collected by Biraben (1975) on the number of locations visited by the plague, that were reported in the chronicles (Figure 8.7(a)). The first wave of disease reflects the pandemic of the Black Death of the mid-fourteenth century. The second wave peaks during the Crisis of the Seventeenth Century. (Incidentally, the height of the second peak is somewhat misleading – the seventeenth century wave was not as traumatic as the fourteenth-century one, but appears to be higher because the extent of spatial coverage by the available

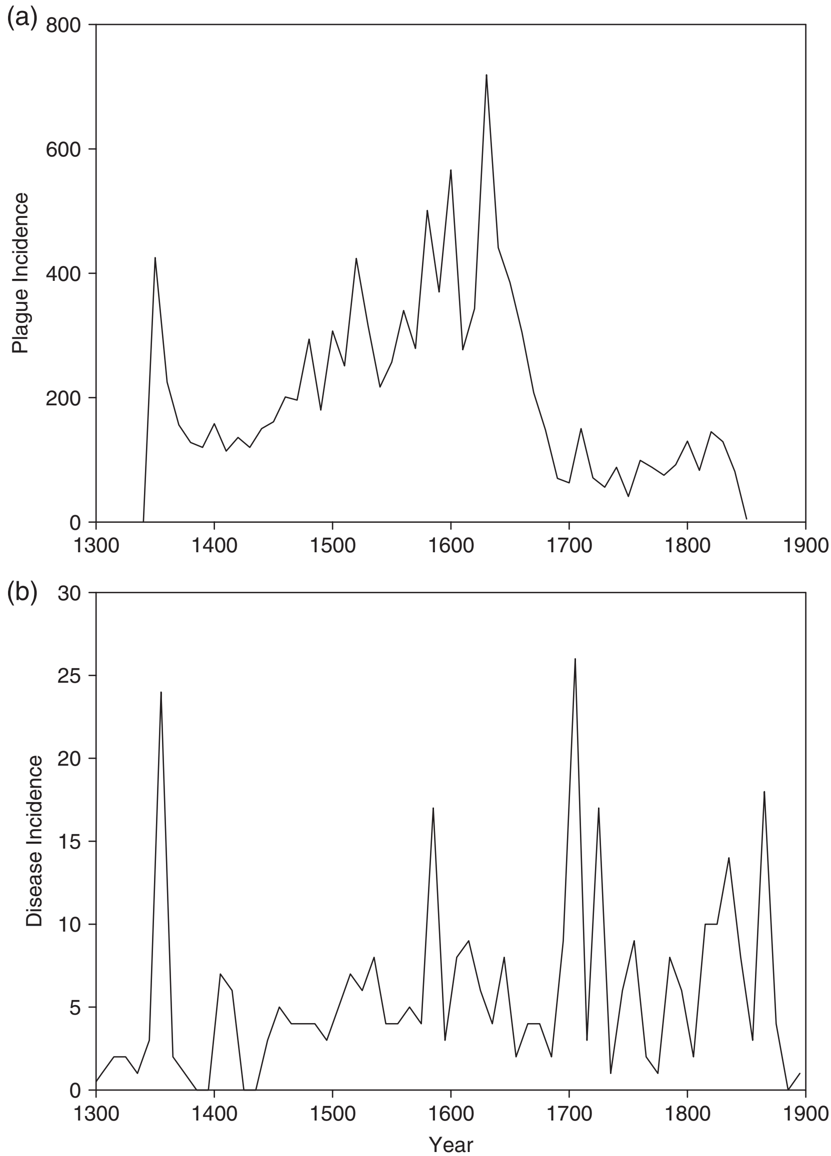

Figure 8.7 (a) Plague incidence in Europe, the Mediterranean, and the Middle East, measured by the number of mentions in chronicles per decade. Data from Biraben (1975). (b) Epidemic incidence in China, measured by the number of provinces reporting disease per decade. Data from McNeill (1976).

sources increases with time. In the future, a more quantitative analysis should take this effect into account, but, for now, my goal is to delineate the dynamical pattern of disease in a qualitative way.) There appears to be a third, much lower peak during the Age of Revolution, but by that point in time the bubonic plague had ceased to be a major killer of European populations (in fact, the plague went extinct in England at the end of the seventeenth century). A much more serious pandemic during the Age of Revolution was that of cholera (Kohn 2001).

At the opposite end of Afro-Eurasia, in China, we observe a similar dynamic of epidemic diseases arriving in waves (Figure 8.7(b)). The fourteenth century wave was apparently synchronous in both western and eastern Afro-Eurasia. The next wave, however, peaked somewhat earlier in China – around 1600. There was an additional Chinese wave in the early eighteenth century, and then another one during the nineteenth century. It is not clear whether the additional Chinese wave in *c.*1700 is a result of Eurasian disease dynamics going out of synchrony, or because this wave was caused by some disease other than the plague. The comparison between the two datasets, thus, is extremely tantalizing, but we will have to wait for better data before taking it any further.

The various trends discussed in this section are summarized in Table 8.4. As can be seen from the table, the spatial scale of interaction networks is at a peak during the stagflation phase. The peak probability of a major pandemic lags behind that of globalization, and becomes highest toward the end of the stagflation phase. In fact, a pandemic or a major epidemic is frequently (but not always) the primary cause of population decline, and the trigger for the crisis.

Recurrent waves of "globalizations" and disease from the Bronze Age onwards

In this chapter, I have proposed a possible explanation for periodic waves of pre-modern "globalizations" – periods of heightened east–west connectivity within Afro-Eurasia. I have argued that the extent and intensity of interaction networks is affected by the phase of the secular cycle. Specifically, long-distance communications reach their peak during the stagflation phase of the secular cycle. There were periods in history when several major regions within Afro-Eurasia moved synchronously through their secular cycles, and, when they all entered stagflation phases, their separate interaction networks knitted together into a single web spanning the whole continent. This development created conditions for pandemic disease to spread through the interaction networks. The disease played at least some role in the ensuing fragmentation ("deglobalization"), although it was not its only cause.

Apparently, world-system pulsations operated even before the first "continentalization" of Afro-Eurasia some 2,000 years ago. Recently, Andrew Sherratt (2003) plotted the long-distance trade routes between 3500 BCE and

Table 8.4 How the phase of the secular cycle affects interaction networks

Phase of the cycle	*Defining features*	*Interaction networks*	*Epidemiological conditions*
Expansion	Population growth; Increasing stability; Golden Age of peasants	PMN: Successful conquest; growing scale of empires; PGN: local but growing	Favorable
Stagflation	Population stagnation; High inflation; Stability still high, but declining; Golden Age of elites	PMN: territorial extent of empires at the peak; PGN: long-distance trade flourishes; Peak of globalization	Worsening; High risk of a pandemic, especially towards the end
Crisis	Population decline; State collapse; Rebellions and civil wars	PMN: empires crumble, appearance of newly independent states; PGN: long-distance trade declining	Unfavorable; Epidemics are a frequent cause of population decline
Depression	Population stagnates; High instability	PMN: fragmented PGN: trade is at a low ebb Deglobalization	Unfavorable, but improving; Epidemics local in scale

PMN = political–military network; PGN = prestige goods network.

1500 CE at 500-year intervals. The total length of the network (Ciolek 2005) exhibits an upward trend, as we would expect, but the trend is not monotonic (Figure 8.8). There is actually a decline during the second millennium BCE, which is partly due to the disappearance of the urban network in Northern India in the first half of the millennium, and a contraction of the Mediterranean network during the second half. The end of the Mediterranean Bronze Age in the twelfth century BCE is one of the best examples of the collapse of complex societies (Tainter 1988, Drews 1993). Interestingly, although data on diseases prior to 500 BCE are extremely fragmentary (even more so than after that), known instances of epidemics seem to be concentrated near the period of collapse. The Old Testament describes the plagues of Egypt during Moses' times (thirteenth century BCE), the Philistine Plague (eleventh century), and the pestilence that killed 70,000 out of 1,300,000 able-bodied men in Israel and Judah during the reign of King David (1000–965 BCE)

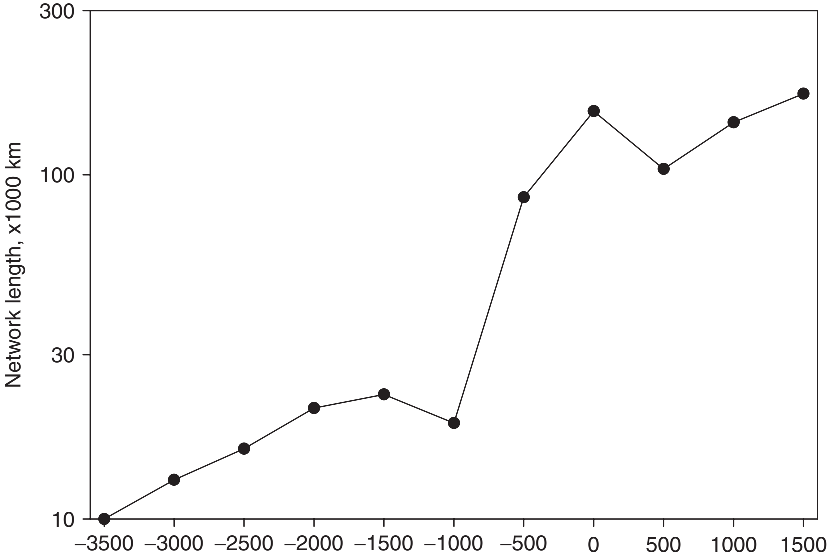

Figure 8.8 Total length of the network of long-distance trade. Analysis by Ciolek (2005), from trade-route maps drawn by Sherratt (2003).

(McNeill 1976: 96). Two rulers of the Hittite empire died one after another (1346–1345 BCE) in an epidemic that spread from Egyptian captives, while the mummy of Ramses V, who died in 1157 BCE, exhibits a typical rash of "pustules" that is characteristic of smallpox (Hopkins 1983: 15–16).

The Early Iron Age (1200–750 BCE) was a dark age in the Mediterranean. The Near Eastern empires collapsed, populations declined (in Greece by an order of magnitude), and cities disappeared (Drews 1993; Morris 2005). The next two and half centuries (the Archaic Age in Greece), however, were a period of revival during which the long-distance interaction networks reknitted and encompassed the whole Mediterranean. Ian Morris (2005) described this process of accelerating economic and social integration as "Mediterraneanization" by analogy with globalization (and one might add, "continentalization"). The increased connectivity within the Mediterranean is highly visible to the archaeologists. From *c.*750 BCE Greek art and culture was heavily influenced by contacts with the ancient Near East – Egypt, Syria, and Mesopotamia, a cultural movement that archaeologists labeled "orientalizing" (Cornell 1995: 85–86). A very similar process affected Etruscan Italy. Further west, the Mediterranean civilization was spread by colonizing Phoenicians (as far as Iberia) and Greeks (as far as southern Gaul). Despite the varieties of languages and religions characterizing various coastal Mediterranean peoples, it becomes possible to speak of the common Mediterranean Civilization, with its shared material culture, social organization (city states), and even elements of religion.

The fifth century was the next period of fragmentation, although the degree of breakdown was quite mild, compared with the Early Iron Age (and economic decline was not completely synchronous across the Mediterranean). For example, during 550-480 BCE Rome was experiencing the full benefits of Mediterranean trade (Toynbee 1965: 370). There were substantial imports of Attic pottery, and excellent terracotta revetments (structures to prevent erosion) were in use during this period. Under the Tarquinian regime, Rome also acquired numerous artisans (Toynbee 1965: 370). After 480 BCE, economic recession set in. Archaeological evidence confirms a drop in Greek imports during the early fifth century (Ward *et al.* 2003: 67). There was dramatic reduction in the volume of archaeological material from Rome (and other Latin sites) after the first quarter of the fifth century BCE. The Romans stopped building large temples. In fact, as far as buildings are concerned, virtually none can be dated to the period between 474 and 400 BCE (Cornell 1995: 266). All indicators of conspicuous consumption by elites – temples, ornate tombs, luxury imports – went into decline, starting in the first half of the fifth century BCE. Decline in any one of these indices could be interpreted as being due to changing tastes or religious preferences, but taken together these trends leave no doubt that elite households had progressively less disposable income during the fifth century and most of the fourth century BCE. The strong tradition of simple living among the Roman elites (Hopkins 1978: 19), so fondly remembered by commentators of the late Republic, dates to this period.

The violent transition from the Monarchy to the Republic in 509 BCE introduced a long period of social and political instability extending to the middle of the fourth century BCE (Ward *et al.* 2003: 60–62). The instability in Rome was not an isolated incident, but must be considered as part of a general conflagration that affected all of Tyrrhenian Italy in the decades around 500 BCE (Cornell 1995: 237). The Eastern Mediterranean entered a period of economic decline and instability somewhat later, starting with the Peloponnesian War (431–404 BCE) and ending with Philip of Macedon picking up the pieces in 338 BCE. This century-long "time of troubles" is similar to the fragmentation period of 1350–1450 BCE, in that both started with a major pandemic. The Great Plague of Athens (431–430 BCE, recurred in 427 BCE), which carried away a third of the Athenian population, is the best known of the fifth century epidemics, but not the only one. For Rome it is actually possible to bring some quantitative data to bear, because detailed annalistic (year-by-year) histories for it were preserved. For example, the analysis of all mentions of disease in Livy indicates that there indeed was a fifth century wave of epidemics, which subsided only after *c.*350 BCE (Figure 8.9). Interestingly, the data suggest another rise in disease incidence during the second century BCE, although the fragmentary nature of available records do not permit any definitive conclusions.

Peoples, genes, and technologies traveled throughout the whole of Eurasia prior to 200 BCE. An early example of technology diffusion is the

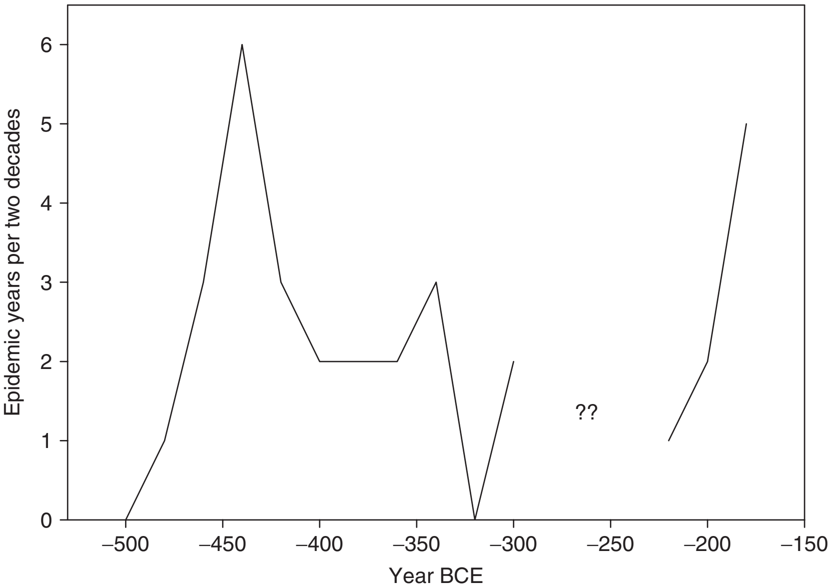

Figure 8.9 The number of epidemic years (per decade) mentioned by Livy (Duncan-Jones 1996). The period where we lack several volumes of Livy's history is indicated with "??".

chariot – invented in *c*.2000 BCE in central Eurasia, dominant on the battlefield from the seventeenth century BCE onwards, reaching India, Egypt, China, and Europe by 1500 BCE (Drews 1993, Anthony and Vinogradov 1995). However, such contacts were not recurrent and routine. The conditions permitting a continent-spanning web arose in the second century BCE, when the eastern and western regions of Afro-Eurasia were unified for the first time by the Han and Roman empires, respectively, and other large empires arose in between.

To generate a crude, but quantitative index of the east–west connectivity in Afro-Eurasia, and how it fluctuated with time across the two millennia from 200 BCE, I have examined the historical maps of Eurasia for 50-year intervals and asked the following question. Suppose a merchant starts from the capital of China and travels west until he reaches the Western Mediterranean, using the route that minimizes the number of state boundaries that he has to cross. How many countries will he visit? Let us suppose that once he reaches any point on the Mediterranean shore, he can take a ship to its western end, and this counts as one step. Furthermore, if the number of steps is ten or more, I simply assigned it ten (there being no point in distinguishing between fine shades of fragmentation). Finally, for the time when China experienced its periodic inter-dynastic crises, I also set the number to ten.

Admittedly, this is a China-centric (and Inner Asia-centric) point of view, and other ways of addressing this issue can be used, but let us see what this

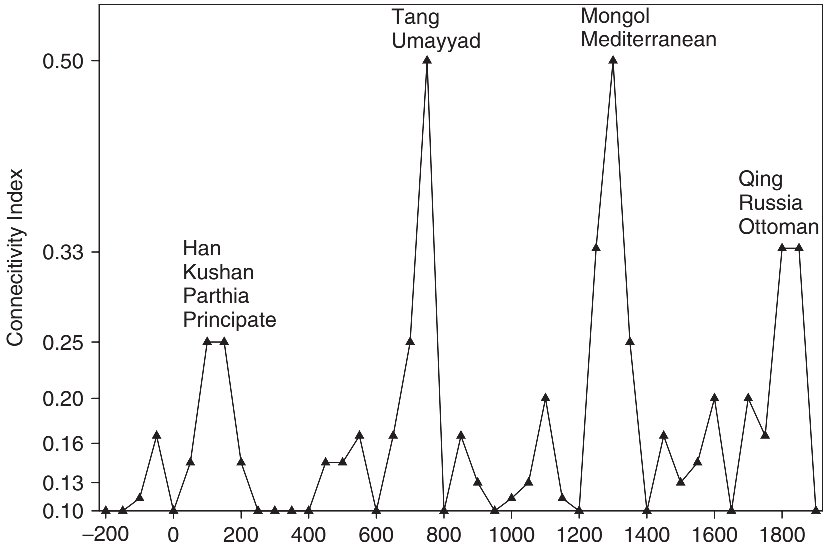

Figure 8.10 The connectivity index of Silk Routes, defined as an inverse of the number of "steps" in which Afro-Eurasia can be spanned. The index varies between 0.1 (ten steps or more) and 0.5 (when only two steps needed to be made).

particular approach gives us. A connectivity index can be defined as an inverse of the minimal number of "steps" (empires and/or the Mediterranean) that the merchant has to make, because the fewer the steps that will span Afro-Eurasia, the better connected the continent (see Figure 8.10).

The first peak of the connectivity index occurs during the second century CE (the heyday of the ancient silk routes). At this time four Eurasian empires were at the peak of their power: the Roman Empire under the Principate (30 BCE to CE 285), the Parthian Empire (250 BCE to CE 226), the Kushan Empire (first century CE to CE 250), and China under the Later (or Eastern) Han Dynasty (CE 25–220). As we discussed above, the Roman Empire experienced a disintegrative trend after the arrival of the Antonine Plagues in 165. China slid into anarchy at approximately the same time as the Roman Empire. It was hit by major epidemics in CE 173 and 179 (although we do not know whether they were caused by the same disease agent as the Antonine Plagues). The central authority collapsed when the Yellow Turbans rose in rebellion in CE 184. Thus, the virtually simultaneous rise and then collapse of the four Eurasian empires brought about the first cycle of globalization–fragmentation that, at its peak connected the far west with the far east of the huge Afro-Eurasian Oikumene. Although by CE 300 the West and the Middle East were reunified by the Roman Empire under the Dominate and the Persian Sassanian Empire, China entered a long period of fragmentation (apart from a very short-lived Western Jin unification, see Table 8.2), and Inner Asia lacked a strong empire.

During the fifth and sixth centuries CE, long-distance trade and cultural exchanges reached a low ebb (Bentley 1993).

Another episode of heightened east–west connectivity was the eighth century, when East Asia was unified by the Tang dynasty (CE 618–907), while the Middle East was under the sway of the Umayyad Caliphate (CE 661–750). Between CE 711 and 716 the Islamic armies conquered Spain and Transoxania. By that time, Eastern Turkestan was already in Tang hands. Thus, a merchant could leave the Tang capital of Chang'an and travel to Cordoba in the far West, in the process crossing only a single international border. In the middle of the eighth century, however, the two great empires were shaken to their foundations – the Abbasid Revolution (CE 750) in the Middle East and the rebellion of An Lu-shan (CE 755–763) in China. The collapse of the Umayyad Caliphate, incidentally, was accompanied by a second wave of the Justinianic Plague (Biraben 1975). This period of instability was relatively brief, and both the Middle Eastern and Chinese empires reconstituted themselves. Other important empires of the period were those of the Byzantines (with a revival after CE 780), the Khazars, and the Carolingians.

The next great Eurasian unification was accomplished by the Mongols in the thirteenth century. In CE 1300 a merchant could travel through the Mongol lands all the way from Korea to the Mediterranean. Western Afro-Eurasia, however, was quite fragmented, so the rest of the trip would have to be accomplished by ship.

Beginning with the Mongol unification, the secular cycles within Afro-Eurasia became synchronized (Figure 8.4). Thus, the "globalization" of the thirteenth century was followed by two other waves of globalization (without quote marks). For example, Immanuel Wallerstein sees two periods of world-system expansion: the sixteenth century and the 1730–1840s (Wallerstein 1974, 1980, 1989). Trade globalization increased between 1795 and 1880 and then again after 1945 (Chase-Dunn *et al.* 2000a).

Are there any lessons that can be learnt from this history that we can apply to the current globalization through which we are now living? I think there may be, but with two very important caveats. First, as I have emphasized repeatedly throughout this chapter, we still have a very sketchy understanding of the causes underlying previous world-system pulsations. Much more modeling and empirical research are needed before we can determine just what history's lessons are. Second, the world has changed dramatically over the last two centuries. Thus, our understanding of pre-industrial globalizations cannot be mechanically transferred to make predictions about the current one. Our models will have to be greatly modified in order to be applied to the modern world. Still, several of the empirical trends associated with the globalization of the twentieth century bear an uncanny resemblance to what has come before. Most obviously, the second half of the twentieth century was a period of massive population growth that has slowed down in the last decade, suggesting that we may be approaching the peak of global population. On the epidemiological front, emerging human infectious diseases have dramatically

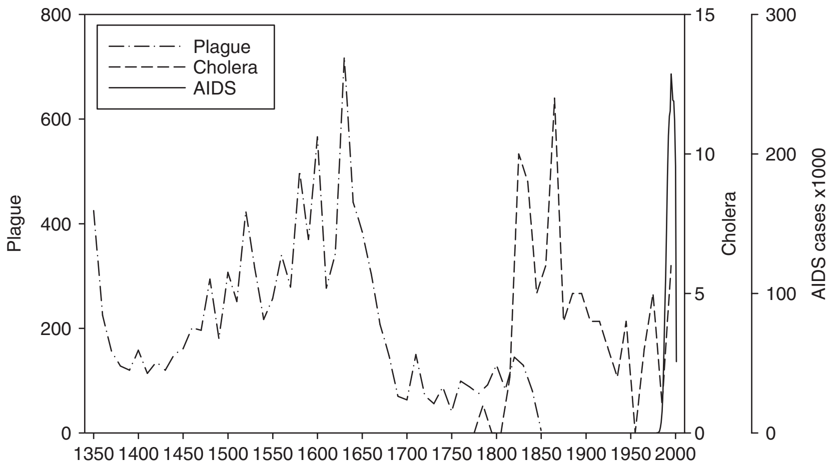

Figure 8.11 Recurrent waves of global pandemics. The plague data are the same as in Figure 8.7(a). The cholera dynamics are given by the number of pandemics or epidemics per decade mentioned in Kohn (2001: appendix 2). The HIV dynamics are the number of AIDS cases reported worldwide, as recorded by the World Health Organization.

increased in incidence during the twentieth century, reaching a peak during the 1980s. (Jones *et al.* 2006). The incidence of cholera has been on the rise (Figure 8.11). The AIDS pandemic (Figure 8.11), as terrifying as it has been, may be the harbinger of even worse diseases to come. These and other trends (for example, the growth of the global inequality of wealth distribution during the last two decades) raise the possibility that studying previous globalizations may not be a purely academic exercise.

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9 Oscillatory dynamics of city-size distributions in world historical systems[1]

Douglas R. White, Laurent Tambayong, and Nataša Kejžar

Globalization, world-system, and historical dynamic theory offer complementary perspectives for the study of city systems as the politico-economic engine of interstate networks. Here we combine these perspectives to examine a dynamical perspective on systems of cities. Globalization theory applied to Eurasia in the last millennium (e.g. Modelski and Thompson, 1996) focuses on centers of economic innovation and political power and their successive periods of rise and fall in dominance. Units of larger scale, as for example polities, are shown to operate at successively longer time-scales in their rise and fall than the economic innovation centers within those polities. World-system theory for similar regions and processes (e.g. Chase-Dunn and Hall, 1997) differs in the way in which it also focuses on innovation at the peripheries of states and empires, that is, on the marcher or boundary polities that resist the encroachment of expanding empires. Marcher states that amalgamate to defeat the spread of an empire often defeat polities formally organized on a much larger scale, thanks to cohesive or decentralized organization that is able to marshal superior combative skills or technology. World-system theory often limits itself to the more prominent types of relations, such as trade in bulk goods and interstate conflict, that form distinct macroregional networks. The structural demographic approach to the political economics of agrarian empires (e.g. Turchin, 2003, 2006) is capable of yielding a more dynamical historical account of how central polities rise and fall as their internal cohesion disintegrates with population growth into factional conflict, and of how once-dominant polities and economies contend with marcher states that coalesce into formidable opponents on their frontiers.

Several of the problems in extending these kinds of complementary approaches to globalization, world-systems, and historical dynamics relate to how networks – social, political, and economic – fit into the processes of change and dynamical patterns that are observed historically. One aspect of major problems that might engage network research involves how changing network fluctuations of long-distance trade influence inter- and intra-regional dynamics. The Silk Road trade, so important in the connections through the marcher states and later empires of Mongol Central Asia between China and the Middle East, for example, also facilitated the diffusion of economic inventions from East to West that were crucial in the rise of the European city system. These included paper money, institutions of credit, and vast new knowledge, weaponry, and technologies. Spufford (2002), for example, shows how important the transmissions of innovations from China were, from a European perspective; while Temple (1987) summarizes the work of Needham (1954–2004) to show the debt owed by the West to China. A related problem, among many other open network problems in historical research is how regional and long-distance trade networks are coupled, along with conflicts and wars, to the rise and fall of cities and city systems. That is the problem we take up here.

We approach the problems of the rise and fall of commercial trade networks, regional city systems, regional conflicts, and the historical dynamics of globalization and world-system interactions in Eurasia, during the last millennium, with a concern for the valid comparative measurement of large-scale phenomena. Tertius Chandler (1987) and other students of historical city sizes (Bairoch, 1988; Braudel, 1992; Modelski, 2003; Pasciuti, 2006, and others) have made it possible to compare the shapes of city-size distribution curves. These are the data we examine here in order to gage and compare the dynamics of city-system rise and fall, both within distinct regions and as changes in one region (such as China) affect changes in others (such as Europe – to give but one example).

Our approach here is to divide up Chandler's (1987) Eurasian largest city-size data into three large regions – China, Europe, and the Mid-Asian region in between – and measure variations over time that depart from the Zipfian rank-size distribution (Zipf, 1949). Zipfian rank-size is the tendency for cities ranked 1 to n in size to approximate a size of M/r, where r is a city's rank compared to the largest city, and M is a maximum city size that gives the best fit for the entire distribution this formulation allows the rank 1 largest city size S_1 to differ from its expected value under a Zipfian rank-size distribution (in which city sizes at rank k are proportional to $1/k$) fitted to an extensive set of the larger cities. The Zipfian distribution has been taken to be a recurrent and possibly universal pattern for city sizes as well as many other complex system phenomena. What we find for Eurasia and regions within Eurasia is that there are systematic historical periods that show significant deviations from the Zipfian distribution. Some of these deviations show the characteristics of a regional collapse of city systems from which there is eventual recovery (unlike the cataclysmic collapse exemplified by the Mayan cities system).

The periods of rise and fall of city systems for each Eurasian region, however, are different. This allows us to test the hypothesis that the rise and fall measure for China anticipates with a time lag the rise and fall measure for Europe, which is a prediction for the period starting in CE 900 consistent with Modelski and Thompson (1996), Temple (1987) and Needham (1954–2004). Finally, for the region of China we have sufficient time-series data to test the predictions from the historical dynamics model of Turchin (2005). This allows some limited results on whether some of the same processes are operative for the rise and fall of city systems as for the historical dynamics of state and empire rise and fall.

In the first section, we pose the problem of instabilities in city sizes and systems, drawing on Chandler's data for 26 historical periods from CE 900 to 1970. In the second section, we examine ways of measuring the departure from Zipfian distributions of city sizes, and introduce the data used for city sizes and possible correlates of city-system change. In the third section we give the results of the scaling of city sizes for different regions, so as to measure city-system changes. In the fourth section, we examine the time-lagged inter-regional cross-correlations for these measures, and summarize the results for cross-region synchrony. In the fifth section, we examine the correlations and time lags between our three Eurasian regions, and for other variables related to known historical oscillations where we have adequate data for testing hypotheses. The variables tested include variables such as trade connectivity, internecine warfare within China, and the development of credit and currency systems that facilitate international exchange as well as innovative national markets. The final section concludes with a summary and the implications of the findings.

City-system instabilities

Jen (2005: 8–9) defines "stability" in terms of dynamical recoveries from small perturbations that return to an original state. The seriousness of the question of city-system instability and of major departures from the Zipfian derives from the assumption that city economies are organized as networks that involve trade and war, and that these economies depend on innovation to join the leading economic or political sectors of more global networks. The two main factors that make for instability are competition and population growth.

Economic competition, aided by power politics, tends to make for oscillations that may return to what might be called structural stability. That is, they make for economic and political oscillations rather than conservative stationarity. Populations of polities, empires, regions, and global world-systems also exhibit oscillations if we average out the trends of population growth, e.g. over the last several millennia. Jen defines "structural stability" as the ability to return from instability through dynamics other than the original (e.g. by varying external parameters) that are qualitatively similar to the original dynamic, as, for example, the standard Lotka-Voltera oscillations. While economic and political systems are not stable in the strict sense, they may have the resilience to return to structural stabilities as they pass through oscillations with differing but qualitatively similar dynamics. Major population growth trends, however, as they interact with dynamical oscillations or limit cycles, may lead to "structural instability" – an inability to return to stability even through dynamics other than the original or to recover a dynamic that is qualitatively similar to the original. The imperative of incessant competitive innovation for successful cities and city systems forms part of what leads to overgrowth of population relative to resources, and thus to subsequent system crashes. Historically, these instabilities lead eventually to industrial revolutions that, rather than conserve materials and energies, may push extravagant degradation of resources into dynamically irreversible crises such as global warming and problems of structural instabilities. Unless innovation turns toward conservation, the problems created will not be solved in the next century or possibly not in the next millennium. The issues here are ones of scale, expansions of scale (the size of cities, the size of polities and empires, and the size of economies); the dynamic interactions that operate at different scales; and how these couple spatially and temporally (as suggested, for example, in Modelski and Thompson, 1996).

The first questions of this study, then, are whether city systems as central economic actors and sites for multitudes of agents are stable or unstable, and if unstable, what kinds of models are appropriate for consistency with their dynamics. The thesis here is that it is not just individual cities that grow and decline, but entire regional (and global) city systems. Here, drawing on our earlier work (White *et al.*, 2005), Michael Batty (2006: 592) states our case for us. “It is now clear that the evident macro-stability in such distributions” as urban rank-size or Zipfian hierarchies at different times “can mask a volatile and often turbulent micro-dynamics, in which objects can change their position or rank-order rapidly while their aggregate distribution appears quite stable” Further, “Our results destroy any notion that rank-size scaling is universal … [they] show cities and civilizations rising and falling in size at many times and on many scales.” What Batty shows, using the same data as we do for historical cities (Chandler, 1987), is legions of cities in the top echelons of city rank being swept away as they are replaced by competitors, largely from other regions.[2]

Data

City-size data for historical Eurasia

Chandler’s (1987) database on historical city sizes is complemented by overlapping UN population data from 1950 to the present (in the interest of brevity we do not present these results here). Chandler reconstructed urban populations from many data sources. These included areas within city walls times the number of people per unit area (see Appendix A); connected house-to-house suburbs lying outside the municipal area; data from city histories provided by city librarians; estimates from numbers of houses times the number of people per house; and the cross-checking of different estimates (see Pasciuti and Chase-Dunn, 2002). From CE 900 to 1970, his size estimates cover over 26 historical periods, usually spaced at 50-year intervals, always comprising a set of largest cities suitable for scaling in a single period. These data include 80 Chinese, 91 European, and, in between, a much larger number of Mid-Asian cities.

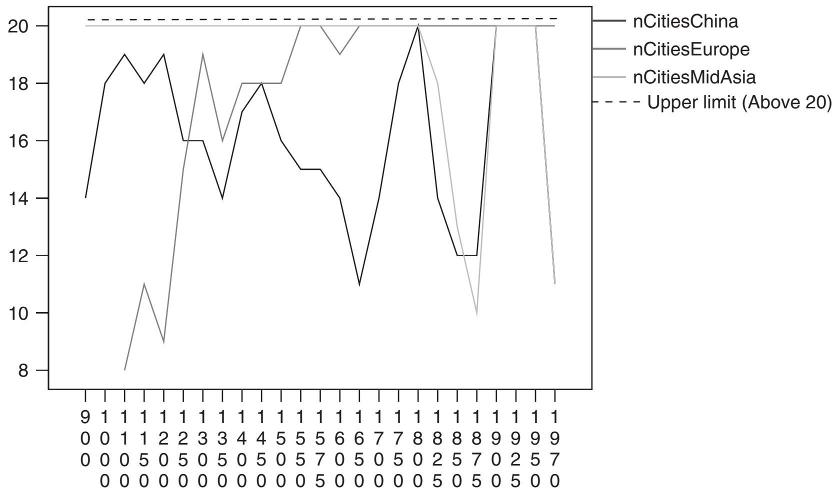


Figure 9.1 Number of centers in the top 75 world cities in each region when they fall below 21.

Figure 9.1 shows numbers of cities in the dataset for each period when they fall below 21. European cities in the top 75 world cities increase from eight to 21 from 1100 to 1575, while those of China drop from 19 to 11 between CE 1200 and 1650. Mid-Asia has more than 20 cities in the top 75 up to 1875. One concern is whether there are too few cities in some periods to differentiate the characteristics of the tail of the size distribution (largest cities) from that part of the size distribution that reaches down to the smaller cities.

Trade routes (Eurasia)

The total length of the Eurasian long-distance trade routes between 3500 BCE and CE 1500 at 50-year intervals have been calculated by Ciolek (2005) from trade-route maps drawn by Sherratt (2003). World-system pulsations in expansion and contraction of trade routes are shown by Turchin (2007). Turchin calculated a connectivity index for the Silk Routes between China and England. His data also show how instances of epidemics are concentrated near the high points of trade before periods of collapse.

Socio-political instability (SPI): Internecine wars (China only)

We define socio-political instability as internecine wars or regional outbreaks of social violence. Turchin (2003: 164) transcribed J. S. Lee's (1931) coded five-year interval data on internecine wars in China, ranging from regional uprisings to widespread rebellions and civil wars, from 221 BCE (first unification by the Ch'in Dynasty Emperor) to 1929, in order to create a ten-year sequential intensity index to 1710. D. R. White converted Turchin's codes into a 25-year index running from 0 CE to 1700 and coded 1725–1925 directly from Lee (1931). Lee coded the period to the end of the Ming Dynasty from a remarkably systematic inventory of conflicts by Chih Shao-nan from the *Tih Wang Nien Piao*, and this was checked for accuracy by Tung-Kien (Lee, 1931: 114). The *Tabula Annua (Seikainenkan)*, cross-checked and supplemented by the *Tai Ping Tien Kuo Chan Ssi*, proved a reliable record of Ch'in Dynasty wars, with those following 1930 from Lee's memory. The systematic pattern discussed by Lee for his graphs is one of two 800-year periods (200 BCE to CE 600, then to CE 1385) in which many more of the intra-territorial China conflicts occur in the last 400–500 years than in the early 400–300 years, and a partial repetition up to 1927 of that same pattern. The other evident pattern is for transitions between dynastic periods to be marked by more frequent and severe conflicts.

Total population and population-change data (Eurasia)

The early data on Chinese population from CE 900 to 1300 are controversial. White had data from Chao and Hsieh (1988), provided by Turchin (2003: 164–165), consulted Ho (1956, 1959), Steurmer (1980), and Heilig (1997, 2002), as well as Heilig's (1999) compilation of data from Mi Hong (1992) and Durand (1960). Given the uncertainty in absolute figures, we coded a binary variable for each 25-year period, where "1" is given for a date at which there is a population peak before collapse, with "0" otherwise. The different total population estimates available to us for China over our full time frame agreed very closely as to where these population peaks occurred. In some cases, two adjacent peaks were indicated.

Turchin (2006, 2007) provided population, carrying capacity, detrended population, and a misery index (inverse wages) for England that could be useful in comparisons with our European city data.

Monetary liquidity (China only)

For 900–1700 CE, we coded an index of monetization (liquidity) in China using Temple's (1986: 117–119) discussions (drawing on Needham 1954–2004) on the development of credit, paper money, banking, and inflation (indexing lower liquidity) into a qualitative judgmental scale from 0–10.

The q/β scaling and hypotheses

Measuring departures from Zipf's law for city-size distributions

We begin by examining the city-size distributions of macroregions in the Eurasian continent, over roughly the last millennium, which is the millennium of Eurasian and then planetary globalization. We examine the

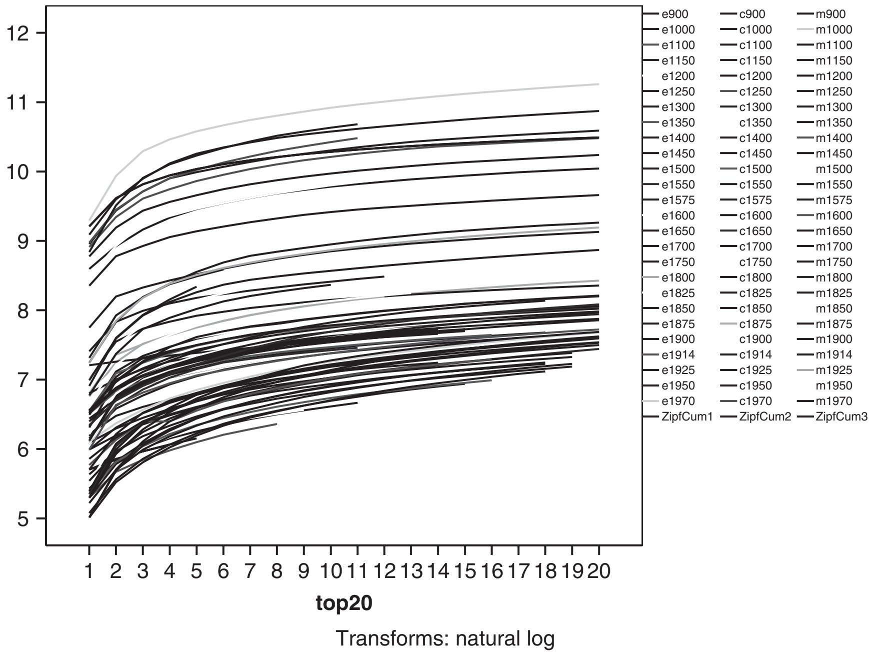


Figure 9.2 The Chandler rank-size city data (semi-log) for Eurasia (Europe, China, and Mid-Asia). Some lighter contrastive curves are not visible. Original in color at http://intersci.ss.uci.edu/wiki/index.php/Tsallis_q_historical_cities_and_city–sizes

extent of instability of city systems in ways that are visually evident by inspection of changes in the shapes of Eurasian city-size distributions, and as measured by shape indices. Figure 9.2 shows a semi-log graph of the cumulative rank-size distribution for divisions of most of Eurasia (excluding Japan/Korea) into three regions: China (*c*.900–*c*.1970), Europe (*c*.900–1970) and the Mid-Asian (*c*.900–*c*.1970) remainder. The curve to which power-law distributions should correspond is shown by the top (ZipfCum) power-law curve. Cumulative population size is logged on the *y*-axis, and the *x*-axis is city-size rank. The Zipfian curve forms a straight line when the rank is also logged, with a Pareto (1896) log–log slope of 2. As can be seen visually, there is some departure from the perfect parallelism in the empirical curves: some lines are more curved or less curved for the top cities than the Zipfian; most lines are flatter than the Zipfian for the smaller cities; and many of the curves bend at different city ranks.

Figure 9.3 shows the same data (all three regions) in a log–log plot where power-law city distributions would all be straight lines and Zipfian distributions would all have the same slope. The lines are neither parallel nor of the same slope, and neither do they have curvatures in the same places.

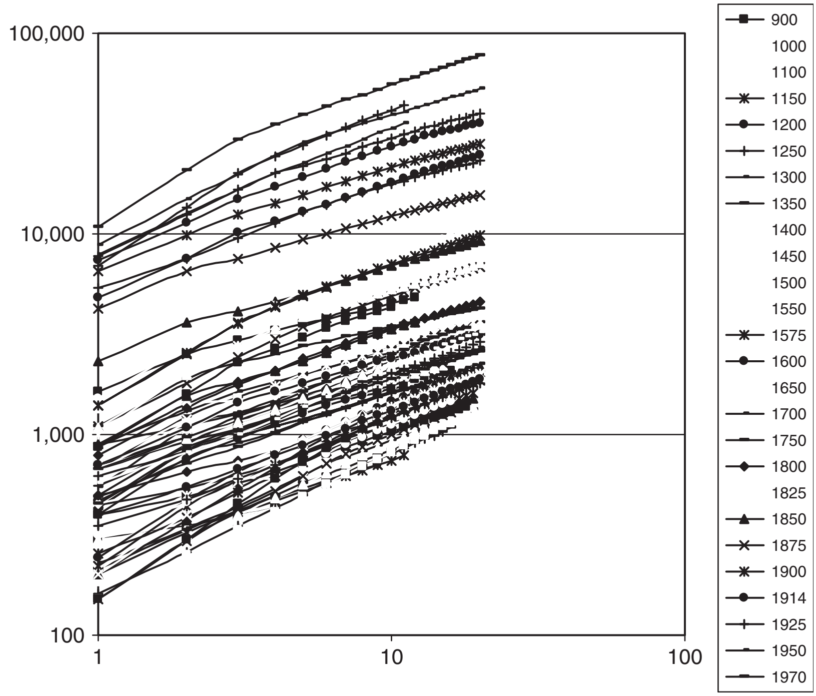


Figure 9.3 The Chandler top 20 rank-size city data (log–log) for Eurasia (Europe, China, and Mid-Asia). Partial legend shown only for Europe (China and Mid-Asia legends not shown). Original in color at http://intersci.ss.uci.edu/wiki/index.php/Tsallis_q_historical_cities_and_city–sizes

Our measurements of the properties of these distributions will be aimed at the hypothesis that these variations provide indicators useful for showing how city-system fluctuations fit into economic and historical dynamics.

We use two measures of how these curves vary. Each measurement model is based on a standard continuous function with parameter fitting based on recasting the data as a cumulative probability in its complementary form. $P(X \geq x)$ is the probability that an urbanite will reside in a city of at least size x. Each model is aimed at capturing the complete (Pareto II) shape of the empirical $P(X \geq x)$ or part of that shape (Pareto I for the tail) as a cumulative complementary distribution function (CCDF). It is important to use maximal likelihood estimates (MLE) in fitting the parameters of distributional models, and especially so with small samples. MLE is consistent and both asymptotically normal and unbiased, the latter meaning that with n independent samples of the same data, the expected values of the estimated parameters for each sample converge more closely to the true parameter values the larger the total sample (Clauset, Shalizi, and Newman 2007).

The first measure is the standard (type I) Pareto distribution with a single parameter β where the Zipfian is the special case of $\beta = 2$:

$$P_\beta(X \geq x) \sim x^{-\beta} \tag{1}$$

The fit to this distribution captures the extent to which the lines are straight in Figure 9.3, as is typical for the tails of city-size distributions.

Fit to a second function, a type-II generalized Pareto distribution, with a cut-off σ (Arnold, 1983), captures the extent to which a given log–log distribution is curved. This function allows the recognition that Zipf's law and power laws for city sizes almost always have one or more cut-offs of a lower size below which the power-law changes or ceases to apply.[3] This function fits a shape parameter θ (analogous to β), and a scale parameter σ, to the urban distribution.

$$P_{\theta,\sigma}(X \geq x) \sim (1 + x/\sigma)^{-\theta} \tag{2}$$

The type-II Pareto has an extra cut-off parameter σ, but given sufficiently large samples and maximal likelihood estimation (MLE) of parameters, there are many advantages to a parameter that specifies the cross-over where the curve breaks for a power-law or Zipfian tail. The Pareto II function:

1 can fit an exponential function or a collapsed tail in cases where a power-law or Zipfian tail is inapplicable.
2 with MLE (maximal likelihood estimation), yields parameter estimates that are consistent and asymptotically unbiased. MLE runs can be batched for multiple datasets, and the MLE commands are easy to copy and paste into *R*.[4] Standard errors are typically very small for city-size data, and the true values of the parameters are likely to be within these limits.

MLE provides consistent parameter estimates that allow one-to-one functional transformations of the parameters into equivalent models (Brown, 1986). The q-exponential $Y_q(S \geq x) = Y0(1 - (1 - q)x/\kappa)^{1/(1-q)}$ and its shape (q) and scale (κ – i.e. kappa) parameters is a one-to-one functional transformation of equation (2) where $q = 1 + 1/\theta$ and $\kappa = \sigma/\theta$. Y_q has been previously used (Malacarne *et al.*, 2001) for city-size distribution scaling. Bootstrap estimates of the standard error and confidence limits of the q, κ parameters derived from θ, σ are provided by Shalizi's (2007) R program for MLE. There are many other advantages of Y_q and Pareto II that we do not exploit here.[5]

A continuity theorem often used with the Y_q model (Tsallis, 1988) gives the relation in the Pareto II and Y_q functions, when $1 < q \leq 2$, between a Y_q tail that asymptotes to a power law with slope $1/(q-1)$ and a Pareto I tail with slope β. The Y_q curvature, however, captures that of the smaller cities in the distribution. The theorem is important to the study of city sizes where smaller cities do not follow a power law and we often lack data on the actual distribution for smaller cities – a problem that we will take up next. More generally, although that is beyond the scope of this chapter, the q-exponential is interpretable as one of the theories developed in "behavioral statistical physics" (Farmer, 2007) and $q = 1$ (the limiting case of an infinite θ) has a special meaning as an entropic system "at rest," lacking complex interactions and power-law behaviors. For cities, $q \leq 1$ is an indicator of system collapse, while for $q > 2$ the larger cities are size outliers that disrupt the estimation of variance.

Measurement error for Pareto II departures from Zipf's law for city-size distributions

There are two potential sources of error for Pareto II parameters that are not soluble without MLE. They are sufficiently important to merit discussion here, because first they affect the accuracy and interpretation of results, and second they provide crucial information needed for others to replicate results using MLE. One is the boundary specification of the region studied. China and Europe, for example, are more naturally bounded areas than our Mid-Asia, which runs from Cordoba to India and Southeast Asia and is partly defined by the spread of Islam. The second is the size of the sample: if there is a small number of largest cities for which there are data, estimation of the scale or crossover parameter $\sigma = \kappa/(q-1)$ of the Pareto II distribution may err because the sample does not provide the relevant evidence for curvature away from a power-law tail. In this case σ will be close to zero to insure an approximation to the ordinary Pareto because the 1 in $1 + x/\sigma$ from equation 2 becomes negligible when the values of x are divided by a diminishingly small σ (i.e. they are multiplied by a large constant). In China and Europe, we find a strong coefficient of determination (significant at $p < 0.005$) between $\sigma < 0.04$ and having fewer than 18 cities in the sample. In this case, σ is commonly in the range $0.00001 > \sigma > 0.0000001$, as contrasted to $\sigma > 5$ (ranging up into the thousands) for the larger city samples. Must we conclude when σ is small, in the cases of small samples of the largest cities, that the appropriate distribution function is Pareto I and not Pareto II (q-exponential) when the Pareto I fit may be due to missing data? These small values of $\sigma (\ll 1)$ are non-arbitrary, however, and the fitted Pareto I parameter $\beta (\approx \theta$ in this case) must converge to $1/(q-1)$ when $1 < q \leq 2$.

We are thankful to Shalizi (2007) for writing an MLE program in R for our use in estimating parameters θ, σ (Arnold, 1983) in equation (2).[6] He also gave us his R program for standard MLE fits to the Pareto distribution.

The left-hand graph of Figure 9.4 shows some of the early, middle and late period q-exponential curves for Chinese cities fitted by MLE using a normalized cumulative probability distribution. These are for periods where $\sigma > 1$ (i.e. $\kappa > 1/\theta = q - 1$). These cases also fit the q-exponential better

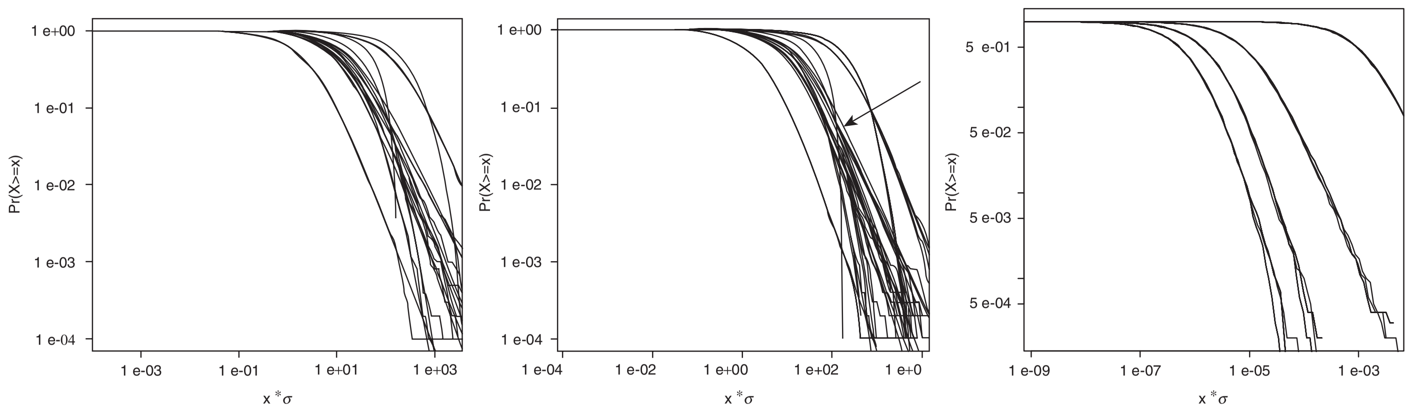


Figure 9.4 Probability distributions of Chandler rank-size city data (log–log) for China. Smooth lines are for the fitted curves in successive time periods, and the jagged lines are illustrative bootstrap sample fitting used to estimate error bounds.

than a power-law MLE for the same data. What this graph shows is a very regular pattern for the fitted curves. First, like the empirical data, the fitted curves tend to asymptote toward a power-law (Pareto I) tail for the larger cities. Second, there is considerable variation in the slopes of these tails. Third, there is a second horizontal asymptote convergent on $P(X \geq x) = 1$, where "cities proper" cease to occur at smaller settlement sizes. This allows an estimate and reconstruction of total urban population at different city sizes. Fourth, there are distinct historical periods, ones that come in three clumps, within which there are ups and downs in slopes. Fifth, each period tends to have something of a fixed pivot (shown by the arrow) below the cross-over from the power-law tail to smaller sizes. The center graph in Figure 9.4 shows the same Pareto II curves, but with additional fits for random samplings of the same data points. Additional fittings like these allow bootstrap estimates of the standard errors of estimates, which in almost all our empirical cases are very small.

The right-hand graph in Figure 9.4 shows the normalized probability MLE fits for China in historical periods where values of σ are small ($\ll 1$). Small σ may be caused by small samples, as seen in many periods in Figure 9.1 for China or Europe, or by summation of distributions from different regions (as with Mid-Asia). The precision of ML parameter estimation solves the problem of comparability of q values given very different σ estimates ($\ll 1$ and > 1), but relabels the x axis in the $\sigma \ll 1$ case on a scale that allows us to focus on the small values of σ but also to see the same shapes of the Pareto II distribution as in the cases where $\sigma > 1$.[7] The bootstrap standard errors for σ and κ are small within each period (but not across periods). The $\sigma \ll 1$ values are thus technically correct, along with q, although precision may be added in further studies through MLE correction for the very smallest sample sizes, since they are more likely to be underestimated.

The Mid-Asian region has more cases where $\sigma \ll 1$, but these are neither caused by nor correlated with small samples. Rather, the broad Mid-Asian power-law tails are likely to result from summing somewhat divergent regions that each have shorter power-law segments in their tails, with summation making for a longer Pareto tail in the aggregate (Farmer, 2007). What this indicates is that the magnitude of the θ parameters for Pareto II might be underestimated (longer tails with lower θs than the true values for properly specified regions).[8] Since our comparisons depend on relative variations within or across regions, these might not affect our findings on Mid-Asia.

The MLE methods, then, solve many but not all the potential measurement errors for Pareto II departures from Zipf's law. Remarkably, when only the power-law tail is present in the sample, without any overt indication of departures from the power-law, MLE still estimates q correctly in a way that converges with a power-law fit for the tail, but it retains the prediction that the fitted q and κ, in the normalized probability distribution, represent a correct prediction of both smaller city sizes and total population.

Hypotheses

Several linked hypotheses build on one another, each supposing the previous hypotheses to be supported, and each adding greater specificity in relation to the parameters of the two models, β for the Pareto I and θ for Pareto II (thus q for the q-exponential):

H1 The Zipfian ($\beta = 2$ and $q = 1.5$ for our CDF) is posited as the most likely historical norm for the tails (β) and bodies (q) of city-size distributions.[9] Over long historical periods these should be expected as average values around which q and β fluctuate.

H2 Variations in q and β are conservative as population measures that are affected by births and normal mortality, but may change quickly when influenced by migration, and by socio-political instability (SPI), that is, internecine wars or outbreaks of violence.

H3 Variations in q and β are thus likely to exhibit stability within historical periods of multiple generations, with Zipfian values on both measures correlated with periods of stability and normality, followed by instabilities that may occur suddenly.

H4 As such, q and β are indicators of rise and fall of urban-system size-distributions in both the body and the tail of the distributions, which may vary with considerable independence.
Tails may (a) collapse and shorten (β dropping toward 1), or grow into (b) longer, thinner and lower ($\beta \leq 2$) sloped tails, (c) Zipfian ($\beta \approx 2$) tails, or into (d) thicker and higher ($\beta \geq 2$) sloped tails.

- (4a) Collapse of tails should co-occur with socio-political instability (SPI), severe economic/political crisis, or major wars.
- (4b) Longer tails should be enhanced by the capitals of empires and by exceptional centers of international trade that serve as economic magnets for migration from impoverished rural areas.
- (4c) Zipfian tails should be enhanced by intra-regional trade with positive urban-hierarchy feedbacks.
- (4d) Shorter tails should correlate with external conquest of a capital or of hub cities.

H5 Intra-regional and inter-regional trade is crucial for city-system rise, and economic collapse may be involved in city-system collapse. Fluctuations of inter-regional trade may act either or both to synchronize city rise and fall between regions, or to predict from city rise and fall in a more developed region that time-delayed rise and fall will occur in a less-developed region that is strongly connected by trade. Currency, credit, banking, and monetary liquidity are leading indices of development in measuring the inter-regional impact of trade.

H6 Historical phases that are clearly marked in the population/instability cycles of structural demographic historical dynamics for periods in which agrarian empires that are relatively self-contained, lacking external perturbations (Turchin, 2003, 2005, 2006), should correlate with some but not necessarily all of the phases of city-system rise and fall, especially those involving SPI fluctuation. In this context, population growth with low pressure on resources should lead to rises in q and β, provided that trade and liquidity allow economic elites to congregate in cities and to provide employment for skilled workers. Peaks of population pressure on resources followed subsequently by high SPI levels should precipitate city-system declines. In these terms, city-system rises and falls:

(6a) are likely to be loosely but not strictly coupled into structural demographic variations.
(6b) are also interactive with inter-regional competition and global wars (Modelski and Thompson, 1996).
(6c) are likely to exhibit both longer and shorter (i.e. less predictable) historical periods of stability, given this combination of regionally endogenous and regionally exogenous dynamics.

Those hypotheses are testable. The following are more speculative observations about evolutionary tendencies, predicated on our findings:

H7 In spite of the growth of gross world product (GWP) rising at faster rates than population, there is no evolutionary historical tendency evident toward either greater stability, greater instability, or alteration in the periodicities of city-system ups and downs, in spite of, and probably because of, the pressures of rising global and rising urban populations. Evolutionary stability in city systems, as a form of recovery from small perturbations, apparently remains something to be learned rather than taken for granted.

H8 Stability as recovery from large perturbations through structural demographic oscillatory dynamics, however, has apparently been learned, but urban instabilities are only weakly coupled to oscillatory structural demographic recoveries, so evolutionary learning is only partial. The introduction of new dynamics complicates the question of whether city systems will acquire greater stability.

Scaling results

Using visual and statistical evidence for changes in the shape parameter, White *et al.* (2005) in an earlier study were able to date six Q-periods in Eurasia over the last millennial period. These changes and periods were seen to be related to the framework for studying globalization developed by Modelski and Thompson (1996). In studying multiple regions, we take a more detailed and dynamical view of this relationship.

Figure 9.5 shows the q and β slope parameters fitted by MLE for the regions of China, Europe, and the region between (Mid-Asia, from the Middle East

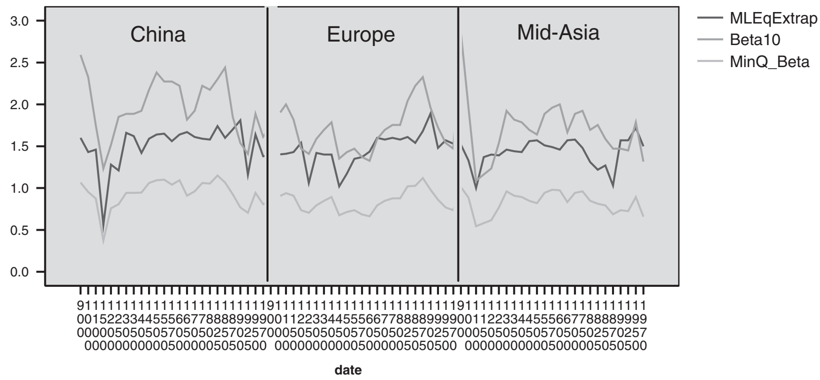


Figure 9.5 Values of q, beta, and their normalized minima.

Table 9.1 Descriptive statistics for city curve shapes

	N	*Minimum*	*Maximum*	*Mean*	*Standard deviation*	*Standard deviation/ Mean*
MLEqChinaExtrap	25	0.56	1.81	1.5120	0.25475	0.16849
MLEEuropeExtrap	23	1.02	1.89	1.4637	0.19358	0.13225
MLEMidAsIndia	25	1.00	1.72	1.4300	0.16763	0.11722
BetaTop10China	23	1.23	2.59	1.9744	0.35334	0.17896
BetaTop10Eur	23	1.33	2.33	1.6971	0.27679	0.16310
BetaTop10MidAsia	25	1.09	2.86	1.7022	0.35392	0.20792
MinQ_BetaChina	25	0.37	1.16	0.9645	0.16247	0.16845
MinQ_BetaEurope	23	0.68	1.26	0.9049	0.15178	0.16773
MinQ_BetaMidAsia	25	0.54	1.01	0.8252	0.13217	0.16017
Vaild *N* (listwise)	19					

to India). Here, a Zipfian tail would have $q = 1.5$ and $\beta = 2$. The horizontal line shows that this slope and shape is approximated more recently in the early modern and modern period. We also show a normalized minimum of q and β, in which we divide q by 1.5 and β by 2.0 to normalize for the Zipfian. Table 9.1 summarizes all the descriptive statistics used.

These results support H1, that the Zipfian is the historical norm both for tails and bodies of city-size distributions, approximating $\beta = 2$ and $q = 1.5$. Mean values for q in the three regions vary around $q = 1.5 \pm 0.07$, consistent with a Zipfian tail, and similarly for variations around $\beta = 2 \pm 0.07$ for the Pareto slope of the top 10 cities. Statistical runs tests of whether the variations around the means are random or patterned into larger temporal periods are shown in Tables 9.2 and 9.3. The runs tests reject the null hypothesis ($p < 0.01$ for Europe, $p < 0.05$ for Mid-Asia, and $p < 0.06$ for China; $p < 0.00003$ overall), supporting H3.

Table 9.2 Runs tests at medians across all three regions

	MLE-q	*Beta10*	*Min(q/1.5, Beta/2)*
Test value (a)	1.51	1.79	0.88
Cases < test value	35	36	35
Cases ≥ test value	36	37	38
Total cases	71	73	73
Number of runs	20	22	22
Z	−3.944	−3.653	−3.645
Asymp. sig. (two-tailed)	0.0001	0.0003	0.0003

Table 9.3 Runs test for temporal variations of q in the three regions

	mle Europ	*mle MidAs*	*mle Chin*
Test value (a)	1.43	1.45	1.59
Cases < test	9	11	10
Cases ≥ test	9	11	12
Total cases	18	22	22
Number of runs	4	7	7
Z	−2.673	−1.966	−1.943
Asymp. sig. (two-tailed)	0.008	0.049	0.052

a Median

The time periods of successive values above and below the medians represent the rise and fall of q to Zipfian or steeper-than-Zipfian slopes alternating with low-q periods with truncated tails of the distributions. Relatively long city-slump periods occur in the medieval period for all three regions, then a second slump occurs in Europe in 1450–1500, another in Mid-Asia in 1800–1850, and one in China in 1925 (not shown) when q falls to 1.02.

As for H6, there are rough correlations for both secular cycles (Turchin, 2003, 2005, 2006, 2007) and Modelski and Thompson (1996) globalization processes with the dates of urban crashes, shown in Table 9.4 below.

As shown by the lower dashed line in Figure 9.6, values of q below 1.3 might be considered as reflecting a city-system crash or collapse/destruction

Table 9.4 Temporal breaks and urban crashes of β/q in the three regions

Breaks	*950*	*1150*	*1430*	*1640*	*1850*
Cycle	*1*	*2*	*3*	*4*	*5 (Modelski and Thompson 1996: table 8.3)*
Mid-Asia:	**1100,**		1450		**1825–75, 1914** (**major**/minor **urban crashes**)
China:	**1150–1250,**			1650	**1925** (**major**/minor **urban crashes**)
Europe:		**1250,**	**1450–1500,**		1950? (**major**/minor **crashes**)

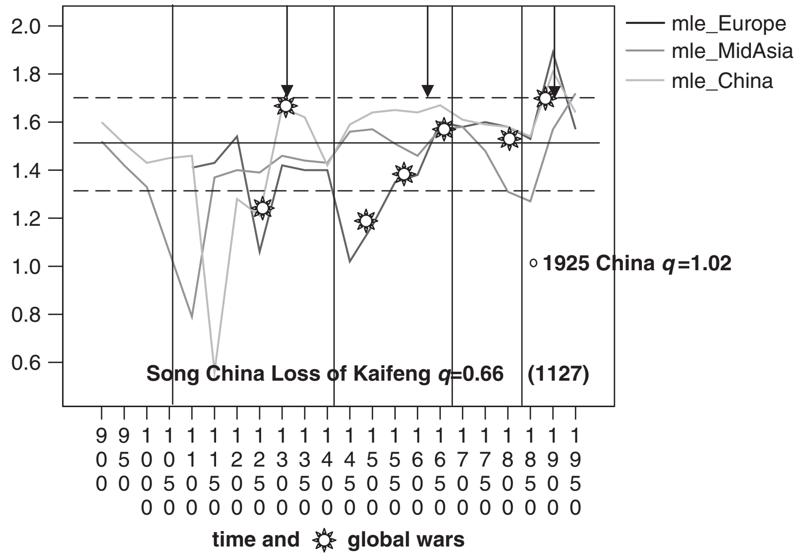


Figure 9.6 Fitted q parameters for Europe, Mid-Asia, and China, CE 900–1970, with 50-year lags. Vertical lines show approximate breaks between Turchin's secular cycles for China and Europe. Downward arrows represent crises of the fourteenth, seventeenth, and twentieth centuries.

of the largest cities. China and Europe experience an abnormal rise in q in 1900 beyond 1.7 (upper dotted line). This results in a thin-tailed distribution (extreme primate cities) that might be considered as a different kind of city-system crisis. Some crashes have to do with wars, like the Song's loss of their capital to the Jin in 1127. Global wars, noted by stars on the lines in Figure 9.6, might be connected with the punctuations of these periods, but we are unable to evaluate that question statistically. Crashes in q often occur at long intervals (**bold** dates in Table 9.4), as in Figure 9.5, with β falling at shorter intervals.

These results support H2, that variations in q and β are *conservative* (since births and normal mortality are slow to affect population measures) but may also *change quickly* in ways consistent with inter-urban migration, internecine wars and outbreaks of violence or general socio-political instability (SPI). They also support H3, that variations in q and β may have long periods of stability, with Zipfian values on both measures correlated with periods of stability and normality, and that stability may be followed by sudden instabilities, or drops in q, β, or both.

Cross-correlation of the scaling measures

One of the major patterns of variability in city distributions is the primate city effect: the primate and top-ranked cities often form a steeper urban hierarchy in periods of economic boom or empire, or when the primate city is a major international trade center. In periods of decline they may form a truncated tail compared with the body of the distribution. Further, the slope of the tail of the size distribution (β) tends to change faster than the body shape of the distributions. This is tested using data from all three regions using the autocorrelation function (AFC), where values of a variable in one time period are correlated its values for 1–16 time lags (in this case each lag being 50 years). The upper and lower confidence limits are at 95 per cent for a two-tailed significance test ($p < 0.05$). The AFC of β compared with q shows a much higher short-term continuity (one lag of 50 years), a recovery period at five to six lags, and then autocorrelation largely disappears, while q varies more continuously with more stable long-term autocorrelations (up to 16 lags or 800 years). The ratio of q/β has autocorrelation only for Europe, and is oscillatory but the autocorrelation is not statistically significant.

Figure 9.5 has shown that q and β vary somewhat independently, often correlated positively when $\sigma \ll 1$ ($\kappa \ll 1$), recalling that β is a negative slope and q varies inversely to that slope but negatively when $\sigma > 1$ ($\kappa > 1$). But which one affects which over time if the two are synchronously somewhat independent? In a time-lagged correlation: does the shape (q) of the body of the city affect the tail (β) in subsequent periods, or the reverse? The β might shape q if long-distance trade has an effect on the larger cities engaged in international trade, but q might shape β if it is the waxing and waning of industries in the smaller cities that feed into the export products for the larger cities, as we often see in China and Europe.

What lagged cross-correlations show for China and Europe – but not in Mid-Asia – is that, starting from the maximal correlation at lag 0, high q (e.g. over 1.5) predicts falls in Pareto β over time, reducing the slope of the power-law tail below that of the Zipfian. This suggests that high q produces an urban system decline in β. This would contradict a hypothesis of long-distance trade as a driver of rise and fall in the larger cities. However, it would not contradict the possibility that long-distance trade was directly beneficial to the smaller cities, with these effects feeding into the success of the larger cities but with a time lag. For China and Europe, where successful long-distance trade was organized on the basis of the diffusion of effective credit mechanisms available to the smaller merchant cities, this seems a plausible explanation for the time-lag findings. These credit mechanisms were not so easily available in Mid-Asia where Islam operated to regulate interest rates to prevent excessive usury.

If there is a correlation between long-distance trade and the rise and fall of population pressure in the secular cycles of agrarian empires, our data might support Turchin's (2007) argument, formulated partly in response to our own studies of the role of trade networks in civilizational dynamics, that it is during the high-pressure (stagflation) period that long-distance trade flourishes. If so, then the impact of trade should be reflected first in variations in q, which vary more slowly than β.

The overall pattern in the cross-correlations for the three regions together shows strong correlation synchronically between q and β at lag 0 ($p < 0.000001$), where high values of q predict falling values of β over time over three 50-year lags. Variables q and β have the least cross-correlation for Mid-Asia, but detailed examination of the Mid-Asia time lags shows a weak cyclical dynamic of Hi-$q \rightarrow$ Lo-$\beta \rightarrow$ Lo-$q \rightarrow$Hi-β that holds up to 1950.

Historical network and interaction processes

H5 posited that intra-regional and inter-regional trade is crucial for city-system rise, and economic collapse may be involved in city-system collapse. The data presented here support this hypothesis, but we approach the question first as to whether, at the inter-regional level, there is synchrony between regions, and of what sort, and whether trade is involved in this synchrony.

Turchin (2007) shows evidence for "a great degree of synchrony between the secular cycles in Europe and China during two periods: (1) around the beginning of the Common Era and (2) during the second millennium." We also find evidence for synchrony in city-system rise and fall in common temporal variations in q for the second millennium. The correlations in q by time period follow a single-factor model, as shown in Table 9.5, with China contributing the most to the 47 per cent common variance in q between the three regions.

The evidence from city sizes adds detail on dynamical interaction to that of inter-regional synchrony for the last millennium, supporting H5. Figure 9.7 shows that changes in q for Mid-Asia lead those of China by 50 years, with a hugely significant correlation at 50-year lag 1; Mid-Asia leads Europe by 150 years (lag 3) but the cross-correlation is not quite significant. The cross-correlation for China's q leading Europe by about 100 years (lag 2) is also not quite significant, although several earlier estimates of q did show significance (recall that the true values of q may vary somewhat even for MLE estimates).

H5 posits the historical specificity that Eurasian synchrony has been partly due to trade, particularly that between China and Europe (also noting that the practice of Islam in the Mid-Asian region during this period tended to restrict the full employment of credit mechanisms). The cross-correlation in Figure 9.8, showing an effect on the growth of β in Europe, sustained by the Silk Road trade, for example, suggests that trade is one of the factors causing the growth of power-law tails in urban size distributions, again supporting H5.

From European data contributed by Turchin, Figure 9.9 shows that there was synchrony between the higher values of q (normal urban hierarchy) and the percentage of the French population attracted to Paris as a regional capital and economic center, with this percentage falling after the peak in q.

Our choice of the last millennium to test the interaction of the city-size fluctuations with historical dynamics was motivated by the evolution

Table 9.5 Principal component single-factor analysis of contemporaneous regional values of q communalities

	Initial	*Extraction*
MLEChina	1.000	0.660
MLEEurope	1.000	0.444
MLEMidAsIndia	1.000	0.318

Extraction method: principal component analysis

Total variance explained

Component	*Initial eigenvalues*			*Extraction sums of squared loadings*		
	Total	*% of variance*	*Cumulative %*	*Total*	*% of variance*	*Cumulative %*
1	1.422	47.403	47.403	1.422	47.403	47.403
2	0.944	31.467	78.870			
3	0.634	21.130	100.000			

Component matrix(a)

	Component
	1
MLEChina	0.812
MLEEurope	0.667
MLEMidAsIndia	0.564

of globalization in Eurasia in this millennium. Key elements in the transition to market-driven globalization occurred in China, starting in the period of the tenth-century invention of national markets, with currencies, banks, and market pricing – a historical sequence that leads, through diffusion and competition, to the global system of today (Modelski and Thompson, 1996).

The data on credit and liquidity in the Chinese economy also closely follows the rise and fall of q, as shown crudely in Figure 9.10, supporting H5. The rise of monetization, the growth of credit, and the development of banking accompany the early Zipfian $q \sim 1.5$ of Song China, and these mechanisms of liquidity plummet with the Jin conquest of Kaifeng. The *c*.700–800 years from 1100 CE, with long periods of inflation, are required to regain liquidity and banking favoring international trade. During the Qing dynasty the Chinese money was silver coin. The first modern bank, the Rishengchang (Ri Sheng Chang) was established in 1824. It broadened to include banks in every major city, folding in bankruptcy in 1932.

For further tests of H6, we have scant data on total population relative to resources, and we have reliable data for the last millennium only for England in comparison with our Eurasian city data. There are few points

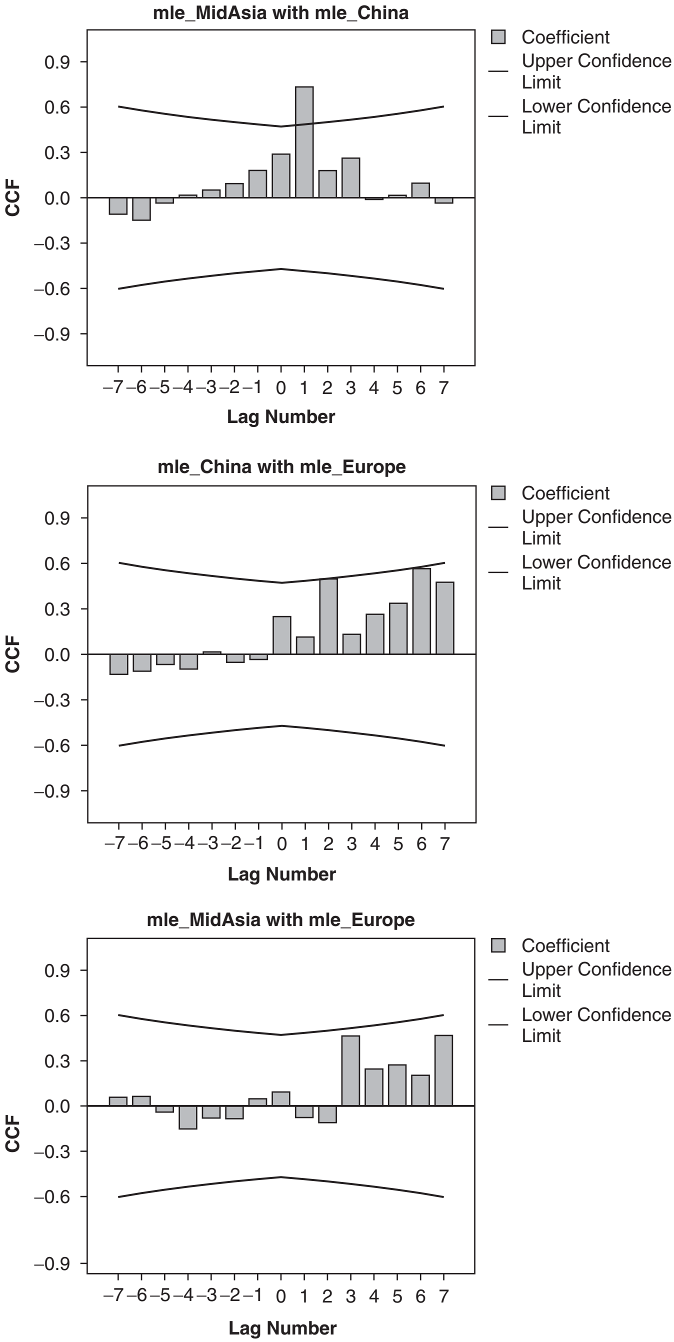


Figure 9.7 Cross-correlations for the temporal effects of one region on another.

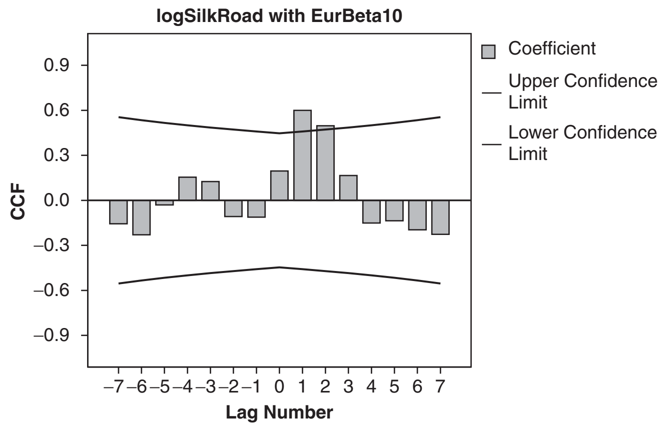


Figure 9.8 Time-lagged cross-correlation effects of the Silk Road trade on Europe.

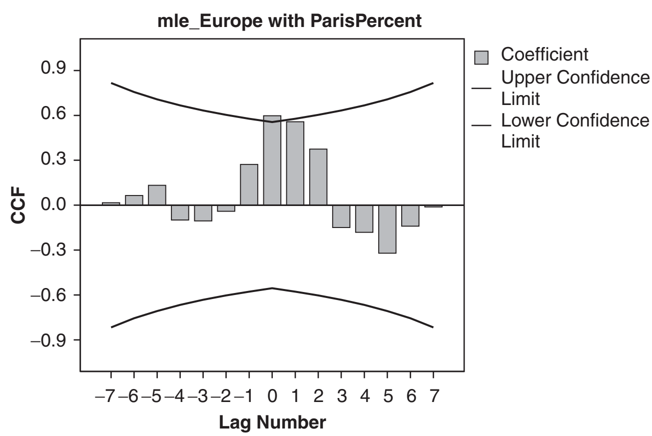
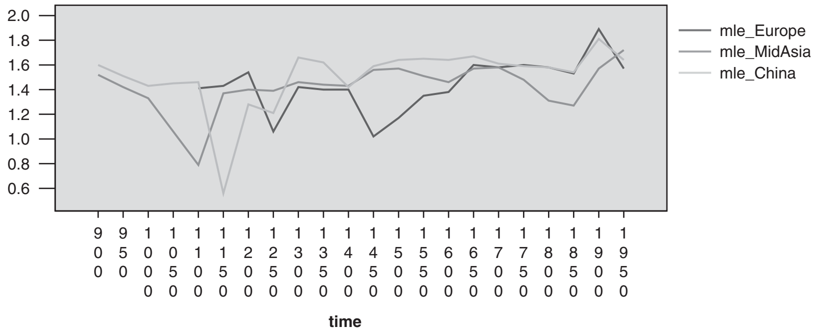


Figure 9.9 One time-lagged effect of regional q on a primate city population.

of comparison, but temporal synchronies appear in those few points: 1300 and 1625 are the peaks of scarcity for ratios of people to resources, and pre-1100, 1450, and 1750 are the troughs of plentiful resources. The peaks of scarcity correspond with slumps in q and the troughs to rises. It is impossible to rule out at this point the possibility suggested in H6 that the urban system fluctuations that we observe are interactively linked to Turchin's secular cycles, particularly if we include both types of fluctuations: those in q, in β, and in our normalized minimum of the two, as well, which may reflects either type of slump.

Figure 9.11 shows support for hypothesis H6 – the coupling between urban system dynamics and structural demographic historical cycles



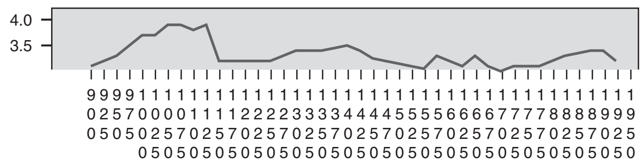


Figure 9.10 A crude long-term correlation between Chinese credit and liquidity (lower graph), estimated from Temple (1986), and Chinese (European, Mid-Asian) data and *q* (upper graph).

(Turchin, 2005). The three insets show Lee's (1931) data on socio-political instability (SPI: specifically, internecine wars) for the periods of the Han, Tang, and Song dynasties (broken lines) against data on detrended population (solid lines).* J. S. Lee interpreted his data on Chinese internecine wars from 200 BCE (Han period) to 1930 as showing 800-year cycles of internecine conflict, weakly separated into two 400-year periods. Figure 9.11 breaks up his data into agrarian empire historical periods in which there are no major disruptive external wars. The relation of population pressure phasing to that of SPI is similar in each case, with SPI lagging population pressure** at a roughly generational interval. This produces four phases: population growth (and certain types of innovation) in phase 1; rising resource scarcity and SPI, rising to a population peak in the stagnation phase, phase 2; a phase 3 of falling SPI and falling population pressure; and a fourth phase with minimum population pressure and SPI. Each period repeats a similar endogenous dynamics defined by the negative time-lagged feedback between *P*, population density per resource, and SPI, fitting a two-equation model (with appropriate constants):

$$SPI_{t} \sim \mathrm{AP}_{t-1} \qquad \text{(population change drives change in SPI)} \qquad (3)$$

$$P_{t} \sim -\mathrm{B}\ \mathrm{SPI}_{t-1} \qquad \text{(SPI has a severe effect on Population)} \qquad (4)$$

*Han and Tang regional populations are divided by the estimated agricultural food supply (Turchin 2005); while the Ming regional population (Zhao and Xie 1988) is divided by the growth trend.

**Here we use our 0/1 population coding defined on page 197.

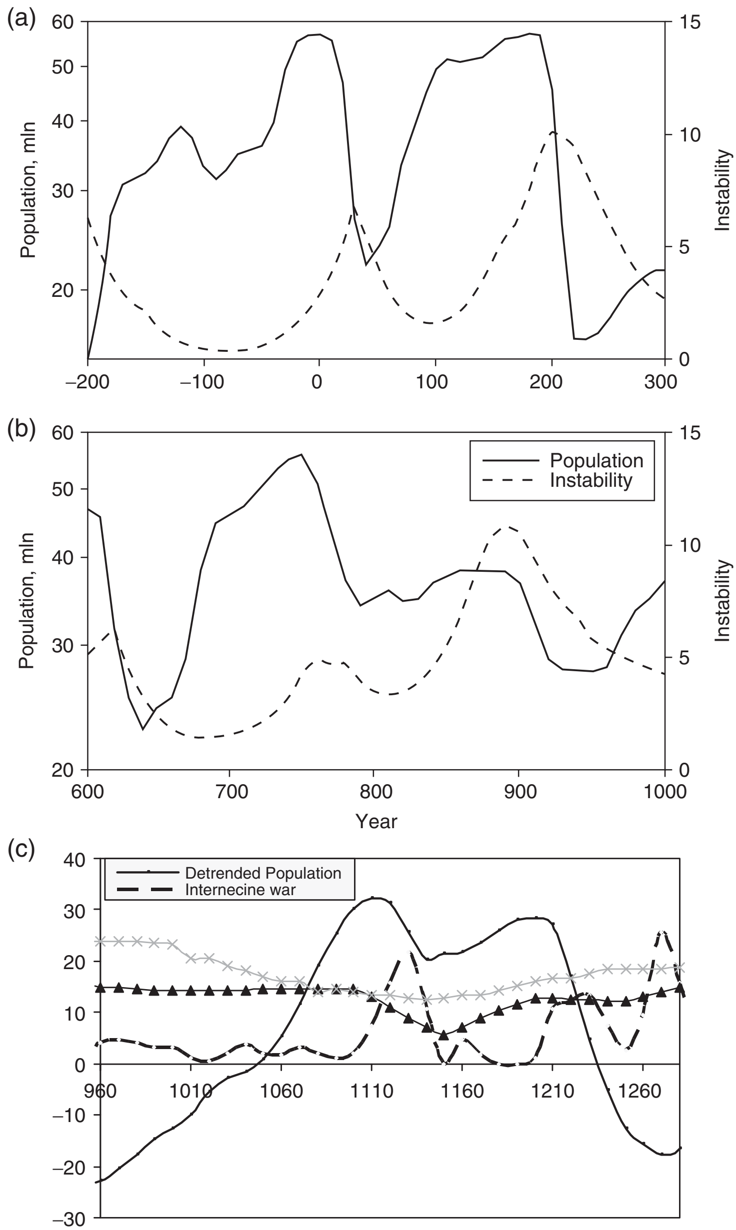


Figure 9.11 China's interactive dynamics of socio-political instability (broken curve for internecine wars – J. S. Lee 1931) and population: (a) Han (200 BCE to CE 300) and (b) Tang (CE 600 to 1000) from Turchin (2005), with population detrended by bushels of grain; (c) Song Dynasty population (CE 960 to 1279) divided by successive trend values.

The third inset in Figure 9.11 falls within our period of study for China and adds our measures of city-system parameters q (diamonds) and β (thin line) each multiplied by 10 for easy visibility.

The fall in β (see the thin line) in Figure 9.11 (c), which indexes a fatter tail for large cities, caused for example by people leaving the largest cities to go to smaller ones, occurs with a rise in population pressure. Decline in q (triangles) signals a change in the shape of the city-size curve that affects the smaller cities and works to their advantage in indexing the disproportional change in size of smaller cities "up" into the thicker tail of the city-size distribution: this occurs in Figure 9.11(c) just before the population peak. The trough of β co-occurs with the peak of the SPI crisis of socio-political violence. The trough of q occurs once the SPI crisis has ended, followed by rising q with renewed growth in population pressure, P, then leveling of q before the next population peak. As in the endogenous dynamic of sustained fluctuation modeled by Turchin's equations (1) and (2), upward P leads upward SPI by a generation and downward SPI leads upward P by a generation.

A four-variable dynamic including q and β, however, is not that simple. Two-equation time-lagged regressions with constants fitted to each term behave similarly for China and Europe, 925–1970, as shown in equations (5) and (6), except that the SPI index affects q without a time lag. Socio-political instability tends to have an immediate effect on the relation between smaller and larger cities that affects q but not β:

$$\beta_{\mathrm{t}} \sim -\mathrm{C}q_{\mathrm{t}-1} + q_{\mathrm{t}-1}\beta_{\mathrm{t}-1}$$

$$\text{(overall } R^2 \sim 0.79, \text{China} \sim 0.75, \text{Europe} \sim 0.69) \tag{5}$$

$$q_{\mathrm{t}} \sim -\mathrm{D}\beta_{\mathrm{t}-1} + q_{\mathrm{t}-1}\beta_{\mathrm{t}-1} - \mathrm{SPI}_{\mathrm{t}}$$

$$\text{(overall } R^2 \sim 0.57, \text{China} \sim 0.54, \text{Europe} \sim 0.66) \tag{6}$$

Further, without the effect of SPI, these two equations, unlike (1) and (2), would predict positive feedback between β and q that would result in either a convergent or a divergent time series.† It is only the SPI index, given the locations of SPI events (which we also estimated for Europe from historical data) with the Turchin dynamics that act as external shocks which make the predicted time series oscillatory, and often synchronous with Turchin's endogenous dynamic (modeled by equations 1 and 2). Significantly, then, there is support for the idea that it is the conflict events within Turchin's endogenous dynamic that drive q in the city dynamic, which in turn drives β (equation 3) in that dynamic. Figure 9.11(c) represents the case for Song China, where q and β are more stable over time than population pressure and SPI,

†A two-equation reciprocal time-lag model, such as that given in equations (3) and (4) produces fluctuations if the signs of the right-hand elements are opposite, but convergence or divergence if they are the same. This can be verified in difference equations using initial values that generate a full time series.

but their periods of collapse are affected synchronically with generational time lag according to the dynamics of Turchin's model of agrarian empires.

Also significant, the three agrarian empire periods (Han, Tang, and Song) in Figure 9.11 are separated by periods of external wars and instabilities that interrupt the endogenous dynamics between population pressure and SPI fluctuations. Each period resumes fluctuation modeled by the two-equation time-lagged dynamics of P and SPI, which tend to obtain only when major external disturbances are absent. The external wars in Lee's (1931) analysis show up as large SPI fluctuations between dynasties (usually leading to their termination and a later successor empire), while internal SPI fluctuations occur within the periods of relatively high endogeneity. These various cycles couple to form the larger 800-year cycles of multiple successive empires, observed by Lee, marked by the most violent transitions. Overall, there is support in the Chinese and European examples for the aspects of hypothesis H6 initially designated 6a, 6b, and 6c.

Strong evidence for the coupling of urban system dynamics with population/instability (structural demography) historical dynamics is presented in Figure 9.12. Much as SPI leads population declines in historical dynamics, the top graph in the figure shows that SPI is synchronously correlated with low β (reduced urban hierarchy) in city distributions for China. β recovers following the peaks in SPI, just as population does. The bottom graph in Figure 9.12 shows a 50-year lag between a high q/β ratio and rise in SPI, much as population growth relative to resources predicts a rise in SPI.

Conclusions

This study and those that preceded it began as experiments in building from two sets of sources, one in quantitative history and the work of Goldstone (1991), Turchin (2003), and Spufford (2002); and the other in more meaningful mathematical and measurement concepts that incorporate city-size distributions as an object of study. The development of consistent and asymptotically unbiased estimates of variations in city-size distributions using maximal likelihood (MLE) allowed a level of precision and accuracy – although we still need continuity corrections for very small samples – that led to useful findings in this study that are likely to be reliable.

By focusing on the 75 largest cities over a series of time periods that go back to antiquity – spaced closely enough to obtain the quantitative variations of the full cycles of city-system oscillations – Chandler (1987) made available a full run of data for studying how city-system evolution couples with agrarian socio-political dynamics. Initially, this will not be equally possible in every region at every time period, but only where the density of cities is sufficient for quantitative study. By focusing on Eurasia and its major regions, including China, we availed ourselves of some of the richest pockets of Chandler's comparative data on cities, especially for the early period of globalization,

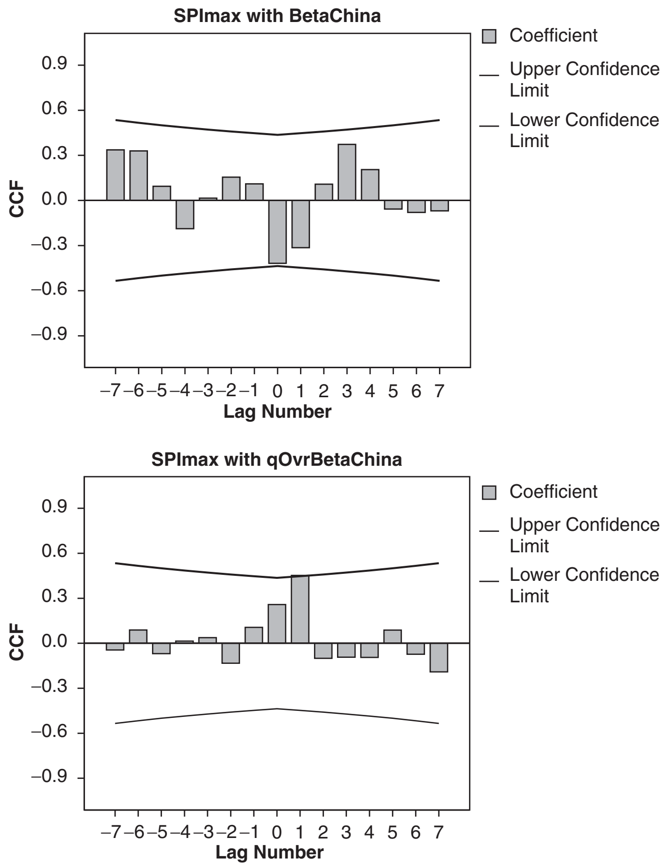


Figure 9.12 Cross-correlations of q with β and sociopolitical instability (SPI).

where China had the largest number of large cities. In refining the present model for comparison with other regions, we will consider whether to adjust for Chandler's possible underestimation of walled city populations for China, but the biasing assumption he made for China's walled cities (Appendix A) does not carry over to other regions.

We did find strong evidence of historical periods of rise and fall in the city systems of different regions, and time-lagged effects of changes in city-size distributions in one region on other regions. These are weak and slow from Mid-Asia to China, and strong and fast from China to Europe, which makes sense in terms of the Silk Roads trade. This provides additional evidence of synchronies missing from Chase-Dunn *et al.* (2006) and the studies of Eurasian synchrony. Many of the correlations, however, are time-lagged rather than temporally synchronous. The effects run in the directions suggested by Modelski and Thompson (1996), e.g., China to Europe. Suggestions for improvement in methods and measurement and the possible impact of measurement biases on our results are given in Appendix B.

We are reasonably confident in concluding that the Pareto I and II (*q*-exponential) measures of city hierarchies through time, especially when used in combination, can provide a measurement paradigm of standardized methods and tests of replication in historical comparisons. The attractive features of the *q*-measure gained added benefit from the precision of our measurements using the MLE method.

The richness of the supporting data should logically take us next to Middle Asia, its subregions, and the larger world from CE 700 that embraced the rise of Islam, the Mongols use of the Silk Roads, and development of new towns and cities on those routes that linked China and the rest of Middle Asia into a global system. Such a further study, modeled on this one, would include the role of the Indic subcontinent, and that of the Mongols (Barfield, 1989; Boyle, 1977) in trade and conquest; the Arab colonization of North Africa and Spain; and in feeding urban developments in the Mediterranean, Russia, and Europe.

When we compare our results, measurements, and mathematical models to those of Goldstone's (1991) studies of structural demography, or the studies of secular cycles by Nefedov (1999) and Turchin (2003, 2005), we find several novelties that separate our findings from that of the standard Lotka–Volterra oscillation model for historical fluctuations. Turchin (2003, 2004), for example, argues the Lotka–Voltera dynamic works optimally when one of the interactive variables (say, the population/resource ratio measure of scarcity and socio-political violence) is offset by one-quarter cycle. Our cycle of city-size oscillations might be two to four times as long as Turchin's secular cycles (J. S. Lee divides his 800-year periods into two periods of 400, suggesting an early growth of early forms of "empire" in a region, then a time of turbulence in the second period; then a new cycle of empire). It is possible that the city cycle operates at one or both these time-scales, and at the spatial scales of larger alternating civilizational networks of states and forms of empire. Long city-size system oscillations of *c*.800 years would not be offset by a one-quarter cycle but by one-eighth of a cycle, which is a long period of instability (vulnerable to conquest from the outside following internal instabilities). From our perspective, however, socio-political instability is not smoothly cyclical but episodic. Rebellions, insurrections, and all sorts of protest are events that mobilize people in a given time and generation, and has impacts that, when repeated frequently, have massive effects. We see this in long-term correlations with SPI, such as internecine wars in China.

We have been able to discern some of the effects of trade fluctuations (if not trade network structure) in these models. The monetary liquidity variable for China, in one of our tests, showed the effect of a trade-related Silk Roads variable on *q*. We think that it is possible to reconstruct trade routes as a historical time series, and to perform an ordinal ranking of trade volumes on these routes. We think that these have strong effects – along with disruptive conflicts and political or empire boundaries – on the economies of individual cities and regions, and that these variables could be shown to have dynamical interactions within the context of secular cycles and the rise and fall of urban systems.

We have not performed a forward-looking prediction, but with MLE we expect to be able to make a better estimation, and possibly to correct the biases in a reconstruction of Chandler's China dataset. Some of the patterns that we see in our data with regard to globalizing modernization are consistent with prior knowledge, but others are startling. The developmental trends of scale are to be expected – larger global cities; larger total urban population; and larger total population. We can also now investigate whether, with time, the parameter (Pareto II "scale" or σ) for crossover to the power-law diminishes, so that more and more of the city distribution becomes power law, and more consistent with much of the previous work on power-law scaling.

What is startling is that some long-wave oscillations in q are very long. Hopefully, a long-term trend and contemporary structure of Zipfian city distributions is an indicator of stability, but even the twentieth-century data indicate that instabilities are still very much present and thus likely to rest on historical contingencies (somewhat like the occurrence of a next earthquake larger than any seen in x years prior to it), and very much open to the effects of warfare and internal conflicts that are likely to be affected by population growth, and as opposed to the stabilization of trade benefiting per capita resources ratios.

The directions of change in q are largely predictable as a function of the current-state variables (such as population/resource ratios and socio-political violence) in the historical dynamics models up to, but not yet including, the contemporary period. It is not yet evident how to derive predictions for the contemporary era, given the new configurations of industrial societies, but it is very probable that the predictions that do emerge for the present will contain processes that have operated in the past.

On the issue of the coupling of cycles, Turchin cycles seem to embed two leading polity cycles (Modelski and Thompson, 1996) that average about 110 years. These are averages, and actual timings vary, but we have given explanations elsewhere for why these average cycle-lengths might tend to diminish by half as each embedded process tends to operate at successively smaller spatial scales. We hypothesize an embedding of dynamical processes that runs from trading zone network sizes and rise and fall of city-size distributions that cycle roughly 200, 400, or 800 years, partly dependent on the severity of the declines.

Notes

1 Our special thanks go to Constantino Tsallis, the inspiration for this study, who patiently taught Doug and Nataša the fundamentals of q-exponential concepts and methods and then answered questions as they proceeded through the substantive

analysis; and to Peter Turchin for generously providing data and suggestions for analysis. Any errors, however, remain our own. Thanks also to Robert McC. Adams, George Modelski, William Thompson, and Carter Butts for critical commentary and suggestions. Support from the EU project ISCOM, "Information Society as a Complex System," headed by David Lane, Sander van der Leeuw, Geoff West, and Denise Pumain, is acknowledged for the city-sizes project. We thank the leaders and members of the project for their critical commentary. The larger project, "Civilizations as Dynamic Networks," forms part of a Santa Fé Institute Working Group, for which SFI support is acknowledged. An early draft of the paper was presented to the Seminar on "Globalization as Evolutionary Process: Modeling, Simulating, and Forecasting Global Change," sponsored by the Calouste Gulbenkian Foundation, meeting at the International Institute of Applied Systems Analysis (IIASA), Laxenburg, Austria, 6–8 April, 2006. The reliability of the final analysis would not have been possible without the help of Cosma Shalizi, who derived and then programmed an MLE solution to the problems of estimating the parameters of historical city-size distributions, many of which had relatively small lists of largest city sizes once we got to the regional level. Because the current MLE methods are not only asymptotically normal and unbiased but also consistent, future research can incorporate a small-sample correction into the estimates of both the Pareto I and Pareto II fits to empirical distributions. Further research can also use the new methods of Clauset, Shalizi and Newman (2007) that provide likelihood ratios for evaluating relative log-likelihood of fit comparing Pareto I and II, lognormal, exponential, and stretched exponential distributions.

2 Noting from the shared database that the top echelon of cities in a single region may be swept away in a short period by inter-regional competition, Batty (2006) refers to our work on instabilities at the level of city systems.

3 For example, excluding two primate city outliers, the next-largest 16 cities for 1998 in the US (over 11 million) show a steep log–log slope, those ranking down to 0.5 million show a shallower slope, those to 0.1 million a much shallower slope, and then the power-law disappears altogether (Malacarne *et al.*, 2001: 2).

4 A typical batch of instructions, for example, might be:

```
china.900 <- c(500,150,90,81,75,75,70,65,60,58,49,47,40,40)
china.900.tsal.fit <- tsal.fit(china.900,xmin=40) # Assigns the results of the fit to
   the object
china.900.tsal.fit # Displays the estimated parameters and information about
   the fit
china.900.tsal.errors <- tsal.bootstrap.errors(china.900.tsal.fit,reps=100)
china.900.tsal.errors # Displays the bootstrapped error estimates.
```

5 These include:

(a) The Y_q estimates an expected "largest city size" M consistent with the body of the size distribution. This requires simultaneous estimation of M and $Y(0)$ to solve $Y(0)\ P_{\theta,\sigma}\ (X \geq M) \approx M$.

(b) The total urban population can be estimated from Y_q without having data on all smaller cities, although this feature is not utilized here.

(c) Equation (1) and Y_q may be fitted *without* the largest city so as to derive from the model an expected size for the largest city.

(d) This gives our model a ratio measure of the largest city size to its expected size from Y_q.

(e) Y_q has a known derivative $Y'_q(x) = Y0/\kappa[1 - (1 - q)x/\kappa]^{(q/(1-q))}$, giving the slope of the curve $Y_q(x)$ for any city size x.

Solving for $Y_q(M) = M$ for the estimated largest city size M consistent with Y_q, gives $Y'_q(M)$ as the slope of the Y_q at M, and converges with $\beta = 1/(q-1)$ for the Pareto power-law slope when $1 < q \leq 2$.

6 Fortunately there is no correlation between city sample size and estimates of q that would invalidate the objectives of this study to fit the q-exponential to these data. Given our small sample sizes from the Chandler data as we moved from a world sample (75 data points) to regional samples, we called on Shalizi in late 2006 to derive the MLE equation for us, which he did. He then found earlier derivations such as those of Arnold (1983) and others. We are greatly indebted to Shalizi for writing functions in R to make MLE estimates of the q-exponential parameters and bootstrap estimates of the standard errors of these estimates.

7 If we remove the $\sigma \ll 1$ cases for China, for example, the relationship expected of our estimates, namely, (–)$\beta \sim 1/(1-q)$, is closely fulfilled where $1 < q \leq 2$, but is contradicted where $\sigma \ll 1$. With the improved methods of Clauset, Shalizi, and Newman (2007), and working with Clauset and Shalizi, we were able to determine two additional parameters which we call xq_{min} and xp_{min} for the Pareto II and Pareto I, respectively, which are the lower cutoffs in size that maximize the MLE fit of each distribution. Using their data on populations of US cities in the 2000 US Census, we were able to determine that $xq_{\mathrm{min}} = 5,000$ for best fit of the q-exponential, which also closely approximates the sizes of smallest cities found archeologically in different times and regions, while they report $xp_{\mathrm{min}} \sim 52,000$ as a cutoff for the best MLE fit of a power-law to these same data (Clauset, Shalizi, and Newman 2007). This later finding, made just before proofreading this chapter, supports the approach of the current study, but also points us towards methods that can be further improved. Having an MLE solution for xq_{min} also entails the possibility of an MLE solution to estimating Y0 in the equation for the q-exponential, that is, an estimation of the total urban population consistent with the q-exponential shape of a city-side distribution.

8 When $\sigma \ll 1$ values are not correlated with small sample sizes, it is a signal to investigate the possibility that the region of aggregation is not properly specified. Having a rule-of-thumb for regional boundary misspecification will be helpful in further research in this and other areas of study.

9 Elsewhere, we explore estimates of the total urban population asymptote, $Y(0)$, from fitting the Pareto II and equivalent q-exponential distributions.

10 Technically, the mathematics assigned to chaos is a deterministic departure from randomness in which a dynamic trajectory never settles down into equilibrium, and small differences in initial conditions lead to divergent trajectories. The link between empirical history and "edge of chaos" is typically done by simulation.

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Appendix A: Chandler's Chinese city data

Many Chinese historians question the estimates of Chinese city population densities given by Chandler (1987: 7): "Chinese cities tend to have an especially low density because of the Chinese refusal to sleep below anyone, so their houses are of nearly all of just one story. Hence, inland Chinese cities had a density of only about 75 per hectare, and even in seaports or the imperial capital the density hardly exceeded 100." One such anonymous reviewer considered this an underestimate by half, based on current knowledge.

To test the effects of these likely underestimates in population, we examined the data from the first of our periods, as shown in after checking Chandler's (1987: 417–51) text to note the basis for his estimates for each city. We adjusted the five city estimates affected, by raising each by 50 per cent (half the attributed error); recomputed the number of cities for each size category; and then compared the power-law coefficients for the original and the revised data as well as changes in the estimates of q. Changes were evident and significant in each case. They did not change the r^2 for goodness of fit, but for q, for example, the value changed from 1.9 to 0.7. Similar tests can be performed for other periods, but we may need independent evidence with regard to the extent to which the critique merits new density computations.

Possible errors of this sort in the assumptions behind Chandler's estimation, then, could change our scaling results. These biases could change the patterns of variation in q seen in our results. Because Chandler uses common assumptions throughout these historical periods up to 1950, however, it is possible that they may not affect our historical comparisons about relative changes in q, at least up until 1950. For 1962, 1968, and 1970, he has taken the city population data of Richard Forstall of the company Rand McNally and Co. To test the robustness of our results, however, would entail a project that builds on the Microsoft Excel™ spreadsheet for the Chandler data as exemplified above. By consulting his book to pick out each variable used to make multiplicative estimates – such as the size of urban area, the number of soldiers (e.g. times six), the number of streets, etc. – a spreadsheet of calculations with the multiples and their base numbers might be useful to improve Chandler's estimates using a Bayesian weighting by consistency. Chandler (1987: 6) also notes that "the large growth of suburbs outside city walls had not begun before 1850 except in the newly rising industrial conurbations of Britain." This might cause problems "since the presence of suburbs has been well documented in history with new walls built to enclose a population that had spread beyond the original walls" (Pasciuti and Chase-Dunn, 2002: 1). Chandler does include suburbs in his criteria for city boundaries, however, and in his estimates throughout the book.

Appendix B: Suggestions toward improvement in methods

We began this study with Newman (2005) as a guide to power-law fitting and Borges (2004) as a guide to *q*-exponential fitting, and ended with the methods of Clauset *et al*. (2007) for the former and Shalizi (2007) for the latter. Physicists using these methods had not thought sufficiently about the relevance of a cutoff for the lower range at which *q*-exponential modeling has real-world limits (like size of smallest cities) as a problem in statistical estimation. We made useful discoveries about the need for such a cutoff for *q*-exponential distributions in addition to the usual crossover parameter; about the substantive meaning of such cutoffs; in their usefulness for direct comparison of Pareto and *q*-exponential MLE fits; and in the possibility of fitting both distributions in the same probability space with meaningful cutoffs and comparisons. Minimal xq_{min} cutoffs for *q*-exponential fitting, akin to those of Clauset *et al*. for the Pareto, are still needed in Shalizi's Pareto II approach to *q*-exponentials, and in Borges' maximum entropy approach.[1]

Clauset *et al*.'s study also showed the need for new procedures to correct for small-sample bias within their framework of consistent and asymptotically unbiased maximal likelihood methods for estimating Pareto distribution parameters.[2] Our tests for small sample effects showed, for samples of twenty cities and under, non-significant correlations between estimates of the Pareto slope and sample size, with a tendency for smaller samples to overestimate Pareto slope. The lack of temerity with which we approached these problems in the face of small samples – where most researchers would be dissuaded to undertake our study – was balanced by our insistence on replication, in test after test, which showed considerable *non*-convergence of different methods of estimating *q* with small samples: Spss nonlinear regression, Excel solver minimization of error, methods of Newton-Raphson, and Shalizi's Pareto II MLE methods.

No one has studied as yet the small-sample bias in *q*-exponential parameter estimates with MLE or other methods, and the need for small-sample corrections for *q*. Our studies demonstrate this need: Our MLE estimates of *q* showed that smaller numbers of cities in single-period samples often tend to significantly overestimate *q*, which implies underestimating the asymptotic slope of the tail, running opposite to small sample MLE overestimation of Pareto slope. Whether this accounts for the nonconformal tendency we observed for Pareto slope estimates and *q*-distribution tails remains to be seen. These divergences may be indicators of city system distribution collapse, not inconsistent with our hypothesis testing results, but there may be better and more accurate ways to tell the story about non-Zipfian tendencies, Zipfian and *q*-exponential cutoffs, and historical dynamics. To do so in the future will require corrections of *q*-estimates for small-sample bias. If this study has been suggestive of routes for getting more accurate historical measures with which to model dynamic interactions among city system and related variables over time, and to control for estimation biases, we will be satisfied in any case as we fully expect future revisions of our findings that provide greater accuracy. There is more to do still on the measurement side for this kind of study. Putting together the modeling from physics, statistics and social science, as we have done in subjecting these methods to scrutiny, will be of major benefit, and has done so already, in motivating improvements in methods of estimation for q-exponentials, small samples, comparisons with other distributions, and ways of handling data that include approximations from historical knowledge.[3] We have no regret in ascertaining the tentative quality of our results to date, as we have shown how hypotheses can be tendered, tested, and then scrutinized for the effects of biased measurement, with more accurate measurements for these tests to follow. We can do no better at this point than to subject our results to self-scrutiny.

Appendix notes

1 What may be needed is a return to the framework of Borges (2004), where fitting is done by maximizing a linear plot fit between the actual data on the x axis and $y_q = e_q^x = (1 + (1 - q)x)^{1/(q-1)}$ ($e_1^x = e^x$) as a function of x on the y axis. Normally Borges' approach is done by adjusting q to an optimum *without* an xq_{min} cutoff for the smallest scale at which the shape of the q-exponential function appears, which proved so fundamental in fitting city-size distributions in our studies. Finding the best xq_{min} cutoff involves using Clauset *et al.*'s (2007) methods to repeat the analysis at successive xq_{min} cutpoints and evaluating where the likelihood ratio is maximized. When MLE methods are used this ratio most often has a U-shaped distribution over xq_{min} with a single optimum. Whether the successive values of q over this U-shaped distribution have continuity within a single time period can be observed empirically. MLE for the best q at each cutpoint is done by minimizing the sum of log differences between the empirical observations of the fitted curve.

2 Pareto MLE fits by Clauset *et al.*'s methods have a small-sample bias with greater overestimates of the Pareto slope the smaller the sample, consistent with our empirical finding. This can be adjusted by a small-sample correction but that has been done or programmed as yet and so we have not been able to use correction methods.

3 There are ways, for example, of improving estimation methods to deal with Chandler's data, in which we often see strings of estimates for smaller cities (40 40 40 40 50 50 50 … which mean, for example, 4 cities of size 40 or more, three of 50 or more) mixed with both precise estimates for larger cities and estimates for cities whose size can only be interpolated from rank size position. Better methods of interpolation could be developed for use alongside neutrality with respect to measures of goodness of fit.

10 Nature, disease, and globalization

An evolutionary perspective

Dennis Pirages

Contemporary globalization represents the culmination of a long evolutionary process that has produced larger and more complex social units over time. Although precursors of contemporary complex human societies emerged in eastern Africa more than 300,000 years ago, our interest in *Homo sapiens* the globalizer begins about 100,000 years ago, when small bands of our species began to migrate out of eastern Africa toward the north and west. The factors responsible for this migration out of Africa remain speculative, but population growth, climate change, fluctuating food supplies, and human curiosity undoubtedly were involved. Within 60,000 to 70,000 years, bands of *Homo sapiens* had settled in the far corners of the world, showing a remarkable ability to adapt to the most varied environments (Cavalli-Sforza and Cavalli-Sforza, 1995).

According to Wallace (1997), the species *Homo sapiens* has spent nine times as many years moving apart as it has spent coming together. The greatest dispersal of these human societies (maximum social entropy) occurred between 10,000 and 15,000 years ago. For most of human history, the fates of these scattered clans and tribes were largely determined by the local constraints of nature and the availability of food, water, and other resources, as well as by local encounters with pests, predators, and pathogens. Over the last 5,000 years, however, beginning with the emergence of the great civilizations in western Asia, populations of *Homo sapiens*, for the most part have grown significantly in size and density and have repeatedly been incorporated into larger and more complex units, these expansions and consolidations being precursors of processes that have culminated in contemporary globalization (McMichael, 2001). These persistent social units are now increasingly being integrated into a very complex global system, and their fates are no longer determined locally, but are increasingly being shaped by more global forces.

It would not be easy, or particularly rewarding, to quantify precisely the number of distinct human societies that have survived previous periods of consolidation and maintained their identities well into the twenty-first century. Because of the dynamics of contemporary globalization, however, their numbers are rapidly dwindling. The number of actively spoken languages in the world is a good surrogate measure. There are currently about 6,000 spoken languages, but linguists think that nearly half of them will be dead or dying within the next 50 years (Ostler, 1999). The point here is not to lament the passing of these distinct societies, although cultural diversity is important. Rather, the focus is on the evolutionary dynamics that have been and still are associated with the integration of smaller social units into larger and more complex ones. Just as natural forces played a major role in shaping the prospects for and fates of early societies and agrarian-era empires, similar forces still shape, and perhaps will limit, the prospects for the deepening integration of remaining societies into a global system.

Organizations of humans (tribes, clans, ethnic groups) have been evolving and devolving into more and less organized and complex forms over thousands of years. The dynamics of the rise and fall of early civilizations, empires, and more recent colonial networks represent episodes of "proto-globalization" from which much can be learned. All of these past experiments in increasing social complexity eventually peaked and declined, often because of environmental changes, and only fragments and traces of these early civilizations and empires remain in the contemporary world. The current round of globalization is denoted by the creation of a much larger and more complex global system – an achievement well beyond the capabilities of those organizing these earlier empires. But the ultimate fate of this endeavor remains unclear, as forces akin to those that limited the reach of earlier complex civilizations and empires now threaten to slow – or even reverse – the course of contemporary globalization.

Human societies, like all living systems, are embedded in varied physical environments that present different kinds of challenges and opportunities. These environments normally provide them with a steady flow of energy and other resources that are required to sustain their growing complexity. As Tainter (1988) has put it:

> More complex societies are more costly to maintain than simpler ones, requiring greater support levels per capita. As societies increase in complexity, more networks are created among individuals, more hierarchical controls are created to regulate these networks, more information is processed, there is more centralization of information flow, there is increasing need to support specialists not directly involved in resource production, and the like.

The contemporary global system represents the most complex social organization yet developed. But, just as previous attempts at building more complex social organizations have eventuated in some form of collapse, the current round of deepening globalization is vulnerable as well. In the end, nature usually bats last. There is no reason to expect that this round of increasing social complexity is immune to the evolutionary dynamics that have been responsible for societal collapses throughout history. In fact, given deepening globalization's growing resource requirements in the face of fledgling forms of governance, it would seem to be extremely vulnerable.

As was the case with the preceding complex civilizations, this current episode of continually increasing complexity requires ever greater resource flows to maintain it.

> At the same time, the mechanisms by which human groups acquire and distribute basic resources are conditioned by, and integrated within, sociopolitical institutions. Energy flow and sociopolitical organization are opposite sides of an equation. Neither can exist, in a human group, without the other, nor can either undergo substantial change without altering both the opposite member and the balance of the equation.
>
> (Tainter, 1988)

Those responsible for governing complex social organizations have to struggle constantly to establish and maintain legitimacy. Maintaining legitimacy, in turn, has required the perpetual mobilization of resources to ward off the forces of social entropy, an unrelenting cost that complex societies must bear. The contemporary round of globalization is no exception. It has received a major impetus from the concerted post-war efforts of a hegemon (the US) to build a global system that serves its own interests. Significant resources have been and must continue to be expended, and new forms of governance must be developed in order to overcome growing obstacles to the continuing integration of diverse societies into an increasingly complex global system.

The forces of nature and complex societies

Understanding the evolutionary dynamics that present possible limits to globalization begins with the obvious, but important, observation that *Homo sapiens* is one of millions of species co-evolving within the ever-changing constraints of nature. Like other primates, *Homo sapiens* has spent much of its history living in small, relatively isolated units that biologists call populations and social scientists refer to as societies. These diverse populations/societies have been shaped over time biologically and culturally through continued interaction with the physical environments in which they have been embedded. Biological and sociocultural evolution – two parallel and linked processes – have facilitated the survival and success of these groups of *Homo sapiens* over the centuries by adapting both bodies and behavior to changing environmental constraints (Durham, 1991; Hallpike, 1986; Harris, 1979). Those populations/societies that have been able to adapt to changing environmental circumstances usually have been able to flourish, while those that are less adaptable have not.

This evolutionary perspective raises two critical points. First, those societies that have persisted and maintained their identities well into this era of deepening globalization are bound by primordial ties that are difficult to break (Geertz, 1973). The resulting biologically and socioculturally similar extended families, clans, or tribes have been fundamental sources of identity, loyalty, and governance for thousands of years. The integration of these tightly integrated societies into more complex units such as states or empires is a costly endeavor, requiring significant resources and even the use of force to break the tight ties that bind them and differentiate them from others. Second, and most important, because these smaller societies historically have been continually buffeted by the forces of nature, those that have persisted over the centuries have either found themselves in idyllic environmental circumstances or have been unusually well organized to deal with periodic resource shortages, disease outbreaks, predator attacks, and natural disasters.

On a larger scale, it is no coincidence that the current period of growing social complexity and deepening globalization has unfolded over several decades that, from a long-range historical perspective, would be characterized as a period of unusually benevolent conditions: climatic stability and relative resource abundance. While *Homo sapiens* (and its predecessors) has suffered through at least eight ice ages and countless other less-dramatic periods of global and regional environmental turmoil over the last 730,000 years, it has been the relatively limited periods of environmental stability, benevolent climate, and productive agriculture that have offered an opportunity to construct and maintain more complex social units and empires (Fagan, 2000; Ladurie, 1971).

Environmental factors have been responsible for the historical collapse of a substantial number of complex societies. Depletion of critical resources and/or declining agricultural productivity, whether these were due to human mismanagement or to changes in nature, have been instrumental in the collapse of many historical civilizations (Tainter, 1988; Bryson and Murray, 1977). Natural disasters such as earthquakes or volcanic eruptions have taken their toll on others (Tainter, 1988). Disease has also been a significant factor limiting the expansion of major civilizations throughout history (Cartright, 1972). Diamond (2005) has found environmental damage and climate change to be two of five factors that account for societal collapse, but adds that a society's response (or lack thereof) is also a very important consideration in explaining the collapse of complexity.

Significant historical volcanic eruptions offer vivid examples of how these spectacular low-probability but high-impact "wildcard" natural forces have repeatedly altered climates, stifled agricultural productivity, promoted disease, and thus played a major role in shaping the course of human history. Volcanologists have identified more than 5,560 major eruptions, the most powerful of which have destroyed many major civilizations, since the end of the last ice age (Fagan, 2000: 169). Many of these eruptions had only a regional economic impact, but the more powerful of them have had far-reaching (even global) economic and political fall-out. The three largest known volcanic eruptions have occurred in Indonesia. The largest was the Toba eruption that occurred 74,000 years ago. It is estimated that the eruption ejected 2,800 cubic kilometers of magma and created a tremendous plume of dust that reached around the world. The related cooling lasted several years, and is thought to have lowered temperatures by as much as ten degrees Celsius. So many people were wiped out worldwide that an evolutionary "bottleneck" was created, the number of humans being pared to about 10,000, bringing the human race close to extinction (deBoer and Sanders, 2002).

More recently, the Tambora (1815) and Krakatoa (1883) eruptions, also occurring in Indonesia, left a much more empirically verifiable trail of chaos and destruction. The Tambora eruption resulted in the ejection of 50 cubic kilometers of magma, and created a plume of dust that blanketed the world and made 1816 the year without summer. In the northeast United States there were snowstorms and killing frosts all summer. There were also bouts of severe weather, famines, and social unrest in Europe (de Boer and Sanders, 2002). The years 1816 and 1817 were very cold and wet, and crop failures there were widespread. Food riots occurred in various parts of France and peasants ambushed grain carts on the way to markets. Weather changes, crop failures, and malnutrition quite naturally led to disease outbreaks. A typhus epidemic broke out in Ireland and killed more than 100,000 people. Cholera broke out in India and spread to Nepal and Afghanistan. Over the next 15 years, cholera spread north to Europe and west to Egypt (deBoer and Sanders, 2002). The subsequent Krakatoa eruption was much smaller, but left a similar trail of global disruption.

The political fall-out from the year without summer was considerable. According to Fagan (2000) social unrest, pillaging, rioting, and criminal violence erupted across Europe in 1816, reaching a climax the following spring. In England, marauding crowds attacked houses and burned barns. In France, the grain riots of 1816–17 were marked by violence levels unknown since the French Revolution. Large vagrant bands plundered the countryside. The subsistence crisis also triggered a massive European migration. Violence associated with the unusual weather and associated famine was also reported in the Ottoman Empire, parts of North Africa, much of Europe, and in New England and Canada (Fagan, 2000).

There can be little doubt that another major volcanic eruption in the present densely populated world would deal a death blow to growing social complexity and deepening globalization. This is especially true since almost no preparation has been made to mitigate the impact of such a low-probability high-impact "wildcard" event. But such future wildcard events are not considered to be policy-relevant, and the world remains ill-prepared for the period of austerity, hunger, chaos, and simplification that would follow.

There are, however, three much more likely and perhaps imminent ecological challenges to social complexity and deepening globalization that are potentially much more manageable than catastrophic volcanic eruptions. The first is the near-term threat of rapidly moving and deadly pandemics (global epidemics) fueled by an accelerated worldwide movement of people and pathogens associated with deepening globalization. The second is a medium-term threat inherent in the increasing fragility of the vital global transportation network that has become heavily dependent on insecure supplies of petroleum and natural gas increasingly found in geographically remote or politically unstable parts of the world. The third is a longer-term threat of global climate change that will raise a whole set of divisive environmental and economic issues between countries likely to emerge as winners and losers in an impending era of global warming. The limited focus in the rest of this chapter is not on eruptions, fossil fuels, or global warming – all topics worthy of future exploration, but on the seemingly most imminent of these three challenges to increasing social complexity and deeper globalization, the dynamics and likely impact of a rapidly moving pandemic.

Social transformations and infectious disease

Throughout history, serious disease outbreaks have been responsible for large numbers of deaths and untold human suffering. Outbreaks and epidemics seem to be a price that nature exacts for increased social complexity. There is considerable historical evidence that the growing complexity of societies; changes in relationships among them; or changes in relationships between them and the environments that sustain them, have been associated with serious disease outbreaks (McNeill, 1976; Crosby, 1986; Hobhouse, 1988; McMichael, 2001). In the past, new settlement patterns; the evolution of larger and more densely populated societies; or any form of increasing physical contact among previously separated civilizations, have frequently been associated with a significant increase in the incidence of infectious diseases.

Clear evolutionary logic underlies these dynamics. Populations of *Homo sapiens* have been continually co-evolving with a host of micro-organisms that are essential to human well-being. This multitude of microbes decomposes various kinds of wastes, enriches soils, and performs vital biological functions in human digestive systems. Only a small portion of these micro-organisms are pathogens, representing disease threats to people, plants, or animals. And most of these pathogens are only nuisances, generally causing relatively little serious damage to people. Yet, there have been many historical periods when very deadly pathogens have emerged and moved rapidly through and among societies, leaving a trail of suffering and death in their wake.

Human immune systems have been sharpened by repeated encounters (learning experiences) with a wide variety of pathogens on the local level, and have developed effective defense mechanisms for dealing with most of them. Prior to the growth of more complex societies and empires, these early human–microbe interactions responsible for building immunity were restricted by the boundaries of relatively isolated societies and ecosystems: local peoples adapting to local pathogens. Significant disease outbreaks, for the most part, have only occurred when, for one reason or another, people have come into contact with deadly new pathogens to which they have developed little immunity.

This normal evolutionary equilibrium between people and pathogens can be upset in several ways. For example, people can settle in new geographic locations, thus exposing themselves to a different array of pathogens. Or, as was the case during the early stages of the agricultural revolution, people can come into closer contact with animals, thereby increasing the potential for new pathogens to jump from animals to people. Perhaps most important, particularly in an era of increasing globalization, greater interaction among previously separated societies can also be a source of disease outbreaks, since people themselves can carry pathogens from one locality to another.

McMichael (2001) suggests that there have been at least five transformational epochs in human history during which this dynamic equilibrium that normally exists between peoples and pathogens has been significantly disturbed. Much about potential microbial challenges to future globalization can be learned by analyzing them. The first such period of transformation occurred in pre-history when people started to hunt game and eat meat, thus exposing themselves to a wide variety of previously unknown parasites and pathogens carried by the game that they hunted. The second large-scale destabilization of the people–pathogen relationship undoubtedly occurred with the migration of tribes out of Africa into new environments and climates, which brought these vulnerable migrants into contact with a host of unfamiliar pathogens.

There have been three more recent discrete periods during which significant transformations of relations between humans and the physical environment or increased contact among peoples have led to waves of debilitating disease outbreaks (McMichael, 2001). There is much evidence that a new era, potentially one of pandemics that could drastically alter the course of our increasing complex global civilization, has now begun (Garrett, 1994).

The first of these more recent epochs of debilitating disease outbreaks resulted from transformations in the human condition that began to gather momentum more than 5,000 years ago when a sedentary agrarian way of life became more established in various parts of the world. The increasing domestication of animals, and living in proximity to them, brought people closer to the potentially dangerous pathogens that these newly tamed species carried. Furthermore, the growth of agrarian communities, and eventually more complex towns and city-states, created denser populations, bringing people into more frequent contact with each other and with accumulating urban wastes that often contained disease organisms. There is evidence that the fledgling kingdoms established during this early period were significantly impacted by infectious diseases. The Egyptians apparently suffered serious disease outbreaks after enslaving the Israelites during the period of the Middle Kingdom. And the Hittites, in turn, suffered similar maladies, very likely coming from enslaved Egyptians (McMichael, 2001).

A second period of transformation in human–pathogen relationships began about 2,500 years ago, as wider and more frequent travel brought increased contacts among the expanding civilizations and empires of Eurasia, and between these core civilizations and the more peripheral areas of the world. Early in this period, a deadly plague, thought to have been carried back from Ethiopia, moved through Athens in 430 BC, substantially destabilizing Athenian society and weakening its military and economic power (McMichael, 2001). About 2,000 years ago, emissaries from the expanding Roman Empire began to make regular contact with the Han Dynasty Chinese via overland trade routes. Pathogens apparently traveled with explorers and merchants in both directions, causing numerous disease outbreaks and epidemics (McMichael, 2001). In Rome during Republican times there were at least 11 major disease outbreaks. They undoubtedly originated in the Empire's periphery, and proved to be a significant limitation on Rome's imperial ambitions. The Antonine smallpox epidemic in AD 165 was the most serious, spreading throughout the Empire. It has been estimated that between one-quarter and one-third of those coming into contact with this pathogen died (McNeill, 1976). This plague played a significant role in the decline of the Roman Empire. Since history is written by the winners and not the losers, the impact of any pathogens that might have been carried outward from Rome to the periphery is not well documented. Additionally, smallpox and measles apparently moved east from Europe and cut the population of Northern China in half in the third and fourth centuries AD (McMichael, 2001).

At the very end of this era, the bubonic plague spread westward from China to Europe and North Africa, moving with caravans along newly established trade routes (McNeill, 1976). The black rat (*Rattus rattus*) brought fleas bearing this bacillus to the cities of Southern Europe in 1346. The plague moved through Europe over the next few years, killing as many as 40 per cent of those who came into contact with it – essentially decimating European civilization. It is estimated that eventually this incidence of the "Black Death" wiped out nearly one-third of the European population (McMichael, 2001).

The most recent period of substantial disease outbreaks and epidemics accompanied the expansion of European colonial activity. The outbreaks began in the late fifteenth century, this time with the diseases moving primarily from European core countries to the periphery, as explorers spread fatal diseases to indigenous peoples in the Western Hemisphere. When Christopher Columbus and his crew set foot in the Americas in 1492, they brought hitch-hiking pathogens from the European disease pool with them. Diseases such as smallpox, measles, and influenza wiped out a large portion of the indigenous peoples, who had little immunity to them. The military history of the period is filled with tales of miraculous conquests of large numbers of indigenous peoples by mere handfuls of European troops. But there were no real miracles involved. This was simply foreign pathogens at work, striking down previously isolated locals who were now unable to mount a decent defense of their territories (McNeill, 1976).

Over time, these imported diseases killed approximately two-thirds of the indigenous peoples who were exposed to them. The island of Hispaniola (contemporary Haiti and the Dominican Republic) is thought to have had nearly one million inhabitants in 1498, when it was first settled by Europeans. By 1520, disease had played a large part in reducing this number to less than 1,000 (Hobhouse, 1989). Unlike earlier disease outbreaks occurring when expanding complex civilizations encountered each other, pathogens usually moving in both directions, these were basically unequal exchanges. The flow of pathogens moved mainly from core European countries to the periphery. Apparently, there were very few serious communicable diseases (with the possible exception of syphilis) endemic to the much less densely populated Western Hemisphere.

European diseases, as well as European flora and fauna, also spread to other parts of colonial empires, including much of the Pacific region (Crosby, 1986). Australia's Aborigines, New Zealand's Maoris, and numerous Pacific island societies were devastated by these foreign diseases. The native Hawaiian population declined from 300,000 to 37,000 within 80 years of the arrival of Europeans in 1778 (McMichael, 2001).

The coming plagues?

There is convincing evidence that the huge increases in trade and travel that are at the core of contemporary globalization are exposing humanity to the risk of another round of serious disease outbreaks (Garrett, 1994). Such outbreaks may well be serious enough to limit, or at least reshape, the nature of globalization. Over the last three decades, 20 previously known diseases have re-emerged or spread geographically, and at least 30 diseases not previously known have been identified, many of them jumping from animals to people in tropical areas of the world. The most obvious mechanism creating this threat is the increasing complexity associated with population growth, large-scale industrialization, and the dynamics of deepening globalization. The co-evolution of human immune systems and pathogens is no longer primarily the local affair that it has been historically; this affair is now taking place on a global scale.

Ecological globalization, a much neglected component of the broader process, involves vast changes in the relationships among people; between them and other organisms; and between them and the physical environment (Pirages and DeGeest, 2004). The dynamics of contemporary globalization are linking together peoples, pathogens, and ecosystems that historically have been separated by geographic, political, and cultural barriers. While there has always been a limited "natural" movement of organisms among the world's diverse ecosystems, the contemporary flow of people, plants, pests, and pathogens through ever more porous borders is producing a planetary mixing of unprecedented magnitude. This growing ecological globalization holds significant consequences for the future well-being of the human race, and it highlights a growing need for new and more coherent forms of global governance.

This current period of growing system complexity, increasing travel and commerce, intense industrialization, growing resource dependence, continuing population growth, increasing urbanization, and growing environmental pollution shares much in common with the earlier periods of disease misery, and it could well contain the seeds of a new wave of outbreaks or even pandemics. These changes now under way are creating three sets of interrelated challenges for the world health community. First, a rapidly accelerating movement of people, products, produce, and pathogens across traditional national borders is increasing the odds of deadly infectious diseases rapidly making their way around the world and into epidemiologically naïve populations. Second, serious infectious diseases endemic to the less-industrialized countries of Africa and Asia are becoming of much greater concern because they can now spread more easily to the industrialized world due to significant increases in North–South travel and commerce. Finally, the continuing spread of industrialization and related urbanization carries with it the risk of more serious disease outbreaks, both because of increased urban pollution and due to the increasing rapidity with which diseases could spread through densely populated crowded urban areas.

Although there have been substantial recent advances in medical technology, the impact of infectious diseases is still substantial. Nearly 15 million people die from communicable diseases each year, albeit by far the largest portion of them in the less-developed countries. Respiratory infections are the leading cause of death, taking about four million lives each year, and HIV/AIDS follows close behind with three million deaths. Diarrhea, tuberculosis, and malaria combined lead to another five million deaths (WHO, 2004).

Aside from the physical suffering and millions of deaths caused by infectious diseases each year, they also exact a significant toll in lost economic growth and represent a continuing threat to deepening globalization. History's great plagues clearly played a major role in reshaping sociocultural evolution, limiting the growth of commerce, and restraining or even reversing the expansion of empires. The destructive plagues that repeatedly afflicted Rome during Republican times undoubtedly substantially reduced Roman power and thus the reach of the empire. Similarly, the bubonic plague in fourteenth-century Europe wiped out such a large portion of the population there that it arguably reshaped the social and economic face of Europe, possibly setting the stage for a burst of labor-saving innovations that eventually gave rise to the Industrial Revolution (Hobhouse, 1988). More recent disease outbreaks, while limited in scope, also have had significant political and economic consequences, which is why some governments have gone to great lengths in an attempt to keep them secret.

Three recent disease outbreaks (HIV/AIDS, SARS, avian flu) could well be harbingers of more serious challenges to come. Suspected of jumping from chimpanzees to humans in Central Africa, HIV/AIDS, first identified in 1981, has slowly but inexorably spread around the world. Although this virus usually can only be passed through intimate contact, its long incubation period, during which individuals may experience no symptoms, has facilitated its spread. It is estimated that HIV/AIDS has already killed in excess of 25 million people.

An estimated 38.6 million more people are now living with the HIV virus, and about 4.1 million new infections occur each year. An estimated 2.8 million are now losing their lives to the disease each year (UNAIDS, 2006). The disease is expected to increase significantly in India, China, Nigeria, Ethiopia, and Russia over the next few years. By 2010 it is estimated that between 50 and 75 million people will be infected in these five countries (NIC, 2000).

Late in 2002, another previously unknown disease apparently jumped from palm civet cats to people in China's Guangdong Province. Although it only sickened about 8,500 people, resulting in close to 900 deaths, this SARS (Severe Acute Respiratory Syndrome) virus offered an example of how quickly infectious diseases can move across borders and disrupt travel and commerce. In only a few weeks the disease had reached much of Asia, and within six months SARS had been reported in 29 countries. (Fidler, 2004) It had a major impact on trade and tourism in Asia, and shaved nearly one hundred billion dollars from economic growth in the region before it was brought under control.

Finally, although it had only taken about 100 human lives by the end of 2006, a widespread outbreak of avian flu (H5N1) among fowl has focused attention on the possibility of a related rapidly moving flu pandemic developing among people. Keeping in mind the heavy toll from three significant influenza pandemics of the last century (1918–19, 1957–58, 1968–69), disease experts are now concerned about the possibility that the avian flu virus could provide the basis for a new pandemic in a much more densely populated world (Garrett, 2005). The current strain of avian flu is very deadly to birds, but it has jumped from them to people only on rare occasions. The fear is that a slight change in the virus could transform it into a killer disease that could be passed easily from person to person, thus creating a twenty-first-century influenza pandemic.

Disease and the global future

The contemporary global system is much more complex, and thus perhaps much more fragile, than its predecessors. It is therefore likely that a future pandemic would be much more disruptive than the more limited epidemics of the past. There are two ways to speculate about the global impact of such a catastrophic event. First, the recent SARS outbreak that moved rapidly through East Asia in 2002–03 offers a useful scale model and thus some indication of how a future pandemic could affect the course of globalization. Second, epidemiologists have constructed very useful speculative models of future pandemics, based on past experience.

The recent SARS outbreak, although very limited in its human casualties, had a devastating impact on commerce and travel within Asia, as well as on the region's global linkages. It was only a few weeks after the first SARS-related death that fear of the disease put the economies of China, Taiwan, and Singapore into a tailspin. The SARS outbreak led to a substantial reduction in travel and exports as the region was increasingly cut off from the rest of the world. Air traffic came to a near standstill, with major carriers grounding up to 40 per cent of their flights. The number of passengers passing through Singapore's airport, normally about 29 million annually, slowed to a trickle. In South China and Hong Kong several major hotels operated at only ten per cent of capacity. The Canton Trade Fair, which usually results in $17 billion in business deals, was an economic disaster. Few potential buyers were willing to brave exposure to the disease in order to attend (Engardio *et al.*, 2003). The ultimate impact on travel and commerce was considerable. In China, the tourism industry lost an estimated $7.6 billion in revenue and 2.8 million jobs. The loss to China's overall travel economy in 2003 was around $20.4 billion. Singapore's tourism industry took a hit of some $1.1 billion and 17,500 jobs were lost (Prystay, 2003). Economists shaved nearly 1.5 percentage points off the 2003 growth estimates for the economies of Hong Kong, Singapore, and Malaysia (Engardio *et al.*, 2003). Fortunately the disease proved to be susceptible to careful sanitary measures; did not spread widely beyond the region; and disappeared rather quickly. Should the disease have spread much more widely, the Asian panic could have been replicated worldwide.

The ongoing avian flu (H5N1) pandemic among fowl, which first appeared in southern China in 1997, represents a much more significant potential threat to the global system. Although the disease is very deadly to the fowl that it infects, it has jumped to humans on relatively few occasions. If the virus should change slightly into a form that could easily be passed among people, the world would likely experience a disaster much greater than the 1918–19 Spanish flu pandemic, which, according to best estimates, killed at least 50 million people. A recent study extrapolating from the 1918–19 Spanish flu data, indicates that a similar influenza outbreak moving through the more integrated and complex contemporary global system would kill 62 million people, 96 per cent of them in the less-industrialized countries (Murray *et al.*, 2006).

McKibbin and Sidorenko (2006) have explored in much more detail the potential human casualties and economic losses that would be associated with such a future influenza pandemic in our densely populated world of more than 6.5 billion people. They have explored four scenarios in which the severity of a possible future pandemic ranges from "mild" to "ultra" A mild pandemic would take 1.4 million lives, and the global economy would lose $330 billion dollars worth of output. This would be about 0.8 per cent of the total world product. Their more serious ultra pandemic, by contrast, would take 142 million lives, and result in a loss of $4.4 trillion, about 12.6 per cent of world product.

There would be a differential impact on the fortunes of countries and regions. Their "severe" pandemic, with dynamics similar to those of the Spanish flu of 1918–19, would wipe out 71 million people. These fatalities likely would be concentrated in China, India, and other less-developed countries since they would probably not have adequate access to vaccines or medications. China would experience 14.2 million fatalities, India 12.1 million, and the rest of the less-developed world 10.0 million (McKibbin and Sidorenko, 2006).

By contrast, there would be approximately 1.0 million deaths in the US, 3.2 million in Europe, and 1.1 million in Japan. But the economic shocks associated with the spread of the disease would be considerable in all impacted countries, and would undoubtedly spread across borders and paralyze world commerce. GDP in the US would drop 3.0 per cent, in Europe it would fall 4.3 per cent, and Japan would be hit by an 8.3 per cent decline. China's GDP would decline 4.8 per cent, India's GDP would decline 4.9 per cent, and the GDP in other less-developed countries would decline by 6.3 per cent (McKibbin and Sidorenko, 2006).

Influenza pandemics on this scale would dramatically slow, or even reverse, the growth of worldwide trade and travel for an extended period. Should the pandemic linger, or should another pandemic develop, then the consequences could be severe. Such events could dramatically transform or even curtail this round of globalization. Given the three significant influenza pandemics in the nineteenth century, and the contemporary resurgence and emergence of many diseases, it would seem that highly infectious diseases represent a serious threat to increasing social complexity and deepening globalization. Given the nature of this challenge, what has been the response?

Moving beyond Westphalia

As Tainter (1988) has deftly put it, growing complexity requires more sophisticated forms of governance. It is clear that future threats from the forces of nature, in this case pandemics, are likely to pose a deepening challenge to globalization, as well as to human security in general. This obviously requires rethinking traditional approaches to international cooperation and global governance.

Until the middle of the nineteenth century, infectious diseases were considered to be primarily national health issues, and there was only very limited inter-state cooperation in arresting their spread. Beginning in Italian city-states in the fifteenth century, European countries slowly adopted unilateral quarantine measures to stop infectious diseases from crossing their borders. By the later half of the seventeenth century, it had become common to require ships leaving foreign ports to obtain a bill of health from the destination state's diplomatic representative there, guaranteeing the last port of call to be free of epidemic diseases such as cholera, plague, or yellow fever. But these efforts "relied exclusively on a nation's own governmental capabilities – diplomats abroad and quarantine officials at home" (Fidler, 2004).

As threats from infectious diseases grew in the first half of the nineteenth century, the major European powers tried to take a more systematic approach to dealing with their spread. Beginning with an international sanitary conference in Paris in 1851, the European powers had some limited success in crafting a series of international sanitary conventions. But these conventions were based on Westphalian principles, with a strong emphasis on sovereignty, and they were intended mainly to restrict trade and travel during periods of medical emergencies. The rules did not address potentially dangerous diseases that might exist within states and spread throughout those states. And they required no actions by states in implementing public health regulations. (Fidler, 2004). The first attempt to set up a worldwide health organization resulted in the Office d'Hygiene Publique being set up in Paris in 1907. Its mandate was to study epidemic diseases, administer international conventions, and to facilitate the exchange of disease data (Gomez-Dantes, 2001).

More contemporary attempts to cooperate in dealing with global public health threats can be traced back to the founding of the World Health Organization (WHO) within the framework of the United Nations in 1948. The WHO adopted a set of International Sanitary Regulations in 1951, which are now called the International Health Regulations. Within the WHO, a World Health Assembly, composed of all WHO member states, has the power to adopt regulations that in principle are binding on member states. But members may "opt out" or refuse to be bound by specific provisions of these International Health Regulations. In this respect the regulations are very similar to conventional treaties; sovereign states are bound only by those agreements that they ratify. A set of International Health Regulations was adopted in 1969 and was updated in 1973, 1981, and 2005. Originally the regulations did not really require WHO members to do much more than notify the organization of outbreaks of plague, cholera, and yellow fever, and to maintain certain public health capabilities at ports and airports. The significant 2005 update, completed at a time of concern over a potential influenza pandemic, requires member states to notify the WHO of all major health threats with the potential to spread. This includes notification of any bioterrorism events. The revised regulations also require both the WHO to assist member states in responding to disease threats, and greater international cooperation to limit the spread of disease.

Thus, at the beginning of the twenty-first century, prior to the outbreak of SARS, capabilities for dealing with large-scale disease outbreaks were somewhat limited, for at least three reasons. First, a revolution in health care in the wealthy countries had created overconfidence, if not arrogance, in the battle against communicable disease. Second, the most deadly diseases, and by far the greatest number of disease victims, were located in the world's poor countries. It was a matter of "out of sight-out of mind." But deepening globalization has now changed all this, and diseases can now move rapidly from poor to wealthy neighborhoods in the emerging global city. Finally, even the HIV/AIDS outbreak, a truly full-blown but slow-moving pandemic, failed to excite people because it was associated with "misbehavior." Unlike influenza, people were thought, for the most part, to have exposed themselves to the disease through their own choices.

But, since the SARS outbreak, pressures for worldwide cooperation in fighting infectious diseases have been growing. Significant progress has been made in increasing surveillance to detect disease outbreaks; in responding to them; in using anticipatory thinking to prepare for and possibly prevent future pandemics; and in encouraging greater transparency in countries likely to experience disease outbreaks. The Program for Monitoring Infectious Diseases (Pro Med-Mail) is an Internet-based service that rapidly circulates reports of disease outbreaks around the world to its 30,000 subscribers. Also, the World Health Organization uses the Internet to link together the Global Outbreak Alert and Response Network (GOARN) which it founded in 2000. Moreover, a nascent global health community dedicated to stemming infectious disease outbreaks is emerging. Nevertheless, the World Health Organization still lacks adequate resources and enforcement power, and it depends heavily upon other organizations, as well as moral suasion, to contain new disease outbreaks.

To sum up, it is clear that this round of globalization is creating an ever more interdependent and complex global society that is increasingly vulnerable to the same forces of nature that have limited the reach of past civilizations. The most immediate and likely of these challenges from nature is another influenza pandemic, perhaps of much greater severity than those that took place in the twentieth century. A race is now under way between deepening globalization, with its potential for the more rapid spread of deadly diseases, and the ability of the scientific community to locate disease outbreaks and to move quickly to contain and remedy them. But the latter requires the willingness of political leaders to recognize that, in the contemporary world, infectious diseases cannot be stopped by borders, and that dealing with future challenges of this nature in a much more complex global system requires a paradigm shift in defining and building global security.

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11 Globalisation in history and the history of globalisation

The application of a globalisation model to historical research

Catia Antunes

Introduction

Globalisation has been a common theme in the social sciences for the last 15 years. History and historians, however, have been reluctant to accept globalisation as a concept applicable to history, and have avoided writing about the history of globalisation.

This essay is an attempt at combining traditional historiographical interpretations with a model of historical globalisation. This article starts with a brief review of modern historiography, a subject that has emphasised the need for broad interpretations in history. These interpretations will be presented as the basis that historians use for bringing the globalisation concept into the historiographical debate (see the second section of this chapter).

The third section of this chapter introduces the model of historical globalisation as it has been presented by D. Held and his co-authors (Held *et al.* 1999). We will analyse the two dimensions of the model and explain the various shortcomings of the analytical framework. We will then suggest possible interpretations of the problems and mention potential solutions that take into consideration the analytical tools available to, and the methodologies used by, historians.

The criticisms of the model will be followed by a discussion of the difficulties that the study of historical globalisation presents to history as a discipline. These intricacies, although cumbersome to historians, may be less complicated to other scholars. The model may, therefore, have a multidisciplinary character, and its effectiveness may depend on the perspectives and methodological demands of each discipline.

Historians and *l'histoire totale*

Historians have tried to look at history from a global point of view since Herodotus. F. Braudel was the first historian to set clear boundaries for universal approaches in history. Although his language was highly deterministic in content, his ideas were revolutionary. He defined historical analysis at three different levels: structure, conjuncture, and events. According to Braudel, history could only be written if these three levels of understanding were put together into an analysis of a certain period. His final goal was to present the world with a *histoire totale*. The methodological approach of presenting structures, conjunctures, and events as a single body was not successful. It was difficult to relate structures and events, or conjunctures and structures. The causality between continuities and changes at all levels was difficult to ascertain, and Braudel failed to present a methodology that would avoid the contradictions of his own system (Braudel, 1966; Braudel, 1979).

Braudel's ideas were followed up by I. Wallerstein in the beginning of the 1970s. Wallerstein was somewhat less ambitious in his work than Braudel. Instead of trying to find a systematic approach to total history, Wallerstein attempted to define the characteristics that he thought were the most important for provoking historical change at a Braudelian structural level. Wallerstein focused upon the events that he thought had been the reason for so-called breaking points in history (revolutions, economic growth, social transformations, and so on). One of those events was the rise and development of capitalism (Wallerstein, 1974).

Wallerstein's improvement on Braudel's three-dimensional analysis was his idea that development in history was bound to a specific time and space. This means that, throughout history, the areas or periods that had accompanied the most developed level of capitalist enterprise were the ones most likely to be successful, and were therefore the centre of historical change. Wallerstein then created a language that would fit his definitions of structural analysis. The first concept was the idea of 'total history'. This 'total history' could only be written about the so-called 'world-system'. According to Wallerstein, a world-system is a social system. In historical perspective, this social system had two different forms. On the one hand, a world-system could be a world-empire, where a direct correlation between central political power and the economic control over a certain geographical area did not necessarily coincide. On the other hand, the world-system could be characterised as being a group of world-economies. These world-economies were economic structures governed by capitalist relations established between the different social elements present in the structure; for example, governments, institutions, groups, or individuals. In practical terms, this means that, unlike a world-empire, in which one centralised political system could encompass several economic systems, a world-economy (although also an economic unit) could include different political systems (Wallerstein, 1974, vol. 1, 347–8).

Wallerstein's distinction between world-empires and world-economies eliminates any notion of world history before 1600, because all earlier systems were obviously world-empires. Because it is difficult to study all world-economies before the 1600s, Wallerstein focused his analysis on the European world-economy and the relationships established between different areas in this system. Wallerstein's first step was the definition of the different areas inside a world-economy. This definition depends on the position that each one of those areas acquires once in contact with the others. The first important concept is the 'core'. The core is the economic centre of the world-economy. Sometimes this economic centrality coincides with a political centrality, according to which one may also refer to the core as the 'core-state(s)'. At the bottom of the system lay the 'periphery(ies)'. The periphery is the part of the world-economy that, due to the capitalist division of labour imposed upon it by the core and the low rank of the goods produced by it, remains on the outer boundaries of the system. As a result of the competition between the different peripheries or the different areas in a particular periphery, some peripheries become semi-peripheries. A 'semi-periphery' is, therefore, an in-between stage of economic evolution and political development. It is almost impossible for the periphery to pose any threat to the core. However, once a periphery has been promoted to a semi-periphery and been made essential to the articulation between the different levels of the world-economy, that same semi-periphery starts to pose a serious threat to the core. Different moments in history have elevated certain semi-peripheries to a core level, leaving the original core with the status of a semi-periphery (Wallerstein, 1979, vol. 1, 302 and 349). In general terms, we can say that Wallerstein conceives of a hierarchical structure of the world-economy, whose boundaries go beyond political unities or nation-states. This hierarchy is the result of the division of labour and the organisation of production between the core, semi-periphery, and periphery, according to which the core extracts the most advantageous elements from the almost parasitical relationship with the other two layers of the system. Wallerstein also emphasises the role played by the external areas in the development and maintenance of the world-economy. According to him, the relationship established between the world-economy and the other systems was reduced to the periodic exchanges of riches.

Wallerstein's work has engendered a fierce debate on the best way to write total history. Following the discussion about the relationship between the world-economy and the external areas, the first counter-argument against Wallerstein is stated by J. Israel. According to him, the relationship between the world-economy and the external areas, classified by Wallerstein as relative in value and regularity, was very important for the development of the world-economy, especially its core. Israel's argument is that the rich trades (trade in luxury products), although occasional, were a regular characteristic of the bilateral relations between the world-economy and the external areas. Those rich trades deeply influenced the way that markets, tastes and fashions developed in the world-economy, creating, therefore, a certain degree of interdependence between external areas and the world-economy (Israel, 1989).

The second critique to the work by Wallerstein is made by J. L. Abu-Lughod. She rejects Wallerstein's theory on the instability of world-economies before 1600. She asserts that Wallerstein's idea of a world-economy is based on the European experience, and that this European focus has impeded his assessment of the behaviour of world economies in other geographical spaces outside

Western Europe. In her major work, Abu-Lughod defends the idea of a stable world-economy before 1600. Her view of the world economy also contradicts Wallerstein's Euro-centrism by placing her analysis in the Middle East and Asia (Abu-Lughod, 1989).

A. G. Frank has voiced further concerns about Wallerstein's model as a whole. Frank's criticism consists of two main issues. The first issue is Wallerstein's Euro-centric tendency. Frank agrees with Abu-Lughod when she mentions Wallerstein's obsession with Western Europe. He argues that Wallerstein's eagerness to explain the rise of the West has blinded him to the search for forces outside the European modern world-economy that might help to explain this development. Frank condemns Wallerstein's lack of interest in the development of the external areas and their privileged relationship with Europe. The example that he uses to show the importance of these external areas is the case of China (Frank, 1998, XXIV–XXV).

A second important point of disagreement between Frank and Wallerstein is the idea of 'total'. According to Frank, by creating a notion of different world-economies and world-empires that may have existed in a certain period of time, Wallerstein denies the idea of *histoire totale*. Frank claims that Wallerstein's model has denied history the possibility of being presented as a unified whole. He recognises Wallerstein's accuracy with regard to the existence of different systems, but he does not believe that this diversity necessarily implies disunity or discontinuity in history. Frank claims that the diversity only makes sense when included in a unity (Frank, 1998, 359).

Frank's conception of global history has been very reluctantly accepted by the established historiography. The idea of unity in diversity has been especially criticised by G. Arrighi, who has identified Frank's failure to allow for diversity in unity. Arrighi fails to acknowledge Frank's ambition to conceive of a global system built upon Wallerstein's different world-systems (world-empires and world-economies). He thinks that Frank does not pay enough attention to the specifics of the world-systems. According to him, Frank undermines his own arguments when he fails to define which historical developments happen at global, national, regional, or local levels (Arrighi, 1999, 339–41). Arrighi goes further in his argument by accusing Frank's globological perspective of being the product of an extreme liberal ideology, as opposed to Marxist arguments by Wallerstein (Arrighi, 1999, 342–3).

The argument between Wallerstein and Frank has been a common theme in the historiographical output of the last ten years (Frank and Gills, 1993). The argument has focused more on issues concerning the historical events that have determined the rise of the West and the Industrial Revolution, rather than on issues concerning the existence or non-existence of a 'unity' with 'diversities' (McNeil, 1990; Frank, 1991; Green, 1992; Benton, 1996; Bentley, 1998; Buck, 1999; Vries, 2002; Christian, 2003). As this review of the ongoing debate surrounding a big-picture of history has shown, consensus of what history as a discipline should or can do is in short supply. Despite the problems inherent in defining such parameters, for the purpose of this essay, we have chosen to call Frank's concept of 'unity' 'global', and to define the process in which the 'diversities' became further interconnected and interdependent as 'globalisation'. In the following section, we will review globalisation as it is understood in the discipline of history and then present the main model applicable to the process of historical globalisation.

Globalisation in history and history of globalisation

The quest for a universal concept of globalisation has not been an easy academic task. There are three problems that seem insurmountable. First, scholars in general cannot agree on a common definition of contemporary globalisation, or even acknowledge its existence (Held *et al.*, 1999, 1). Those who believe that a concept such as globalisation is viable have established a set of criteria that may help to sharpen their concept. So far, the problem is that each researcher comes up with a different set of criteria, and that implies that with each study there is a different methodological approach and consequently a dissimilar definition (Katzenstein, 1975; Kleinknecht and ter Wengel, 1988; Panic, 1988; Cohen, 1990; Jones, 1995; Hirst and Thompson, 1996). The lack of consistent methodologies and strong conceptual definitions will only aggravate the already difficult management of notions of globalisation. Second, globalisation has mostly been accepted as a static concept applied to a particular time and space. Third, although scholars from other disciplines have accepted or criticised the concept of globalisation, historians are still lagging behind in studying this phenomenon. For historians, it is difficult to apply factors of analysis or means of measuring globalisation in history, due to the lack of data in available primary sources.

We would argue that the creation of a new concept of globalisation would surely bring more disruption than consensus, and it seems to us that this concept has already been created and re-created by the extensive literature on the subject. But a definition is still needed. Our idea of globalisation fits the essence of the definition by Held, McGrew, Goldblatt and Perraton. They argue that globalisation is the increasing world interconnectedness of all aspects of social life (Held *et al.*, 1999, 2). To clarify this notion of world interconnectedness we would add that globalisation also has to be defined as total, dynamic, interdependent, and planetary (Castells, 1992).

As mentioned previously, a fierce debate has ensued from and around the concept of globalisation. Three main groups have fuelled the globalisation debate: the hyperglobalisers, the sceptics and the transformationalists. In this essay we are particularly interested in the last group. The transformationalist thesis states that globalisation is a very important force of rapid change of all aspects of society. Globalisation is believed to change societies and individuals at all levels of their existence. One of the most important claims presented by this group is that the traditional core–periphery theory put forward by Wallerstein is no longer a geographical concept, but a social one (Hoogvelt, 1997, XII). Subsequently, they argue that the strength of globalisation is based on the interconnectedness of all social transformations of a growing interdependent world (Held *et al.*, 1999, 7–9). It is therefore not surprising that the transformationalists would conceive the possibility that globalisation may be seen as a historical process and, thus, has a history of its own.

The spatio-temporal dimension

By opening the door to historical analysis of globalisation, the transformationalists were forced to create a methodological framework that may be used by historians. Held and his co-authors have built a two-dimensional system, where variables can be used to measure historical events.

This analytical framework organised by the transformationalists works in two different dimensions: the spatio-temporal and the organisational. The spatio-temporal dimension is used to measure globalisation at three levels: extensity, intensity, and velocity (see Table 11.1). Extensity is used to measure the coverage of globalisation of different aspects of social life, using different networks to determine the outcome.

Intensity shows how deeply globalisation has been felt and, therefore, reflects the levels of interconnectedness and interdependency established between the networks. Velocity expresses the speed in which the global flows produced by the networks and brought closer by the phenomena of interconnectedness spread throughout the world. These three levels of measurement together determine the impact of globalisation. This means that the three-dimensional relation between extensity, intensity, and velocity determines the success of globalisation as a historical process.

Table 11.2 shows the measurements done through the spatio-temporal dimension in different historical periods. The twentieth century is associated with diffused globalisation. This type of globalisation is characterised by a good internal functioning of the networks, associated with a large interdependent

Table 11.1 Historical forms of globalisation–an analytical framework

Key dimensions	*Key characteristics*
Spatio-temporal dimension	• Extensity of global networks • Intensity of global interconnectedness • Velocity of global flows • Impact propensity of global interconnectedness
Organisational dimension	• Infrastructure of globalisation • Institutionalisation of global networks and the exercise of power • Pattern of global stratification • Dominant modes of global interaction

Source: Held *et al.* (1999: 20).

Table 11.2 The spatio-temporal dimension: types of historical globalisation

Type	*Features*	*Historical period*
Diffused globalisation	High extensity High intensity High velocity Low impact	Twentieth century
Thick globalisation	High extensity High intensity High velocity High impact	Nineteenth century
Expansive globalisation	High extensity Low intensity Low velocity High impact	Early Modern period
Thin globalisation	High extensity Low intensity Low velocity Low impact	Medieval period

Source: Held *et al.* (1999: 20).

movement between them at a high speed. However, the impact of these features is quite low. The reason for this low impact is the permanent dispute between local, regional, and supranational power structures that has prevented the phenomenon of globalisation from having a higher impact.

The nineteenth-century globalisation is called 'thick', which means that the range of the global networks extended throughout the world at high speed and covering all components of society. The net result was that globalisation had a strong impact.

The other two types are deeply connected with pre-industrial forms of globalisation. The first type is linked with the Early Modern period in general. At that time, the movement of general expansion of the socio-economic networks throughout the world was not enough to change the permanence of long-term interdependencies and to induce a speedy spread of those networks, mostly due to the deficient infrastructural system. Nonetheless, the Early Modern expansive globalisation had a high impact, for two reasons. First, the creation, development and dynamics of different networks brought together different production outlets and consumption markets; second, the proximity of different cultures and habits greatly shaped tastes, fashions, and general civilisational developments.

The last type is the beginning of historical globalisation. 'Thin' globalisation is presented almost as incidental. It refers mainly to the long-distance commercial circuits of luxury products that travelled from the Far East into Western Europe, without having much of an impact, except on the individuals directly involved in these networks.

The question at this point is: why do high extensity, intensity, and velocity have a low impact in the twentieth century and a high impact in the nineteenth century? We can ask a similar question about the pre-industrial forms of globalisation. Why do high extensity, low intensity, and low velocity provoke a low impact in the Middle Ages and a high impact in the Early Modern period? There are three hypotheses that may explain these discrepancies.

The first hypothesis is that the discrepancies are the product of the general vision of the historical process. If one looks at history from the past to the present, we can understand that the impact of the Medieval socio-economic and politico-cultural networks was lower than in the Early Modern period. For example, although sugar was an important luxury product during the Middle Ages, its penetration in the European consumption markets as a whole remained low. The small amount of sugar available on the world markets, the traditional use of honey, and the rudimentary means of transportation, all contributed to the high price of sugar, and made it only affordable to the elite. In the Early Modern period, with the expansion of sugar plantations to different areas of the world there was a concomitant increase in the amount of sugar on the world markets. At the same time, significant technological innovations, especially linked to the transport sector, allowed for a faster and more regular supply of sugar for the European markets. This increase in production and the speed of transportation lowered the price of sugar, thereby making it available to larger segments of the population. Therefore, it is reasonable to state that the process of acceptance and penetration of sugar as a product went through two stages. One stage was that of low impact during the Middle Ages, and the other stage was of high impact during the Early Modern period. The same assumptions can be made for the discrepancies found in the spatio-temporal dimension for the nineteenth and the twentieth centuries.

The second hypothesis is that the attempt to generalise, as is to be expected from a model allied with a vision of the historical process determined by the events in the present, may be the origin of the problem. The model states that both the nineteenth century and the Early Modern period witnessed a high impact of globalisation. Although that theory seems to be accurate, if one looks at the fact that both periods appear to be times of high extensity, the theory becomes less clear and compelling when we see that the nineteenth century was a period of high intensity and high velocity and the Early Modern period was a time of low intensity and low velocity. One can argue that the answer may lie, once again in the historical perspective being used. If one looks at the nineteenth century, the intensity (how many products, people, capital, and ideas moved in and between the networks) and the velocity (speed at which products, people, capital, and ideas travelled in and between the networks) are obviously higher than in the Early Modern period. Technological development during the Industrial Revolution is to be credited for the nineteenth-century success, especially if we look at the development in means of transport. In this case it is legitimate to say that intensity and velocity were high in the nineteenth century and low in the Early Modern period. However, we cannot say that the intensity and velocity of the Early Modern period were as low as in the Middle Ages. That was not the case. European expansion after 1415, the development of new maritime technology, and the interdependency established between Europe and the rest of the world, leave no doubt in our minds that the intensity and the velocity in the Early Modern period were definitively higher than in the Middle Ages. So the problem is that the adjectives 'low' or 'high' are not good enough to classify the gradation in development from one period to the other. A possible solution for this problem might be the use of the descriptors 'very low', 'low', 'high', and 'very high' to describe the different degrees of extensity, intensity, velocity, and impact presented by the model.

A third hypothesis is that the problem lies in the concept of impact. As we have already mentioned, in the Middle Ages and in the Early Modern period, low intensity and low velocity have incited low and high impact. This may mean that impact is not determined solely by the features of the spatio-temporal dimension. The difference between the impact of Early Modern and Medieval globalisation may lie in the organisational dimension. At that level, the qualitative difference between the Medieval and Early Modern globalisations may exercise some influence in the 'high' or 'low' behaviour of the features of the spatio-temporal dimension. The qualitative difference identified at the organisational level may, therefore, determine the impact of globalisation.

Another question that we need to raise is: can we accept that this thin globalisation is the beginning of globalisation as a historical process? If one answers 'yes', then we ignore all history before the Middle Ages, and that seems unacceptable. Looking at the scholarship produced in the last ten years, it seems that globalisation as we are defining it has been about for far longer than the Middle Ages (Chase-Dunn *et al.*, 2006; Chew, 2006; Frank and Thompson, 2006). If one argues 'no', then it is worthwhile thinking about the historical periods that preceded the Middle Ages and seeing whether this framework can or cannot be applied. If the framework can be used before the Middle Ages, then we could argue that it might be possible to see whether what preceded a period of thin globalisation was a period of diffused globalisation, which itself was preceded by an epoch of thick globalisation and so on, and so forth. If that was the path of the process, then one might start talking about the movements of globalisation in the *longue-durée* (see Figure 11.1) (Braudel, 1968; Braudel, 1979).

There are two analytical possibilities for the period before the Middle Ages. The first and most straightforward possibility is that all the historical developments before the Middle Ages constitute thin globalisation, and that the period up to 1500 was nothing else but a continuum of a very low rate of global change and transformation. That seems to be the idea behind the Held and his co-authors when they mention the 'pre-modern' period as containing changes that range from the creation of writing and domestication of animals

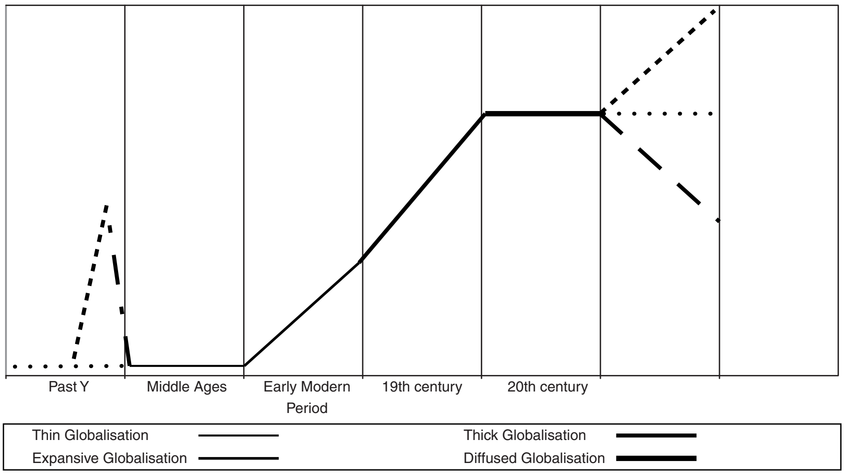

Figure 11.1 Globalisation as a historical process in the *longue-durée*.

to the creation of taxation systems and maritime developments (Held *et al.*, 1999, 438). We do not think that these developments have the same magnitude and therefore should not be equally compared at the theoretical level (see Figure 11.1).

The second possibility – in our opinion more in tune with the model and historical reality – is that what preceded the Medieval thin globalisation was a period of diffused globalisation, best characterised by the disintegration of the Roman Empire and the subsequent division of Europe into fifths, with the same thing happening to the Eastern Empires in China and the Indian sub-continent. Before this period of diffused globalisation, we would argue that there was a period of thick globalisation that included the formation of imperial systems in China, the Indian sub-continent, and the Mediterranean basin (Hittite, Assyrian, Egyptian, Persian, Greek, Roman). Prior to the age of the ancient empires, we conceive of a period of expansive globalisation, which entailed the discovery and/or spread of techniques of domestication of animals and the use of written forms (see Figure 11.1).[1]

Accepting that globalisation is a historical process carved in the *longue-durée* raises a number of questions about the nature of such a process, especially concerning its development, evolution, and predictability. Historical globalisation can only be accepted as being a 'development' if we understand development as a vital event or change. This implies an advance from a less complex form to a more intricate and established form. In this case, if we argue that historical globalisation is a development in history, then we fear that thin globalisation will follow diffused globalisation. That is to say, after the phase that we are experiencing at this moment, the world will become less interconnected, and thin globalisation will follow this age of informational linkage. The question remains whether a movement towards thin globalisation would be possible. We would argue that the possibility exists. The proliferation of socio-economic and politico-military conflicts may drive the majority of the world population into isolation, undermining any further development of the globalisation process.

If the word 'development' implies the advancement, maturity, and growing complexity of globalisation, then it cannot be dissociated from the term 'evolution'. In this case, one should understand 'evolution' as G. Modelski and T. Devezas have defined it as 'political globalization [*can be understood*] in evolutionary terms (as one centered on innovative sequences of search and selection) makes it possible to construct a time-table for global politics, and to derive from it an agenda of priority global problems' (Modelski and Devezas, 2006, 1). As a result, the understanding of globalisation as a historical process needs to be reviewed. It is true that globalisation, and particularly political globalisation, can be analysed from a historical perspective, but different degrees of globalisation were achieved at different times and in different places. For example, when speaking of the European expansion overseas, many have identified a new phase of globalisation. However, if the process can be seen as a means of globalisation for the Europeans, the question remains whether that was the case for the peoples and territories that they reached. Historians seem to profoundly disagree on this matter. The discussion has been polarised between the scholars who state that the opening of contacts is already enough to call this new development a step into globalisation, and the others who argue that without clear signs of market integration, there is little that one can say about the process. Others go even further by accusing established historiography and historiographical production of a Euro-centric view of history. That is especially the case when historians fail to recognise the technological, urban, and demographic superiority of Asia at the moment when the Europeans arrived there, for the first time using maritime routes (Frank, 1998; Findlay and O'Rourke, 2001; Antunes, 2004).

Simultaneously, if we relate the idea of 'evolution' and therefore of a 'more innovative' form' of globalisation, we are necessarily implying that globalisation has gone through a process of betterment. This would bring historians into a an area in which they are deeply uncomfortable, since one of the qualities implied in the function of history-writing is the idea that history should be interpreted in a neutral and non-affected way, to allow enough room and plenty of coverage for the different sides of the same story. In one sentence, historians are not sociologists or political scientists, and they should not take part in the judgement of history or processes in history (Bloch, 1949), hence our reluctance to associate globalisation with the idea of evolutionary processes in history.

The inability to, and refusal to, judge history or historical processes as evolutionary arises with the inability to accept the idea of predictability in history. The verb 'to predict' means 'tell about something in advance of its occurrence by means of special knowledge or inference'. We do not have at this moment in time, anywhere in the world, as far as it is known to the scientific community, any device, system, or methodology to predict the future. We lack that 'special knowledge' by which we might be able to say what the future holds. However, we agree that inference is a possible means to speculate on what might happen in the years or centuries to come, but this 'inference' falls out of the scope of history as a discipline. 'Inference' and 'speculation' are two privileges that historians cannot afford, since primary sources open a narrow window of understanding about what happened in the past. We are completely unable to grasp the totality of the historical 'truth', and historians seldom agree on how to interpret the realities presented by the existing primary sources. If the perception of the past is as complicated as this, then it is therefore unwise to base 'inference' and 'speculation' about the future and, therefore, about the predictability of globalisation as a process, on realities that are themselves only perceptions of what the past was. If we are not completely sure of the data that we have about the past, what makes us think that we may infer future events?

The constraints imposed by the study of history, and therefore its inherent inability to allow for predictions, does not mean that other scholars cannot use the model of historical globalisation to contemplate what the future may hold (see Figure 11.1).[2] However, it is beyond the scope of history and historians to determine whether the future will hold a thin, diffused, or new form of globalisation.

Expansive globalisation: an example of global historical dynamics

The Medieval international economic circuits were directly connected with three main centres. The Eastern trade encompassed the products brought from Asia, through different land routes. These land routes terminated at the Eastern Mediterranean coast. Cities like Constantinople or Alexandria, and the islands of Rhodes and Cyprus, were important gateways for these land routes (Hunt and Murray, 1999: 5–6). Although the land routes ended in the Eastern Mediterranean ports and islands, the journey of the products transported by the caravans did not stop in the East. The Eastern products were transported in Venetian or Genoese boats from the Eastern Mediterranean to Italy, other Mediterranean ports, and, finally, delivered to Northern Europe. Venice and Genoa, and their merchant communities in the Mediterranean, were the second key element for the maintenance and furtherance of world contacts during the late Middle Ages. The transport of Asian products to Northern Europe was achieved via two different routes. The products would be taken via the inland routes (land or river) and then traded at the Champagne fairs in France. The second option was that the Eastern products would be taken by sea (via the Atlantic route) to Northern Europe – more precisely, to the Flemish cities. At that moment, the Italian merchants would have finished their part in this process. But this was not the end of the road for the Asian products. From the Flemish cities, they would be transported to Scandinavia, Germany and

Eastern Europe by the merchants associated with the Hansa cities. The Hansa merchants and cities were, therefore, the third important link in this Medieval global economy.

The first important characteristic of this Medieval network is the role of ports. They functioned as windows of contact between different intermediaries. They provided ideal warehouses, and they constituted important consumption markets. The second important characteristic of this network is the products. They were mainly luxury goods such as silk, gold, silver, jewellery, precious stones, sugar, spices, and other rich traded goods. The amount of goods transported was not considerable, and the regularity of the transport was measured on a yearly basis, at the most. This means that the price of these products in the consumption markets was very high. These high prices presented an obstacle to the development of a consumption shift, which in theory might have touched larger sections of the European population. A third important characteristic is the role played by individual merchants and merchant communities. They were connecting elements between the production outlets in Asia and the consumption markets in Europe. They also controlled the transportation system. That meant that they held a privileged position in determining the price of their merchandise, since a great deal of the price of a product was bound to be based on the transportation costs of that same product from the production outlet to the consumption market (Lopez, 1976).

The products that travelled from Asia into Europe were the main reason for the existence of this Asian–Euro–Asian commercial network. But we believe that products were not the only important element in this network. We have already mentioned the role played by individual merchants and merchant colonies in supporting this network. Their role as intermediaries between different traders, ports and consumers gave them an essential role in the effectiveness of the network as a socio-economic system. In order to be efficient and take care of one's business, periodic travelling or complete migration were required. That was the only way to guard one's interests in this complex system. So, we can find colonies of Genoese or Venetian merchants all over the Mediterranean, as we can find Hansa merchants in Bruges. Less common, but still seen from time to time, was the existence of Venetian colonies in England, or Hansa merchants in Lisbon (Scammel, 1981).

Merchants, products and trade are concepts that are closely associated. Merchants use trade to exchange goods, and to transport and sell these same goods. This exchange of products, as well as the organisation of transport, requires large capital investments. First, merchants needed to pay for the products that they wanted to buy. They could do that by investing their own capital, or by ensuring that the seller was interested in the products the merchant had to exchange. This was the case with Venetian glass and sumptuous draperies that were often used to trade for Eastern products arriving from the Levant. Once the transaction was completed, products had to be transported or shipped to the consumption markets, which implies investment in the means of transportation, personnel (ship crews, for example), protection (armed convoys, for example) and extra money to pay tolls and other occasional costs. All of these elements (transportation costs) add up to create the final price of the product at the consumption markets. It is possible that individual merchants financed these operations with personal capital, but often that was impossible due to the high costs and risks involved. So, Medieval merchants tended to stick together and either organise joint ventures or borrow money to finance their personal enterprises.

Capital is also an important factor in the consumption markets. As we have seen, the Asian–Euro–Asian network was divided into several stages where the products had to be paid for. They had to be paid for at the production outlet, in the Mediterranean ports, at the fairs in Champagne, in the Flemish cities, and in the Hansa cities (Schneider, 1986). This network crossed different political units and several territories, which implied a proliferation of currencies and means of payment. The best way of solving this problem was the issuing of bills of exchange that could be used as international means of payment and, at the same time, as a means of currency exchange.

Geographically, one cannot speak of a global economy. The areas involved in the network mentioned above did not cover all the continents and, therefore, it is also difficult to accept the categorisation by the historical globalisation model that identifies the Middle Ages as a period of high extensity. Still, even if we perceive extensity as the coverage of different aspects of social life (for example, trade, merchants, or capital transactions), extensity remains a weak characteristic of thin globalisation. Looking at intensity, we will have to agree with the model's claim that thin globalisation had low levels of intensity. In fact, the contacts between East and West were sporadic, and we can only speak of one real network, composed of rich trades. We can identify a certain degree of interconnectedness between products, merchants and capital, as much as we can find interdependencies between production outlets, means of transportation and consumption markets, but we cannot discuss the level of dependence established between this network of rich products and, for example, bulk products. The velocity of thin globalisation is also well characterised by the model. The speed in which the elements inside the network interacted and the technological limitations of the time did not allow for high speed. The model fails to explain why Medieval extensity is high, especially if we compare it with the expansive globalisation extensity. However, the statement that thin globalisation had low impact seems to fit the description of the network that we have mentioned above. This low impact can be understood in two ways. The impact is low geographically, due to the amount of areas involved in the network or profiting from it. And, the impact can be considered low because there was not a substantial amount of social (social, economic, political, and cultural) impact of the network upon the elements involved in that same network or in the regions connected to it. For example, the use of spices by the European population took at least another two centuries to go down the social ladder. At the same time, Europeans and

Asians were quite ignorant of each other's traditions, languages, or religious practices.

To address the question of whether or not it makes a difference to use the term 'globalisation' instead of 'world-economy': the answer is yes. Globalisation is a concept that, according to the model, includes and explains the full complexity of the multidimensional characteristics of the network, and it is able to put more emphasis on the interdependencies established between different elements of the network than the concept of a 'world-economy'. The latter remains a strict concept, according to which hierarchical relationships are more important than interdependent relationships. However, this is not to say that the interdependencies essential to define globalisation have to be balanced and that the door for the explanation of imbalances, inequalities, discontinuities or competition has been shut. What it means is that these imbalances, inequalities, discontinuities and competition do not occupy the centre of the historical analysis, as is the case with the concept of a 'world-economy', but that all these elements make up part of the system. The system as a whole, with both the positive and negative impulses, stands at the centre of one's attention. If we borrow some concepts from biology, a 'world-system' is focused on the parasitical relationship between core and periphery, while 'globalisation' tends to give primacy to the symbiotic relationships in the networks.

Looking back at the model of historical globalisation, we have seen that thin globalisation was followed by expansive globalisation. If we would have to point out a moment to indicate the beginning of this second stage of historical globalisation, we would have to choose the year 1415. In that year, the Portuguese conquered the fortress and city of Ceuta in the north of Africa, opening a new chapter in the history of the world. The conquest of Ceuta marks the beginning of the European expansion overseas that was to change the knowledge of the world and international relations for ever. If 1415 was the beginning of European expansion, then 1500 marked the opening up of expansive globalisation. The direct contacts between Europeans, Africans, Asians and Americans after the sailing of the Cape Route to Asia and the arrival in America initiated an era when the traditional Asian–European–Asian Medieval network was replaced by several networks world-wide (see Figure 11.2).

The first difference between the Medieval world and the post-1500 world was the European trading networks. Europe replaced the sporadic contacts between the Levant and Northern Europe with a range of European networks, whose main function was the commercialisation of bulk products. The Levant network controlled by Genoa and Venice had been partially supplanted by the maritime connection via the Cape of Good Hope with Asia. The loss of its international character did not condemn the Levant route to disappearance. The Mediterranean became a network in and of itself, and the most important exports to areas outside of the region were wine and fruit. These were balanced by the import of grain and manufactured goods. The production outlet for

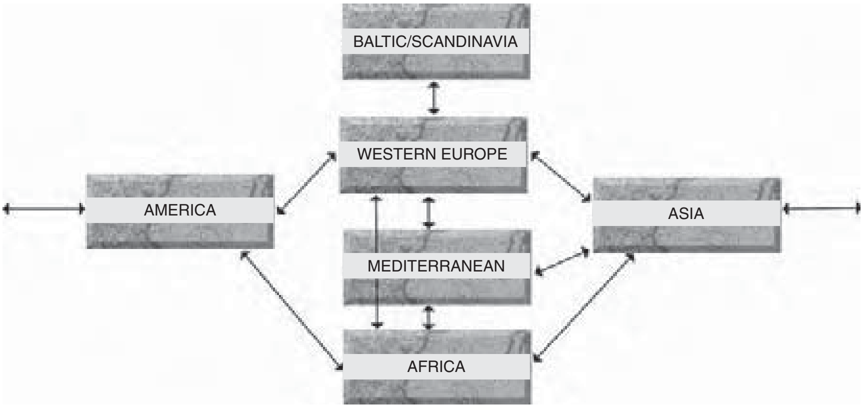

Figure 11.2 Visualising expansive globalisation.

these products was Northern Europe. The grain was stockpiled in Northern European ports like Antwerp, Amsterdam, or London, and afterwards re-exported to the Mediterranean or the SW European ports (Bogucka, 1980). The basis of the relationship established between the Northern European ports and the bulk producing areas, the Baltic and Scandinavia, was the import of grain, wood and copper, in exchange for wine, fruit, salt, manufactured goods, luxury goods and silver. The salt was obtained in the ports of Atlantic Western Europe (the French, Spanish or Portuguese ports) and taken to the Baltic and Scandinavia. The luxury products and silver were acquired through the networks connecting Western Europe and other continents (Davis, 1973; Rapp, 1975).

Chronologically, the first intercontinental maritime network was established between Europe and the West Coast of Africa. Africa supplied Europe with gold and slaves, and Europe sent food, manufactured goods and arms and armaments to Africa. Gold was important to sustain the position of certain European currencies and to balance trade routes, but slaves were never a vital product in the European–African relationship. Slaves became crucial to the intercontinental networks at the moment the Europeans depended on a slave labour force to exploit America (Herbert, 1981; Marques and Serrão, 1996, vol. 2).

The second intercontinental network was the Euro–Asian–European maritime network. The exploration of the west coast of Africa led the Europeans to the Cape of Good Hope and to the maritime route to Asia. The Europeans did not have much to offer to Asia, as had already been the case in the Middle Ages. They exported arms and armaments, but the bulk of their trade had to be paid for with silver. The imports from Asia did not change much. Tea was a novelty, but textiles, porcelain, spices, dyestuffs, precious stones and other luxury goods already made up part of the network at the time that Europe and Asia communicated only through the Levant. When the Europeans became engaged in the trade routes in the Indian Ocean, it became clear that the east coasts of Africa and Asia already had contacts based on the African export of ivory and gold, and the Asian export of textiles and spices (Wake, 1979; Reid, 1992).

The last intercontinental network to come into operation was the Atlantic route connecting America to the rest of the world. America exported sugar, tobacco, cocoa, dyestuffs, tropical wood, gold and silver to Europe. Europe sent manufactured goods and food to America. In order to maintain the sugar, tobacco, and cocoa plantations in America, the Europeans bought slaves on the west coast of Africa and sold them in America. The European settlers in South America competed with this original scheme by buying slaves directly on the west coast of Africa and exporting food (and also materials for warfare). Further explorations in the American continent opened up the opportunity for American–Asian contacts. Silver was exported from the east coast of America via the Pacific to the Philippines, and from there onwards to Asia. In exchange, and following the same route, textiles and luxury goods were sent to America. However, the lion's share of these silver imports from America via the Pacific was still used to balance out the European transactions in Asia (Adon and Gordus, 1981; Szászdi, 1981; Yuan, 1981; Chaudhuri, 1986; Schneider, 1992).

Looking at the international contacts before 1415 and after 1500, what are the most important developments that one has to point out? The first main difference that needs to be mentioned is the existence of multiple networks. We went from one main network linking East and West, to several networks. The multiplicity of the networks was a phenomenon that must be understood at two levels. There were more networks on a world scale: continents were in contact with each other. On a continental scale, the number of networks connecting different areas also increased. That was the case for the Baltic/Scandinavian, Atlantic or Mediterranean networks in Europe. This multiplicity of interconnected networks can be assessed when looking into freight contracts registered by different notaries throughout the main European ports. These contracts clearly show the routes followed by products, people and capital during the Early Modern period, as well as the level of interdependency inside each network and between different networks.

The second important feature that needs to be mentioned is the nature of the products transacted through the networks. The Medieval network was basically composed of luxury goods. After 1500, some luxury goods were slowly adopted as day-to-day products, and so lost their luxury status (Berg and Clifford, 1999; Ashworth, 2003). The multiplying of the networks and their geographical range opened up the possibility for larger transactions. This means that there were more products being exchanged and that they became more diverse in nature. Luxury goods were then joined in the network by bulk goods and manufactured items. The world could now profit from the multiple networks and the diversity that they could offer. This diversity was further extended to the human and capital elements. Merchants were not the only ones to enjoy the advantages that the new socio-economic networks could provide. Administrative personnel (bureaucrats), diplomats, missionaries, or labour specialists (soldiers, sailors, book-keepers, engineers, slaves and others) were all using the networks either to exercise their professions or to improve their socio-economic position. Diplomatic and state papers disclose the importance of labour specialists as actors in the Early Modern globalisation process.

Intra- and intercontinental migration is, therefore, a new factor that one has to account for in the post-1500 world. Last but not least, variable capital also suffered significant changes. We have already mentioned how important bills of exchange were as a means of payment during the period of thin globalisation. During the period of expansive globalisation, bills of exchange maintained their role as a means of international payment, but the complexity of the financial transactions was such that they slowly became a means of credit as well. Their role was no longer confined to the payment for products in foreign currencies. They could also be used to buy shares in commercial companies in the land of origin of the investor, or even abroad. It is legitimate to argue that, in spite of the fact that the variables (products, people, capital) in the network analysis were the same in the Medieval and Early Modern period, the diversity of products and their nature; the increase of regular migratory movements of different socio-economic groups; and the growing complexity of the financial system and transactions, all indicated that the Early Modern world was far more complete, global, and interdependent than the world of thin globalisation.

The relationship between the different economic areas of the network also seemed to have changed. The explosive growth of the geographical coverage of the networks increased the amount of production outlets and of consumption markets that could potentially establish a relationship with each other. This implies three immediate consequences. The first consequence was that there was a greater diversity of products available on the market. The second consequence was that all of this diversity could not be met by a balanced exchange of products between a particular production outlet and a certain consumption market. This was the reason for the third consequence, which entailed the interdependency of the networks. To satisfy a certain consumption market, one had to gather different products from different production outlets, which in their turn, would receive different exchange products, which originated via an undetermined number of networks.

The organisational dimension

Should scholars in general, and historians in particular, choose to address globalisation using the model presented here, they need to examine the organisational dimension. This level is divided into four key characteristics: infrastructure, institutionalisation, stratification, and modes of interaction (see Table 11.1).

The infrastructures of globalisation are the means through which flows stream in the networks. Held and his co-authors have identified three types of infrastructure: physical, legal, and symbolic. The physical infrastructures include the infrastructures available for transportation, which can increase or decrease the velocity of globalisation and its impact. The laws governing certain networks make up the legal infrastructure. They promote better or worse conditions for the creation, development, and success of a network, this being a group of nodes that facilitate an efficient connection between multiple poles. The symbolic infrastructure is connected with the means of communication throughout the networks, for example languages and cultural differences, which may deeply influence the impact of globalisation in any period. The performance of the infrastructures is therefore connected with the higher or lower extensity and intensity of certain areas of a particular network (Held *et al.*, 1999, 19).

The examples that Held *et al.* give for the pre-modern, early modern, modern, and contemporary globalisation are consistent with the development of physical infrastructures – starting with the domestication of animals; moving to transformations in shipbuilding activities into the creation of railways and mechanised shipping; and ending with the endless possibilities brought to us by the aviation industry. This progress in physical infrastructure was a determining factor for the speed at which different elements and individuals in the networks moved, influencing the impact of globalisation in time and space (Held *et al.*, 1999, 438). The impact of these infrastructural changes can be measured historically by determining the time needed to transport products and people from point A to point B. The Silk Route took up to two years to be fully traversed from China to Western Europe in AD 1000, but in 2006 you can fly from New York to Beijing in 13 hours and 45 minutes. However, the fact that the connections are faster and arguably more intense today than 1,000 years ago does not necessarily mean that ancient trade flows and migratory movements were either unimportant or negligible.

The model of historical globalisation fails to provide clear examples of a legal infrastructure and its evolution throughout history. By arguing that the legal infrastructure is a means to define the laws governing the functioning of the networks, Held and his co-authors could have picked a good example of the regulatory measures stemming from early periods to control, tax, and administer the different flows of products, capital, and people. For example, the first trade flows depended solely upon the words informally exchanged between the interested parties. This informality decreased during the Early Modern period, with the widespread use of commercial contracts sanctioned by notaries, as well as diplomatic treaties defended by central regional authorities. Although these Early Modern forms of legal infrastructure are still used today, diffused globalisation is characterised by internationally recognised world treaties, as is the case for the directives approved by the European Union, the World Trade Organisation, OPEC, or the African Union, among many others. This movement from private informality to worldwide contractual use is of extreme importance for the determination of levels of institutionalisation of the networks, as we will see next.

The symbolic infrastructure is exemplified by Held *et al.* as knowledge–technological developments that helped the establishment, advance, and growth of networks. That was the case for the ability to write; printing; the creation of postal systems; and the discovery and use of telegraphy, telephony, computers, and digitalisation (Held *et al.*, 1999, 438). Once again, these developments show growing trends of extensive and intensive use of the networks, and therefore of progressive globalisation.

The level of institutionalisation represents the frameworks used by the governing powers to control and regulate the networks. This institutionalisation of the networks can be quite positive. In fact, the higher the institutionalisation level the better chance the network has to unify and promote financial flows, labour force migration, and so on. One may still argue that the growing efficiency of the network, achieved by increasing levels of institutionalisation, makes a large difference not only for the impact of globalisation in space, but also in time – that is to say in depth and width.

The scholars responsible for the model of historical globalisation are quite laconic when they point out the levels of institutionalisation attributed to globalisation in different periods in history. They simply acknowledge that institutionalisation was very low until the beginning of the Industrial Revolution, at that point reaching a moderate level, increasing to a high level in the diffused globalisation of the twentieth century (Held *et al.*, 1999, 438).

In the way that we see history, institutionalisation and infrastructural development are impossible to dissociate. That is especially the case with the legal infrastructures. Although we would agree that pre-modern institutionalisation may have been low – going no further than a common regional taxation system – we cannot agree with the idea that institutionalisation in the Early Modern period was very low. As we have seen while analysing the evolution of legal infrastructures, the increasing regulation of commercial activities seems to have experienced an explosive growth during the period of European expansion.

The increase in private regulatory mechanisms for private commercial exchanges was also followed by the central and regional authorities by recognising the need for the international recognition of areas of influence and protection of production outlets and consumption markets. This central display of legal institutionalisation was achieved at two levels: first, with the spread of diplomats and representatives to deal with controversial issues. Diplomacy became one of the most efficient means of network institutionalisation before the Industrial Revolution (Antunes, 2004, 141–182). We can also include in this first level all the servants of central governments who departed to regions outside of the core networks in order to administer – in the name of and in the interests of the centre – those same regions. This corps of bureaucratic civil servants at the service of territorial or commercial empires was in itself a vehicle of institutionalisation.

The second level of institutionalisation was achieved by the private sector. Commercial regulation at a private level grew into public participation in 'multinationals', as was the case of the Dutch or English East and West Indies companies. These companies, their regulations, and employees all contributed to a very serious movement towards the institutionalisation of old and new commercial, financial, and migratory networks, thus contributing to a higher degree, depth, width, and speed in the process of globalisation.

Held and his co-authors fail to acknowledge Early Modern institutionalisation as much as they fail to recognise the modern development of nation-states as the fundamental institutionalisation instrument during the Industrial era. The development of the idea and reality of nation-states goes beyond the creation of political perceptions and identities. The birth of nation-states brought along economic integration, the 'nationalisation' of political and intellectual elites, and the formation of unified interest groups that went beyond the borders of the state itself. Therefore, we would have to strongly disagree with the model that states that institutionalisation in the modern period was in the 'medium' range. We would argue that institutionalisation was as thick as the extensity, intensity, and velocity in which the networks operated during this period and that we have mentioned earlier. For example, the growth of the amount of constitutional monarchies during this period is in itself a sign that the process of openness and 'democratisation' of globalisation starts exactly at this moment.

We will conclude by stating that we do not see the possibility of separating the infrastructural level from the institutional. The increase in and efficient development of the infrastructures sponsored and determined the levels of institutionalisation at different times in history. We think that more research is needed to explain the specific role of institutionalisation in the process of historical globalisation as a whole.

While the good condition of the infrastructure and the high performance of the institutional framework can change the impact of globalisation, once it is in motion there is still the question of to what extent globalisation is a true achievement. That is why the level of stratification is important. Stratification is the means through which one may identify the organisational changes operated throughout the networks after being included in a globalisation process. These changes are often contradictory. They express the asymmetries and discontinuities of the networks identified during spatio-temporal analysis (Held *et al.*, 1999, 20).

Finally, we would like to mention the modes of interaction. They characterise the relationship established between two or more networks. Held and his co-authors argue that there are four types of interaction: imperial or coercive, cooperative, competitive, and conflictual. Some of these concepts can be immediately related to certain periods of world history. But what seems important at this level is the correct description and characterisation of the relationships established between networks involved in the globalisation process (Held *et al.*, 1999, 20).

So far one may conclude that the analysis of historical globalisation should be done through a spatio-temporal and an organisational dimension. The outcome of each one of these levels of analysis is the net product of the dynamic elements at each one of their levels. The performance achieved at each one of those levels determines the characteristics of each dimension, which is afterwards used to describe and classify types of globalisation, which differ according to historical events and developments.

Conclusion

The model of historical globalisation is a good theoretical instrument for entering into the debate fuelled by Wallerstein and Frank. The biggest advantage of this model is the presentation of a methodology aimed at determining the 'amount', 'kind', and impact of globalisation in a certain period. But, even if the existence of a clear methodological approach to historical globalisation is very positive, once we focus on the methodology itself, there are also certain weaknesses that we cannot ignore.

The model by Held *et al.* offers a broad methodological basis for an argumentative view of the historical process, although it is not without flaws. Nonetheless, when compared with other models related to world history, the model of historical globalisation focuses less on inequalities and notions of historical exploitation, and pays more attention to the levels of cooperation and interconnectedness. By doing that, historical globalisation becomes a somehow less teleological model than Wallerstein's world-economy and, at the same time, pushes historians back to Braudel's noble goal of a *histoire totale.*

The fact that the model of historical globalisation is far more integrative and incorporative than any other historical model, means that the diversities of history (continuities and discontinuities) occupy an important place for describing and studying the unity of the historical process. However, this is not to say that unity loses its composition as a whole, because diversity also has a central place in this model. On the contrary, the concept of unity can only gain by being so closely associated with diversity and vice versa.

Finally, the great achievement of Held and his co-authors is the presentation of a model of historical globalisation that is wholly encompassing, backed by a methodological framework that can be applied to the past by historians and to the future by other scholars. This potential multidisciplinary and complementary nature of the model is something that has been unmatched so far in the social sciences.

Notes

1 These possibilities are shown in Figure 11.1, in the part dedicated to what we have called 'Past Y'.

2 See the three possibilities shown in Figure 11.1, under the concept of 'Future X.'

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Part III

Global change and the information age

12 Three globalizing phases of the world system and modernity[1]

Shumpei Kumon and Yasuhide Yamanouchi

Introduction: globalizing modernity

Recent decades have seen an expansion of researchers' interests in the world system. According to Chase-Dunn and Hall (1997: 11–26), world-system theories now enjoy a situation in which "a hundred flowers bloom." The two authors propose that it is beneficial to compare and examine the explanatory potential of these theoretical frameworks by working on:

1 the definition of world systems;
2 their time and space boundaries; and
3 their systemic logic.

This chapter postulates an integrated interpretation of the historical and evolutionary development of the modern world system. Comprehensiveness and consistency should be key to such a world-interpretation (*Weltanshaung*) according to the principle of parsimony. The validity of a world-interpretation here is whether it could offer a concise enough integrated and consistent explanatory framework for multifaceted observations on globalization.

Our framework will be introduced in this chapter as follows: first, the development of the world system from the sixteenth century onwards is defined as the superposing of three phases of globalization, i.e. "nation state–international society," "industrial enterprises–world marketplace," and "information intelprises–global intelplace." Modernization is nothing other than the world-wide spread of these three layers of sub-system and mutual regulations inside the system (Figure 12.1). Second, we will integrate this world-view with the arguments of the general system theory. The left–right double arrow indicates that each layer of the sub-system consists of micro–macro feedback between a large number of actors (agents, players, subjects) and a place (the field, "Ba") (Nonaka and Konno, 1998). Third, we will demonstrate briefly how this world-interpretation is consistent with observations from different areas of social sciences.

The third industrialization and informatization

According to Kumon (2004: 50), the present stage in globalizing modernity is as follows (Figure 12.2). The present stage is situated within the breakthrough

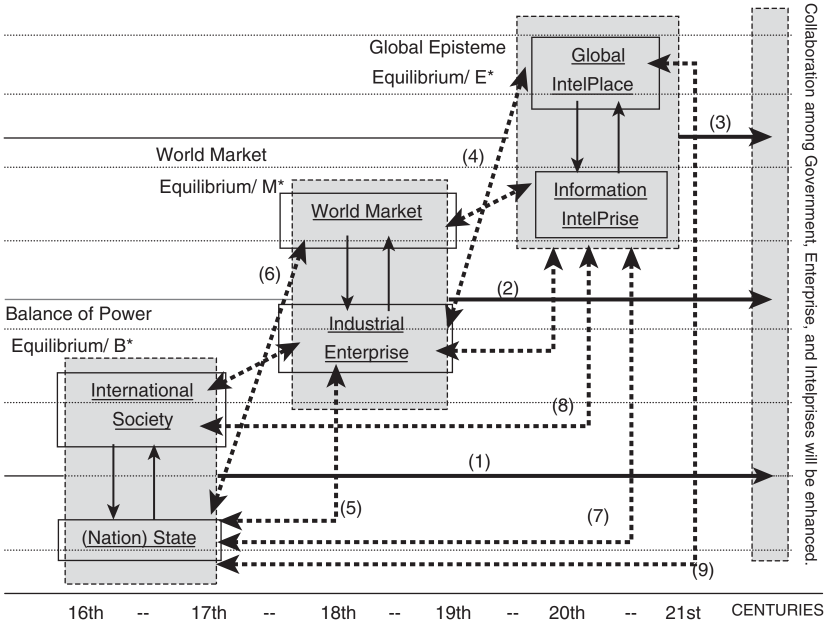

Figure 12.1 Balance of power, world market, and global episteme.

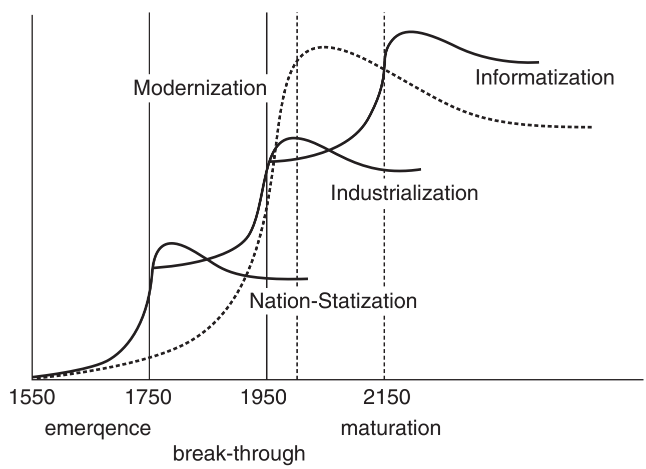

Figure 12.2 Three phases of modernization.

phase of informatization/modernization that will occur to its fullest extent during the twenty-first century. At the same time, the present stage is situated within the maturation phase of industrialization/modernization through the third industrial revolution. The third industrial revolution, i.e. industrialization led by the information and communication industries at the level of "industrial enterprises and the world marketplace" is taking over from "industrialization led by major manufacturing industries, i.e. the second industrial revolution, also known as the breakthrough phase of industrialization" that occurred during the twentieth century.

Some advanced industrialized countries were thought to be moving into so-called post-modern situations (Lyotard, 1984). On the other hand, in certain developing countries such as China or India, characterized by significant economic growth, governments are strengthening political integration through nationalism and the enhancement of military capabilities. Cambodia and East Timor have started to build nation-states with the assistance of the United Nations and the international community. It is therefore incorrect to say that the first system of the globalizing modernity, i.e. nation-state building/modernization is completely losing its functionality.

The Internet has, since the 1990s, offered the common field of the third sub-system of "information intelprises–global intelplace." It is the first single, integrated and world-wide mutually interactive common place for all participating players. The activity in this layer is at the "first information revolution–emergence phase of the information society," where not only industrial firms and governmental agencies, but also the "netizens" (Hauben and Hauben, 1997) of the information society are expanding their knowledge capacity by making full use of the latest technologies. The information society is what will succeed the industrial society in the process of modernization, and it is most likely to become the last stage of the whole modernization process. To sum up, the three layering structures of globalizing modernity are in good shape, even while in a long-term period of transition. We can safely conjecture that the present world system is not in a "post-modern" phase, but rather in the "last-modern" one.

Globalizing modernity and general systems theory

We shall now demonstrate, relying mainly on general system theory, that the three layers in globalizing modernity have identical characteristics. The historical origins of the three layers differ from one another, but their systemic properties are isomorphic.

International society and the world market

Descriptive characterizations of the firstly and secondly propagated subsystems are as follows. Studies on modern industrialized societies have been about the transitions and interactions of: (1) nation-states and international society, and (2) industrialized enterprises and the world market. Nation-states are "embedded" in international society, where they contest and (usually) adapt to environments, while industrial enterprises are embedded in the world market, where they compete and are (often) selected. The elements of state's actions in the relationship of "nation-state–international society" consist of their capacity to control the behavior of others. Military power, as *ultima ratio*, is at the end of the spectrum. The mutually interwoven contexts of power-relations and the institutionalization of these relationships are what constitutes the common place of international society, i.e. international regimes, international organizations, and elements of global governance (Rosenau and Czempiel, 1992; Keohane and Nye, 2000).

In the relationship of "industrialized enterprise–world market," enterprises are engaged in the pursuit of wealth, and what constitutes the field of world markets are mutually interwoven prices, and the demand and supply of commercial goods and financial flows. A wide range of consumer markets in developing countries are now attracting attention, alongside the globalization of economies and the successful industrial surge of the BRICs (Brazil–Russia–India–China). The targets are those who had been "non-consumers" at the bottom of the pyramid in the global market economy (Prahalad, 2006). When industrialization/market economization (*Vermarktwirtschaftung*) prevails globally as the second stage of modernization, the income standards of developing countries have now reached the stage where they can justify services by using "disruptive technologies," for example.[2] Social development via the world market attracts the attention of the foreign aid community, e.g. the World Bank and the UN Development Plan.

Globalizing modernity model and system theories

The concepts of the actor (player, subject, agent), and that of the actors generating a contextually common place (field, structure), have attracted attention from both system theorists and sociologists. The actor is a cybernetic system (Wiener, 1961). It is a unit of recognition, evaluation, decision-making, and behavior, and possesses a propensity for self-reflection, i.e. intentional feedback. Bertalanffy (1976) emphasized the "progressive centralization" in a complex system, e.g. embryonic developments. Certain types of common place are a prerequisite during canalization in an epigenetic landscape of embryonic developments (Waddington, 1962). In 1983, in *Synergetics*, Haken proposed "order-parameter" and "enslaving" principles. Complexity is reduced significantly when a few order parameters, which converge gradually, and a large number of enslaving elements, which are dumped quickly, diverge. Order parameters offer general patterns in the common place (field). When a synergetic system consists of a large number of actors and a contextually common place, that synergetic system is neither a unit of recognition, evaluation, decision-making, and behavior, nor possesses the ability to self-reflect *per se*. Therefore it is a non-actor system (Figure 12.3). Sociological structuration theory (Giddens, 1986) declares that a social system is nothing other than the continuous reproduction by individual actors, who, on the other hand, are employing the contextual rules and resources from the structure in the social system.

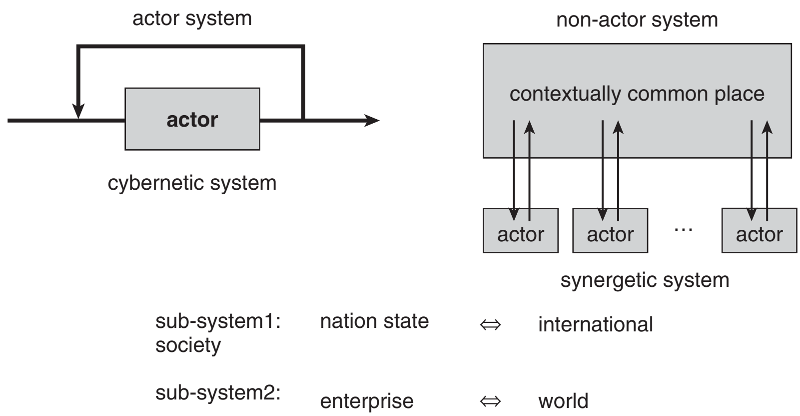

Figure 12.3 Micro–macro feedback between actors and the common place.

The essential loops of micro–macro feedback between actors and the place are indicated by down arrows and up arrows ("↑↓") in Figure 12.3. This is one of the generalized models for self-organization processes, the emerging patterns of which include fractals, chaotic attractors, and power-law distributions. Each of the three layers of globalizing modernity in Figure 12.1 consists of this micro–macro feedback. Here, a number of actor-systems (cybernetic systems) and a single globally contextual place are engaged in a constant structuration process.

Three sub-systems, whose contextually common places are the international society, the world market, and the Internet, are non-actor systems (synergetic systems). They prevail globally and produce self-emerging patterns and types of order, but do not have aims and intentions *per se*. We can expect that the above-mentioned emerging patterns have been discernible on various occasions in the world system. Takayasu (2001) reported a number of examples of fractals in financial fluctuations and monetary flows. Since the late 1990s, power-law distributions have been found among Internet topologies and web-sites' link numbers (Faloutsos, 1999). Barabasi (2002) described the emergence of a power law from the mechanism of "preferential attachment." This shows that when a set of actors takes microscopically rational actions, while looking at certain indexes at the contextual place, a specific pattern, like a power-law distribution, emerges from accumulated behaviors.

The descriptions of this third sub-system are as follows. Search engine and platform businesses like Yahoo and Google; long-tail-oriented businesses like Amazon and i-Tunes; consumer-generated media, like blogs and wikis; and Internet telephone/conference services like Skype, are becoming popular and are spreading quickly. Individual activists; small- and medium-sized enterprises and news media; the research and academic communities; and NPOs/NGOs (non-profit organizations/non-governmental organizations) are both enthusiastic users and producers of the contents. This social layer consists of, and will give birth to numerous actors and artificial agents/intelligences, whose aims are the sharing of information and knowledge; making compilations of documents and multi-media; referencing and indexing these documents and media; and linking and ranking web-sites, i.e. the creation of a contextually common place. Continuous entries of new actors will expand activities in the "information intelprise–global intelplace" further and globally.

At present, the mainstream actors in this sub-system are socially non-recognizant in either the "nation-state–international society" or the "industrialized enterprise-world market." The terms "information intelprises" and "global intelplace" were coined by Kumon (1994) to give expression to those actors and places that are still emerging. Those non-governmental and non-market-oriented actors are expected to assume a more definitive shape in the course of the development of the information society. This is an analogy of the relationship between the public/citizens and the nation-state, and that between industrial farms/households and the market, where actors and the contextually common places have experienced long-term co-evolution. As indicated in Figure 12.2, the present time is situated at the fixation phase of nation-state building; the maturing phase of industrialization; and the emerging phase of informatization. Social phenomena are taking shape through developments, superimpositions, and reflections of these S-shaped globalizing modernity processes. If those reflecting relationships are intentional behavior from actor-systems to actor-systems in different sub-systems, or from actor-systems to the places of non-actor-systems in different layers, then they become "mutual regulations."

We indicated eight mutual regulations by dashed lines in Figure 12.1. Apparently, actors in this third sub-system manifest the overlapping effects from at least two long-term social transitions, i.e. the third industrial revolution as the extension of industrialization from the twentieth century, and the first information revolution continuing to the twenty-first century. Structural duality in actor character is notable. For example, Lessig (2000) quoted abundant examples from open-source and free software movements, as well as peer-to-peer file-exchange services, in order to exemplify new attitudes about intellectual property rights, which are different from incumbent industrial standards and institutional backgrounds.

Time and space boundaries in globalizing modernity

In this section, we shall describe the historical origins and the propagation processes of globalizing modernity. The three sub-systems described above had the technological and institutional backgrounds/momentum to expand globally, becoming the impetus of the fundamental social transformations in our time, such as modernization. The three sub-systems appeared as nation-statization, industrialization, and informatization within the changes in each society. Modernization is the globally thorough penetration of these social changes. Historians named the inaugurations of these social changes as military revolution, industrial revolution, and information revolution.

Military revolution and nation-state building

Interestingly, the "information RMA (Revolution in Military Affairs)" of the 1990s after the Gulf War offered military historians a good opportunity to reconsider the military revolutions that recurred in military campaigns. Knox and Murray (2001) distinguished the RMAs from military revolutions, and proposed five military revolutions, i.e.:

1. the sovereign state and organized military institutions in the seventeenth century;
2. the French Revolution and the creation of a national army;
3. the Industrial Revolution;
4. the First World War, and
5. the deployment of nuclear weapons.

Parker (1988) argued that the military revolution in the sixteenth century, i.e. the preparations of the standing army; the fortifications against advanced artillery; and the constructions of naval fleets – all of which accompanied large-scale budgetary expansions, taxations, and bureaucracy – forced the process of territorial integration by Western monarchies.

Modernization started by creating territorial integrity and, by the middle of the nineteenth century, had proceeded, via changes in polities, toward nationality-based liberal and democratic systems. Subsequently, Western pressures on the international society caused the acceptance of the nation-state system as the institutional apparatus for modernization by other regions. Military revolutions guided sequential adoptions of the model of nation-state building, repeatedly and globally. The end of the American Civil War in 1865; Japan's Meiji Restoration in 1868; the Franco-Prussian War and the unification of Germany in 1871; and the establishment of the Soviet Union (guided by the Bolshevik Revolution) in 1917 have been equally consequential. The simultaneous surges of global nation-state building occurred at least three times subsequently: i.e. liberation in the occupied areas after the Second World War; independence from colonialism in colonial territories in 1950s and 1960s through the Non-Aligned Movement; and the breakdown of the former Eastern bloc into independent states after the conclusion of the Cold War in the 1990s.

Industrial revolution and industrialization

As for industrialization/modernization, three economic long cycles are discernible, based on the developments of the main technologies and the associated social infrastructures. Murakami (1996) proposed that each of these long cycles consisted of two 50-year-long Kondratieff waves. These 100-year-long cycles indicate the recursive emergence of the main industrial technologies and economic domains. The first long cycle consists of the first industrial revolution, which was led by the steam engine and the textile industry, starting from the latter half of the eighteenth century. The second industrial revolution, which started from the later half of the nineteenth century and lasted about the same length, was led by the internal-combustion engine, electrification, and heavy and chemical industries. The third industrial revolution started from the latter half of the twentieth century, and was led by the information–communication industries and bio-industries and became the present long-cycle.

The development of information communications technologies (ICTs) in the early 1990s offered economic historians the opportunity to reconsider economic long waves. Through the comparisons of techno-economic paradigms among the OECD countries, Freeman (1987) concluded that the top industrialized countries have entered the rising phase of the fifth Kondratieff global long wave. On the other hand, economists have remained suspicious of the relevance of the information revolution, because ICT-driven investments have not contributed immediately to statistically supportive increases in productivity. David and Wright (1999), using the analogy of electrification in the early twentieth century, proposed that large-scale transitions in the techno-economic regime necessitated a time-lag between innovation-led investments and the increase in production capacity, for example 25 to 35 years in the case of electrification. They concluded that the developments in ICT were significantly revolutionary.

In *Leading Sectors and World Powers*, Modelski and Thompson (1995: 3) demonstrated the relationship between the 50–60-year technological innovation-based long wave (the Kondratieff or K-wave) and the 100–120-year long cycle (LC) of global politics of the world-powers. They traced the long-term transitions of the global political system back to the tenth-century Northern Sung, and detected 20 K-waves and ten LCs.

> Working within the parameters of the theory of long cycles of global politics, we argue that the rise and decline of leading sectors in the global economy (the K-wave) are coordinated with the rise and decline of world powers (the long cycle of global politics) in such a fashion that one long cycle (one period of ascendancy) is associated with two K-waves organized around innovative sectors in world commerce and industry.

The military revolution and the first sub-system described in this chapter took off with LC5–6 and K9–K12, the Industrial Revolution and the second sub-system began with LC7–8 and K13–K16 (the world power was Britain I–II), and the information revolution started with LC9–10 and K19/K20 (in the US). While agreeing that the long cycles before the sixteenth century were significantly important in the world system, we bring out the peculiarities of the three sub-systems in globalizing modernity in the following terms.

First, the geographically thorough penetrations of our three sub-systems are unprecedented. As Wilkinson (1987: 338) stated, "there presently exists one and only one civilization, appropriately styled 'Global Civilization,' after its most obvious differentia, the engulfment of the entire planet by a single network." Second, the actors' empowerment in each sub-system is not only significant in magnitude but also universal and non-discriminate. In fact, actors have asserted a form of natural right to be participants in particular places, i.e. nation-states in the international society; industrial firms in the international marketplace; and netizens on the Internet. Third, what we see is not a linearly extending single wave, but rather three superimposed S-shaped processes. The historical incidents of the first and second processes are still in the process of development.

Examples from East Asia reveal that countries in that region entered the global system at different times, caused by modernization's propagation process. Japan adopted Western social institutions based on nation-state-building some 300 years later than Britain. With regard to the role of industrialization in globalizing modernity, Japan was about 150 years behind in reaching the emergence phase. The time difference diminished to about ten to 20 years when the emerging phase of informatization as the third stage of industrialization started, as in the introduction of mainframe computers in the 1960s. Such time differences in continuous catch-ups with regard to modernization seem to be significantly compressed both in South Korea and China. Newly industrialized countries use the institutional designs in advanced countries as precedent models, aspiring to guide nation-state building, industrialization, and informatization – sometimes authoritatively. They even expect to leapfrog various stages. Both successful industrial policies and social policies are required as consistent institutional settings for newly industrialized countries, in case they adopt market economies and capitalistic political regimes in a developmentalist fashion (Johnson, 1983; Murakami, 1996). For example, these institutional settings include national spatial planning, growth-oriented financial policy, income redistribution policy, and national innovation systems (World Bank, 1993; Nelson, 1993). Former Soviet Union and Eastern bloc countries adopted planning economies and socialist political regimes to construct a semi-autonomous global economic system in promoting their own modernization. It seemed that the world market subsumed this alteration after 1991. China adopted a combination of a market economy and a socialistic political regime from 1992. In a sense, this combination significantly simplified interactions among social sub-systems domestically, although complicated maneuvers by the government and the communist party have ensued.

These examples suggest the explanatory potential in our framework. Globalizing modernity and multiple sub-systems' superpositions, mutual regulations, and resulting institutional designs seem to consist of certain fundamental cause-and-effect chains produced by ongoing social, economic, and political issues.

Globalization and regulations inside the world system

In this section, we will contend that this world-interpretation is consistent with observations about evolving globalization. First, we find that there exist seemingly contradictory statements about globalization. On the one hand, globalization is expected to offer a borderless and mutually interdependent world system (Omae, 1990). On the other hand, by the same token, according to *Empire* by Hardt and Negri (2000: 34), a global empire is taking shape following the end of modern sovereignty. In their book, the authors defined the "imperial machine" as follows:

> The machine is self validating, autopoietic – that is, systemic. Imperial machine lives by producing a context of equilibrium and/or reducing complexities, pretending to put forward a project of universal citizenship and toward this end intensifying the effectiveness of its intervention over every element of the communicative relationship, all the while dissolving identity and history in a completely postmodernist fashion.

However, from the United Nations-led peace-building operations in early 1990s to the operations by the multinational force in Iraq from 2003 onward, state building – the construction of institutionally equivalent nation-states – continues to be one of the main issues in international society. According to Fukuyama (2004: ix), externally imposed nation-state building has become the first item on the agenda in international society:

> State-building is the creation of new government institutions and the strengthening of existing ones. In this book I argue that state-building is one of the most important issues for the world community because weak or failed states are the source of many of the world's most serious problems, from poverty to AIDS to drugs to terrorism. I also argue that while we know a lot about state-building, there is a great deal we don't know, particularly about how to transfer strong institutions to developing countries.

Fukuyama's argument seems to confirm that the formation of nation-states is a continuous global tendency and would penetrate world-wide. Similarly, seemingly contradictory statements are discernible among market and state relationships. According to Friedman (2005) in *The World is Flat*, we have come to the stage of "globalization 3.0" since 2000. The playing field is now leveled for labor-intensive service industries, as a result of international outsourcing and offshoring that has occurred with the help of information technology. But, Porter (1990: 73) argues, from a business-management perspective, that the role of the nation-state is on the rise:

> In a world of increasingly global competition, nations have become more, not less, important. As the basis of competition has shifted more and

> more to the creation and assimilation of knowledge, the role of the nation has grown. Competitive advantage is created and sustained through a highly localized process. Differences in national values, culture, economic structures, institutions, and histories all contribute to competitive success.

On the other hand, we also see the rapid growth of transnational social movements such as the international campaign to ban landmines, which received the Nobel Peace Prize in 1997. Human rights, women's issues, environmental protection, humanitarian aid, social rehabilitation, Internet governance, and disarmament with respect to weapons of mass destruction are examples of agendas in which NGOs and NPOs are playing an increasing role. Keck and Sikkink (1998) reported on human rights issues in Latin America, where domestic advocacy movements have significantly expanded their influence through international NGOs. That international movement has helped to change governmental policies from the outside. Haas (1990) has examined the process of multilateral regimes in Europe (such as the Convention on Long-range Trans-boundary Air Pollution and the Mediterranean Convention), and has concluded that pro-environmental-protection NGOs and bureaucrats, through working groups and multilateral meetings, have organized an international network based on common recognition. That epistemic network has contributed significantly toward the creation of international regimes, while competing against the pro-industrial circles of incumbent academics and governmental agencies. When a number of academic- and political-circles collaborate with respect to global governance issues, these politico-academic/epistemic communities compete with each other, and tentative equilibria might emerge. Here "epistemes" means knowledge frameworks at historically unique points. This competition involves both power games and knowledge games simultaneously in the Foucaultian sense. When applying comparative static analysis to the contextually common places, global non-actor systems might have a balance of power in international society; market equilibrium in the world marketplace; and, by analogy, epistemic equilibrium in the global intelplace.

A globalizing modernity model suggests that the above observations relate to one or several inter- and intra- processes, reflections, and regulations among the three layers of the sub-system. Actors, as beings in the world-sub-systems, mutually interfere and try to put constraints on actors and/or common places in other sub-systems. Those constraints include political regimes, economic resources, and visionary ideas. The constraints are institutionally complementary. We have listed these relations in Table 12.1 and Figure 12.1.

Globalizing modernity in a domestic context: the risk society

Beck *et al*. (1994: 1–55) wrote about the recent "modernization of modernization" or, radicalization of modernity. An interpretation of this observation is that the results of modernization are recursively affecting modernization

Table 12.1 Interpretations of evolving globalization

Authors	*Main topics*	*Numbers in parentheses in Figure 12.1*
Hardt and Negri	Empire	Whole process of globalizing modernity (1), (2), and (3)
Fukuyama	Nation-building	Mainly nation-statization in international society: (1)
Friedman	Level playing-field	Mainly expansion of world market globally: (2)/enterprises to Internet: (4)
Porter	Competitive advantage of nations	State to world market/state to enterprises (rather, to the cluster of enterprises): (5) and (6)
Keck and Sikkink	International activism	NGO to state: (7)
Hass	Epistemic community	Intelprise (epistemic network)to state /intelprise to international society/state to intelplace: (7), (8), and (9)

processes in domestic contexts. For example, the establishment of socialist regimes and planned economies had been the consequence of modernization, upon which another consequence of modernization, the global struggle against capitalist regimes and the cold war, were superimposed. The collapse of the socialist regime was the end result. A large-scale social change was a result of the impacts of modernization processes upon other modernization processes. Therefore, in a sense, the change was reflexive. We have already gone through the phases of emergence, breakthrough, and maturation of globalizing modernity, increasingly manifested globally and in every aspect of our daily lives. This could be more evidence that the present time should be placed within the last modern era rather than in a post-modern period as a whole.

According to some sociologists, reflexive modernization has produced a "risk society," because of the liquidation of social structures (Bauman, 2000), as the citizens of Berlin witnessed in November 1989. According to Beck *et al.* (1994: 44), a prescription for a risk society runs as the follows:

> The general confusion and opposition inside and outside the institutions necessitates and favors the formation of support networks crossing the boundaries of systems and institutions, which must be personally connected and preserved. In a certain way, then the disintegration of institutions makes room for a refeudalization of social relationships. It is the opening for a neo-Machiavellianism in all areas of social action. Orderings must be created, forged and formed. Only networks, which

must be connected together and preserved and have their own 'currency', allow the formation of power or opposing power.

If our analyses are appropriate, then, in a risk society in which individualization has proceeded and critical formations/re-formations of social networks have advanced information communication technology, the outcome of this would apply to an increasingly larger portion of society's members. According to Lin (2001: 25) the modernization process differentiates investment's targets. While investors' targets had been industrial manufacturing facilities during the nineteenth century, they shifted to human capital in the middle of the twentieth century, and today the target is social capital, i.e. the human network itself. Social capital here means resources embedded in the social network as utilized by stakeholders. The essence of the information revolution is knowledge-based. It empowers the relationships among related persons and accumulates inside their inter-agents/inter-subjective networks an enormous amount of information and knowledge as social capital. Good examples are certain kinds of group-ware, wiki, and the World-wide Web. To be engulfed deeply in these virtual and human networks may allow the younger generation to nurture a unique model of human character, which is different from those of modern and individualistic styles of personality, because the younger generations are more database-directed than inwardly directed (Riesman, 1961; Rheingold, 2003).

This reflexivity of globalizing modernity activates the politicization of social issues in every aspect, which, in turn, promotes a focus on activists who organize new political coalitions. The self-organization of human relations and re-embedding of oneself within these networks validates the importance of networking, which transcends different sub-systems. Ronfeldt and Arquilla (2001) named these political activities "netwars." In fact, the emergence of the risk society in reflexive modernization, and the global developments of netwar-like social movements, are two sides of the same coin. These social tendencies will promote the propagation of the informatization/modernization sub-system much more deeply and ever more widely.

Notes

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2 According to Christensen *et al.* (2004), disruptive technologies such as the Internet and Internet telephony make it possible to very cheaply and effectively provide services which have been outside the domain of the incumbent service providers,

and to eventually overturn the existing dominant business models in the global marketplace.

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13 Accelerating socio-technological evolution

From ephemeralization and stigmergy to the Global Brain

Francis Heylighen

Evolutionary progress

The present chapter wishes to directly address the issue of globalization as an evolutionary process. As observed by Modelski (2007) in Chapter 2 of this volume, globalization can be characterized by two complementary processes, both taking place at the planetary scale:

1 growing connectivity between people and nations; and
2 the emergence of global institutions.

The first process is essentially economic and technological: the flows of matter, energy and information that circulate across the globe become ever larger, faster and broader in reach, thanks to increasingly powerful technologies for transport and communication, which open up ever-larger markets and forums for the exchange of goods and services. The second process is fundamentally political and social: these increasingly powerful flows that cross the national borders – and therefore the boundaries of most jurisdictions – need to be regulated efficiently. This requires the development of a complex, global system of agreements between all the actors involved, specifying the rules to be followed and the mechanisms to enforce them.

The present chapter wishes to explore the deeper evolutionary forces driving these two processes. These forces are so fundamental that we find them not only in the evolution of global society, but in evolutionary processes at the physical, chemical, biological or cognitive level (Heylighen, 1999a, 2007a; Stewart, 2000). Although I will mostly discuss issues of globalization to illustrate these effects, the conceptual framework is perfectly general, and equally applicable to other domains, such as animal behavior. In agreement with Devezas and Modelski (2003) and Modelski (2007), I see evolution basically as a learning process. This implies specific evolutionary dynamics with a non-arbitrary directionality.

However, unlike Devezas and Modelski (2003) and most other authors in this collection, I do not see any clear cyclicity in this process. Instead, I will argue that the effects of evolution can best be represented as a monotonous (always increasing) function, although the speed of the corresponding advance is variable, with ups and downs that may give an impression of periodicity, but – most importantly – a strong tendency towards acceleration. This combination of monotonicity and acceleration allows us to make extrapolations for the relatively short-term future. However, the trends that I will be speaking about are mostly qualitative, and can only be partially captured by numerical data. Therefore, my forecast of globalization is basically a complex picture of how a future global social system may look, which I will designate by the metaphor of the "Global Brain."

The theoretical background that supports this model may be called evolutionary–cybernetic, since it integrates the main insights from cybernetics and from evolutionary theory (Turchin, 1977; Heylighen, 2007c). It is closely related to the presently popular approach of complex adaptive systems (Holland, 1996) with its basis in multi-agent computer simulations, although its historical roots are more ancient. Cybernetics (Ashby, 1964; Heylighen and Joslyn, 2001) is the science that studies how goal-directed systems can succeed in a complex, variable environment, by counteracting any perturbations that make them deviate from their preferred course. Adopting a more modern terminology, we will call such systems, which try to reach their goal by acting upon their environment, "*agents*." Agents can be people, organizations, cells, robots, or any living organisms.

Evolutionary theory adds that the implicit goal of all systems created through natural selection (and thus of all non-artificial agents) is the maximization of *fitness*, i.e. survival, reproduction and development. Evolution can in general be seen as a learning process, during which the evolving system accumulates knowledge or information about how best to survive and thrive in its environment. This has been argued by evolutionary epistemology (Campbell, 1974), which sees all forms of knowledge as a product of evolution, and – in its more radical version – all evolutionary adaptation as a form of knowledge. Its main idea is that evolution is a problem-solving process based on trial-and-error, where the successful trials are selectively retained or "memorized" – thus adding to the evolving system's store of knowledge, whereas the errors are eliminated.

Cybernetics adds a somewhat more abstract perspective to the basic evolutionary mechanism of variation and selection (Ashby, 1962). Information as originally defined by Shannon is a reduction of uncertainty. Selection means the elimination of a number of possible variants or options, and therefore a reduction in uncertainty. *Natural selection therefore, by definition, creates information*: the selected system now "knows" which of its variants are fit, and which unfit. The more variation and selection it undergoes, the more knowledge or information it accumulates, and the better it will be able to tackle the problems that the environment throws at it. To have variation, it is sufficient that the system undergoes some form of either random or directed change – if only because of thermal fluctuations. As Ashby (1962) has shown, any system whose dynamics are not completely reversible will undergo selection, by leaving the unstable or unfit states and preferentially seeking out the fitter ones (Gershenson and Heylighen, 2003).

Therefore, all systems tend to evolve towards better adaptation or fit, which implies greater information or knowledge about their environment. In that sense, there is an unambiguous advance, "progress" or "arrow" characterizing evolution, which tends to be accompanied by greater complexity, intelligence and integration (Heylighen, 1999a; Stewart, 2000; Wright, 2000). Note that this philosophy does not preclude errors, setbacks, or "overshoots": variation is a process that by definition makes errors, sometimes resulting in an overall reduction of fitness; moreover, the environment changes, and what used to be fit may no longer be fit under changed circumstances. However, considered in the longest term and at the largest scale, evolution is clearly progressive (Heylighen, 1999a; Heylighen and Bernheim, 2000b), in spite of the "postmodern" critiques of the idea of progress in biological evolution (Gould, 1996) and in society (Marx and Mazlish, 1996).

Having sketched the mechanism of progress in the most general or abstract sense, I will now apply it more concretely to understand the evolution, first, of technology and its impact on global connectivity, second, of social organization, and its implementation at the global level. I will then examine the variations in the speed of evolutionary progress, arguing for acceleration, and against periodicity.

Technological evolution

Ephemeralization

Let us start by perhaps the simplest and most obvious form of progress: *doing more with less*. All living organisms are subject to physical constraints: they require a finite amount of matter, energy and time in order to perform any action, including the most simple activity necessary for survival. These physical resources are subject to conservation laws: you cannot create matter or energy out of nothing. However, the same matter or energy can be used in many different ways, some highly efficient, others utterly wasteful. Given the general scarcity of resources for which a growing number of agents compete, this entails a strong selective pressure: agents that through trial-and-error have learned to use their resources more efficiently will have a strong advantage over the others, and thus will be picked out by natural selection. This applies in particular to society. If an agent can achieve the same or more output (products, services, information, etc.) while requiring less input (effort, time, resources, etc.) then that agent has increased its power to reach its goals – whatever these goals are. This increase in power applies under all circumstances, since a reduced need for effort or resources will make the agent less dependent on the particular conditions under which it tries to reach its goals.

This entails a strong *selective pressure* on all evolutionary systems in society: whenever there is a competition between individuals, groups, institutions, technologies or – most generally – systems of action, then, *ceteris paribus*, the more productive one will win. Indeed, whatever criterion directs the competition (producing cars, providing information, selling soft drinks, making religious converts, etc.), the competitor who can achieve more for the same amount of investment will have a robust advantage over the others. This means that whenever a new variant appears that is somehow more productive than its competitors, it tends to become dominant, and the others will have to follow suit, or be eliminated. Thus, as long as there is *variation* (the appearance of new variants) and *selection* (the elimination of the less successful variants), evolution will produce an on-going increase in efficiency or productivity (Heylighen and Bernheim, 2000b). Following Buckminster Fuller (1969), we may call this process of constantly achieving more with less "*ephemeralization*."

Since the development of modern science in the seventeenth and eighteenth centuries, and its application to technology leading to the Industrial Revolution, this evolution has accelerated spectacularly. Rather than having to wait for a chance discovery, new techniques are now being developed in a *systematic* way, using the sophisticated methods for modeling and testing that characterize science. Ephemeralization, moreover, is self-reinforcing: the greater efficiency of institutions and technologies not only leads to greater output of goods and services, but also to a faster rate of further innovation, as new ideas are generated, developed, tested and communicated with less effort, while ever more time and energy becomes available to invest in research and development. The results are staggering: culture, society and even the natural world are changing in all aspects and this at a breakneck speed (Toffler, 1970).

Some well-known examples may illustrate this accelerating change. Because of better techniques, such as irrigation, crop improvement, fertilizers, pesticides and harvesting machines, agricultural productivity has increased spectacularly over the past two centuries: both the area of land and amount of human labor needed to produce a given amount of food has been reduced to a mere fraction of what it was. As a result, the price of food in real terms has declined by 75 percent over the last half century (Goklany, 2000). Over the same period, the fuel consumption of cars has decreased just as spectacularly, while their speed, safety and comfort have increased. More generally, the average speed of transport has been increasing over the past few centuries, with the effect that people and goods need a much shorter time to reach any far-away destination. In the sixteenth century, Magellan's ships needed more than two years to sail around the globe. In the nineteenth century, Jules Verne gave a detailed account of how to travel around the world in 80 days. In 1945, a plane could do this trip in two weeks. Present-day supersonic planes need less than a day.

Without doubt, the most spectacular efficiency gains have been made in the transmission and processing of information. In pre-industrial times, people communicated over long distance by letters, carried by couriers on horseback. Assuming that an average letter contained 10,000 bytes, and that a journey took one month, we can estimate the average speed of information transmission as 0.03 bits per second. In the nineteenth century, with the invention of the telegraph, assuming that it takes a little over two seconds to punch in the Morse code for one character, we get a transmission rate of three bits per second. The first data connections between computers in the 1960s would run at speeds of 300 bits per second, another dramatic improvement. Presently, the most basic modems reach some 60,000 bits per second. However, the most powerful long-distance connections, using fiber-optic cables, already transmit billions of bits per second. In a mere 200 years, the speed of information transmission has increased some 100 billion times!

We see a similar explosive development of power in information processing, which follows the well-known law of Moore, according to which the speed of microprocessors doubles every 18 months, while their price halves. As a result, a single chip used in a present-day electronic toy may contain more computing power than was available in the whole world in 1960. Again, this is a beautiful illustration of ephemeralization, as more (processing) is achieved with less (time, materials).

Reduction of friction

The net result of the drive towards increasing efficiency is that matter, energy and information are processed and transported ever more easily throughout the social system. This can be seen as a reduction of *friction*. Normally, objects are difficult to move because friction creates a force opposing the movement, which dissipates energy, and thereby slows down movement, until standstill. *Noise* plays a similar role in information transmission: over imperfect lines, parts of the signal get lost on the way, until the message becomes uninterpretable.

Physically, friction can be seen as the force responsible for the dissipation of energy and the concomitant increase of entropy (disorder), as implied by the second law of thermodynamics. Entropy increase entails the loss of information, structure, and "free" energy, that is, energy available for performing further work. This energy must be replenished from outside sources, and therefore a system performing work requires a constant input of energy-carrying resources. However, the second law only specifies that entropy must increase (or remain constant), but not how much entropy is actually produced. Different processes or systems will produce entropy to varying degrees. Ephemeralization can be seen most abstractly as a *reduction of entropy production*, meaning that inputs are processed with less dissipation of resources. The result is that, for a given input, a system's output will contain more usable energy and information, and less noise or waste.

This has a fundamental consequence for cause-and-effect chains. Every process, object, or organization can be seen as an input–output system, which produces a certain output in reaction to a given input (Mesarovic and Takahara, 1975). Inputs and outputs can be material, energetic and/or informational, but they are necessarily connected by a causal relation, which maps input (cause) on to output (effect) according to a particular set of rules or dynamics that characterizes the system. Given these rules, the state of the system, and the cause or input, you can predict the effect or output. What friction affects is the *strength* of this cause–effect relationship. A high-friction or high-entropy relation is one in which a strong, distinct cause will produce no more than a weak, difficult to discern, effect.

Imagine a billiard-ball (system) being hit by a billiard-cue (input or cause). The kinetic energy of the hit will be transferred almost completely to the ball, making it move with a speed proportional to the momentum imparted by the cue (output or effect). Now imagine hitting a ball made of soft clay with that same cue. The kinetic energy of the impact (input) will be almost completely absorbed or dissipated by the clay, resulting in a barely perceptible movement of the ball (output). The hard, smooth billiard-ball is a low-friction system, with a strong cause–effect relation. The soft, irregular ball of clay, on the other hand, is a high-friction system, with a weak cause–effect relation.

Now imagine coupling different causal processes or input–output systems in a chain. The output of the first system provides the input to the next one, and so on. If all systems in the sequence are frictionless (an extreme, unrealistic case), then any input given to the first system would be transmitted without any loss of strength to all subsequent systems. If the systems have friction, however, each next output will be weaker than the previous one, until it has become so weak that it no longer has any discernible effect.

Let us discuss a few examples of such causal chains. Imagine a long, straight row of billiard-balls, each ball a short distance from the next one. If you hit the first ball with your cue (cause), then it will hit the second ball (effect), which will itself hit the third ball (second effect), and so on. Because of friction, energy is lost, and each subsequent ball will move more slowly than the previous one, until the point where the ball stops before it has reached the next one in line: the causal chain has been broken. If the balls, and the surface on which they move, are hard and smooth, then the friction will be small, and a good hit may bring a dozen balls into motion. If the balls and surface are soft or irregular, on the other hand, then the chain is likely to break after a single step.

For an example more relevant to society, consider food production. The initial inputs of the chain are water, nutrients and sunlight – the resources necessary to grow crops. The final output is the food consumed by people. In between there are several processing and transport stages, each accompanied by a loss of resources. For example, most of the water used for irrigation will be lost by evaporation and diffusion in the soil before it even reaches the plants. From all the plant tissue produced, a large part will be lost because it is eaten by pests, succumbs to diseases or drought, rots away during humid episodes, etc.

More will be lost because of damage during harvesting and transport. Further losses occur during storage because of decay, rodents, etc. Processing the fruits or leaves to make them more tasty or edible, such as grinding, cooking, or mixing with other ingredients, will only lead to further loss. What the consumer finally eats constitutes only a tiny fraction of the resources that went into the process.

As we noted above, ephemeralization has led to a spectacular reduction in these losses. In primitive agricultural systems, such as are still being used in many African countries, the output per unit of area or of water is minimal, and in bad years, hardly any produce will reach the population, leading to widespread famines. Modern techniques are much more efficient. For example, advanced irrigation systems bring the water via tubes directly to the root of the plant, minimizing evaporation and dissipation, and use sophisticated sensors in the leaves to monitor how much water the plant needs at any moment, so that they can supply just the amount for optimal growth. The gain compared with traditional irrigation systems, where water runs in ditches between the fields, can be a hundredfold. Similar gains are achieved during all stages of the production and distribution process, virtually eliminating losses because of pests, decay, oxidation, etc., with the help of refrigeration, pasteurization, airtight enclosures, various conserving agents, etc.

A last example of the role of friction in causal chains will focus on information transmission. Imagine giving your neighbor a detailed account of something that happened in your neighborhood, such as an accident or a police arrest. Your neighbor tells the story to his aunt, who passes it on to her friend, who tells it to her hairdresser, and so on. It is clear that after a few of such oral, person-to-person transmissions, very few details of the original account will have been conserved, because of forgetting, omissions, simplifications, etc. Moreover, the story is likely to have accumulated a number of errors, because of misunderstandings, embellishments, exaggerations, mixing up with other stories, etc. In the end, the story is likely to be forgotten and to stop spreading, or, in the rare case that some elements have caught the public's imagination, continue to spread, but in a form that is barely recognizable compared with the original. In either case, hardly anything will remain of the initial message. A simple way to reduce such "friction" or "noise" in this chain of "Chinese whispers" is to write down the account and send it to your neighbor by electronic mail. The neighbor can then simply forward the original message to his aunt, who forwards it to her friend, and so on. Unless someone actively manipulates the text, no information will be lost, and the causal chain will extend for as long as people are willing to forward the message.

Vanishing physical constraints

A general effect of ephemeralization is that things that used to be scarce or difficult to obtain have become abundant. For example, in the developed countries, the problem with food is no longer scarcity but overabundance, as people need to limit their consumption of calories in order to avoid being overweight. Even in the poorest countries, the percentage of people that are undernourished is constantly decreasing (Simon, 1995; Goklany, 2000). More generally, the trend is clearly visible in the spectacular growth in wealth, usually measured as GDP per capita, since the beginning of the nineteenth century (Goklany, 2000). The ever-increasing productivity not only results in people earning more, but in them needing to work fewer hours to achieve this wealth. Moreover, this economic development is typically accompanied by a general increase in the factors that underlie overall quality of life: health, safety, education, democracy and freedom (Simon, 1995; Goklany, 2000; Heylighen and Bernheim, 2000a).

This is of course not to say that we live in the best of possible worlds. Many things are still much less abundant than we would like them to be, and although increasing productivity leads to an ever more efficient use of natural resources, ecologists have rightly pointed out that our present usage of many resources is unsustainable. The focus of this chapter, however, is not on the remaining scarcities and wastages, which, hopefully, ephemeralization will eradicate sooner or later, but on the problems of social coordination created by such "hyperefficient" processes. To get there, we first need to understand more fundamentally how ephemeralization affects the dynamics of society.

In practice, most of the physical constraints that used to govern space, time, matter, energy and information have vanished. In the developed world, most people can basically get as many material goods and as much information as they need, and this for a negligible investment in time and energy (of course, you can always *desire* more than you may need or be able to get). Moreover, distance as a factor has become largely irrelevant, as it costs hardly more effort to get goods, services or information from thousands of miles away than from a neighboring quarter. This is the real force behind globalization: the observation that social, economical and cultural processes are no longer impeded by geographic borders or distances, but cover the world as a whole. This is most clear on the Internet, where you can exchange information virtually instantaneously, without being aware whether your correspondent is situated around the corner, or on the other side of the planet. This practical disappearance of distance constraints has been referred to as *the death of distance* (Cairncross, 2001), or *the end of geography* (O'Brien, 1992).

Similarly, most of the constraints of duration have disappeared: apart from large-scale developments (such as building a house), most of the things an individual might need can be obtained in an interval of seconds (information, communication) to hours (most consumer goods and services), In the Middle Ages, on the other hand, most of these commodities might have needed months to acquire, if they were available at all. Just imagine that you sit at your desk and suddenly start feeling hungry: a single phone call or web visit is sufficient to order a pizza, which will be delivered at your door 15 minutes later. The result may be called the *real-time society*: soon, all your wishes will be fulfilled virtually instantaneously, with a negligible waiting time.

Energy too is no longer a real constraint on the individual level: practically any system that we might need to produce some work or heat can just be plugged into the ubiquitous electricity network, to get all the energy it needs, for a price that is a mere fraction of our income. Finally, matter too becomes less and less of a constraint in any practical problem-solving. The raw material out of which a product is made (e.g. steel, plastic, aluminum) contributes ever less to the value of that product. In spite of dire warnings about the exhaustion of limited reserves, the real price of physical resources (e.g. copper, tin, coal, etc.) has been constantly decreasing over the past century (Simon, 1995), and has become insignificant as a fraction of the income that we spend on consumption. This has led to a post-industrial economy that is mostly based on the exchange of immaterial resources, such as knowledge, organization and human attention. It is on this level, as we will see, that new, "cybernetic" issues emerge.

Social evolution

We have reviewed how the dynamics of evolution pushes agents to adopt ever more efficient methods and technologies, resulting in a minimization of physical and informational friction, and the virtual disappearance of the constraints of space, time and matter. But a similar dynamic affects social interactions between agents. Initially, agents are selected to be "selfish," i.e. to care only for their own benefit or "fitness," with a disregard for others except immediate kin (Dawkins, 1989; Heylighen, 2007a). But, as the causal effects of their actions extend further over time and space, agents inevitably come to interact with an increasing number of other agents.

Social friction and the evolution of cooperation

Initially, interactions tend to be primordially competitive, in that a resource consumed by one agent is no longer available for another one. In that respect, interactions are characterized by *social friction* (Gershenson, 2007), since the actions of one agent towards its goals tend to hinder other agents in reaching their goals, thus reducing the productivity of all agents' actions. Note that the two common meanings of the word "friction" – (physical) resistance, and (social) conflict – describe the same process of unintended obstruction of one process or system by another, resulting in the waste of resources. Even the actual mechanisms are similar, as illustrated by Helbing's (1992) mathematical model of the flow of pedestrians going in different directions, and thus unintentionally hindering each other's movements, in the same way that molecules in a fluid collide with other molecules, thus producing physical friction.

Like physical friction, social friction creates a selective pressure for reducing it, by shifting the agents' rules of action towards interactions that minimally obstruct other agents. Interactions, however, do not only produce friction, resulting in a loss of resources, they can also produce *synergy*, resulting in a gain of resources. Actions are defined to be synergetic if they produce more benefit when performed together than when performed separately. For example, a pack of wolves can kill larger prey when acting as a group than when acting on their own. These are the well-known advantages of cooperation (Dawkins, 1989; Heylighen and Campbell, 1995; Heylighen, 2007a).

The evolution of cooperation is a complex and extensively researched subject (e.g. Axelrod, 1984). The problem of overcoming the conflicts intrinsic to competitive relations is exemplified by the Prisoners' Dilemma and the Tragedy of the Commons (Heylighen and Campbell, 1995). In different situations, different solutions have typically evolved. However, these solutions are all related, in the sense that they can be viewed as *institutions* in the broadest sense of the word, i.e. as socially agreed-upon systems of rules and control mechanisms for enforcing them, which regulate and coordinate interactions between agents so as to minimize friction and maximize synergy (Stewart, 2000; Wright, 2000; Martens, 2004). Traffic rules provide a concrete example to illustrate the power of even the simplest institutions. Vehicles on the road compete for space. If two cars coming from different directions try to pass the same narrow crossing, they may obstruct each other to the point that neither of them can reach its destination. However, simple priority rules – if necessary supported by stop signs or traffic lights (Gershenson, 2007) – can virtually eliminate this form of friction, letting everybody pass with a minimum of delay.

Recently, in collaboration with Carlos Gershenson and other PhD students of mine, I have started conceptualizing the spontaneous evolution or self-organization of such institutions as the emergence of a *mediator* (Gershenson, 2007; Heylighen, 2007a). Actions, by definition, affect the agent's environment. In so far as agents share the same environment, the action of the one will have an effect on the situation of the other. This effect may be positive (synergy), negative (friction), or neutral (indifference). Therefore, the part of the environment that is shared (meaning that it is experienced by both agents) functions as a *medium* that carries their interactions. This medium affects, and is affected by, the agents. Agent and medium intimately interact and, therefore, co-evolve (although the medium is initially a purely passive, physical system, it too undergoes evolution, i.e. it experiences variations, some of which are selectively retained, some of which are eliminated).

The introduction of the variable "medium" in the equation allows us to avoid the classic Prisoners' Dilemma type of problems. Indeed, agent and medium are in general not competing, since they are wholly different types of entities requiring different types of resources (Heylighen, 2007a). Therefore, it is easy for them to evolve a synergetic relation, i.e. such that the effect of both agent on medium and medium on agent are beneficial to the recipient. An example is an ecosystem in which a variety of species (agents) support their shared environment (medium) while being supported by it. Unsustainable interactions between agent and environment (medium) are just that: they cannot be maintained, and will eventually be eliminated by changes forced upon agent, medium or both. Thus, as always, natural selection in the long term produces increasingly stable or fit configurations.

Stigmergy

Let us zoom in on the interaction between agents via the medium. An action by one agent that hinders another agent will tend to be resisted or counteracted by the second agent, with the result that the first agent fails to fully reach its goals. For example, a rabbit that tries to dig its hole near an ant nest will soon find its work undone by the activities of the ants. This creates a selective pressure for the agent to find a more effective action strategy, i.e. one that is unlikely to be obstructed. For example, the rabbit will eventually give up, and choose another location for its burrow.

If the change in the medium brought about by this new action moreover happens to benefit another agent, that agent will tend to reinforce or support the change, thus in turn benefiting the first agent. Thus, there is a selective pressure on agents and their actions not only to reduce inter-agent friction, but also to promote synergy. For example, an animal that creates a passage across a field by flattening or breaking tall grasses will thus facilitate the movement of other animals, who will tend to follow in its footsteps, thus further flattening the trail, until a clear path is formed that is beneficial to all.

Note that this form of mutually beneficial interaction does not require any intention to cooperate, or even awareness of the other agent's existence. Such *implicit collaboration*, which was originally observed in social insects such as termites (Theraulaz and Bonabeau, 1999), is called *stigmergy* (Dorigo *et al.*, 2000; Susi and Ziemke, 2001): the environmental change brought about by one agent's action incites another agent to act in turn, thus unconsciously contributing to their common benefit. This mechanism is general enough to explain the evolution of cooperation even in the absence of any form of rationality or ability to foresee the consequences of one's actions. This already allows us to side-step the Prisoners' Dilemma and other game-theoretical conundrums, which assume some form of rational decision-making from the agents. It moreover allows us to apply the procedure under the conditions of extreme unpredictability and complexity that characterize socio-technological evolution in this age of globalization.

The mechanism of stigmergy – i.e. indirect, environment-mediated cooperation – brings additional advantages. Because this form of action is directed at the shared environment, it will gradually reshape this medium into a structure that supports increasingly efficient and synergetic interactions. For example, the erosion of grasses, bushes and other obstacles along well-traveled routes will create a network of smooth paths connecting the most important destinations (such as feeding grounds and watering holes) for a group of animals. In places where several animals tend to pass at once, the path will widen so as to allow everyone free passage. This simultaneously reduces physical, informational and social friction: animals will be able to travel with less physical effort, they will have less need to orient themselves, and there will be less danger of obstruction from other animals.

After a while, the network of trails will have stabilized so that individual animals only need to contribute a minimal effort to its maintenance. Thus, the influence of individual agents on the medium tends to decrease. On the other hand, as the network becomes more reliable and extensive, the influence of the medium on the agents' activities increases. Eventually, the asymmetry is inverted: where initially we would see the agents as manipulating the medium, now it becomes more parsimonious to see the medium as directing the agents. The medium has turned into a *mediator*: it coordinates the individual activities so as to minimize friction or conflict, and to maximize synergy. The classic example of such an "active" coordination medium can be found in the pheromone trails that ants create while searching for food (Bonabeau *et al.*, 1999; Dorigo *et al.*, 2000). The trail network functions like an external memory or "collective mental map" for the ant colony, directing the individual ants to the different food sources and the nest via the most efficient routes (Heylighen, 1999b). Similarly, in human society, hiking paths and dirt roads eventually evolved into a dense network of streets and highways, which are complemented by road markings, separations between lanes, and traffic signs, that efficiently direct traffic so as to keep obstruction minimal.

Towards a global mediator

This leads us, after what might seem a long digression, back to the evolution of our globalizing society. Human action has shaped a variety of media, i.e. shared environments supporting interaction. Initially, these were mostly concerned with the exchange of material goods and services. Examples are the different transport, industrial production and economic infrastructures. As discussed earlier, ephemeralization has made these increasingly efficient and global in reach. But there are limits to the reduction of physical friction: it becomes increasingly difficult to reduce the consumption of matter and energy simply because there is a minimal amount of matter/energy necessary for processes like feeding, movement, and construction. On the other hand, there is no clear limit to the reduction of informational or social friction, in that the losses of frictional interactions (negative sum) can be turned into the gains of synergetic interactions (positive sum) (Heylighen and Campbell, 1995; Wright, 2000).

One way to understand this unlimited capacity for growth is by noting that information, unlike matter and energy, is not a conserved quantity: it can in principle be replicated without limit. The Internet, which – because of its digital character, instantaneous communication, and negligible use of energy – can be viewed as a virtually frictionless medium, makes this unlimited replication possible in practice (Heylighen, 2007b). As noted in the introduction, any evolutionary advance can be conceived as a gain in information. Communication between agents across one or more media makes it possible to spread that gain at an exponential rate. With a highly efficient, world-spanning medium like the Internet, a discovery made by one individual (say, a new way to avoid influenza) can, in principle, within days improve the life of people globally.

However, the remarkable efficiency of the Internet is at present still mostly physical or informational, not social. The Internet has grown so quickly that it has not had the time to evolve efficient institutions, i.e. collective systems of rules that coordinate individual actions. The result is a messy, confusing and constantly changing information landscape, which in principle offers immense benefits, but in practice only works reliably for a limited number of applications, while producing confusion, information overload, and various forms of "cybercrime." As a result, an individual discovery published on the Internet may indeed change the world's outlook within days, but the more likely outcome is that it will get buried within masses of other, mostly much less-relevant information, and not receive the attention that it deserves.

In conclusion, the evolutionary dynamics underlying globalization have already led to a relatively efficient physical distribution of matter, energy and information across the globe, but still need to produce the social institutions that go with it. This is not a very original observation: critics of the globalization of markets have pointed out that the extension of the free trade in goods and services needs to be counterbalanced by the further development of transnational institutions, such as UN, UNESCO, WHO, etc., to protect the rights of children, workers, consumers, cultural groups or the environment (cf. Modelski, 2007). The "stigmergic" theory proposed here, however, suggests a number of complementary mechanisms through which new types of institutions are likely to evolve.

The main idea is that the external interaction medium, a role that is increasingly dominated by the Internet, will evolve into a mediator. This mediator will not only facilitate, but direct, and eventually control, interactions so as to maximize their synergy. To achieve that, the medium needs to develop a form of intelligent management of the communication processes that it supports, leading to what may be called *collective intelligence* (Lévy, 1997; Heylighen, 1999b) or *distributed cognition* (Susi and Ziemke, 2001; Heylighen *et al.*, 2004). When this distributed intelligence spans the world, the resulting system may be called the *Global Brain* (Mayer-Kress and Barczys, 1995; Goertzel, 2001; Heylighen, 2004, 2007c).

The emerging Global Brain

As I have described both the social and technological aspects and implications of the Global Brain concept in detail elsewhere (e.g. Heylighen, 1999b, 2004, 2007c; Heylighen and Bollen, 1996), I will here only present a short review, albeit from the new, stigmergic perspective. Two types of stigmergy can be distinguished (Théraulaz and Bonabeau, 1999): quantitative and qualitative. Quantitative stigmergy *ranks* or *prioritizes* existing possibilities for action, thus helping agents to choose the action that is most likely to be beneficial. Qualitative stigmergy *creates* a potential for action by changing the medium in such a way that novel possibilities arise.

The web as neural network

The use of pheromones to mark foraging trails by ants is a paradigmatic example of quantitative stigmergy: the more often ants successfully travel a trail to find food, the more pheromones they leave behind, and therefore the more the trail becomes attractive to other ants searching for food. The strength of a pheromone trail is a quantitative measure of its probability to lead to a positive outcome. The basic mechanism whereby useful paths are gradually reinforced, and less useful ones weakened, provides a very general heuristic to tackle a variety of problems. It can be seen as a quantitative, stigmergic instantiation of the mechanism of evolution itself: maintain and increase the fit (useful); reduce, and eventually eliminate, the unfit. Under the label of "ant algorithms," it has become popular in computer science as a method to solve otherwise nearly intractable problems (Bonabeau *et al.*, 1999; Dorigo *et al.*, 2000).

Furthermore, the same mechanism seems to underlie learning in the brain: neuronal connections that are successfully used become stronger; the others become weaker. It is this analogy that initially inspired me to conceive of the World-Wide Web as a potential Global Brain (Heylighen and Bollen, 1996). The web is a distributed network of documents connected by hyperlinks along which people travel ("surf") from page to page. The idea I developed together with my PhD student Johan Bollen was to strengthen and if necessary shortcut paths that are traveled frequently, while weakening the others, by applying a set of simple rules.

While the algorithm has not as yet been implemented on the scale of the web as a whole, a similar phenomenon already occurs implicitly: when people surfing the web end up in a particularly interesting page, they are likely to create one or more new links from their own pages pointing directly to it, thus shortcutting the long sequence that they followed before finding it. This increases the number of links to the page, and the probability that other people would encounter it. The overall effect is captured by Google's PageRank algorithm, which provides a measure of the importance of a website as determined by the links directly or indirectly pointing to it. This is another example of quantitative stigmergy: the actions of many independent agents (people inserting links) on a shared medium (the web) produce a collective ranking (PageRank) that helps other agents find the options (documents) most likely to be useful to them.

As I have described elsewhere (Heylighen, 1999b; Heylighen and Bollen, 2002), several refinements can be conceived to make this mechanism much more efficient, thus enabling the web to rapidly learn from the way that it is used and become ever better at anticipating and delivering what its users individually and collectively desire. This can potentially eliminate the friction caused by the chaotic organization of the present Internet, and the concomitant "data smog." Similar methods could be used to optimize not just data networks, but social networks. For example, various services already exist on the web that introduce people to potentially useful contacts or partners (Coenen, 2006).

Moreover, the optimized networks of priority-ranked trails that are created in this way can be traveled not only by humans, but by software agents. A "swarm" of such agents (Rodriguez, 2007) is able to explore many paths in parallel according to the method of *spreading activation* (Heylighen and Bollen, 2002) – which is again inspired by the functioning of the brain. It allows the intelligent network not only to explore a vastly larger array of potentially interesting information sources, but also to take into account the ever-changing context and often subconscious preferences of its users while selecting the sources most likely to be useful. The result is that users do not even need to enter keywords or explicitly formulate their queries, as their software agents implicitly learn their interests, while immediately taking into account changes in focus of attention.

Finally, agent swarms can perform not only the equivalent of intuitive, subconscious processes of activation spreading through the brain, but of systematic, logical search and deduction. To achieve that, the knowledge in the web needs to be organized according to a consensual ontology, i.e. a formal system of categories and relationships. Developing such ontologies is the goal of the Semantic Web project (Berners-Lee, 1999). Given such a semantic network, a software agent could be programmed with a "grammar" of rules that tell it to only explore or return certain categories of nodes and links (Rodriguez, 2007). A swarm of such agents should for example be able to find all birds that do not fly, or, as another example, the most representative researchers (as measured e.g. by PageRank or citation impact) who have written about globalization and evolution, cite publications of Modelski, and work in one of the NATO countries and have a PhD, so that you can invite them to your NATO-sponsored workshop.

In conclusion, quantitative stigmergy is able to turn the web from a passive medium for communication and storage of information, into an intelligent mediator that uses learning and inference mechanisms similar to those of the human brain in order to recommend to its users the actions, information sources, or people most likely to be helpful for their aims. To achieve this, the intelligent web draws on the experience and knowledge of its users collectively, as externalized in the "trace" of preferences that they leave on the paths they have traveled.

Collective production of new knowledge

Quantitative stigmergy, as we have defined it, only recommends the use of existing resources – it does not create anything new. To do that, we need to actively shape the medium into something that did not exist before.

An example of such qualitative stigmergy in the world of social insects is nest-building by wasps, where individual wasps differentially add cells to the emerging structure of the nest (Théraulaz and Bonabeau, 1999).

A more practical example is Wikipedia, the global electronic encyclopedia that is being written collaboratively by millions of people (Lih, 2004). Any user of the web can add to or edit the text of any Wikipedia article – or create a new one, if its subject is not covered yet. All previous versions of an article are automatically stored, so that if an important section is deleted by accident (or by intention), it can always be restored by a subsequent user. In that way, the information in Wikipedia can only grow, as the people who consult it add their own knowledge so as to improve the coverage of the subjects that they are interested in. The activity is clearly synergetic, since no single individual would be able to provide such an extensive coverage of all of humanity's knowledge. And since the different contributions are integrated into a well-organized and extensively cross-linked web of articles, the whole is clearly more than the sum of its parts.

Yet, the collaboration between Wikipedia contributors is essentially indirect. Over its history of a few years, a typical article has been edited by a few dozen different people from different parts of the globe. In general, these people have never met or even communicated from person to person. Their only interaction is indirect, through the changes that the one makes to the text written by the other. When they disagree about how to express a particular subject, the one may repeatedly correct the statements written by the other and vice versa, until perhaps a compromise or synthesis emerges – which may have been proposed by one or more third parties. This is variation and selection at work: different people contribute different text fragments, some of which are clear, accurate and relevant, some of which are less so. The continuing process of revision by a variety of users will normally leave the good contributions in place, and get rid of the poor ones, until the text as a whole provides a clear, coherent and in-depth coverage of its subject, without glaring mistakes. When the subject is controversial, an evolved text will typically provide a balanced overview of the different perspectives, noting the arguments for and against each position.

This example shows the true power of stigmergy: thanks to the availability of the medium (in this case the Wikipedia website) independent agents together perform a complex activity that is beneficial to all, minimizing social friction and stimulating synergy – and this without need for a hierarchical control or coordination, a clear plan, or even any direct communication between the agents (Heylighen, 2007b). In the present web, similar mechanisms are being used to collaboratively develop not just an encyclopedia of existing knowledge, but a variety of novel knowledge and applications, including various types of open-source software, scientific papers, and even forecasts of the world to come (using web versions of the well-known Delphi procedure). Thus, Internet-supported stigmergy strongly promotes the collective development of new knowledge and tools.

Again, there is a direct analogy with the functioning of the brain. Whereas quantitative stigmergy can be likened to the neural processes that characterize subconscious cognition, qualitative stigmergy is most akin to the higher-order, symbolic processes that we associate with conscious thought. According to evolutionary psychology, the brain consists of an array of many, largely independent modules, each specialized in a particular task – such as recognition of specific shapes, emotions, or control of specific movements – that work in parallel. These brain modules have few direct connections that allow them to communicate so as to form a global picture of the situation. One way for them to pool their expertise is by exteriorizing the inferences made by some of the modules, so that the results can be perceived, i.e. re-entered into the brain and thus processed by the other modules. Exteriorizing cognition takes place through the creation of physical symbols, such as drawings, utterances or writings that represent the mental contents. Typical examples of this process are talking to oneself, or taking notes and drawing schemas while thinking about a complex problem. This is an example of stigmergic interaction between the modules within one's brain: a module's outcome through action is converted into a change of the environment; this change is then perceived again, triggering new inferences by the same or other modules, that produce a new action, and a subsequent modification of the external symbols; in this way, an idea is step-by-step elaborated and refined.

As the individual becomes experienced with this process, however, shortcuts are developed and symbols are interiorized again. Thus, children talking to themselves while thinking will soon learn to use inner speech, i.e. forming sentences in their head without actually vocalizing them. According to the global workspace theory (Baars, 1997), higher-level consciousness is nothing more than the "working memory" or "theater" within the brain where these interiorized symbols are produced and combined, so that they can be submitted to the scrutiny of the various more specialized modules. This global workspace is a shared internal environment or mediator that the brain has evolved in order to facilitate the coordination and control of its otherwise largely autonomous and instinctively reacting modules. From this perspective, it seems obvious that the World-wide Web too is a global workspace that serves the coordination of autonomous individuals, together forming a brain-like system at the planetary scale. The novel ideas developed collectively in that workspace form the equivalent of the thought processes of the Global Brain. As the conventions, protocols, software and hardware tools supporting this workspace evolve, they become more efficient, and novel ideas and solutions to existing problems will be produced more quickly and more easily, thus greatly increasing collective intelligence and creativity.

The dynamics of global evolution

The model proposed in this paper sees evolution characterized by unambiguous advance or progress towards more synergetic systems, characterized by reduced friction, and therefore more productive use of resources. The same kind of progress can be found on the levels of matter, energy, information, cognition and cooperation, thus spanning the whole hierarchy from physics to society (Heylighen, 1999a, 2007a; Stewart, 2000). The technological and institutional innovations come together in what we have called the "medium," i.e. the part of the environment, shared by different agents, that is used as their workspace, or means for communication and collaboration. The thrust of the argument is that there is no need for intentional use or design of such a workspace: any medium that can accumulate changes produced by the agents tends to evolve into a mediator that coordinates their actions, and thus promotes synergy. This is because the variation-and-selection dynamics that underlie individual evolution are extended to collective evolution via the mechanism of stigmergy, where the changes to the medium made by one agent indirectly affect the actions of the other agents.

The socio-technological singularity

A major effect of stigmergy is the *acceleration* of evolution: a solution to an evolutionary problem found by one agent can now, by impressing it upon the medium, be used and improved by other agents. Since the medium benefits all agents' fitness, there will be a selective pressure on the agents to find solutions that make the medium itself more powerful. The further the medium extends, and the easier it becomes for agents to interact with it, the quicker innovations will spread and undergo further improvements. This leads to a self-reinforcing process: improvement of the medium facilitates further innovation, which in turn helps improve the medium. This explains the explosive advance in science and technology over the last few centuries, as exemplified by the (at least) exponential increase in the number of scientific publications (Kurzweil, 2006).

Some aspects of such accelerating growth can be captured in mathematical models. An elegant example is the explanation by Korotayev (2006) of the hyperbolic growth of the world population until 1960 (von Foerster *et al.*, 1960). In the model, population growth is initially modeled by a traditional logistic growth equation (1), where population N starts by growing exponentially but then slows down until it reaches the maximum value expressed by the carrying capacity bT of the environment. This carrying capacity is proportional to the overall productivity T of technology, i.e. its ability to extract from the natural environment the resources necessary for survival. In a second equation (2), the growth $\mathrm{d}T$ of technological productivity is considered to be proportional to the technology T that is already there (simple exponential growth), but also to the population number N, under the simple assumption that more individuals will discover more innovations.

$$\frac{\mathrm{d}N}{\mathrm{d}t} = a(bT - N)N \tag{1}$$

$$\frac{dT}{dt} = cNT \tag{2}$$

The authors show that the two equations together produce a hyperbolic growth curve that mimics the observed historical growth of world population with surprising accuracy (explaining over 99 percent of the variation for the period 500 BC to AD 1962). The growth is much faster than could be expected from a traditional logistic or even exponential curve, because of the positive feedback between population ("agents") and technology ("medium").

It is obvious that hyperbolic growth (which would lead to an infinite value within a finite time) is not sustainable for population. This explains why the model breaks down after 1962, when the demographic transition to smaller family sizes starts to occur. But that can be perfectly understood from an evolutionary point of view, as a shift from r-selection (fast reproduction, short life) to K-selection (slow reproduction, long life) (Heylighen and Bernheim, 2004). When life becomes less risky, fitness is better served by long-term investments in longevity and quality of life than by a short-term strategy for producing many offspring as possible. The most recent population models of the UNDP therefore forecast a stabilization of world population by about the year 2100.

However, this does not entail an end to the population–technology feedback: K-selection implies on-going growth in the general health, wealth, development, education and even IQ levels (Heylighen and Bernheim, 2000a, 2004) of the population. This in turn will increase the potential of each individual to innovate, and thus the speed of technological progress. Vice versa, technological progress enhances the general development level of individuals, via improvements in health, education, wealth, autonomy, etc. Thus, it is conceivable that the technology-supported hyperbolic growth in the human population has simply shifted to a growth in "human potential" or "human development." While human potential may be difficult to quantify, the human–technology feedback implies that technology too should obey a hyperbolic growth, and this could be measured via various indices of productivity.

The essence of hyperbolic growth is that it will produce an infinite value within a finite time. In mathematics, the point where the value of an otherwise finite and continuous function becomes infinite is called a *singularity*. It can be seen as the point where quantitative extrapolation must break down. Vinge (1993), Kurzweil (2006) and others have argued that technological innovation is racing towards such a singularity. In the short term, scientific and technological innovation appears to obey an exponential growth pattern, as illustrated by a variety of statistical trends (e.g. Moore's law, or the increase in scientific publications). In the somewhat longer term, however, the rate of growth itself appears to be growing (Kurzweil, 2006). For example, our review of information transmission speeds over the past two centuries indicates a much faster than exponential growth. This makes the process super-exponential, and possibly hyperbolic. Extrapolation of these trends leads to different estimates for the year of the singularity:

- 2005 to 2030 according to Vinge's (1993)interpretation of the increase in machine intelligence;
- 2026 according to the original extrapolation of hyperbolic population growth by von Foerster *et al.* (1960);
- 2045 according to Kurzweil's (2006, p. 136) compilation of technological trends;
- 2052 ± 10 according to Johansen and Sornette's (2001) extrapolation of various population, economic and financial growth curves.

The implication is that at some point within the next half century the speed of innovation will – at least for all practical purposes – become infinite. This means that an infinite amount of knowledge (and the concomitant wealth) would be generated in a finite time. At such a point, every further extrapolation that we could make based on our present understanding of evolution, society or technology would become meaningless. The world will have entered a new phase, where wholly different laws apply. Whatever remains of the global system as we know it will have changed beyond recognition.

While my interpretation of accelerating change is somewhat more cautious than the one of "*singularitarians*" like Kurzweil, I believe that this acceleration does point to the evolutionary emergence of a higher level of organization – what Turchin (1977) has called a *metasystem transition*. An example of such an evolutionary transition is the emergence of multicellular organisms from individual cells. The *global superorganism* (Stock, 1993; Heylighen, 2007c) directed by its Global Brain (Heylighen, 2004) is a metaphor for the "metasystem" that would be formed in this way – a system that would integrate the whole of humanity together with all its supporting technologies and most of its surrounding ecosystems, and that would function at a level of intelligence, awareness and complexity that we at present simply cannot imagine.

Is global progress cyclic?

As part of a volume where many contributions have their roots in the "long wave" tradition (e.g. Devezas and Modelski, 2003; Modelski, 2006), this chapter should also address the issue of periodicity in the evolution of the world system. It is clear that in a model where the focus is on ever-accelerating growth racing towards an apparent singularity, there is little room for slow oscillations, i.e. long-term cycles of renewal and growth followed by decline and fall, which repeat at regular intervals. Yet, as illustrated by Kurzweil (2006, p. 43) and Johansen and Sornette (2001), it is possible to superpose a certain amount of cyclicity on an exponential or hyperbolic growth curve, by assuming that the speed (or acceleration) of growth oscillates somewhat around its "normal" value. A rationale for doing this is the assumption that innovation is not a continuous process, but a sequence of discrete discoveries, inventions or paradigm shifts, each bringing forth a new technology, institution, or way of thinking. Each major innovation needs time to diffuse and be adopted by the whole of society. Such diffusion process is traditionally modeled as a logistic or S-curve, characterized by initially fast growth which then slows down until saturation, when it has reached most of the population.

To achieve periodicity, we moreover need to assume that major innovations do not occur independently, but that, before it starts spreading, the later one "waits" until the former one has reached saturation. This is a not unreasonable assumption, if we consider major socio-technological paradigms that dominate people psychologically and economically to such an extent that they are not interested in exploring alternatives until the present paradigm has run out of steam. However, when we consider the variety of smaller and larger innovations that are constantly being produced by evolutionary trial-and-error, some of which depend on or compete to various degrees with others, then the fixed "waiting period" between innovations becomes less plausible.

Moreover, even if innovations were polite enough to wait until their predecessor has run out of steam, the time to saturation is unlikely to be constant. Some inventions are simply more difficult to adopt than others, because of psychological, economic or infrastructure constraints. For example, the World-wide Web and cellular phone technologies appeared at about the same time, but the latter spread much more quickly than the former (at least outside the USA), because portable phones are less costly and easier to learn to use than Internet-connected computers.

Finally, even if we could determine a "typical" delay for major inventions to diffuse, we would find that delay to be decreasing because of accelerating progress (Kurzweil, 2006, p. 43). Thus, we could hope to find a superposition of increasingly short logistic curves on top of our overall super-exponential curve pointing towards infinity (a related, but simpler mathematical model is Coren's (1998) "logistic escalation": a sequence of ever shorter and steeper logistic growth processes culminating in a singularity). However, if we take into account the variability in size and diffusion speed of innovations, the net result is likely to be an almost random-seeming pattern of fractal fluctuations with increasingly high frequencies around the large-scale super-exponential trend.

While this analysis explains my skepticism towards "long wave" models of the present process of globalization, it does not imply that I wish to dismiss these models altogether. The intensity of present-day acceleration implies that, in comparison, during most of history, progress occurred at an almost glacial pace. Centuries ago, technological advance was slow enough that it might not have been noticeable within one generation. Moreover, the number of simultaneous inventions was much smaller. In such circumstances, the speed of diffusion is likely to have been practically constant, and there would have been much less competition between parallel innovations.

This would make the above assumptions leading up to periodicity much more plausible.

Conclusion

In this chapter I have reviewed the evolutionary mechanisms that drive the present process of globalization. Evolution in general is a trial-and-error learning process, leading to the progressive accumulation and improvement of knowledge. Its subjects are agents, which I have defined as cybernetic systems that act upon their environment in order to achieve their goals. Natural selection of agents and the knowledge that they use to plan their actions pressures them to become progressively better in achieving their goals.

In the realm of technology, this progress is most visible as *ephemeralization*, the on-going increase in "total factor productivity." It can be conceptualized most simply as a reduction in the friction that normally produces the dissipation of energy, information and other resources. As a consequence, ever more results can be achieved with ever fewer resources. On the level of society, this entails a spectacular expansion in the flows of matter, energy and information that circulate across the globe. Thus, the obstacles of time, distance and material scarcity have largely vanished, making the different parts of the world increasingly interconnected.

Connectivity implies an increase in the number of agents that one is interacting with, and therefore an increase in social complexity, with the concomitant threats of competition, conflict and confusion. These problems too can be conceptualized most generally as a form of friction, i.e. the (generally unintended) obstruction of one agent's actions by one or more other agents' actions. As in the case of technological progress, the trial-and-error of evolution will tend to reduce this social friction by creating adapted institutions. Institutions, or more generally *mediators*, are systems that coordinate the activities of different agents so as to minimize friction and maximize synergy.

A largely overlooked, but very powerful, mechanism for the spontaneous evolution of mediators is *stigmergy*, which relies on the medium or environment shared by the agents. Stigmergic interaction means that the change produced by one agent to the medium stimulates another agent to perform a complementary action, promoting their collective benefit even without any conscious intention to cooperate. Stigmergic activity will gradually reshape the passive medium into an active mediator, which elicits and directs the agents' actions.

The most "ephemeralized" example of the technological infrastructure underlying global connectivity is the Internet. A quick inspection shows that it provides a near ideal medium for stigmergic interaction (cf. Heylighen, 2007b): it instantaneously connects people all across the planet; is nearly always and everywhere available; can be used virtually without cost; and it is plastic enough to accommodate practically any "shape" or information that is imprinted upon it, while it will accurately register and store this information for as long as necessary. What it still lacks are the more evolved mediator functions. Yet, there already exist several examples of Internet services – such as the Google search engine or the Wikipedia website – that very successfully apply stigmergic principles to coordinate individual activities, thus offering their users a form of distributed intelligence well beyond the capabilities of a single individual.

A straightforward extrapolation of this evolution that injects ever more intelligence into the Internet leads me to expect a near-term shift from World-Wide Web to Global Brain (Heylighen and Bollen, 1996). The "Global Brain" is more than a fancy term for a large-scale intelligent system, however: the analogy runs much deeper. An analysis of the stigmergic mechanisms that seem most effective in supporting such distributed intelligence shows that they are virtually identical to the mechanisms used by the human brain. The quantitative stigmergy exemplified by "ant algorithms" is nearly identical to the process of Hebbian or reinforcement learning that differentially strengthens connections between neurons in the brain. The "ants" that trace and explore the quantitatively weighted network formed in this way correspond with human or software agents searching the web, or to bursts of activation spreading across the brain. Qualitative stigmergy, which is the true motor of innovation, can be seen as the basis of symbolic consciousness in the brain. It is exemplified on the web by a variety of collaborative, "open access" sites where people freely improve on each other's contributions (Heylighen, 2007b).

The chapter concluded with an attempt to provide a quantitative underpinning to this purely conceptual forecast of the emerging global network. Over the past centuries, both technological and social evolutions appear to be accelerating spectacularly. The stigmergic interaction between medium (technology) and agents (society), moreover points to a positive feedback relation, where the one catalyzes the development of the other. Such cross-catalytic interaction is elegantly captured by the mathematical model proposed by Korotayev (2006) to explain the growth in the world population. However, the resulting hyperbolic growth model entails a singularity, i.e. a point in the near future where the speed of innovation becomes virtually infinite. Different authors have estimated such a singularity to take place around the year 2040, give or take a decade or two. While I do not want to put too much emphasis on such a number, which I consider to be much less reliable or important than the qualitative transition that it represents, these numbers agree with my intuition that a momentous change is likely to happen within a surprisingly short term – probably still within my own lifetime.

The speed and radical nature of the transition, and the inscrutability of what will come after, implies that I have little confidence in traditional methods of quantitative extrapolation, and in particular in those based on "long wave" periodicity. While I see a possible utility in distinguishing some degree of cyclicity in the long-term upward trends that I have described (cf. Johansen and Sornette, 2001), the extreme acceleration of change implies that those cyclical fluctuations can only become shorter and shallower as the metasystem transition to the Global Brain regime approaches.

As to a more qualitative extrapolation of social and technological trends, I refer to a slightly older companion paper which reviews the cybernetic organization and evolution of the emerging global "superorganism" (Heylighen, 2007c). In spite of the intrinsic difficulty of forecasting an evolution that is so rapid, complex and radical, I hope that both papers together may offer a reasonably realistic outline of the momentous transformations that our globally networked society is undergoing.

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14 The growth of the Internet, long waves, and global change

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Introduction

The Internet has appeared seemingly out of nowhere, and become firmly embedded in everyday life, even for those who are not habitual Internet users. Internet users (presently 68 percent of the US population, 45 percent of the EU population, and approximately 11 percent worldwide) are now a huge community of more than 800 million people, sending and receiving e-mails and using the Web routinely as an integrated part of their lives. The Internet is now a household word everywhere and, as Leonard Kleinrock (2001), one of its creators, stated some years ago, it is ubiquitous, always available, and as invisible as electricity.

However, on the other hand, some recent studies, including the present one, have shown that such explosive growth is slowing down and we are presently witnessing a transition to a new phase of existence of the Internet. Wellman and Haythornthwaite (2002) named this new phase the second age of the Internet, and called attention to the fact that the first age of the Internet was a "bright line" shining above everyday concerns, and that in the euphoria many analysts lost their perspective. Vinton Cerf (2001), another of the Internet creators, extrapolating growth data available between 1988 and 2001, predicted that the Internet community in 2006 would involve nearly a billion interacting devices worldwide, a number that will be hard to reach in the next ten years if we look at today's data. Some years before, Gaines (1998) wrote:

> The January 1997 data may be put into perspective by comparing it with the world population of 5.8 billion and noting that it constitutes one machine on the Net for every 360 people on the planet. The growth rate has been consistently some 100 percent a year so that, if this were sustained, within nine years there would be one Internet computer for each person.

Internet usage statistics abound on the Web and are not as reliable as for world population, since different sources give different numbers. In a very recent study, Modis (2005), compiling a set as completely and reliably as possible from different sources, and extrapolating the data available since 1994 by using a logistic fit (characteristic of natural growth processes) has shown that we are witnessing the end of the Internet rush, with a ceiling within the next decade of about 14 percent (or even less) for the world users of the Internet as a percentage of the world population. Note that we are speaking about the number of Internet users, and not about the number of devices all around the world.

The purpose of this paper is threefold: first, to show that the Internet has all the characteristics of a basic innovation; second, that its growth dynamics show a good fit to the Generation-Learning model developed by Devezas and Corredine (2001) and the long wave theory; and finally, that we are indeed facing the end of the rush as stated by Modis (2005), and entering a new phase (or maybe a second age) of the existence of the Internet, namely the *consolidation structural cycle*, when a new pattern of global change might entrench, namely one of simultaneous globalization and localization ("glocalization").

Long waves revisited

Economists, and/or economic historians, are divided on the nature and interpretation of the long wave phenomenon, or Kondratieff waves (K-waves for short hereafter), and, as we can infer from a very recent scientific meeting on the theme (Devezas, 2006), this is a matter that has still not been settled. Two areas are object of intense debate. First, on the facts, are long waves a real phenomenon? Second, given the first, what is the nature of the long wave movement?

A recent study from Reati and Toporowski (2004) offers a very good discussion about the above questions, which will be reviewed shortly hereafter. The reason for the first question is that mainstream economists in general do not accept long waves, mostly based in the fact that econometric research from the 1980s onwards does not give unambiguous support to the existence of long waves in output. Metz (2006) has recently summarized the difficulties, and has reviewed his own results published in the 1990s. He confirms the difficulty of finding clear empirical evidence of the existence of K-waves when using time-series of important indicators of general economic activity, but concludes that it seems clear that long-term growth (in developed countries and worldwide) is not steady and there are successive phases of accelerating and decelerating growth.

This discussion relies on the methodological background used in these attempts to find empirical evidence when using econometric data. Such methods are moving-average smoothing techniques, growth rate computation, and spectral analysis using linear filters. Freeman and Louçã (2001) criticize this approach on two grounds – theoretical and technical. On the theoretical level they observe that the rationale for separating growth and fluctuations is based on the general equilibrium paradigm – an approach that seems paradox within the context of modern evolutionary economics where there is no equilibrium at all. At the technical level we have two additional oddities: first, the fact that the influence of a trend needs to be removed from time-series data, since the usual statistical techniques to identify long waves require that series be stationary, and second, and most important, in order to apply spectral analysis, there is the requirement that the cycles are of a regular amplitude. This last is not found in reality and is not necessary for the existence of long waves.

About this point (empirical evidence) it is very important to make two observations. In the first place, as already pointed out by Marchetti in several publications (that can be seen and downloaded from his webpage: http://cesaremarchetti.org), the best empirical evidence for the real existence of long waves is not to be found in time-series of econometric parameters, but rather in the observation of physical entities associated with the economic realm, like innovations, energy consumption, infrastructures, etc. Second, we have the fact that Berry (1991, 2000), using both a nonlinear dynamics approach (chaos theory) and a sophisticated spectral analysis (based on the eigen-analysis of an autocorrelation matrix, applied on the macroeconomic American data inflation rate and rate of growth per capita GNP, observed annually since 1790), has found sound and robust evidence of the existence of K-waves and Kuznets cycles as well. Moreover, Berry (1991) pioneered the observation that K-waves *are not growth cycles*, but instead *structural cycles*. That explains the very regular "clock ticking" of about 55 years found by Marchetti in his extensive analysis of physical parameters.

Turning to the second question, and the essence of the discussion on long waves: i.e. their nature in relation to structural cycles and clusters of innovations, it is very important to note that, on the one hand, Metz (2006) has not found evidence for the existence of long waves working with econometric time-series, but, on the other hand, he recognizes the robust evidence of clusters of innovation activity. To obtain his new results, he used a very different database (15,000 innovations for the period from 1750 to 1991, collected by researchers from the Institute of Employment Research in Nuremberg) to those used by previous authors, and he found clusters peaking in 1840, 1890, 1935, and 1986. He then makes the point that his new graphs fit very well to the distribution of basic innovations according to Mensch (1979) (with the exception of the last peak that had not happened at the time that Mensch published his book). Moreover, his new results show that the innovation activity was followed by an upswing in growth of the economic activity, with a lag of about 18 years, which could be a proof of the depression trigger hypothesis formulated originally by Mensch. This again shows a good fit to the Generational-Learning model to be discussed later in this chapter.

Mensch (2006), recently reviewing his original Metamorphosis Model (1979), presented it as a structural model, free of the limitations imposed by the axioms of the general equilibrium theory, and as a special evolutionary theory that is incorporating structural instability analysis in the study of economic systems. He states that structural instability goes hand in hand with structural readiness for breakthroughs of something new (good or bad), a point that we will consider later in this paper when analyzing the history of the development of the Internet.

Another good reason for debate and disregard of part of mainstream economics is the "quasi-cyclical" pattern of long waves. Some economists maintain that so-called "long waves" are instead phases of capitalist development, that is, structural cycles, and as such have unique and unrepeatable characteristics. But in spite of the peculiarities of each of the until now observed four K-waves[1] since the entrenchment of the Industrial Revolution, it is possible to single out some common characteristics that provide a good theoretical framework for analyzing the economic development.

Among the theories presented to explain K-waves, the most plausible by far is their close correlation with clusters of radical innovations that peak during the "downswing" phases of each K-wave. This cluster of innovations originate a completely new technological environment, or "*technosphere*" (Devezas and Corredine, 2001, 2002), which will result in a new worldwide economic order, and consequently in a renewed economic expansion phase. The 50-to 60-year K-waves are usually measured from trough to trough, but for our purposes it is more meaningful to calculate the waves from peak to peak. Thus a *technosphere* commences with the downswing of the K-wave, the period of knowledge innovation or Schumpeter's "creative destruction," and proceeds through the trough to the knowledge consolidation in the next K-wave upswing, culminating at its peak (Figure 14.1). Each such a period from peak to peak has associated with it an overarching technology that has a dominant impact. The mechanization of the textile industry galvanized the first K-wave upswing before 1800. Steam-powered transportation was the dominant technology of the period encompassing the subsequent first K-wave downswing and second K-wave upswing (about 1800 to 1856). Steel and electricity shared the spotlight in the second downswing and third upswing (about 1856 to 1916), while oil was the key technology in the era of the third downswing and fourth upswing (about 1916 to 1969). The overarching technology now, in the cycle of the fourth downswing and the fifth upswing (about 1969 to 2024), is clearly information technology (Perez, 1983; Linstone and Mitroff, 1994).

The innovations start in some core countries (technological leaders), and then spread to other economies. For example, the leaders in the steam-powered transportation era were Britain, France, Belgium, the US, and Germany, and the followers were Italy, the Netherlands, Switzerland and Austria–Hungary. The technological leaders now are the US; Japan; the European countries; Canada, Australia, South Korea, and Taiwan.

It has been widely noted that the K-wave rhythm is observed not only in the economic sphere, where Kondratieff first focused his attention, but also in the global reliance on energy; and in breakthrough or disruptive innovations in communication, transportation modes and infrastructure, manufacturing,

Table 14.1 Cyclical patterns

Domain of innovation	*First to second wave 1800–1856*	*Second to third wave 1856–1916*	*Third to fourth wave 1916–1970*	*Fourth to fifth wave 1970–2025*
Overarching technology	Steam power	Steel/ electricity	Oil	IT*
Transportation	Railroads	Automobiles	Aircraft	Spacecraft
Communication	Periodicals	Telegraph; telephone	Radio; TV	Internet; World Wide Web
Primary global energy	Wood	Coal	Oil	Natural gas; nuclear
Manufacturing process	Factory	Scientific manage-ment; assembly lines	Mass production; in-house R&D	Minimal inventory; CAD†
Corporate organization	Hierarchy	Division	Matrix	Network; virtual company
US public administration	Jacksonian populism	Merit-based civil service	New deal	Deregulation

*IT = Information technology
†CAD = Computer-aided design

business organization, and public administration reform (see Table 14.1) (Linstone and Mitroff, 1994).

These domains are, of course, related. As Marchetti (1988) stated long ago, "with increasing mechanical transport and speed, the personal territory increases, and so rises the opportunity to set up communications poles farther and farther away. Movement generates communication (not vice-versa)." Indeed, the ubiquitous nature of this pattern led him to conceive it not as an economic phenomenon, but an expression of a deeper "physical" one related to the basic working of society, specifically, *society as a learning system* (Marchetti, 1980). This concept will be discussed further in the next section.

It is thus not surprising that our present globalized society has originated the so-called information highway, a scale-free network of networks, which has as its core basic innovations the Internet and World Wide Web (and personal computers and cellular phones as well). As we will see later in this work, this new technosphere was formed during the downswing phase of the fourth K-wave, and has some unique characteristics that will be considered in the sixth section on "The Internet and Global Change." For instance, it is not related to any new primary energy source and it is not energy intensive.

The Generational-Learning model

This model conceives the techno-economic system as an evolving learning dissipative structure, representing a new techno-economic environment that is created, used and exhausted, following the path of an overall logistic curve, and dragging within it not only new technologies and industries, but also new ways of life, new occupations and new forms of organization – not only in business but also in politics and social order. This overall logistic growth is the envelope curve encompassing two logistic structural cycles, whose unfolding is reproduced in Figure 14.1.

The first logistic structural growth curve, corresponding with the downswing of the long wave, is triggered during the ceiling (saturation) of the previous techno-economic system, a period of high instability, economic stagnation and recession, soon followed by a deep economic depression. It corresponds with a phase of renovation, mutation, and selection, during which basic innovations accumulate and interact synergistically, and new ideas emerge apparently out of nowhere. Once the necessary knowledge is established and accumulated, and the new technological environment is reasonably entrenched, the economic expansion starts again. It is the upswing of the long wave, corresponding to the second logistic structural growth curve, a phase of consolidation during which the established technosphere matures and reaches its ceiling, giving way to the blossoming of the next technosphere. For detailed discussion of the model, see Devezas and Corredine (2001).

The prime mover of any evolutionary process, be it in the biological or in the socio-economic realm, is that of *information transfer*, which is fundamentally a *learning process*. The rate of information transfer is initially low, then, overcoming the inertial resistance of the system, it grows, reaches a maximum rate of growth, slows down and then reaches a ceiling, thus following a typical logistic growth pattern. What is being transferred are discrete inputs and outputs or bits of information. In the evolutionary process, a system self-organizes and learns, configuring and reconfiguring itself toward greater and greater efficiency, and in this manner, with each iteration, performs some activity better. Each stage corresponds with a given structure that encompasses previous self-organization, learning and the current limitations. This is to say that *self-organization and learning are embodied in the system's structure*, and the learning rate is an overall system property (Devezas and Corredine, 2001, 2002).

One of the fundamentals of the Generational-Learning model consists of the very important role played by the learning rate as a co-determinant of the timing of a long wave. Analyzing the mathematical relationship between the differential (continuous) and discrete logistic equations, it was demonstrated that the rate parameter δ of the differential logistic equation (or Verhulst equation), and the gain-determining constant k of the recursive discrete logistic equation, are closely related through the

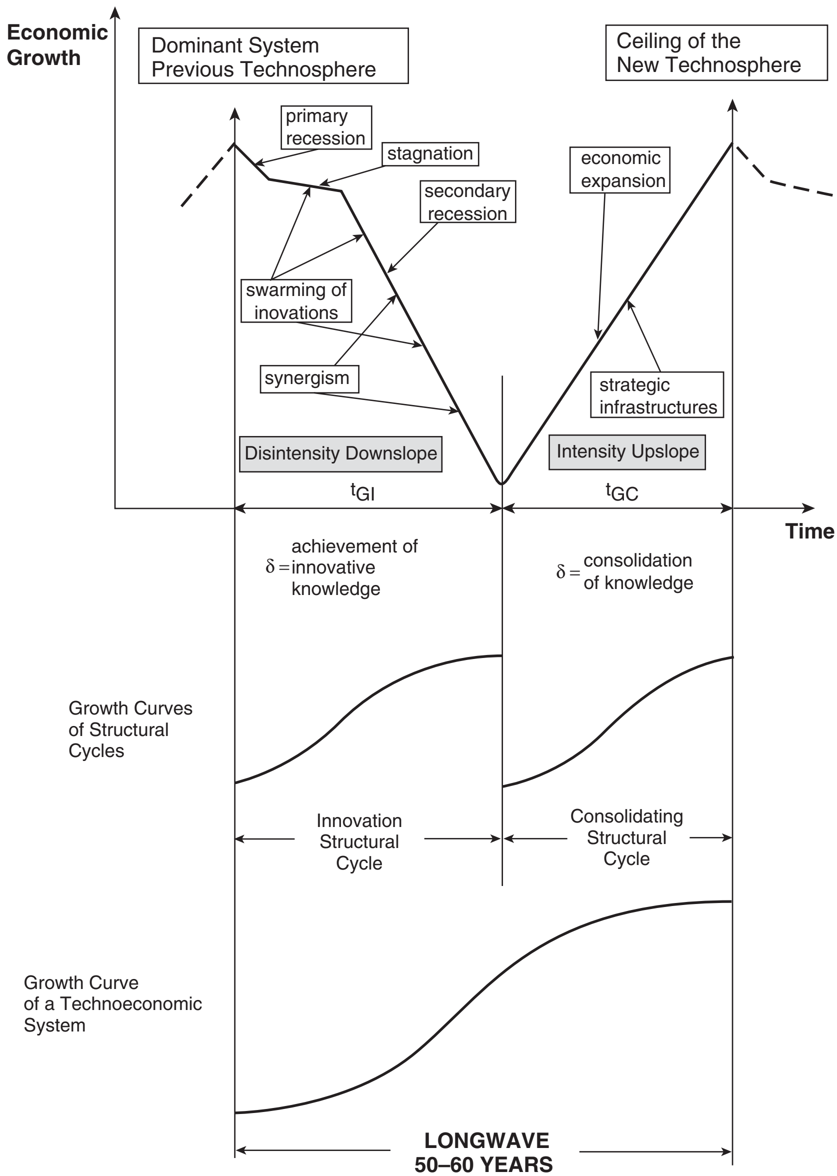


Figure 14.1 The Generational-Learning model of long-waves. The overall logistic growth curve of a new techno-economic system (the "*technosphere*") encompasses two successive logistic structural cycles: an innovation structural cycle with characteristic duration t_{GI} triggered during the "disintensity downslope" of the previous technosphere, and a consolidating structural cycle, with a characteristic duration t_{GC}, which marks the definitive entrenching of the new technosphere and the vigorous "intensity upslope" of the long wave.

expression $k = \delta \cdot t_G$, where δ, the diffusion-learning rate, is the cognitive biological determinant – the rate at which humankind learns to deal with new environments, and t_G, mathematically known as the characteristic time of the logistic function, is the effective generational determinant, consisting of biologically based rhythms. Further discussed were the possible values assumed by the coupling $\delta \cdot t_G$ in the light of deterministic chaos theory, concluding that sustainable growth and evolution requires $3 < \delta \cdot t_G < 4$, granting the necessary oscillations or chaotic behavior. The system is said to be chaotic within predicable boundaries. Social systems are complex adaptive systems exhibiting manifold stability, and $[\delta, t_G]$ are the *biological control parameters* of the long wave behavior, determining the rate of change of the whole process.

The growth and unfolding of the Internet and related innovations will be analyzed in the next two sections, in the light of this model.

The Internet as a basic innovation: A historical analysis

Table 14.1 exhibits a self-explanatory sequence of basic innovations in the domain of communications. This historical sequence has set the stage to form a highly integrated planetary network, the Internet and World Wide Web – a global information–communications infrastructure, a means of collaboration among people and organizations, and a support for "human-based" expert systems.

Looking back at its history we can observe two striking aspects – both strongly characteristic of basic innovations. The first one is related to the fact, first pointed out by Gaines (1998), that the Internet typifies a technology that came into being through serendipity rather than design, in that the intentions and aspirations of the originators bore little relation to what it has become. The second one is related to Bright's seven stages of innovation (Bright, 1968). The Internet, like any other true basic innovation, has already undergone all seven stages, as we will describe below.

Turning to the first point, and using Gaines' argument, we may assert that as the electronic digital computer can be attributed to the needs and funding in the 1940s arising out of World War II, so the origin of the Internet can be attributed to needs and funding in the 1960s arising out of the Cold War. The Eisenhower administration reacted to the Soviet launch of the Sputnik, the first artificial satellite, in 1957, with the formation of ARPA (the Advanced Research Projects Agency) within the Department of Defense in order to galvanize advanced technology. Some years later (1966) the concept of a cooperative network of time-shared computers emerged within ARPA and the first ARPANET plan was proposed. In 1969, ARPANET was commissioned for research into networking with nodes at two (soon at four) American universities. What followed was a sequence of separated and serendipitous events that converged to bring today's Internet into existence. In order to avoid a detailed description of all following events, which can be found elsewhere (http://www.zakon.org/robert/internet/timeline), we tried to map out the sequence of events using three timeline-like tables, presented in the following pages as Table 14.2 – The Invention Phase: 1960–1984, Table 14.3 – The Innovation Phase: 1984–1995, and Table 14.4 – The Diffusion Phase: 1995–2010. Altogether these three tables embrace a time range of about 50 years, beginning near the peak of the fourth K-wave and extending into the fifth K-wave.

Using as framework Bright's stages of innovation, we can time travel through these tables. Regarding Table 14.1, we might say that from Bright's seven stages of innovation, at least three were accomplished in the period 1960–1984. The first stage, *scientific findings*, happened with the papers of Kleinrock (1964) and Baran (1964) on packet-switching theory and packet-switching networks respectively. The second stage, the *laboratory feasibility*, was achieved in 1969 when the first network came to life, with two nodes (UCLA and SRI), and soon after with four (UCLA, SRI, UCSB, and at the University of Utah), a number that grew rapidly to 15 nodes in 1971. By 1973, the first international connections to UK and Norway had been created. In the following years, many new functionalities were added to the network (NCP, e-mail, Ethernet, Usenet, TCP/IP, etc.) and in 1982 the name "Internet" was defined as the set of networks using TCP/IP protocols. In 1983 ARPANET split into ARPANET and MILNET, and 68 of the 113 existing nodes went to MILNET, creating the National Defense Network. The third stage, the *operating prototype*, was in full operation in 1984 when the Domain Name System was created and the number of hosts surpassed 1,000.

Jumping now to Table 14.3 – The Innovation Phase: 1984–1995, we see the start of the fourth stage in 1984: *commercial introduction*, with the creation of dotcom domains and the involvement of private corporations, like IBM and Merit, in the management of the NSFNET, developed by the National Science Foundation in 1985. At this time, Microsoft was already participating in the game, and had launched its Windows 1.0 for desktop PCs. In the following years we have witnessed the increasing involvement of telecommunications companies and the appearance of the first Internet service providers via telephone connection. Such development quickly led to the fifth stage, *widespread adoption*, in 1991 when at least two definitive innovations were brought to the Internet: the introduction of Gopher and the World Wide Web. Both took the Internet by storm and had a ripening effect on its structure, which soon saw the birth of the on-line shopping (in 1994 with "CD-Now" and Amazon.com pioneering the shopping mall). We may say then that in 1995 the innovation phase was completed and the Internet entered a new life cycle, starting with Bright's sixth stage, the *diffusion to other areas*. In fact, when we look to Table 14.4 – The Diffusion Phase: 1995–2010, what we see is the proliferation of a large number of new companies and Internet providers, involving a huge amount of different business activities, never conceived by Lawrence G. Roberts when he conceived the ARPANET in the 1960s. Bright's seventh stage of innovation, the *social and economic impact*, is exactly what we are

Table 14.2 The Internet's history – the Invention Phase – 1960–1984

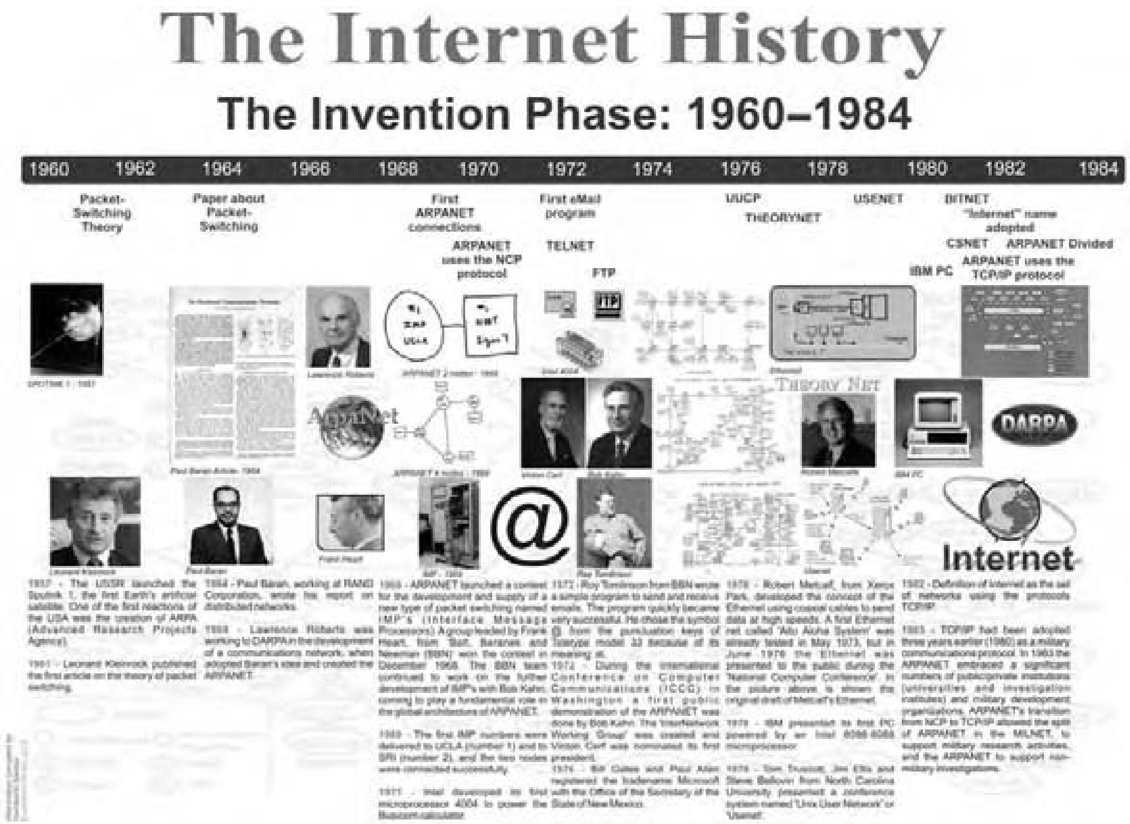


Table 14.3 The Internet's history – the Innovation Phase – 1984–1995

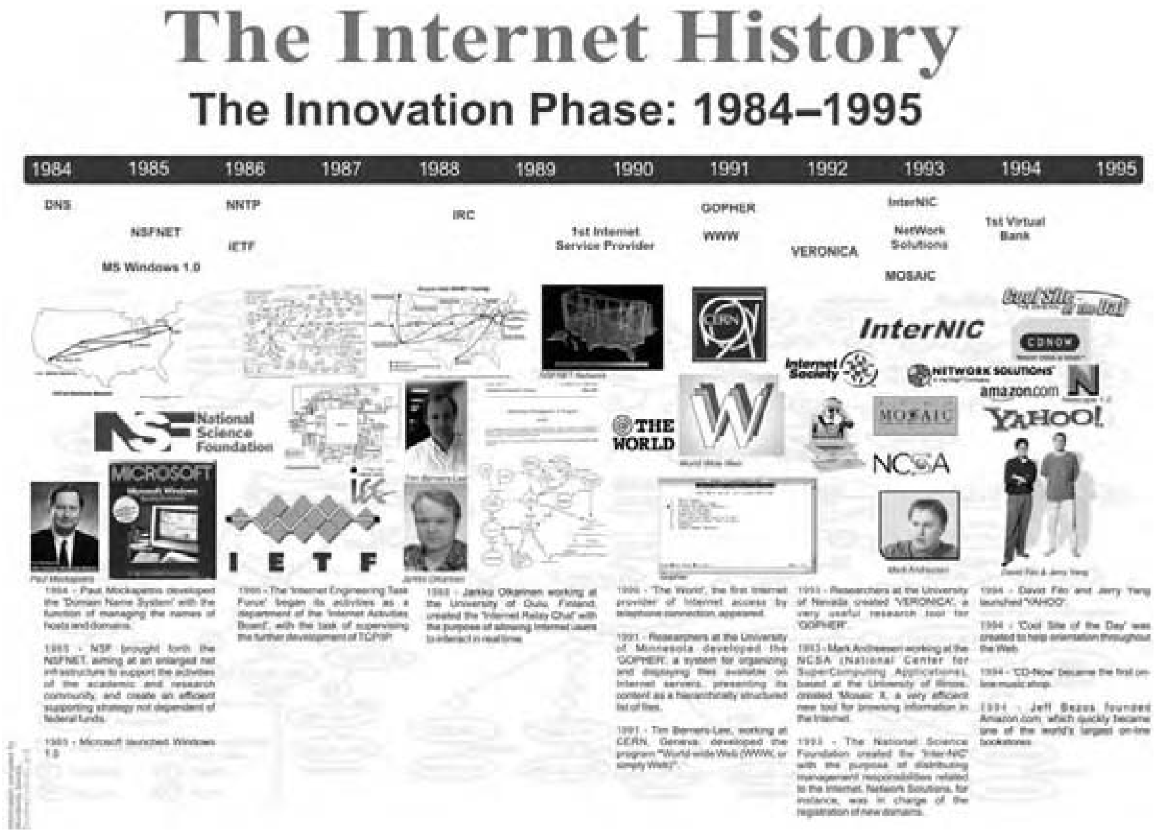
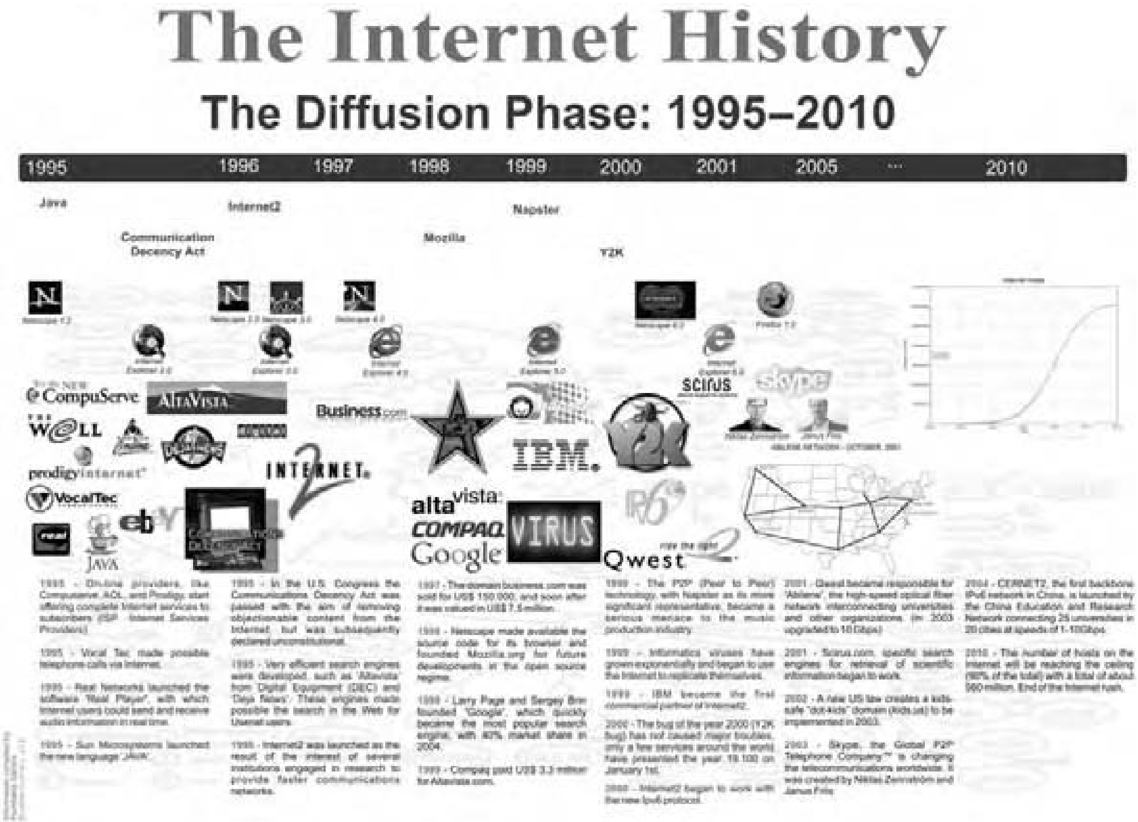


Table 14.4 The Internet's history – the Diffusion Phase – 1995–2010



witnessing presently: social moods and business have changed dramatically. The reason for adopting 2010 as the date of the end of the diffusion phase will be discussed in the next section.

Figure 14.2 shows how the above-related succession of events took place perfectly in phase with the unfolding of the fourth K-wave, here represented in schematic form, taken from the original created by Media General Financial Services. For other sources, see also http://thelongwaveanalyst.ca/home.html. We can observe the inventions appearing during the up-wave and during the first recession period; innovations clustering all along the down-wave and further recession period; and finally the widespread diffusion occurring at the trough and transition period into the fifth K-wave. It is also important to observe that all Internet-related inventions and innovations appeared in the US, with only two exceptions: Jarkko Oikarinen's "Internet Relay Chat" developed at the University of Oulu, Finland, and Tim Berners-Lee's "World Wide Web" created at CERN, Switzerland.

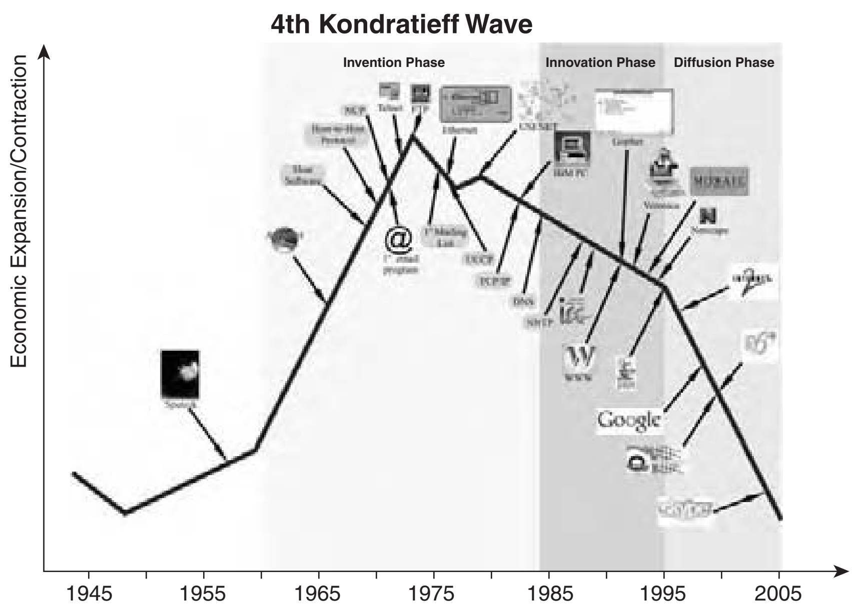


Figure 14.2 The unfolding of the fourth K-wave and the succession of main events marking the evolution of the Internet, here represented in schematic form. We can observe how this succession of events took place perfectly in phase with the fourth K-wave – the inventions appearing during the up-wave and during the first recession period; innovations clustering all along the down-wave and further recession period; and finally the widespread adoption occurring at the trough and transition period into the fifth K-wave.

The growth of the Internet: Quantitative analysis

In order to quantify the growth of the Internet, embracing the complete chain of events described in Tables 14.2–14.4, we choose as growth descriptors two different sets of events, which characterize different phases of development of the Net. The first set is that of computer communication-related software and protocols, closely related to the invention phase and transition to the innovation phase. The second set is the explosive growth of Internet hosts, which is closely related to the transition from the innovation phase to the diffusion phase and with the final thrust of the entrenching of the Internet.

Figures 14.3 and 14.4 show the logistic curves describing the unfolding of each of the software/protocols and hosts, respectively. The logistic curve depicted in Figure 14.3 represents the cumulative growth of the 26 most representative events related to the software and protocols necessary for the communication and/or traffic of information between computers, servers and nodes worldwide. A list of these events is presented in Table 14.5. This growth was completed within 26 years (ΔT, time span for growth from 10 percent to 90 percent) at a rate of 0.17 (δ of the logistic equation). The growth of the number of hosts depicted in Figure 14.4 fits the natural logistic growth curve very well. It was explosive, notably between 2000 and 2005, but is

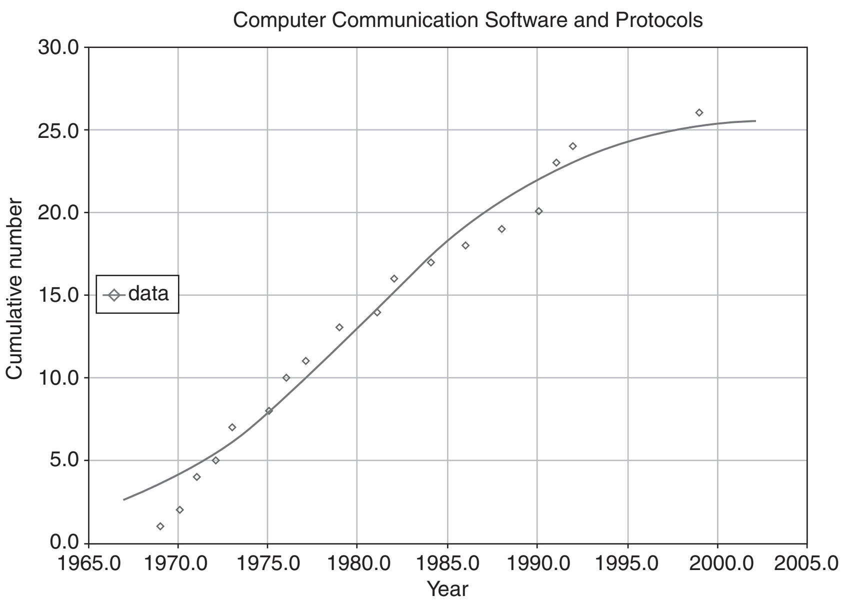


Figure 14.3 The cumulative growth of the 26 most representative events related to the software and protocols necessary for the communication and/or traffic of information between computers, servers, and nodes worldwide (see Table 14.5).

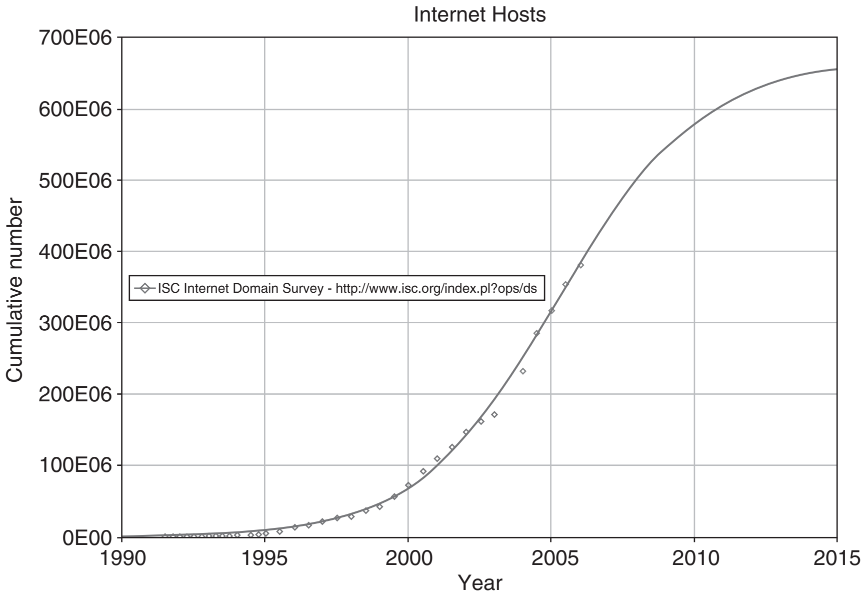


Figure 14.4 The growth in the number of Internet hosts on the Internet fits very well to a natural logistic growth curve.

already reaching the inflection point, showing a take-over time (ΔT) of about 10–11 years and $\delta = 0.41$. It will be saturated around 2010–11, when the number of hosts will be approaching the ceiling of about 660 million. For this reason, we have used 2010 as the end of our timeline in Table 14.4.

In Figure 14.5 both growth phenomena are depicted for comparison as straight lines in a Fisher–Pry plot, and it is important to observe that the center points of the lines are separated by a time span of exactly 25 years, which corresponds approximately with the time span of a generation. It is then curious to observe that today's explosive growth of Internet users is being perpetrated by the direct descendents of the generation coeval with the Internet developers. The superlogistic curve embracing the two logistic curves of Figures 14.3 and 14.4 is shown in Figure 14.6. The result is a well-defined logistic curve with a take-over time of about 32 years, spanning from 1976 to 2008, and a growth rate $\delta = 0.137$. It represents the natural growth process of what is to date known as the Internet. This results fit well with the Generational-Learning model presented in Figure 14.1 – the growth of the Internet, being completed within this decade, corresponds with the *Innovation Structural Cycle* of the presently entrenching technosphere. Its growth rate $\delta = 0.137$ matches well with that of typical basic innovations, as already discussed by Devezas and Corredine (2001) and Grübler (1998). As indicated in Devezas and Corredine (2001), it represents the *learning rate for the achievement of innovative knowledge*, or in

Table 14.5 Chronology for the events involving the development of software and protocols used on the Internet

Decade	*Year*	*Event*
1960s	1969	"*Host*" software
1970s	1970	Protocol "*Host-to-Host*"
	1971	First "*e-mail*" program
	1971	"*Network Control Protocol*" (NCP)
	1972	*Telnet* specification
	1973	*FTP* specification
	1973	"*Network Voice Protocol*" (NVP)
	1975	First "*Mailing List*"
	1976	*UUCP* developed
	1976	*Ethernet* developed
	1977	"*e-mail*" specification
	1979	*USENET* established
	1979	First *MUD* system
1980s	1981	*BITNET* started
	1982	*TCP/IP* protocol
	1982	"*Exterior Gateway*" protocol
	1984	*DNS* introduced
	1986	*NNTP* protocol
	1988	*IRC* developed
1990s	1990	*Archie* launched
	1991	"*Wide Area Information Servers*" (WAIS) introduced
	1991	*GOPHER* launched
	1991	"*World Wide Web*" (WWW) – *html* protocol
	1992	*VERONICA* launched
	1995	*JAVA* launched
	1999	Internet2 starts using IP v6
Total		**26 events**

other words, it is the learning rate at which humankind learned to deal with a completely new communication–information environment. We are presently facing the transition to the *Consolidating Structural Cycle* of this Internet-led technosphere that will push the definitive start of the fifth K-wave.

The Internet and global change

Positioned as we are presently in the neighborhood of the trough of a K-wave and living in a typical transition era, can make any attempt to forecast future scenarios precarious and prone to failure. Transitions are marked by chaotic oscillations and wild fluctuations that lead people who cherish stability to incline to pessimism. Fear and recklessness become the dominant conditions

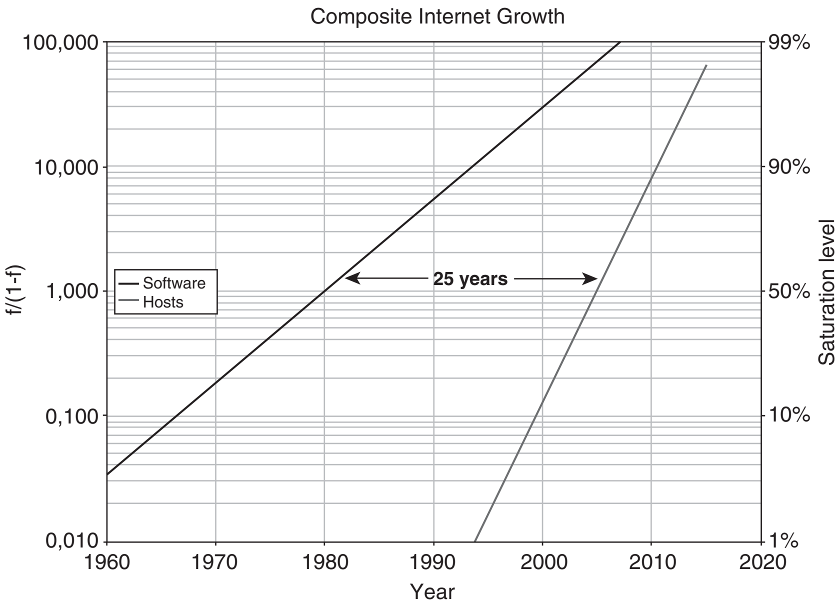


Figure 14.5 In this graph, both growth phenomena (software/protocols and hosts) are depicted for comparison as straight lines on a Fisher–Pry plot. We can observe that the center points of the lines are separated by a time span of exactly 25 years, which corresponds approximately with the time span of a generation.

of mind, and some people speak about the beginning of the end. They disregard the fact that we might actually be facing the end of a new beginning.

Here we want to make the point that the same forces that are the prime movers leading to the wave-like behavior of the world techno-economic system are still in operation, as the pattern described in the previous two sections strongly suggests. K-waves are part of the "normal" functioning of the capitalist world economy. Such so-called normal functioning does not cease because the system has entered a systemic (structural) crisis. The system is resilient, and the various mechanisms that account for the behavior of a capitalist system are still in place. When the present downswing, carrying within it the genesis of the new technosphere (or better, the *innovation structural cycle*) has exhausted itself, we shall undoubtedly have a new upswing, carrying within it the new *consolidation structural cycle.* Our analysis and results on the growth dynamics of the Internet show that the pattern is likely to persist, even though the trajectory may be different.

Ayres (2006) recently made the point that the fourth K-wave occurred on schedule and ended about 1990–92, being followed by the presumed start of the fifth K-wave, driven by the digital revolution and the Internet. But he

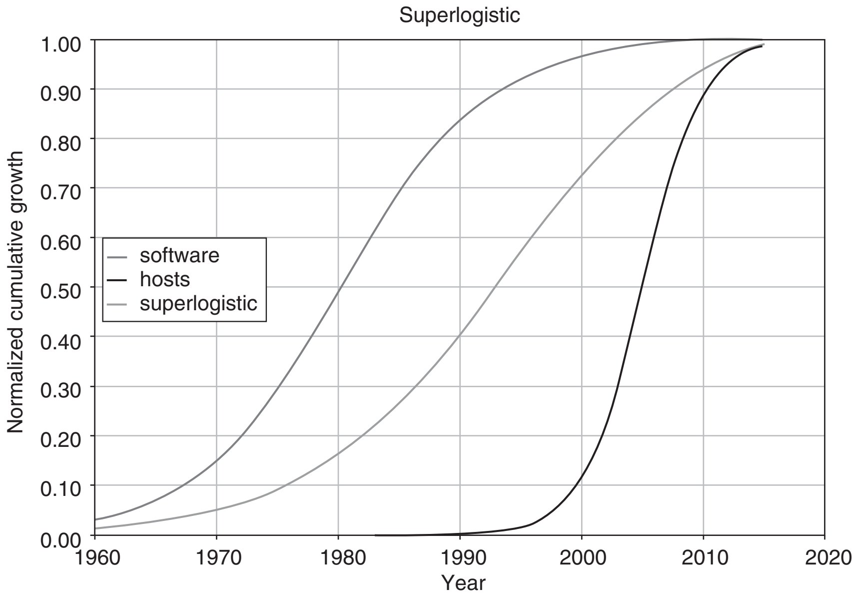


Figure 14.6 This graph shows the superlogistic curve embracing the two logistics of Figures 14.3 and 14.4. The result is a well-defined logistic curve with a take-over time of about 32 years, spanning from 1976 to 2008. It represents the natural growth process of what is to date known as the Internet; its take-over time is typical of the recession periods of past K-waves.

states that recent events, especially since 2000, suggest that the pattern may have broken, i.e. that globalization might have aborted the K-wave. His point is based on three main arguments: first, the fact that there have been no major energy–power–work-related innovations driving the conjectural fifth K-wave; his second argument, closely related to the first, is that the innovations which appeared in the context of the new digital revolution have not shown any spillover potential, as was so clearly evident in the radical innovations that appeared in previous K-waves; and finally, his third argument is that the US is facing serious difficulties in re-setting its economy in the direction of real growth, due to the lack of important basic innovations (for him most US innovations stalled after 1970) and also due to its engagement in a war for resources and an excess of military–technology expending (with little spillover potential).

All three of Ayres' arguments were discussed in depth (and refuted) in a recent article by the present authors (Devezas *et al.*, 2005). These arguments are clearly open to debate. In any future scenario, we should consider the possibility of a K wave *pattern* change as well as a *trajectory* change.

In this context, it is worth mentioning an elegant and insightful piece published some years ago by Wallerstein (2000). He begins by stating that globalization is a misleading concept, since what is described as globalization has been happening for 500 years (this point is discussed in Chapter 3 of this book). The discourse on globalization is in fact a gigantic misreading of the current reality. He leads the reader to an in-depth analysis of the current world situation, using two time frames: 1945 to the present and *c.*1450 to the present. Performing the former, he uses the usual description of the fourth K-wave upswing, clearly led by the US and peaking about 1967–73. It established a new world order (the upswing *consolidating structural cycle* described in Figure 14.1). Such a world order worked well until the end of 1960s, when a series of economic and political occurrences brought the world economy to stagnation (and the term "stagflation" was coined), followed by the downturn to the 1990s. He then asks:

> After that, will we at least see a new Kondratieff A-phase (upswing)? Yes, assuredly, but one with a secular deflation as in the 17th and 19th centuries, and not one within a secular inflation as in the 16th, 18th and 20th centuries. But we shall see also something different.

Wallerstein then jumps to the long-term analysis of the capitalist world system, using a broader time frame – 1450 to the present. He points to three major secular trends (wages, material inputs and taxation) of the capitalist establishment that are approaching their asymptotes, and thereby each of them creates limits to the accumulation of capital. But since the endless accumulation of capital is the defining feature of capitalism as a historical system, this triple pressure is tending to stall the primary motor of the system, creating a structural crisis. He then states:

> So there we are – three major structural pressures on the ability of capitalists to accumulate capital which are the result of secular trends and which continuously ratchet upward. This crisis, not in growth, but in capital accumulation, is further complicated by a different phenomenon, the loss of legitimation of the state structures.

As we see, the point brought out by Wallerstein is that the present transition is not merely a transition to a new K-wave, but a transition of much broader significance, that will affect the entire world order, implying a new trajectory. He adds that the start of the fifth wave does not need to await the resolution of this enormous pressure on capital accumulation, because such a transition to a new order can take some decades more, and may also include important geopolitical and demographic transitions.

Regarding this point – a change in trajectory, there is another very important aspect to be considered when speculating about future trends of global change.

The evolution of complex systems from simple ones may be likened to a spiral growth pattern, beginning with an elementary system and moving by a process of combination or integration to a more complex system, which in turn grows until its structure demands differentiation or separation, followed by recombination at a higher level. For example, the family combines with other families to form a clan; the clan grows until it becomes unwieldy, leading to a village community, then to a city-state, to a nation and to a global organization. Chemical elements and traditional business organizations follow a similar route. The spiral-like pattern is depicted in Figure 14.7, taken from Linstone and Mitroff (1994).

The Internet and related communication and information technologies have now dramatically transformed this pattern. The effect may be termed simultaneous centralization and decentralization, or globalization and localization (sometimes labeled "glocalization"). Table 14.6 (from Linstone, 1999) illustrates this phenomenon in many spheres of human activity. For example, the individual can now create his or her own communications by e-mail, blog, or desktop publishing, while at the same time viewing global CNN. A single rogue trader can bring down a global bank (e.g. the trader Leeson at Barings Bank) or an individual can create a global terrorist network (Osama Bin Laden), while drug traffic is run by global crime syndicates that operate transnationally so as to minimize detection and prosecution. National boundaries become irrelevant in such cases.

The Internet, with its networking potential, compels us to address the co-evolution of technology and organizational structures. It can make a highly decentralized organization more centralized and a highly centralized organization more decentralized. The challenge is to fine-tune the balance between centralization and decentralization so as to maximize organizational effectiveness.

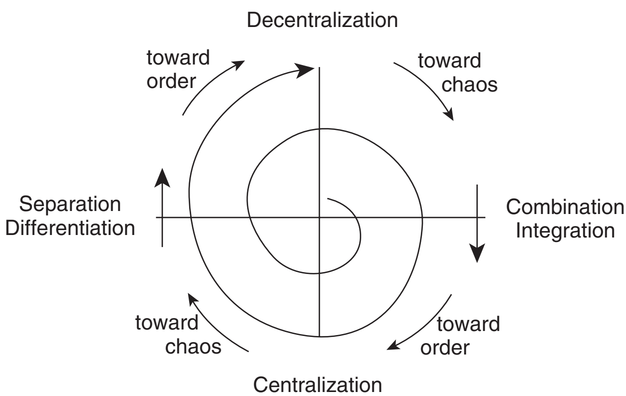


Figure 14.7 The evolution of complex systems (Linstone and Mitroff, 1994).

In the corporate world, top managers can obtain information more quickly and accurately, while middle- and lower-level managers are better informed and make more timely decisions that are less parochial and suboptimal. This should lead to fewer hierarchical levels, while expanding the corporate "memory" encapsulated in many databases and in-house expert systems (Huber, 1990; Coates, 2003). Managers will see in real time how their organization is performing, and relationships with customers can be much more tailored to their specific needs and preferences. Supply-chain management can be fine-tuned, and virtual corporations with constantly changing linkages involving associated companies and individual contractors will become the norm. There will thus be far more flexibility and fluidity in organizations.

As shown in Table 14.6, virtual corporations, "glocal" companies and metanational organizations have already been created. The latter involve global prospecting or scanning for new ideas, and local implementation to produce new products. Nokia thus sensed the potential of small digital cell-phones by reconnoitering in California, Japan, and London. The information is disseminated inside the company and new phones are manufactured. Marketing then becomes global again (Doz *et al.*, 2001). In the case of Nike, the parent firm relays new shoe designs by satellite from its Portland, Oregon, headquarters to a computer-aided manufacturing facility in Taiwan. Prototypes are constructed and modified, and final plans are sent by fax or by e-mails to subcontractors in the region (UNCTAD, 1993).

It has been widely assumed that the speed and globalization of innovation benefit from networking. A globalization hypothesis states that:

> as the search for competitive advantages through strategic partnering increases, corporate integration across national boundaries expands. A stable alliance structure then emerges, consisting of a core block of networks occupied by corporations from different nations, rather than a structure characterized by nationally or regionally homogeneous blocks.

However, a recent analysis does not support this globalization hypothesis. Instead, national and sub-national regional alliance patterns emerge (Rycroft, 2007).

The technology also facilitates the creation of "high-reliability organizations" that can shift instantaneously from hierarchical to flat (i.e. all at the same level) when a crisis occurs (LaPorte, 1989). Examples are airlines dealing with an aircraft crash, or a homeland security organization confronting a terrorist attack. Indeed we have another striking example of "glocalization" in asymmetric warfare: very small cells or individuals linked in a global network. Such warfare poses a new and difficult challenge for well-entrenched twentieth century military organizations. Their success in the wars of the twentieth century by no means assures their success in the twenty-first. Much will depend on their organizational and operational agility in adapting to a totally new environment.

Table 14.6 Information, technology, and organizational change – some examples of "glocalization" (adapted from Linstone, 1999: 64)

Cultural and social agents	*Localization*	*Globalization*
Media	E-mails; blogs; desktop publishing	Giant media conglomerates, e.g. CNN
Languages	Provençal, Catalan	Global English
Cultures	Ethnic enclaves; political fragmentation	Global economy (IMF, WTO, World Bank)
	Single-issue vested interests (NRA)	"McWorld" (jeans, Coca-Cola^{TM}, Disney)
	Individual empowerment	"The electronic herd" (Friedman, 2000)
Faiths	Religious cults and sects (Aum Shinrikyo)	Global religions (Catholicism, Islam)
Crime	A lone hacker infiltrates government computers	Global crime syndicates
	One rogue trader brings down a major bank	
Conflicts	Ethnic feuds, tribal warlords	Global terrorist networks (Al-Qaeda)
		World wars
Weapons	Assassinations; suicide bombers	Weapons of mass destruction
		Information and electronic warfare
Governance	Tribalism; separation (Soviet Union, Yugoslavia, Iraq)	Integration (European Union, NAFTA, OPEC)
Health	Genetics-based customization of medications	Need for global health policies and effective enforcement
		Global-warming impacts
Innovation	Silicon Valley entrepreneurs	Regional clusters and networks (US, Europe, Japan)

(continued)

Table 14.6 cont'd

Cultural and social agents	*Localization*	*Globalization*
Corporations	*Coordination-intensive structures*	
	High-reliability organizations that can shift instantaneously from hierarchical to flat	
	Internal markets	Global alliances of enterprise units
	Decentralized information services (American Airlines)	Global sourcing (General Motors)
	Customization of products (clothes manufactured to order)	Global franchising (Hertz, Best Western)
		Global innovation prospecting, followed by … … ideas disseminated internally ("metanational") Doz *et al.* (2001)
	Multilocal or glocal (global–local) companies (McDonald's)	
	Local ownership	Global management concepts; quality standards
	Local food variations (e.g. different types of chicken sandwiches in the UK and Germany)	Global/regional sourcing (e.g. Poland: meat, potatoes; Mexico: sesame seeds)
	Virtual corporations	
	(Nokia Display Products)	
	Marketing and sales done by International Technology Associates Inc.	
	Customer services and technical support done by Trillium Industries Inc.	

In the twentieth century, the timing and mode of an attack may have been a surprise, but the identity of the enemy was clear, in most cases a well-defined nation-state. In the twenty-first century the situation is quite different. The enemy may well be diffused globally among neutral or friendly civilian populations – a formless flow with no recognized national standing. The vast increase of players, ranging from global organizations to individuals, will reduce predictability. It is dawning on us that the "glocalized" world of the twenty-first century will be far more complex than the nation-state dominated world of the twentieth century. We recall, for example, that militant Islam does not recognize any separation between religion and the state. In this setting, global monitoring and tagging of individuals, money flows, cargo containers, and other critical elements become a foremost challenge for technology.

A major concern of globalization is the impact on the less-developed world. If the widening of the gap between rich and poor worlds is not to be accelerated, it will be necessary to provide access to the Internet and a telecommunications infrastructure now lacking in many poor countries. Electronic switching technology and mobile phones are two means to speed information flow and cut transaction costs between buyers, sellers and government institutions. A program has begun to provide every child in Libya with a laptop computer. Such efforts are vital for achieving competitiveness in the face of the rapid changes in consumer demand and shortened product cycles that characterize the global economy of the information age (James, 2002).

Acknowledgment

Part of this chapter (the first five sections), with minor modifications, was reprinted from Devezas, T. C., H. A. Linstone and H. J. S. Santos (2005) "The Growth of the Internet and the Long Wave Theory." *Technological Forecasting and Social Change* 72: 913–935, with permission from Elsevier (permission granted on 7 February 2007).

Note

1 In this chapter, we are using a K-waves reckoning that is different from that used by Devezas and Modelski (2007, Chapter 3 of this volume). The reckoning used in that chapter is based on the model developed by Modelski and Thompson (1996), which considers the beginning of the phenomenon since the emergence of the market economy in Sung China about 930 AD. The fourth presently finishing K-wave corresponds with their eighteenth K-wave.

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15 The value of an evolutionary view to globalizing Informatics research

One anthropologist's perspective

David Hakken

Introduction

This volume and the conference on which it is based are/were organized around a two-part intellectual intervention in the study of globalization. The theoretical part of the intervention is to advocate for analyzing globalization as an evolutionary process; the methodological part is that, so understood, globalization is a process susceptible to formal modeling. The point of intervening is to affect the ways that scholars frame globalization issues, and the scholarship regarding these issues, are pursued.

In this chapter, I evaluate this intervention, from the particular perspective of its utility for a particular task – that of globalizing the research agenda of a new professional field, Informatics. How useful to globalizing Informatics research is it to think of globalization as an evolutionary process amenable to formal modeling?

I begin my evaluation by briefly discussing the personal roots of my interest in globalizing Informatics research here in my new position so at Indiana University. I then go on to outline what I think of as the most persuasive general arguments for doing so. These include the implicit American-centric bias of existing Informatics, which contrasts with the international character of our faculties, our students, the careers that they pursue, and the labor markets and organizations in which they pursue them. They also include a problem of scholarship: the weak research base for one of the key assumptions of much contemporary talk about globalization, the central causative place assigned *to* automated information and communication technologies (AICTs) in accounts *of* globalization. This causality is often echoed in promotions of IT-related academic endeavors, like the new US i-schools, of which IU Informatics is the foremost "greenfield" site. The weakness of this claim is a key reason for globalizing Informatics *research.* In sum, for the sake of the new profession that we are creating, we need more clarity on how to think about globalization and the validity, as well as the limits, of such arguments.

I will then survey several ways to think of globalization, especially from the perspective of what they suggest about the value of evolutionism/formalism. I concentrate most on the tradition of cultural evolutionism in Americanist anthropology, a tradition which offers considerable justification for thinking evolutionarily about globalization, but less for formalism. I illustrate this anthropological view in two ways. One is more theoretical, an evolutionary way to make empirical the question pointed out above, about the relationship of AICTs and social change. The second, more epistemological illustration is drawn from my current study of Free/Libre and Open Source Software (F/LOSS) advocacy and development in Malaysia, as well as subsequent efforts to develop tools to promote comparative research on AICTs and development and contemporary techno-science in Asia.

While in general sympathetic to David Held-type (Held and McGrew, 2003) conceptualizations of contemporary globalization, a central theoretical goal of my work, like that of my anthropological colleagues, has been to complexify globalization talk. For example, I advocate the use of notions like "glocalization," as well as "localization," as complements within a common frame with "globalization." Driven to such terminological practices by our empirical work, anthropologists are cautious about formal approaches. All too often these fit rich empirical phenomena into simplistic universalisms, leading to the loose ways in which terms like globalization are used by, for example, some of my new Informatics colleagues. In a methodological register, I raise questions about a formal modeling program through analysis of intellectual programs like network science. While these are admittedly efforts more to universalize than globalize, the two are often confused. Nonetheless, I will summarize by cautiously endorsing the efforts of the conference organizers.

The personal roots of my interest in globalization

These follow in part from my administrative, research, and teaching responsibilities at the new School of Informatics at Indiana University's main campus in Bloomington. As a professional school, we define Informatics as the solution of problems with and/or caused by automated information and/or communications technologies (AICTs). Our understandings of the skills, competencies, and inclinations that we hope to impart to our students are derived in large part from the study of AICTs in-use, particularly the reflective practices (Schön, 1983) characteristic of professional informists when the computers show up in organizations and communities. Describing the field in these ways illustrates why a preoccupation with the technology itself is not a sufficient basis for building this new profession; we need social as well as technical Informatics. It also explains why people like me – anthropologists and other social scientists and humanists with a long experience of looking at AICTs in context – are an important part of Informatics as we do it in Indiana.

The School of Informatics wishes to make its activities more systematically global. It does this for a number of both practical reasons – for example, the international character of our students and faculty – and theoretical reasons – for example, the transnational way in which Informatics is emerging as a profession. That I share these reasons is part of my motivation in assuming academic responsibility for chairing the School's globalization committee and becoming Director of its International Activities. The remit of these roles, which includes globalizing Informatics research, is hence one source of my interest in strategic interventions in this area; others include my personal research and recently initiated teaching in this area.

I have recently come to Informatics from a long career in cultural anthropology, the central theme of which has been the study of the relationship of automated information and communication technologies (AICTs) to social change. Notions of cultural evolution, roughly analogous to biological evolution in physical anthropology, have long been a part of the Americanist tradition in cultural anthropology in which I was trained and which I tend to reflect, as illustrated in what follows. As evolutionary perspectives have been more or less equally praised and reviled in cultural anthropology, and as I have framed my personal research on AICTs and social change in evolutionary terms, I am in a good disciplinary position to evaluate this volume's advocated evolutionism.

At the School of Informatics, many of my colleagues are experienced in and attracted to formal modeling. Consequently, while they are inclined to see calls for thinking about the social dimensions of informatization, such as globalization, as a distraction, they are more amenable when such calls are wrapped in the garb of a strong modeling program. Were formalism is to be the preferred means to globalize Informatics research, incorporating globalization as a topic in Informatics research would seem less an "outside" intervention from, for example, anthropologically trained social scientists like myself. Formal modeling has promise as a shared methodological means collectively to globalize our as-yet still forming Informatics research agendas. (For additional reasons – e.g. that "Informatics" is a relatively under-defined entity/activity in the United States, and that we at Indiana offer the first US PhD in it – our Indiana attitude toward the interventions advocated by the conference may have wide purchase.)

My reasons for choosing to speak of "automated information and communications technologies," rather than something simpler like "IT," are indicative of why I came to be interested in globalizing Informatics. Simplistic references to "IT" among my colleagues at the State University of New York where I began teaching almost 30 years ago foreshadowed a tendency to act as if only contemporary technologies were worth thinking about, just as societies like that of the United States were presumed to be a "model" for all societies, or at least their future. As an anthropologist, I see all human social formations as equally mediated by technologies, although of course the relevant technologies varied widely. Similarly, an important impetus for globalizing Informatics is, again as encouraged by anthropology, an epistemological commitment to the equal relevance of each distinct culture to what it means to be human. In the

1970s I became an advocate of the cultural study of computing. This subfield was handicapped by the fact that, while anthropologists most frequently attended to Southern, or non-Western social formations, most of us studying computing tended to ground our work in North Atlantic social formations. This initially made sense, because that was where most of the computers were. By 2000, however, I had decided to move my work into more traditionally anthropological territory, to illustrate how to broaden the comparative breadth of our contextual framings of AICTs and their social correlates. I decided after 11 September 2001 to locate a site, if possible, in the Muslim World, since anthropology provided one of the few academic platforms with some hope of taking Islamic social formations seriously while outside a "clash of civilizations" framing.

The most persuasive arguments for globalizing Informatics research

When I was in Malaysia in 2005, I was often asked to explain why I chose to locate my research on Free/Libre and Open Source Software advocacy and development there. I would usually describe myself as being interested in culture's influence on what happens when computers show up. Malaysians tended to understand quickly, and to agree that this was an interesting topic. In contrast, my experience in the US is that I often have to spend more time justifying my project, especially to technologists and techno-scientists. Their attitude is one example of what might be called "implicit Orientalism" (iO). That is, current Informatics research agendas take for granted the ways of thinking about technology characteristic of the US, presuming that they are "natural," linguistically unmarked, and therefore inherently universal. On such iO, for example, while one might presume not only the relevance of thinking about AICTs from a "digital property" perspective, one would also presume that the proper way to do so is to frame this concern in terms of "intellectual property" – i.e. the way that digital property is framed in US legal and legislative discourse. What happens when computers are used in the US, in other words, can be taken as indicative of their fundamental character, so they really need only be studied "in-use" here. Any variation from the US standard in other places may be of interest, but only idiosyncratically so; if not a mere fluke, it is of necessity a result of the exotic (Oriental) characteristics of the places' otherness.

Implicit Orientalism is characteristic of how we in the US think about technology, a consequence in part of teaching technology as if it were external to or "pre" cultural. The problems that follow from doing this are a central preoccupation of scholarship in the field of Science, Technology, and Society (e.g. Jasinoff *et al*. 2002). While some of them (especially from India) may think of the tenets of iO as a desirable ideal, my international colleagues and students, as well as my Malaysian interlocutors, find iO an odd presumption for Informatics to start with. It is certainly not the desired posture of the transnational organizations which recruit them for global careers, and neither does it make sense as a posture for coming to terms with the changes associated with off-shoring, out-sourcing, or other AICT-in-use phenomena talked about under the rubric of "globalization."

There are also strong practical reasons for globalizing Informatics' research base. Often professional informists find themselves responsible for helping organizations deal with the transition from an unautomated to an automated (or a less to a more automated) information and/or communication system. If Social Informatics has a central finding, it is the likelihood that such transitions will be accompanied by other, unpredicted changes in the way things are done. Part of the informist's responsibility is likely to be to help the organization conceptualize both the forms and extents of changes, so that they can be anticipated and dealt with. The popular mythology that AICTs "change everything" is quite helpful in convincing organizations to incorporate informists into their implementation teams; all of us at the School of Informatics benefit in this way from this transformationalism. At the same time, this mythology is often the major impediment to an informist's ability to help the organization arrive at a realistic rather than overheated concept of what is likely to happen when the new systems are up and running.

Social transformativity, most recently in presumed profound affordances to globalization (e.g. Friedman, 2005), is a central tenet of popular cultural constructions of AICTs. It is tempting to take advantage of them in performing legitimations of our new Informatics profession. However, the dangers of over-hyping the social transformativity endemic in popular AICT talk may also be the greatest threat to successful professionalization of the field. In sum, a conceptually sophisticated and empirically robust globalization of the study of AICTs should be a high priority for Informatics.

Various approaches to thinking globally in Informatics research

As indicated above, I study Free/Libre and Open Source Software in Malaysia. Partly this is because Malaysian F/LOSSing is interesting in itself, and partly because I was able to make it accessible for me to study. However, because of my concern about implicit Orientalism, I am interested in studying the social correlates of AICTs *anywhere other than in the United States*. We need to understand just how much culture matters, and such research will help us do so.

Further, I study F/LOSS because of the explicit priority given to the social in this way of doing software. On the standard F/LOSS accounts (e.g. Raymond, 1999; Stallman, 2002), F/LOSS is better because of the dominant qualities of the social relationships among F/LOSS developers, which are more collaborative than bureaucratic – developers not being part of an alienated division of labor but willing volunteers, motivated altruistically rather than instrumentally, etc. However accurate it is, the social focus of this discourse means that F/LOSSERs pay attention to the social dimensions of their activities and frequently do things that have as their explicit goal the fostering of the desired social qualities. It thus makes sense that someone interested in understanding the (often difficult to see) social dimensions of technological practices would focus on F/LOSS, since these ways of talking, foci, and acting all tend to make the social less opaque. Moreover, it would be a good idea for someone interested in thinking culturally about technological practices to do so comparatively while looking at F/LOSSing, in order to distinguish those patterns which are general, those manifest in several (but not all) places, and those patterns unique to particular places.

I return below to the patterns indicative of Malaysian F/LOSSing; my intention here is to use the above to illustrate one fairly straightforward way to globalize Informatics research. This is to pick a set of IT-in-use practices whose social dimensions *should* be relatively transparent and then look for places where they actually *are* and in which one can do empirical work. Over time, especially if aided by tools that lend themselves to illuminating rather than hiding the social, a more general understanding of just which computing practices are truly universal (rather than being misperceived as such, following from implicit Orientalisms) should emerge; that is, a more global rather than ethnocentric Informatics.

Yet developing such comparative ethnographies of, for example, F/LOSS, is only one strategy for globalizing the Informatics (or any other disciplinary) research agenda. One might also do so historically. Eric Hobsbawm (1994) does something like this when he suggests that the twentieth century might well be characterized as the "Short Century." Hobsbawm would begin the historical century with the Bolshevik Revolution of 1917 and would end it with the tearing down of the Berlin Wall in 1989. For my purposes, the interesting aspect of Hobsbawm's argument is that the period between 1917 and 1989 was relatively anti-globalization, whereas that proceeding and that following was/is characterized by the broad expansion of international and even worldwide institutional structures.

Political scientist David Held presents another view of globalization. His catalog of key political ideas about globalization (at http://www.polity.co.uk/global/research.htm) can be characterized in the following manner:

- that it is not a condition, neither is it developmentally linear, and nor does it imply global integration;
- rather, it is a set of processes leading to the enmeshment of social formations in interregional networks and systems;
- that it is a multifaceted and differentiated phenomenon, both de-coupling and recoupling spaces and places;
- that nonetheless it still makes sense to speak of a "global order," one of evolving structures of constraints and empowerments, of patterns of growing interconnectedness at the global level, which few arenas escape; and
- that, in general, power in the "order" is exercised, expanded, and stretched at increasing scales.

Held's is a theory of the contemporary moment of globalization, rather than a theory of all moments of globalization. Below I will suggest modifying his list to include the notions that complement globalization (e.g. "glocalization") as well as the opposite idea of localization. Here I wish to contrast a Heldian concept of globalization, one that stresses historical change in scale – e.g. a change in the frequencies of the levels at which different social formations reproduce, from more particular to more inclusive scales – with an essentially different notion, that of universality. Of course, one can see universality as an end point on a "scaling" model of globalization, the point at which all social formations reproduce at the maximal (worldwide) scale, but this is not the way the notion is normally understood. Universals do not come into being in recent (or most other) times; they are always and already there, or at least came into being a very long time ago.

This kind of universal is what my natural-science-trained colleagues at Informatics have been trained to look for, as in a "law of nature." It is at center of a project important to many of them, especially those who take a network science (e.g. Barabasi, 2003) approach to the study of complex systems (e.g. Vespignani and Pastor-Satorras, 2004). Whereas the aspects of social formation reproduction to which Held-type globalization theory draws attention (at least, those that I have discussed so far) involve developmental movement toward qualified convergences, those attended to by network science have always already been everywhere. Searches for social universals, unlike historical accounts of globalizations, tend toward reductionism – the identification of underlying preconditions for the reproduction of *every* social formation. It is such widely perceptible, universal elements which are the phenomena most often the object of efforts at formal modeling, rather than those aspects of social formations participating in evolutionary developments, like those Heldian ones outlined above. By pointing this out, I intend to suggest a difficulty in informally modeling cultural evolution (I return to the question of fitting developmental/evolutionary processes and formal modeling below).

Anthropological concepts of cultural evolution (and globalization as a form of it)

There were several points during the conference in Laxenburg at which participants drew or at least touched on anthropological data. This is reasonable, since the broad comparative perspective of the participants has several similarities with common discourse styles in this discipline – notably cultural evolutionism. As pointed out above, notions of cultural evolution have long been a part of the Americanist tradition in cultural anthropology. Roughly analogous to biological evolution in physical anthropology, cultural evolutionism could be defined as the idea that cultural systems tend to follow a developmental sequence, that there are a limited number of general types of social formations in such sequences, and that distinct social formations tend to go through these types over time. The evolution of cultural forms is distinct from biological evolution but has parallels with it, in that while neither hierarchical nor teleological, it is still directional: once a social formation has reached a particular stage, it is unlikely to "go back" (e.g. from agriculture to horticulture). These ideas were perhaps most systematically developed by Leslie White (1949). They borrow a great deal from anthropological archaeology, which, as in Space/Time Systematics, presumes that stylistic similarities in artifacts provide a basis for equating strata not only across different sites but also within evolutionary types (so one can speak of, say Bronze or Iron Ages).

This kind of connection between theory in archaeology and in cultural anthropology is a hallmark of the Americanist "four field" (cultural anthropology, archaeology, linguistic anthropology, and physical anthropology) tradition. It illustrates the extent to which cultural evolutionism is basic to this tradition. In pointing this out, I diverge a bit from the way in which this tradition is usually presented – as moving from moments of strong commitment to evolutionism (e.g. Henry Lewis Morgan, 1877) to those of an anti-evolutionist particularism (Margaret Mead, 2001). I wish instead to stress the continuity of some notion of social formations tending to have a developmental history as a central element of this approach. That is, there are multiple types of social formations, each type with a different dynamic, for each has a different mode of both physical and social reproduction. Thus, for example, Elman Service (1962) liked to draw attention to notions of the diverse levels of socio-cultural integration that lay behind an evolutionary sequence moving from hunters to gardeners to farmers to industrial workers, or from band to village to state.

Thus, when Eric Wolf (1978) turned to consideration of Immanuel Wallerstein's notion of a modern world system (1974), his analysis highlighted continuities in cultural dynamics across geographic locations that were well within the tradition of cultural evolutionism. The result was the ironically titled *Europe and the peoples without history* (which, Gunder Frank (2005) now informs us, Wolf intended to end with a question mark!). In sum, cultural evolutionism is built into the comparative language of anthropology, in a manner similar to the place of evolutionism in the terminology of biology. Moreover, this tradition of cultural evolutionism demonstrates that, as in the biology articulated by Stephen Jay Gould (2002), one can have evolutionism as a succession of types, without being teleological.

It was within just such a notion of cultural evolutionism that I argued contemporary talk of the relationship between computing and social change should be framed (Hakken, 1999). That is, order could be introduced into this talk by thinking of it as involving a set of alternative evolutionary conceptions of "The Computer Revolution," ranging from:

1 a transcending species revolution, involving perhaps the End of the Age of Humans and Their Replacement by Silicon Life Forms;
2 a new human social-formation type: e.g. the End of Labor;

3 a new stage in the existing employment social formation: e.g. the End of Fordism;
4 just another form of the machinofacture/Fordist stage of the Labor social formation;
5 a regressive stage, back to something like manufactory urbanism, in the employment social formation;
6 a further regression, to something like a pre-labor social formation: e.g. the new feudalism of the Mad Max movies; or finally;
7 a regression to a pre-human bio-formation, parallel to the end of the Dinosaur Age (see, e.g. Margaret Atwood's *Oryx and crake*, 2003).

I still think that this is a useful way to summarize "CompRev" talk. Whether it is or not, my point here is that it makes sense to conceive of social changes as either involving or not involving changes in social-formation types. Further, the fact that these type changes (which themselves can range in degrees of reach) can be fit into a developmental sequence, is both conceptually useful and part of a long tradition in anthropology.

Thus, when anthropologists think of globalization, it is reasonable to enquire what kind of a stage in evolution it is, remembering that one is talking about cultural rather than biological evolution. This is why anthropologists, for example, tended to respond positively (but also with a sense that much in his argument was obvious) to Wallerstein's "World System" intervention. Encouraged by 1960s critical perspectives, we saw Wallerstein as critiquing the privileging of the national in talk about culture in, for example, the Parsonian dispensation (Parsons and Shils, 2001). Like Benedict Anderson in *Imagined communities* (1983), he was historicizing the presumed one-to-one correspondence between people, nation, and society then dominant in Western social science. Wolf's rejoinder, that other peoples had substantial inter-"national" histories, too, made the case for a construction of a truly global history. Extended further, this history would allow us to separate out cultural processes that were truly globalizing from those which merely incorporated new groups into existing trans-local structures (Gunder Frank, 2005).

It is this scholarly tradition of cultural evolutionism out of which the recent *The anthropology of globalization* (Jonathan Inda and Renato Rosaldo, 2002) develops. This book fairly represents much contemporary anthropological thinking on globalization. Inda's and Rosaldo's "Introduction," both acknowledging and echoing Held, argues that:

> [T]he intensification of global interconnectedness, suggest[s] … a world full of movement and mixture, contact and linkages, and persistent cultural interaction and exchange …, … [C]omplex mobilities and interconnections … characterize the globe today…, … [T]here are important cultural flows … through which the spaces of the globe are becoming increasingly increasingly intertwined … Places … have become nodes in

> the rapidly developing and ever-densening network of … interconnections that epitomize the modern world.
>
> (Inda and Rosaldo, 2002: 2)

But, even more,

> the world today is witnessing an intensification of circuits of economic, political, cultural and ecological interdependence … [a] radical acceleration in the flows … have brought even the most remote parts of the world in contact with metropolitan centers … a fundamental reordering of time and spaces.
>
> (Inda and Rosaldo, 2002: 4)

This reference to a "fundamental reordering" suggests that this form of cultural evolution is both globalizing and unprecedented – a new form. Inda and Rosaldo give causative privilege to technology: "Twentieth-century innovations in technology – particularly in transportation and communication – have made it easier and quicker for people and things to get around" (p. 4), although they do not explore this argument.

They do, however, stress some discontinuities:

> It is not necessarily the case, though, that the world is shrinking for everyone and in all places … The experience of globalization is a rather uneven process … quite a number of people and places whose experience is marginal to or excluded from these movements and links.
>
> (Inda and Rosaldo, 2002: 4)

For Inda and Rosaldo, anthropology's unique perspective is to focus not just on the macroscopic, but instead, it:

> is most concerned with the articulation of the global and the local … how golbalizing processes exist in the context of, and must come to terms with, the realities of particular societies[,] … the situated and conjunctural nature of globalization … [H]ow subjects mediate the processes … highlights human agency and imagination.
>
> (Inda and Rosaldo, 2002: 4 and 5)

In sum, when the cultural dynamics of globalization is examined, one sees that they:

> involve … substantial movements of culture from the periphery to the core as well as within the periphery itself. … [W]estern texts are perceived as having a self-evident cultural effect on Third World subjects, the effect being to Westernize them. But this is an erroneous perception … more often than not, they customize these imported forms.
>
> (Inda and Rosaldo, 2002: 6)

So,

> we need a more nuanced view of the globe than that provided by the discourse of cultural imperialism … that of dislocation … structures whose center has been displaced … in such a way as to be supplement not by another center but by a plurality of them … The West has been displaced and now has to compete with a plurality of power centers … it no longer occupies a unchallenged position of dominance … global cultural power … has become somewhat diffused … the traffic in culture or the flow of meaning does not just originate in the West but also in places all over the globe. [We need to] … view the … world not in terms of a monolithic core–periphery model but as a complexly interconnected cultural space, one full of crisscrossing flows and intersecting systems of meaning.
>
> (Inda and Rosaldo, 2002: 7)

An extended example: Free/libre and open-source software advocacy and development in Malaysia

In sum, the task for contemporary cultural anthropology is to attend to the "densening" of connections pointed at by "globalization," while giving at least initially equal attention to the dislocations and continuities of older structures. To illustrate what kinds of accounts this should result in, I turn to my recent fieldwork in Malaysia. The research design of this field project is an example of composite ethnography, a combining of virtual and *in situ* fieldwork which is becoming the standard in studies of cyberspaces (Hakken, 1999, 2003). The fieldwork included two preliminary field visits (2002, 2003) to explore research options and open initial contacts, in conjunction with the initiation of virtual ethnography. This centered on a study of knowledge networking as manifest on the Malaysian National Computing Confederations Open Source Special Interest Group (MNCC OSSIG) online list, using a variety of visualization tools. Extended field study in Malaysia took place from January to June, 2005, financed by a Fulbright Research grant. Since returning from the field, I have continued to read the OSSIG list, as well as analyzing the data already collected, which is reported on in several publications (Hakken, 2006a, 2006b, 2007, forthcoming). In addition, I have organized a small research group which is concentrating on the design of tools to support comparison of computing and related techno-science phenomena (Hakken, 2006b).

Let me briefly describe some comparative empirical findings from this research. Among the patterns of F/LOSSing that I observed, I think the following are worthy of note:

1 The quicker grasp of the intent of my research was indicative of a broader phenomenon, which I would describe as the larger role for meta-discourse in Malaysian F/LOSSing than among US F/LOSSers. F/LOSSers there are

more aware of and talk about the contexts of their actions. I am inclined to think this would be similar in other places that consider themselves to be more peripheral to the center of techno-science development.

2 There was also a greater role for the State, doubtless due, among other things, to both directly and indirectly relevant States policies, like that mandating a purchasing preference for Open Source when technically as desirable as proprietary software, or the high profile of the succeeding Five Year Plans.
3 Race/ethnicity/gender dynamics loom large, as in the over-representation of Chinese and South Asians, and under-representation of ethnic Malays, among F/LOSSERs, and the over-representation of males. This latter is of interest because Malaysia has among the highest rates of female participants in the computing workforce.
4 Despite Malaysia being a center of the substantial debate over Islamic science and technology during the 1980s and 1990s, these issues were not raised by any of my informants as being important to their efforts (see Hakken, 2006a); and
5 While Malaysia illustrates that it is possible to create a substantial F/LOSS movement in the absence of basic civil society institutions, like a free press, my experience there left me feeling that free software will have a hard time in the absence of free speech.

These are a few the patterns that I discerned during my work in Malaysia, as well as some of the conclusions to which they led me. They are illustrative of the kinds of fieldwork-based patterns that are relevant to several Informatics debates, including which modality – open or proprietary – will likely dominate the future of software, and the role of state policy in techno-science. While some patterns – the roles of the state, meta-discourse, race, and gender – are "glocal," indicative of the kinds of patterns to which Inda and Rosaldo draw attention, others, like the absence of continuity with an earlier Islamist discourse, may well be evidence of globalization. My intent here is not to offer anything like a complete account of what I learned about F/LOSSing in Malaysia. This is not only because of space restrictions: any conclusion about these patterns depends upon further comparative research, which would enable me to be more specific about what is particularly Malaysian, what is characteristic of some broader group of social formations, and what seems to correlate highly with F/LOSSing wherever one encounters it. Such comparative research is one thing that I am trying to further at Indiana, as in a recent conference on "Globalizing Informatics Research" (Hakken, 2006b).

Attempting to simulate globalization as an evolutionary process via formal modeling

A model in science is a statement of possibly governing relationships among the factors relevant to understanding a process of interest. The building of models is central to the experimental method in science; one cannot be said to have explained a process without being able to model it. Because models aim for precision, they are held necessarily to be numerical; besides, only if they are numerical can one take advantage of the discipline of mathematics in relating the properties of one's model to other models, in order to move beyond discursive accounts of the kind of model that one has.

One of the most frequently justifications for the transformativity of AICTs is given on such science terrain. This is the idea that AICTs can automate the model-building process and thus accelerate the rate of production of new knowledge. On a currently popular articulation of this argument in Informatics, "data mining" will allow us to model huge sets of data by running a very large number of correlation algorithms, in the hope of coming across statistically significant relationships. This is cited as one of several ways in which computing was said to already have transformed the process of converting information into knowledge.

An example of this approach to modeling and knowledge – one which suggests much about the difficulties of using it to study any evolutionary process – is a recent presentation by Mark Bedau (2005) entitled "*The creativity of technological evolution*." Bedau begins the abstract of his argument with the following claim:

> Many are attracted to the idea that cultural evolution is deeply akin to biological evolution, but it has proved difficult to confront this suggestion with extensive empirical data.

I find this argument offensive – a dismissal of the large body of anthropological work which I outline above. He goes on:

> This problem can be addressed by applying evolutionary activity statistics […] to the evolution of technology as reflected in the past 30 years of patent citation data. These statistics extend bibliometric and scientometric citation analysis by highlighting specifically the dynamic and adaptive aspects of technological evolution. This talk applies evolutionary activity statistics to a massive data set consisting of 4 million patents and an order of magnitude more citations. Since the same statistics can be applied to systems undergoing biological evolution, this enables a quantitative and empirical comparison between the evolution of technology and the evolution of the biosphere. It turns out that the evolution of the biosphere as reflected in the fossil record and the evolution of technology as reflected in patent citation data both exhibit the statistical signature of a hyper-creative process.
>
> (Bedau, 2005)

In his longer talk, Bedau proceeded to fulfill the tendency, reaffirmed in this last bit of his abstract, to reduce cultural to biological evolution. That is, he fails to look for information that would tend to indicate the differences between the two. Yet what he proudly reported in his presentation was a demonstration by his data mining techniques that the most important technological innovation of the last 50 years of AICT development was a particular process for inkjet color printing!

In other words, those historians and anthropologists who have been trying to develop typologies of social-formation types which could be mapped on to theoretically articulated accounts of transitions have been wasting their time. Their arguments can be dispensed with, because we now have AICTs that get us to the really important stuff. During part of the 1980s and 1990s, I took seriously the promise of computer simulation. Under the promise of knowledge management, I was enticed by the belief that simulation would allow scholars to discover implications of alternative scenarios that were not obvious; I hoped in particular to use simulation to model various alternative social service futures, as a tool to involve workers and clients in the policy-making process (Hakken, 2003). To this end I organized "*Applied Simulist*," an online forum for researchers like myself who wanted to use simulation as a tool for, if not discovery, at least the modeling of alternative futures.

The *Applied Simulist* attracted little interest, few lurkers, and fewer posters. I was unable to locate others trying to use simulations as tools to solve problems in, for example, assistive technology for people with disabilities. It seems that the simulators were interested in something else. I gained some insight into what was wrong with my expectations in the midst of being trained to use a Knowledge Management tool kit for which the US taxpayer, via the Defense Department, had already paid over $40,000,000. After several efforts to use the tools, the trainer revealed that the system worked best when one drew out first, in paper and pencil, the relationships in which one was interested. In other words, while good for representation, it was not very useful as a discovery tool! (In the late 1990s, I proposed using simulations as elements in several Knowledge Networking projects; e.g. Knowledge Networking Oneida County. These, too, "failed," but I did learn that, in order to succeed, one would have to be working with bureaucrats who really did want to network knowledge, which unfortunately involves redistributing control and sharing information.)

As in these cases, many so-called Knowledge Management tools turned out to be elaborate packages for communicating what has already been learned via some other process, not for discovering anything new. When given a strong orientation toward security, they can even be used as means to *prevent* anything new from being discovered! What is present in Bedau's work is a different problem, the diversion of data about one thing so that it can be used to address a different problem. When I suggested to Bedau that he compare his model of cultural evolution with some of those developed in anthropology, he indicated that he would probably not be able to do this, because the cultural anthropological data set would be too small. I conclude that he is not really interested in understanding cultural evolution, but only a certain kind of technological development. He wants to do this as a way to come up with models to compare with others. In this world, what is actually being modeled tends to fall away, with the model taking its place.

The conclusion that I draw from these experiences is to be skeptical about the value of simulation to the study of globalization as a moment in cultural evolution. On the one hand, much of what is described as simulation is clearly useful representationally, as well as ways to sort out ideas and reveal problems in existing understandings. This was generally true of the modeling efforts I witnessed at the conference, and this in general is the way that I relate formal models to my experiential (rather than experimental) research on culture. On the other hand, I remain unconvinced that computer-based simulations constitute a generally substantial new discovery activity. When regarded as such, simulations of globalization or similar macro-scale changes in social reproduction are too easily diverted to other purposes. One consequence may be, as some my colleagues in life science Informatics fear, that such activities justify collecting very large sets of data because one can and one has obtained funds for computers to do so. The subsequent fixation on gathering as much data via as many sensors connected to as complex and "life like" a simulation as one can construct (since the results can all be "data mined" later), can dull scientists' abilities to differentiate more- from less-useful scientific questions. Another potential hijacking, manifest in the Bedau case, is similarly undisciplined, "scattergun" search for underlying, universal law-like regularities (e.g. network science) which it is hoped will eventually constitute another "science of everything." Committed to showing how otherwise profoundly incommensurate processes are in certain ways (e.g. long tail distributions) similar, such activities in the past, again not driven by any particular scientific question, have not produced rewarding results.

Summary

I conclude the following about efforts to conceptualize globalization as an evolutionary process, one, that, further, may benefit from formal modeling, as in computer-based simulation. About the general effort to think of *globalization as an evolutionary process*, I am quite positive when they are seen as part of cultural evolution. This is especially the case if one does not confuse the current moment of wide "up-scaling" as a globalization "*Ding an Sich*" (thing in itself), but instead sees it, as conference participants tended to, as one of many moments of movement toward greater generality in the history of the world. As long as one makes no teleological (e.g. Hegelian) presumptions about ends, it makes sense to see the history of social-formation reproduction as a developmental one – that is, a history that it is difficult, if not impossible, to undo. From this perspective it is useful to think comparatively about the various moments of relative globalization in human and global history, and even to identify similarities and differences among them. Such thinking will, it seems to me, help us avoid the "train is leaving the station" hype of so much comment on contemporary globalization.

I am also quite willing to countenance the possibility that the current moment of globalization may represent a distinct stage in cultural evolution, a very new type of globalization, and even that we may be in the process of creating a new type of social formation. As an anthropologist, I ask only that arguments for such views attempt to encompass all the relevant data; in particular, that, as well as the global, equal theoretical attention be given to the "glocal" and local moments that are also a part of contemporary social-formation reproduction. It makes sense to view globalization an effort to influence social-formation reproduction in particular directions, efforts that have antecedents, knowledge of which is useful to our evaluation of the strategic options that we face. In short, we should view globalization as a project.

About the methodological initiative – the idea that we should try to model globalization formally, as via computer simulation – I am less positive. I see some value in simulations of the features of particular social formations, even of particular social-formation types, as part of an effort to achieve more precise understandings of the distinct stages in efforts toward general accounts of actual cultural evolution. These simulations may be able to take the diversity of forms manifest in actual history to take into account the "glocally" as well as the globally relevant. Indeed, formalisms can help us to make our thinking clearer, as is I think the purpose of the various models of the future. Yet, as I have tried to show, it is very difficult to keep teleology out of any search for universals.

I fear that simulations can easily divert us from the task of greater understanding of our particular moment in history – which I take as my principal objective – into sterile efforts at universalism.

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Part IV

Forecasting and simulating globalization

16 Forecasting globalization

The use of International Futures (IFs)

Barry B. Hughes

What is globalization?

Can we forecast the unfolding of globalization? That is the question that this chapter explores. As one of the most widely discussed phenomena of global change, understood by many to be the "meta-driver" of global change (e.g. NIC, 2004), globalization certainly merits attempts to measure and foresee its future.

It is impossible to forecast the unfolding of a phenomenon that cannot be conceptualized, defined and operationalized. Globalization comes close to being such a phenomenon, which is one of the reasons that this volume devotes considerable attention to defining it as an evolutionary process. A widely used term that rose rapidly to great popularity, even to cliché status in the second half of the twentieth century (Chanda, 2002, declares it to have appeared in 1962), analysts have given it a multitude of meanings. Most simply and almost certainly too limited in conceptualization, many observers describe it simply as the expansion of global trade and financial flows. A more encompassing, still largely connectivist conceptualization sees it as the expansion also of human flows and interactions, as well as those of ideas and cultural elements.

A large number of analysts, however, understand the process of expansion of flows to be more fundamentally transformative of human patterns (or stocks), and include the transformational elements in the conceptualization:

> A process (or set of processes) which embodies a transformation in the spatial organization of social relations and transactions – assessed in terms of their extensity, intensity, velocity and impact – generating transcontinental or interregional flows and networks of activity, interaction, and the exercise of power.
>
> (Held *et al.*, 1999: 16)

Held and McGrew (2003) have elaborated the nature of that transformation at some length, largely summarized in this statement (which, however, emphasizes interactive flows rather than social or institutional stocks):

> It is characterized by four types of change. First, it involves a *stretching* of social, political and economic activities across frontiers, regions and continents. Second, it is marked by the *intensification*, or the growing magnitude, of interconnectedness and flows of trade, investment, finance, migration, culture, etc. Third, it can be linked to a *speeding up* of global interactions and processes, as the development of world-wide systems of transport and communication increases the *velocity* of the diffusion of ideas, goods, information, capital and people. And, fourth, the growing *extensity, intensity* and *velocity* of global interactions can be associated with their deepening *impact* such that the effects of distant events can be highly significant elsewhere and specific local developments can come to have considerable global consequences. In this sense, the boundaries between domestic matters and global affairs become increasingly fluid. Globalization, in short, can be thought of as the widening, intensifying, speeding up, and growing impact of world-wide interconnectedness.
>
> (David Held and Anthony McGrew website on Global Transformations at http://www.polity.co.uk/global/globocp.htm)

Conceptualization without operationalization runs the risk of creating an apparent understanding that does not stand up to the rigors of either measurement or forecasting. That is, different observers could potentially describe the same situation in quite different terms with respect to the extent/character of globalization or change in it over time. Operationalization does not absolutely require quantification, but certainly can benefit from it.

When the topic turns to possible quantitative operationalizations of globalization, only one leaps out: the A. T. Kearney/*Foreign Policy* Globalization Index (GI). *Foreign Policy* released the fifth annual results in their May/June 2005 issue.[1] There is no truly competitive index of globalization. See articles by Kurdle (2004) and Lockwood (2004) for some evaluations of the GI.

Although the GI has changed a little over time, its structure has remained relatively stable. It consists of four sub-indices:

1 political engagement (international organization memberships, UN peace-keeping, treaties ratified, and government transfers or aid);
2 technological connectivity (Internet users, Internet hosts, secure servers);
3 personal contact (travel and tourism; international telephone traffic; remittances and personal transfers); and
4 economic integration (trade and foreign direct investment; in past years this also included portfolio flows and income payments).

Looking at those sub-indices, it is apparent that the last three primarily tap the increased flow or connectivity elements of globalization conceptualizations.

Only the first sub-index seems primarily to tap the transformational or evolutionary elements, but certainly without the richness of the Held–McGrew definition. Still, even the flow elements, and especially technological connectivity, promise some help with operationalization of the concept.

How then can we proceed with exploration of the potential for forecasting globalization? There are a number of approaches that could be taken, but that of this chapter will be to examine the degree to which a specific quantitative forecasting project, namely the International Futures (IFs) simulation, might be able to help us forecast it. The next section provides some basic information about IFs. The following one returns to globalization and attempts to map the key dynamics of it. The succeeding two sections turn back to IFs and the manner in which it operationalizes and forecasts globalization. The final section will draw conclusions about the strengths and weaknesses of forecasting with IFs, and the prospects for doing better.

What is the International Futures (IFs) modeling system?

In this chapter, the International Futures (IFs) modeling system is being used as a test-bed for thinking about the forecasting of globalization processes. This section provides a very brief introduction to IFs. Somewhat more information will follow in the discussion of the ways in which IFs represent elements of globalization. Much more information is available in Hughes and Hillebrand (2006), on the project's website (which includes extensive documentation including Hughes *et al.*, 2004), and in the Help system of the model where even model equations and code are available. See http://www.du.edu/~bhughes/ifswelcome.html for the IFs website, and http://www.ifs.du.edu for both a web-based version of the model and a downloadable version of it. See also applications of IFs (Hughes, 1997, 2001; Hughes and Johnston, 2005).

International Futures (IFs) is a large-scale integrated global modeling system. The broad purpose of the International Futures (IFs) modeling system is to serve as a thinking tool for the analysis of near- to long-term country-specific, regional, and global futures across multiple, interacting issue areas.[2]

More specifically, IFs is a thinking tool, allowing variable time horizons up to 100 years, for exploring human leverage with respect to pursuit of key goals in the face of great uncertainty. The goals around which IFs was designed fall generally into three categories: human development; social fairness and peace; and environmental sustainability (see Table 16.1).

The IFs system is heavily data-based and also deeply rooted in theory. It represents major agent-classes (households, governments, firms) interacting in a variety of global structures (demographic, economic, social and environmental). The system draws upon standard approaches to modeling specific

Table 16.1 The dimensions of sustainable human development in IFs

Humans as individuals	Human development/freedom
Humans with each other	Security social fairness
Humans with the environment	Sustainable material well-being

issue areas whenever possible, extending those as necessary and integrating them across issue areas.

The menu–driven interface of the International Futures software system allows display of results from the base case and from alternative scenarios over time horizons from AD 2000 up to 2100. It provides tables, standard graphical formats and a basic Geographic Information System (GIS) or mapping capability. It also provides specialized display formats for age-cohort demographic structures and social accounting matrices.

The system facilitates scenario development and policy analysis via a scenario-tree that simplifies changes in framing assumptions and agent-class interventions. Scenarios can be saved for development and refinement over time. Standard framing scenarios, such as those from the United Nations Environment Programme's *Global Environmental Outlook 4*, are available (UNEP 2007, in press; see UNEP 2002 for an earlier representation).

The modeling system also provides access to an extensive database for longitudinal and cross-sectional analysis. In so far as possible, data represent 182 countries since 1960. In addition to providing a basis for developing formulations within the model, the database facilitates comparison of data with "historic forecasts" over the 1960–2000 period, which also allows assessment of model credibility (for more general discussion of issues of verification, validation, and accreditation, see Hughes, 2006).

A number of assumptions underlie the development of IFs. First, issues touching human development systems are growing in scope and scale as human interaction and human impact on the broader environment grow. This does not mean that the issues are necessarily becoming more threatening or fundamentally insurmountable than in past eras. But it does mean that attention to the issues must have a global perspective, as well as local and regional ones.

Second, goals and priorities for human systems are becoming clearer and are more frequently and consistently enunciated. For instance, the UN Millennium Summit and the 2002 conference in Johannesburg (UNDP, 2003) set specific Millennium Development Goals (MDGs) for 2015 that include many focusing on the human condition. Such goals increasingly guide a sense of collective human opportunity and responsibility. Also, our ability to measure the human condition relative to these and other goals has improved enormously in recent years with advances in data and measurement.

Third, understanding of the dynamics of human systems is growing rapidly. As discussed later, IFs development has roots that go back to the 1970s. Understandings of the systems included in the IFs model are remarkably more sophisticated now than they were then.

Fourth, and derivatively, the domain of human choice and action is broadening. The reason for the creation of IFs is to help in thinking about such intervention and its consequences.

Elements and dynamics of globalization

As discussed in the first section of this chapter, forecasting of a phenomenon requires conceptualization of it. Forecasting also involves, of course, understanding the dynamics underlying it. Elaborating the dynamics of globalization is an ongoing scholarly enterprise that is unlikely to ever reach any real consensus. For instance, the three-volume series of Manuel Castells, particularly the first on the *Rise of the Network Society* (2000), are all part of that large, collective scholarly project.

This chapter will, therefore, not pretend to be representing the dynamics of globalization in a manner that would likely satisfy a wide range of those who are elaborating these dynamics. It will, however, attempt to present a schematic of some key aspects of the dynamics that may be quite useful. To do so, it discusses some core positive-feedback loops that generally characterize most discussions of globalization. It will then outline some important negative-feedback loops that operate around those central positive dynamics and that can periodically disrupt the long-term growth of globalization.

Figure 16.1 shows important positive loops in the globalization process. Almost all observers point to the importance of ongoing technological progress as a key driver. In particular, transportation and communication technologies inherently facilitate the wide variety of flows that characterize globalization. Historically, the development of new types of shipping or the opening of new trade routes have often marked new waves in the process (Rasler and Thompson, 1994; Modelski and Thompson, 1996; Devezas and Modelski, 2006). Technological advance and existing knowledge feed on themselves to create one of the dominant feedback loops driving globalization.

Technologies other than transportation and communication have obviously been very important. Many analysts like those cited above have emphasized technologies associated with warfare. Those, too, have tended over time to extend their geographic reach and globally integrating character.

A second positive loop is via economic advance with associated expansion of assorted flows. That also tends (*ceteris paribus*) to accelerate technological advance. For instance, the developments in information and communication technology (ICT) late in the twentieth century have been argued by many to be setting the foundations for a New Economy with faster productivity growth and a more global character; the web's expansion

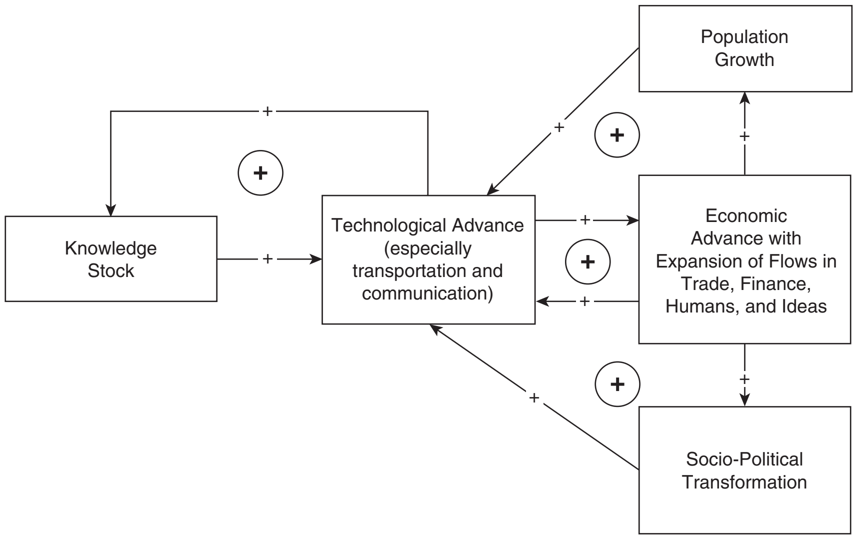

Figure 16.1 Positive-feedback processes that drive globalization dynamics.

throughout the economy is, in turn, supporting scientific and technological advance.

A third positive loop flows through population growth. Julian Simon (1981) argued that population is *The Ultimate Resource*. That may or may not be true, but population growth has also facilitated technological advance.

The final positive loop portrayed is via socio-political transformation. Over time the physical extent of human political units has expanded (even if historically very large empires often organized some significant populations) and some significant aspects of governance have become global. A wide range of global regimes has emerged.

Positive-feedback loops produce exponential growth patterns. Globalization has often been associated with such growth. Chanda (2002) traces the globalization process and exponential growth back to the spread of humans around the world and then their gradual increase in connectivity:

The exponential growth in the exchange of goods, ideas, institutions and people that we see today is part of a long-term historical trend. Over the course of human history, the desire for something better and greater has motivated people to move themselves, their goods, and their ideas around the world. Yet even if globalization has been a very long-term process with generally exponential character, and some may debate that, no one can fail to recognize that it has been subject to wave-like patterns. Most recently, the *belle époque* (roughly 1890–1914) was a cyclical high point in terms of global flows (Arrighi, 1999). Some argue that flow levels (often measured in that period across a small number of states or empires, to the detriment of objective longitudinal comparison) were not

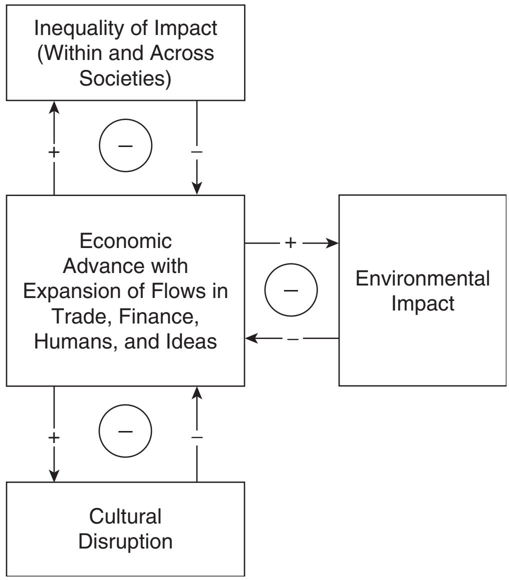

Figure 16.2 Negative-feedback processes that limit or stop globalization dynamics.

surpassed until late in the twentieth century. More generally, broad-sweep historians, world systems theorists and long-wave theorists regularly map waves in the process, even while often identifying a secular trend below those waves.

Negative-feedback loops produce oscillating patterns such as the waves of globalization. Figure 16.2 attempts to augment Figure 16.1, identifying some of the key negative loops.

Perhaps the loop most frequently emphasized is that around the inequality of impact of globalization processes. Such inequality lies near the heart of analysis around the rise and fall of global system leadership; shifts in technological leadership are a substantial part of the explanation for leadership transitions. Inequality within societies may also be the natural consequence of the rising phase of cycles, as some benefit more quickly than others from new technology and economic processes. A significant debate has raged within economics around the relative contributions of increased trade and changing technology to increased domestic inequality in many countries during recent decades (Rodrick, 1997).

A second negative loop involves culture or identity. Friedman (1999) most succinctly captured this tension with globalization processes in his association of the Lexus automobile with globalization and the olive tree with identity. Huntington (1993) posited that the "clash of civilizations" unleashed by that tension could derail the globalization process by unleashing conflicts based in identity.

The third negative loop involves the environment. Long-sweep historians, not least Toynbee (1972), have often explained the fall of civilizations and the collapse of the related connectivity as a result of the overexploitation of the environment. Contemporary environmentalists (Brown, 2001; Rifkin, 2002) have used that historical pattern as a warning about the dangers of currently rapid economic growth and global exploitation of the inputs and sinks of the environment.

Not surprisingly, the critics of contemporary globalization processes almost invariably draw on one or more of the negative-feedback loops for inspiration with respect to their critiques (International Forum on Globalization, 2002). The street protesters of Seattle, Genoa and other locales, demonstrating against possible progress on trade negotiations or meetings of the World Bank and IMF, intuitively pick up on all of the negative loops with signs and garb that often seem unintelligible to globalization supporters, who inherently see the positive-feedback loops as both fundamentally powerful and generally beneficial.

From Figures 16.1 and 16.2, it is not at all obvious what the future of globalization will be, although they and the discussion suggest a plausible generalization: globalization will continue to advance, but the changes associated with it will be painful to some and there will likely be continued waves around the advance. Only the negative-feedback loop around the environment would appear potentially strong enough to indefinitely disrupt the process, because socio-political systems and cultures are, with lags, ultimately adaptive. Environmental damage of the most severe types, in contrast, can be irreversible.

There are certainly many missing components in the above discussion with respect to the dynamics of globalization. It might be useful to float at least two additional thoughts.

First, energy systems may have particular importance in the historic and future processes of globalization or its retrenchment. For instance, the transition from coal to oil and natural gas has been associated with the dramatic expansion of global trade in those commodities, and with associated financial flow expansions. They have also given rise to many points of international political interaction, with a special focus on the Middle East. Would not a transition in the current century to much more decentralized and variable energy sources (a range of renewable forms) significantly alter, if not remove, this important pressure for a range of global flows? (Lovins *et al.*, 2005 explore how rapidly such a new energy system could develop).

Second, and somewhat related, will the continued unfolding of the ICT revolution change patterns in important ways? It has been argued by many that the global system has in the last two centuries been transformed from one in which progress in well-being was tied to the land to one in which it has become tied to trade (Rosecrance, 1986). Even in the second half of the twentieth century, major advances in globalization were linked to changes in trade such as those allowed by oil supertankers and large container ships (with intermodal transport links to land systems). The advance of ICT in the early phases facilitates further trade expansion (for instance, by adding sophisticated logistics and allowing corporations to build complex and long value-chains of production). Is there the possibility, however, that more advanced phases in the ICT wave will lead to the diffusion of a wide range of production technologies, perhaps across agricultural, energy and industrial systems, facilitating localization instead of globalization (as in the Great Transition scenario of Raskin *et al.*, 2002)? Could the territory to trade transition be followed by a trade to terabyte transition?

Again, the discussion here is highly incomplete, but it has attempted to provide a basis for both some qualitative thinking about the future of globalization and the more quantitative forecasting of it. The next two sections turn to the latter.

Measuring globalization in IFs

The last section used the basic tool of systems dynamics, the feedback loop, to facilitate thinking about the dynamics of globalization. This section moves to forecasting using the International Futures (IFs) model. IFs is not a systems dynamic model, although, like any useful long-term forecasting tool, it does build upon the representation of positive and negative-feedback processes. As described elsewhere, IFs also draws upon the standard accounting systems of its various constituent issue areas (such as cohort-component systems in population and social accounting systems in economics) and on statistical or econometric estimation of the dominant relationships that generate its dynamics. This section will look at the operationalization or measurement of globalization in IFs. The next section will turn to the representation of globalization dynamics.

It was noted earlier that the Globalization Index (GI) of A. T. Kearney/ *Foreign Policy* consists of four sub-indices, which were listed with associated component measures. IFs has patterned its own index of globalization, in the variable named GLOBALIZ, after the GI. For a full explanation see Hughes (2005, May). The reader may find this section's explanation of that index among the least enjoyable portions of this chapter and is certainly welcome to skip directly to the next section, which begins to address the important model dynamics below the index. Nonetheless, this is an important discussion for full understanding of the strengths and weaknesses of IFs for forecasting globalization.

The implementation of globalization (GLOBALIZ) in IFs proceeds in stages. First, personal contact (PERSCON) is computed as a simple average of two submeasures: a telephone infrastructure measure that is built as the ratio of telephone infrastructure in a country relative to what would be expected at that level of GDP, and a worker remittance measure that compares the ratio of net remittances (sent or received) to GDP with the global average for such remittances:

$$\text{PERSCON}_r = \frac{\text{TeleRatio}_r + \text{WorkRemit}_r}{2}$$

where

$$\text{TeleRatio}_r = \frac{\text{INFRATELE}_r}{\text{ANALFUNC}(\text{GDPPCP}_r)}$$

and

$$\text{WorkRemit}_r = \frac{\frac{\text{ABS}(\text{XWORKREMIT}_r)}{\text{GDP}_r}}{\frac{\sum^R \text{ABS}(\text{XWORKREMIT}_r)}{\sum^R \text{GDP}_r}}$$

Second, economic integration (ECONINTEG) is computed as a weighted average (FDI given twice the weight of trade following the GI measure) of trade and FDI measures. The trade measure is the sum of exports and imports over GDP (the typical measure of trade openness) relative to the global level of trade openness. The FDI measure is the sum of stocks of investment into and out of a country, over GDP relative to the global level of such FDI connectedness:

$$\text{ECONINTEG}_r = \frac{\text{TradeComp}_r + 2^*\text{InvComp}_r}{3}$$

where

$$\text{TradeComp}_r = \frac{\frac{\text{XRPA}_r + \text{MRPA}_r}{\text{GDP}_r}}{\frac{\sum^R (\text{XRPA}_r + \text{MRPA}_r)}{\sum^R \text{GDP}_r}}$$

and

$$\text{InvComp}_r = \frac{\frac{\text{XFDISTOCK}_r + \text{XFDISTOUT}_r}{\text{GDP}_r}}{\frac{\sum^R (\text{XFDISTOCK}_r + \text{XFDISTOUT}_r)}{\sum^R \text{GDP}_r}}$$

Third, a measure of political engagement (PolEngage) is calculated from the sum of foreign aid expenditures or receipts as a portion of GDP relative to the global average. Although the GI presumably focuses on expenditures, as with worker remittances and FDI, it is reasonable to assume that receipts are a significant component of globalization also:

$$\text{PolEngage}_r = \frac{\frac{\text{ABS}(\text{AID}_r)}{\text{GDP}_r}}{\frac{\sum^R \text{ABS}(\text{AID}_r)}{\sum^R \text{GDP}_r}}$$

Fourth, the overall globalization measure is computed as a weighted average of political engagement (not shown in capital letters because it is not a variable in IFs that can be displayed), the electronic network infrastructure measure (explained in chapter 3 of Hughes, 2005), personal contact, and economic integration:

$$\text{GLOBALIZ}_r = \frac{\text{PolEngage}_r + \text{INFRANET}_r + \text{PERSCON}_r + \text{ECONINTEG}_r}{4}$$

Before the four components are averaged in the above calculation, they are scaled from 0 to 100, from the lowest to the highest values for countries in IFs. The GI uses rankings rather than scaled values. The IFs system uses the scaled values because it preserves underlying interval-level information. It does the same with the GLOBALIZ measure itself, which runs from lowest (0) to highest (100) values for all countries and country groupings in IFs.

Using this analog within IFs of the A. T. Kearney/*Foreign Policy* Globalization Index, Figure 16.3 shows the general pattern of globalization around the world as a function of GDP per capita, as of the beginning of the century.

There are some obvious similarities between the values in the Figure 16.3 and the rankings of the GI. For instance, both place the Scandinavian countries and the Netherlands highly. But there are also some striking differences. For instance, the United States does not rank nearly as high in Figure 16.3 as it does in the annual GI tables. When one considers the component measures of the GLOBALIZ index, that is not surprising. The PolEngage measure of IFs includes only official developmental assistance as a portion of GDP, and the US scores low on this; in the GI, political engagement carries other components, including treaty memberships (although were it scaled by size the US would not necessarily be high-ranking on that either). The Economic Integration (ECONINTEG) dimension of both GLOBALIZ and GI scales the countries by GDP; trade is a relatively small portion of the GDP of large countries like the United States, and in both IFs and the GI measures it would probably make sense to control in some way for size. And although FDI stocks of the US abroad and of other countries in the US are huge, when one controls for GDP, there are large numbers of countries at similar levels or higher. The same is true of personal connections when one controls for population size. It is quite possible that the use by GI of rankings rather than scaling, as well as the restriction of the GI to developed countries, give the US much higher total scores on the GI measure than it achieves on the IFs GLOBALIZ measure. Because there is a strong argument for not throwing away the information that one has in interval measures in order to substitute ordinal ones, the use by IFs of scaling has a good basis.

There are other surprises in Figure 16.3. Although there is some tendency for richer countries to show up at higher levels of the GLOBALIZ index than do poorer countries, it is not a particularly strong relationship (although the R^2 is a respectable 0.265). In fact, a very large number of developing countries cluster just below the middle of the GLOBALIZ scale. Although richer countries may be absolutely more significant on the global stage, when GDP and population size are controlled, developing countries are clearly very much influenced by and involved in globalization processes. The 2005 release of the GI calculation reported only on 62 countries. Because those included cover 96 percent of the global GDP and 85 percent of the world's population, they are obviously the richest and largest of the 182 countries covered by IFs. Figure 16.3 shows that many of the other 120 countries in IFs are highly globalized, especially when the measures tap penetration by the outside world (aid and FDI receipts, remittances from workers abroad, etc.) as well as penetration of the outside world. A striking case is China, which ranked 54 of 62 on the A.T. Kearney/*Foreign Policy* GI measure in 2005. As Figure 16.3 shows, when we control for GDP and population size, China appears below the vast majority of not just richer, but also of smaller, poorer countries on the GLOBALIZ measure.

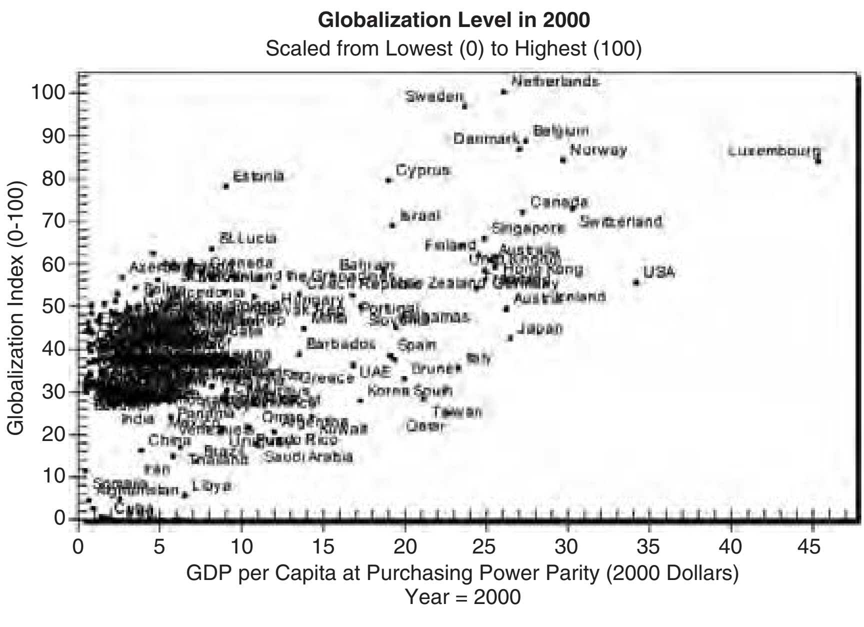

Figure 16.3 Globalization (as measured in IFs) as a function of GDP per capita.

A measure like GLOBALIZ is, however, only the tip of the forecasting iceberg. It is the representation of dynamics beneath the measure that determines the ability of the measure to be useful in forecasting. The next section addresses the representation of dynamics.

Representing globalization more broadly with IFs

International Futures is a dynamic global modeling system. The extensive database underlying it includes data for 182 countries over as much of the period since 1960 as possible. The model itself is a recursive system that can run without intervention from its initial year (currently 2000) through temporal horizons as distant as 2100, while the model interface facilitates interventions flexibly across time, issue, and geography.

Figure 16.4 shows the major conceptual blocks of the International Futures system. The elements of the technology block are, in fact, scattered throughout the model. The named linkages between blocks and the linkages themselves are illustrative, not exhaustive.

Does the IFs system have the drivers and dynamics, as mapped out in the third section of this chapter, to help us forecast processes of globalization?

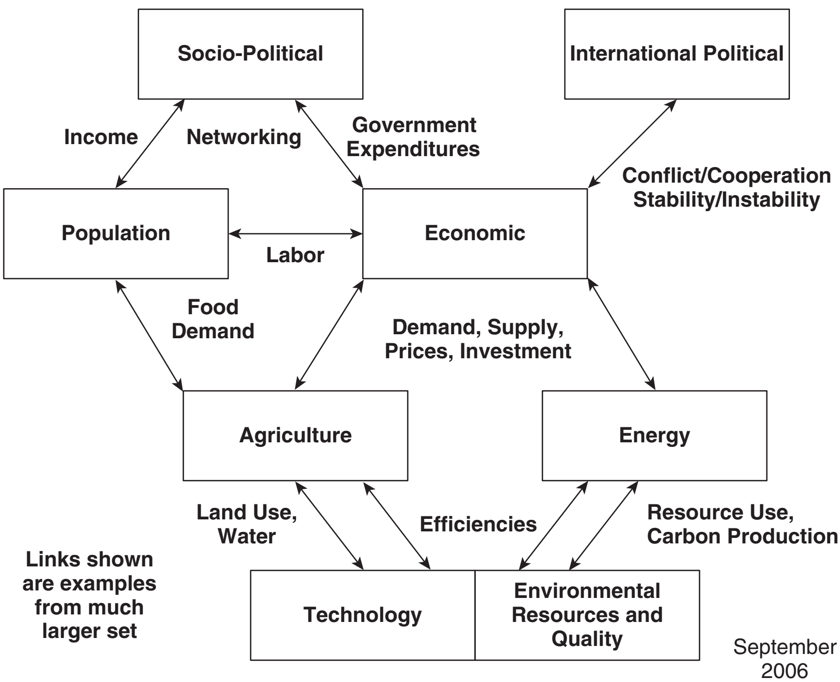

Figure 16.4 An overview of International Futures (IFs).

Looking first at the positive-feedback loops identified earlier, IFs incorporates full submodels for population and economics. Inside the economic model is a fairly substantial representation of ongoing aggregate technological change in the form of changes in multifactor productivity. The annual flow of new technology and resultant stock of knowledge accumulated over time are represented as a function of variables from other submodules, such as the development of human capital (education and health), social capital (quality and character of governance), physical/natural capital (focusing on energy prices), and the knowledge development and diffusion processes (partly via R&D).

Turning to the negative-feedback loops, there is representation of cultural values and value change in terms of the two central dimensions of the World Value Survey project, namely survival/self-expression and traditional/secular rational. But there are no formulations in the model that really capture increasing cultural tensions due to the globalization processes, much less a feedback from those to the globalization dynamic.

There is also representation of environmental impact of growth processes, including especially deforestation and atmospheric accumulation of carbon dioxide. Again, however, there is not a feedback from either that would significantly alter the globalization growth process generated by the positive-feedback dynamics.

Finally, there is a representation of changes in domestic and, more strongly founded, in international income distributions. Still again, there is no feedback represented from those to the core positive dynamics. Along the same lines, the model can be used to examine the likely changes in global power capabilities over time (with an explicit POWER measure), but the power transitions generated in that representation are not used to generate warfare or other system disruption. Along the same line, there is no explicit representation of systemic leadership with respect to global finance, and therefore no manner in which the leader could exhaust its capability to provide public goods – such as being the lender of last resort in financial crises (Kindleberger, 1973).

Further, the model does represent ongoing democratization processes, and even has a basic representation that can generate waves in democratization. There is, however, no portrayal of shifts in governance away from states to regional and global actors or regimes. This failure affects the measurement of contemporary globalization levels as well as the forecasting of future ones.

In short, the central positive dynamics have basic representation, but while some of the key variables in the negative-feedback loops are represented, the loops are not closed. It is predictable, therefore, that the forecasts of the model will display more of the longer-term growth in globalization than the periodic oscillations or systemic crises.

At the same time, however, there are other useful features of the system. For instance, its substantial representation of energy systems does capture the movement from fossil fuels to renewable sources over time, and therefore allows some examination of the relationships between the energy system and globalization processes. The model also has a basic representation of the growth of the Internet, and could therefore help us to think about possible change in the dynamics underlying advances in human well-being that are the subject of speculation in the third section of this chapter (from territory to trade to terabytes).

With respect to the general issue raised in this section, namely whether IFs can help us forecast globalization or not, the answer is clearly "yes and no." There are important foundations, but many missing elements. Some missing elements might well be handled via scenarios.

Why are a number of potentially important feedback linkages missing in the model? One part of the explanation is that they are fundamentally less well understood than are the basic positive-feedback dynamics. Another part could be that for long-range forecasting the power of the core positive feedbacks may outweigh the long-range influence of the negative feedbacks, at least as they have unfolded in the last century or more. Even the Great Depression and the major world wars of the twentieth century were hard to find in the systemic indicators at the end of the century.

In spite of the limitations for forecasting identified here, the next section will take a preliminary look at the kinds of forecasts that IFs generates with respect to globalization.

Forecasting globalization

Using the index of globalization within IFs (rooted in the A. T. Kearney/*Foreign Policy* index) and using the dynamics that do exist in IFs, what might we learn, if anything, about the possible progression of globalization through the twenty-first century?

Figure 16.5 begins the exploration by showing long-term forecasts from the base case for, respectively the OECD and non-OECD countries (as rough proxies for the North and South of the world). Note that on the 100-point index rooted in the experience of 2000, the world continues a fairly steady process of globalization and reaches very high levels by 2100, especially in OECD countries. The absence of much fluctuation around the growth pattern reflects the weakness (essential absence) of the negative-feedback loops, as discussed earlier. The slowing down of the growth process in the long term has two explanations: saturation effects created by the operationalization and saturation effects inherent in the process. With respect to the former, the measure is constrained by an upper limit of 100, therefore imposing saturation in the forecasts. A first reaction might logically be that such saturation is artificial. Nonetheless, the pattern should simultaneously raise the question of deeper substantive significance to be pursued here: could the globalization process truly be subject to saturation and, if so, might the current century be the century in which saturation would become apparent?

In addition to the saturation effect, the other eye-catching aspect of Figure 16.5 is the bending of the curve in the middle of the second decade of

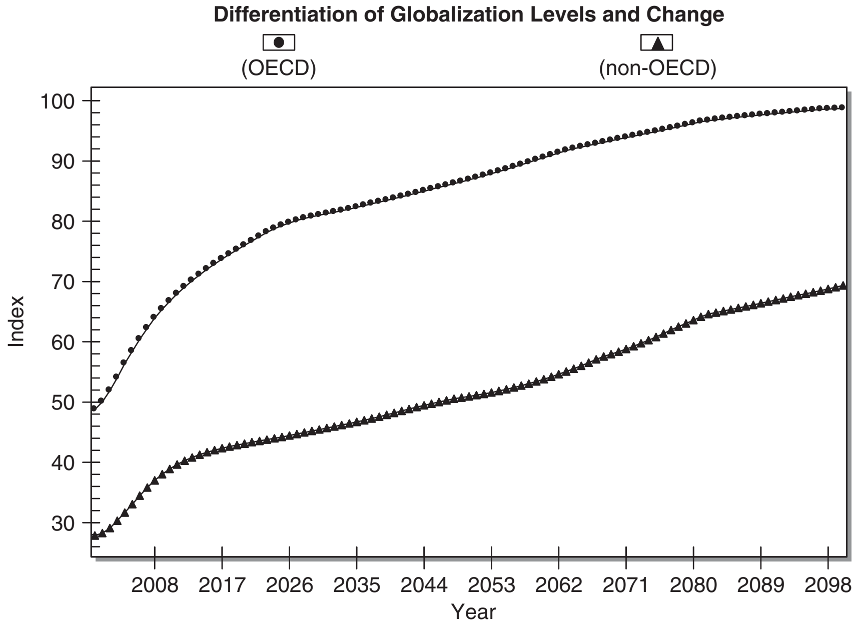

Figure 16.5 Globalization forecast in IFs base case.

this century. Why does that occur? The easiest way to explore for an explanation is to investigate the sub-dimensions of the globalization measure. Figure 16.6 shows the sub-dimension for personal contacts, which again indicates some saturation effect, but no substantial curve bending.

The second component measure is global economic integration, also shown in Figure 16.6. There the curve bending does appear. Why?

Figures 16.7 and 16.8 explore the two sub-dimensions of global economic integration in the IFs measure, namely global trade and foreign direct investment. The trade figure, representing global trade over global GDP, shows a slight downturn in growth early in the century, related in part to the energy system transformation discussed earlier. But, thereafter, the curve actually bends somewhat upward as the trade share rises quite steadily.

In contrast, the global stock of FDI over GDP (below) does exhibit the curve bending. Again the question is why?

The explanation for the curve bending becomes apparent from study of Figure 16.9, which focuses on flows of FDI instead of stocks. After a period of recovery from the sharp downturn in FDI flows that followed the stock-market retrenchments of the early century (most of FDI is related to mergers and acquisitions and all of it reflects confidence in global markets), the pace of FDI flows over GDP resumes a relatively steady but slow upward growth. The relatively slow growth pattern will cause the global stocks to begin saturating (as in the above figure) because they suggest essentially a systemic

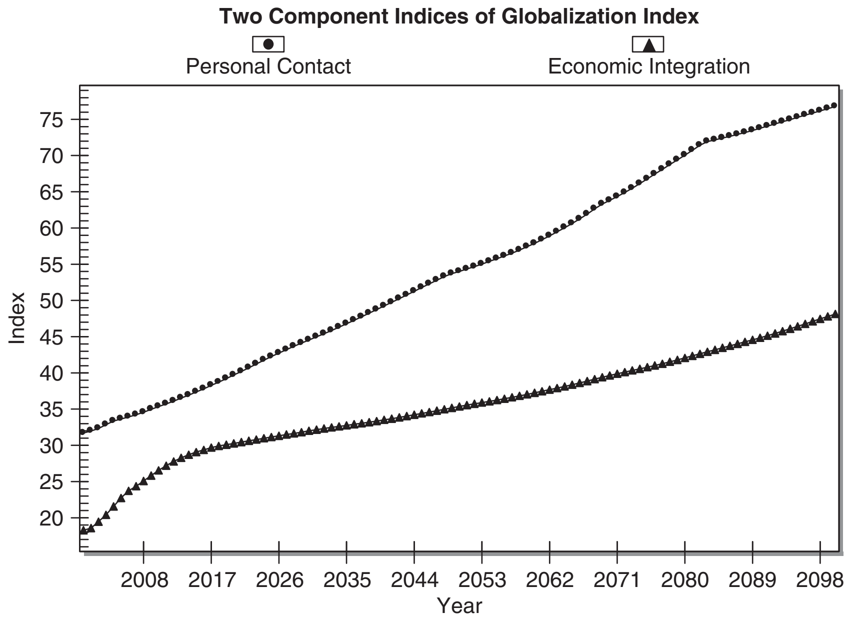

Figure 16.6 Component indices forecast in IFs base case.

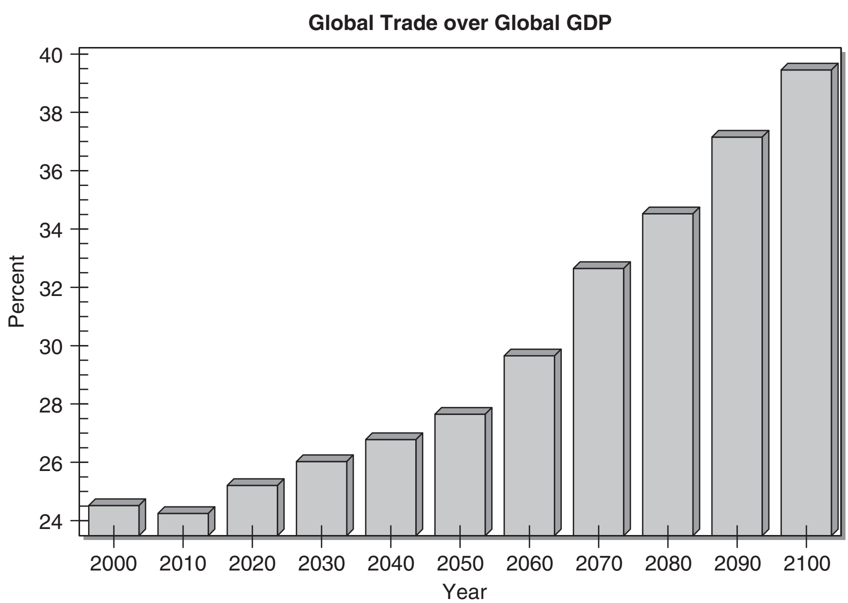

Figure 16.7 Trade openness forecast in IFs base case.

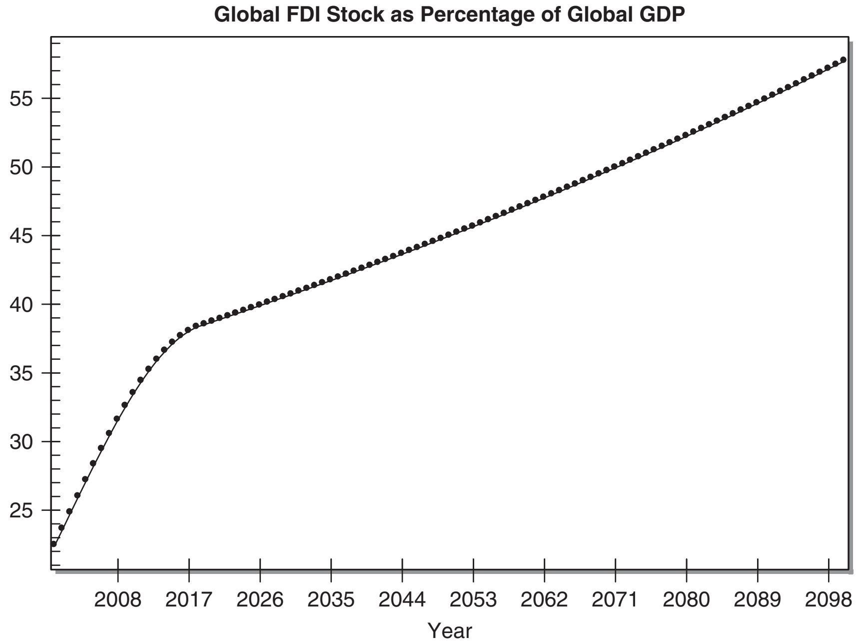

Figure 16.8 Global FDI stocks over GDP forecast in IFs base case.

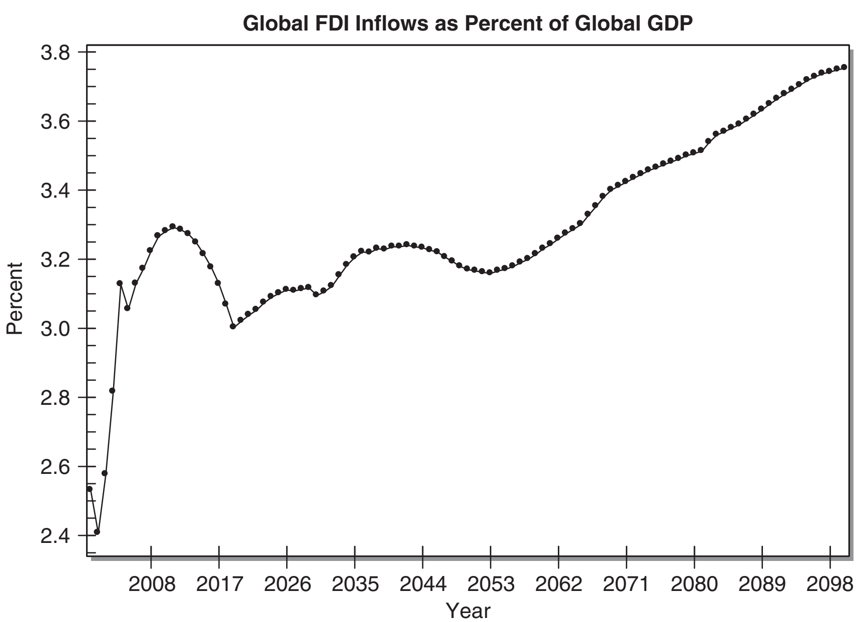

Figure 16.9 Global FDI flows over GDP forecast in IFs base case.

shift from low flow rates and stock levels in the early 1980s to fairly high flow and stock levels by about 2020. Since global investment over GDP falls over time in the range of 20–30 percent of GDP, saturation of FDI over GDP at the level of about three percent of GDP may be somewhat low, but there is inevitably going to be such saturation, causing the kind of curve bending we have seen. Once again, this may indicate a weakness in the measure, but it may be a hint of true saturation processes ahead.

Interestingly, turning to the third component of the globalization measure, namely the extent of electronic connection through networking, we again see in Figure 16.10 both the shorter-run bending of the curve and the longer-term saturation effect. No more than 100 percent of the world's population is likely to ever be connected to the World Wide Web. Again, this may simply suggest a conceptualization/measurement weakness, because even if everyone is connected, the amount of information exchanged could grow for some considerable time. Nonetheless, the figure does logically raise the deeper question: might such saturation truly occur?

All of the above figures being discussed were produced for the base case of IFs, a forecast that has been calibrated with both historical patterns and other forecasting projects. Nonetheless, the base case represents only one of an infinite number of possible futures, and, given the range of possibilities, it must be considered a low-probability future. Figure 16.11 shows the globalization index across four alternative scenarios, those of the United Nations Environmental Programme's Global Environmental

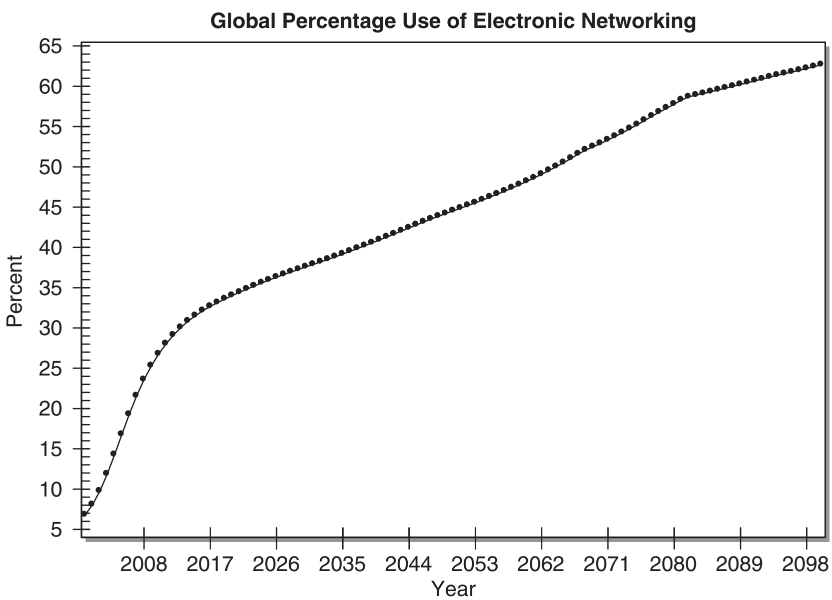

Figure 16.10 Global percent networked forecast in IFs base case.

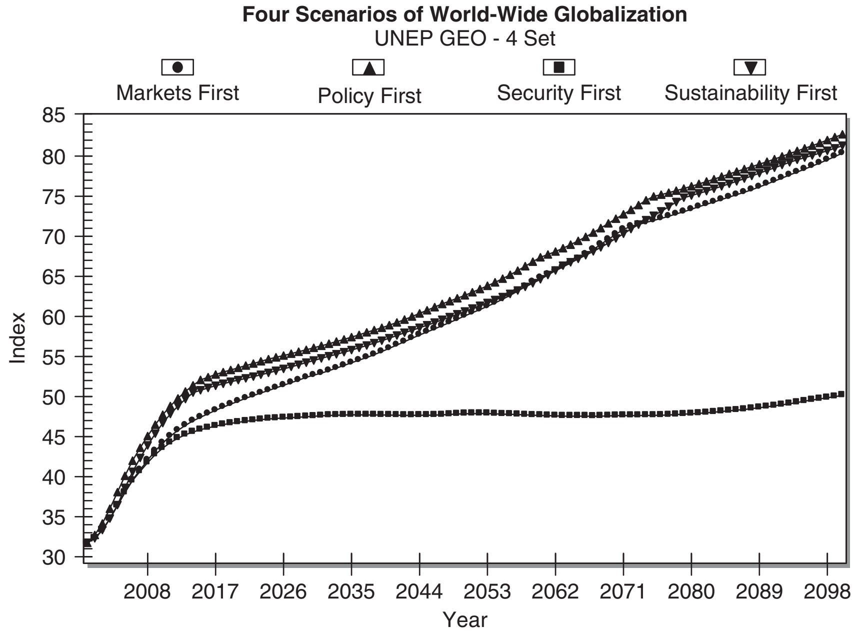

Figure 16.11 Alternative scenarios of globalization for IFs.

Outlook 4 (UNEP, 2007, in press). Interestingly, the Security First scenario, which posits a breakdown of global trade and aid, as well as much less rapid economic progress in the global South, leads to a stabilization of globalization levels. The only real surprise, perhaps, is that it does not cause a drop in them. The other three scenarios all lead to similar patterns in the continuing growth of globalization. Scenarios are built to frame future uncertainties. If these scenarios do so successfully, some continued advance in globalization, and quite possible considerable advance, seems likely.

As this chapter has noted repeatedly, however, there is much that the IFs model omits that would be relevant to a forecast of globalization. Figure 16.12 shows one such element, namely the nearly certain coming power transition between the United States and China.[3] The figure shows the percentage share of systemic power capabilities (for details on the measure and flexibility of it, see Hughes and Hillebrand, 2006). The graph has its own story to tell, including the apparent peaking of Chinese power share not long after its overtaking of a (relatively) declining United States (related to continued rise of India and other parts of the global South). But, for this analysis, the key point is that the earlier figures discussed are not affected within IFs by this transition, even though we know well that past power transitions have fed back to the globalization process. The difficulty is, of course, in knowing how that feedback should be structured in the IFs model.

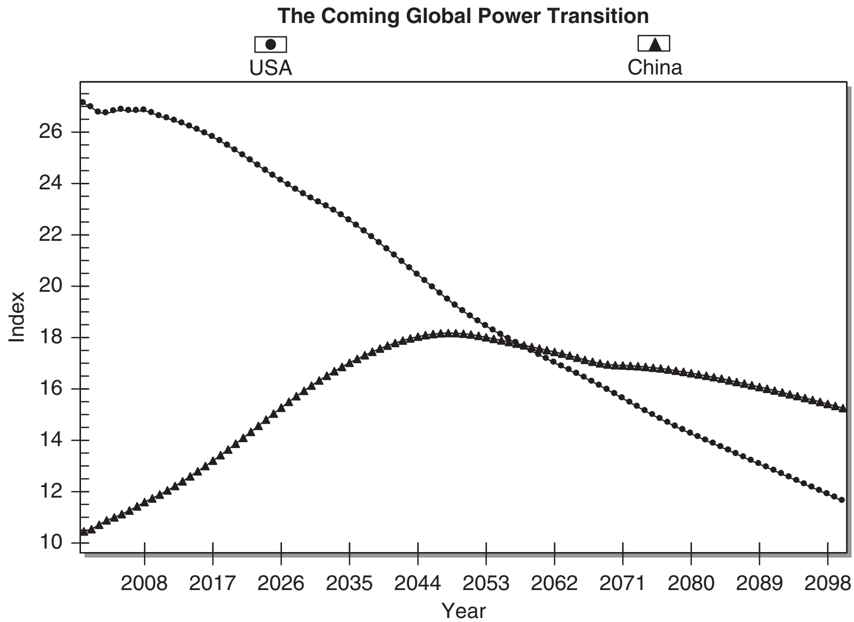

Figure 16.12 Global power transition forecast in IFs base case.

Finally, Figure 16.13 shows a forecast of global democratization. Like power structures in Figure 16.12, democratization moves us beyond the analysis of flows and connectedness, and more directly into the analysis of social structures and globalization as evolutionary and transformative processes. What it shows is the possibility that various drivers (including economic growth and the spread and deepening of education, a transformative factor itself) will push most of the world, including most of the developing world, through the stages of unconsolidated democracy to quite high levels of (consolidated) democracy. If so, that has great implications for globalization.

Conclusions on the forecasting of globalization

What can this chapter tell us about the prospects for forecasting globalization processes? Several things, as follows:

- Many of the general dynamics of those processes are reasonably well understood, as suggested in the portrayal of them here in terms of key positive and negative feedbacks.
- Large portions of the specifics of the processes are less clear, as suggested by the failure within the International Futures model to close the negative-feedback loops, in particular. Even if those closures could be represented in terms of rough magnitudes of impact on the underlying process, it is

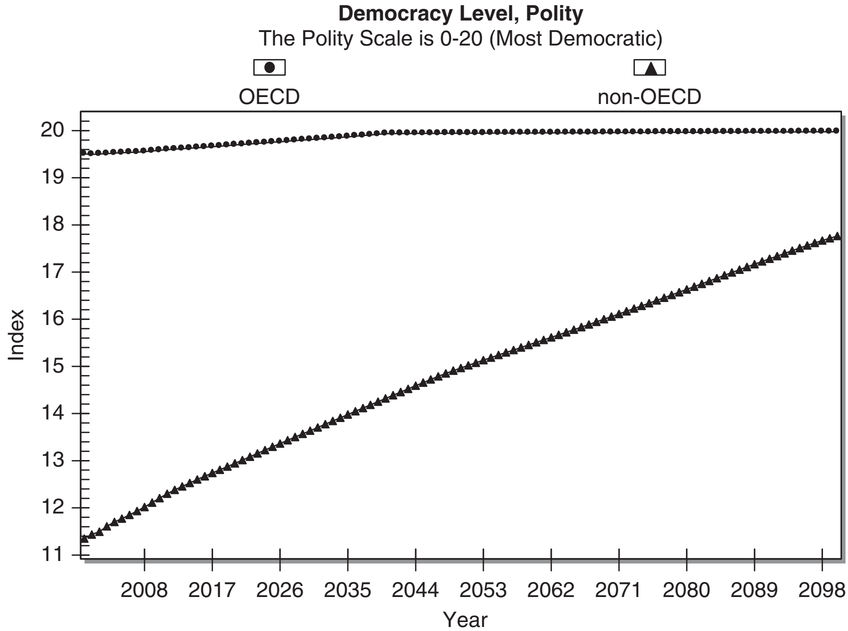

Figure 16.13 Global democratization forecast in IFs base case.

difficult to believe that the timing of the key negative effects would be easy to forecast.

- It is not just the dynamics of the processes that complicate forecasting. The very measurement or representation of globalization is far from simple. Alternative representations, particularly with respect to measures that saturate or do not, could make large differences in forecasts.
- Alternative scenarios should be used in forecasting. Differences in forecasts across credible scenarios can be large.

To the extent that the very basic forecasting effort described here has any remaining credibility after the caveats above, it suggests the following conclusions:

- Globalization appears highly likely to continue through the century, even if there are setbacks (the Security First scenario suggests that the process could stall altogether).
- Globalization appears likely to continue not just in terms of flows or connectedness, but also in terms of socio-political transformations or evolution, such as increasingly widespread movement towards democracy (with one foundation in substantial advance of educational levels).
- Consideration should be given to at least one possible additional conclusion, that the globalization process may be subject to some form of

saturation effect. Might there be limits to some of the sub-processes, if not the overall phenomenon, and might we be approaching some such limits this century?

Although forecasting of globalization looks to be strewn with pitfalls, the process remains the meta-trend of global change. There is therefore much reason to continue enhancing our capability to anticipate the future of that key force.

Notes

1 The timing of annual release has become somewhat later over time. The two previous years were released in January/February 2003 and March/April 2004.

2 Current development of IFs is being funded primarily by Frederick S. Pardee, by the US National Intelligence Council, and the United Nations Environment Programme in support of its Global Environment Outlook 4. Development of International Futures in 2000–2005 was funded in substantial part by the TERRA project of the European Commission, the Strategic Assessments Group of the US Central Intelligence Agency (which supported work on the globalization index of IFs), and the European Union Center at the University of Michigan (supporting enhancement of the user interface). None of these institutions bears any responsibility for the analysis presented here, but their support is greatly appreciated. Thanks also to the National Science Foundation, the Cleveland Foundation, the Exxon Education Foundation, the Kettering Family Foundation, the Pacific Cultural Foundation, the United States Institute of Peace, General Motors and the RAND Pardee Center for funding that contributed to earlier generations of IFs. Also of great importance, IFs owes much to the large number of students, instructors, and analysts who have used the system over many years and provided much appreciated advice for enhancement (some are identified in the Help system). The project also owes great appreciation to Anwar Hossain, Mohammod Irfan, and José Solórzano for data, modeling, and programming support within the most recent model generation, as well as to earlier student participants in the project (see again the Help system, as recently revised by Jonathan Moyer).

3 "Nearly certain" may seem too high, given the fairly narrow range of power superiority obtained by China (see Figure 16.12) and knowing (1) the crudeness of power measures and its forecasting and (2) the possibility that a democratic US would have stronger alliance support than a potentially still authoritarian China. A wide range of alternative assumptions within IFs, however, produce similar results.

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17 On forecasting globalization using world models

Rafael Reuveny

Introduction

The literature employs the term "globalization" to describe the growing cross-national connectivity and interdependence experienced since the 1960s. However, scholars debate the exact meaning and critical features of this interconnectedness. Modelski (2007, Chapter 2 of this volume), for example, emphasizes the role of institutions, including markets, states, alliances, international governmental organizations (IGO), and learning networks. The A. T. Kearney/*Foreign Policy* Index (*Foreign Policy*, 2003) focuses on political engagements (e.g. memberships in IGO), contacts (e.g. travel, phone), and economic activities (e.g. trade, investments). Kudrle (2004) employs this index, but notes that it omits environmental and military aspects. Andersen and Herbertsson (2005), Bhadari and Heshmati (2005), and Heshmati (2006) focus on economic aspects. Held *et al*. (2007) cast the widest net, focusing on the political–legal (e.g. treaties), military (e.g. armies), economic (e.g. trade), social (e.g. migration), and environmental (pollution, natural resources) aspects of interconnectedness, as well as the extent of international income and wealth inequality and exclusion from the processes of globalization.[1] Taking all these conceptualizations at face value, it seems that globalization implies a process of growing cross-border connectivity and interdependence within *all the key domains of human activity*.

Let us assume that we are entrusted by an IGO comprising all the countries in the world, with the mission of answering the following questions on the nature, evolution, scope, and effects of this growing international connectivity and interdependence on all the key domains of human activity.

1 Assuming that all countries will continue to employ current policies, know-how, consumption patterns, and technologies of production, what will be the time trajectories of key domains of social activities such as the standard of living and quality of life, for various units of analyses, including states and the planet, in the next 50 years?
2 How will the time trajectories change if we alter policies in a certain pre-defined manner, but keep the state of know-how and technology as it is?

3 How will the time trajectories change if we alter the state of know-how and technologies in a certain pre-defined manner, but do not change policies?
4 How will these trajectories change if we alter both policies and technologies in a certain pre-defined manner?

Taken together, answering these questions amounts to forecasting scenarios regarding the future of globalization. This task is very complex, because the components of globalization are highly interconnected. Changes in some variables may feed back into other variables, and so on. Nevertheless, without answering our questions, we cannot make informed choices about policies and technologies. The issue boils down to one of uncertainty. We typically assume that people do not like uncertainty; we all want a certain level of stability and predictability in our lives. Of course, no one knows how exactly the future will unfold, but, by answering those four questions we can presumably reduce the amount of uncertainty that we face, as well as undertake corrective policies, should the forecast suggest the possibility of some undesirable outcomes.

The wide-scope interconnectedness implied by globalization, and the requirement that we present quantitative scenarios suggest that our forecasting apparatus can benefit from a theory-driven mathematical model. Since this model must provide information on many forces across many units of analyses and over time, it will probably be large and complex, involving many equations. Given its size, the model will probably not have a closed-form solution (formulas specifying sizes of variables as a function of assumed parameters, including policy and technology parameters), but rather will have to be solved numerically over time. Such a model is often called a "world model," because it computes outcomes for different nations, regions, and even the planet as a whole. Given the many computations involved, world models are simulated by using a computer program that enables analysts to study the behaviors of the system and its components under different assumptions, generating alternative scenarios for variables over time.

This chapter seeks to make a step toward developing a world model suitable for forecasting globalization, broadly defined to include all the above-mentioned variables. To meet this goal, I will outline two existing world models, World3 and Globus, and evaluate the implications of using their modeling approach for our purpose. With this overview in place, I will sketch principles of a proposed multi-person/multi-year research plan to incorporate features of these two models into a third existing model, International Futures, with the goal of generating a fuller model that will be more suitable for forecasting the future of globalization.

Setting the stage

This section sets the stage for the rest of the chapter. I will first describe some general features of world models and then provide a few details on representative world models. Finally, I will choose two specific world models from these examples, which will be discussed in greater detail and used as vehicles in the remainder of this chapter.

World models feature mathematical forms that describe dynamics, such as differential or difference equations. The models' parameters, which may represent policies or behavioral constants, come from empirical data or other studies. The model's output consists of a set of variables as a function of time until the end of the forecasting horizon. Some of the models' parameters can be manipulated by the user, generating different scenarios, while others cannot be changed easily. The causal explanations for the models' equations reflect the state of knowledge at the time of building the models, as well as considerations of data availability, numerical accuracy, computing power, and mathematical complexity.

Taken as a group, existing world models describe many key aspects of human behavior, including population dynamics; economic forces such as production, consumption, and investment; domestic political processes involving government spending or civil strife; international interactions such as arms races, disputes, migration, and trade; social forces such as income inequality and education; and environmental forces such as resource depletion, pollution, and climate change. Not every model includes all of these components; one group of models focuses on the economy, another focuses on the environment, a third group focuses on economic-environmental processes, and a fourth group focuses on economic–socio-political processes. The units of analysis also vary. Some models employ the planet as the unit of analysis, others employ regions, and a third group employs the nation-state. Within each unit of analysis there may be more than one actor whose behavior is modeled, such as producers, consumers, investors, governments, and organizations.

Regardless of their specific focus, all world models include many equations, at times thousands. In general, the left side variable of many equations may appear on the right side of other equations, resulting in an interdependent system of equations. Other variables are exogenous or appear only on the right side of some equations. Given this mathematical complexity, it is impossible to predict the trajectories of the endogenous variables without actually solving the equations numerically, and it is not practical to obtain such a solution without using a computer program. Each of these model solutions provides the endogenous variables as a function of time, given a set of parameters, trajectories for the exogenous variables, and initial conditions.

Work on world models began in the 1960s. A number of models were developed by various research groups around the world. The Link project developed an econometric model of the world economy, broken down by regions (Klein, 1976). World3 is a systems dynamics model of the society–environment nexus at the planetary level, developed for the Club of Rome (Meadows *et al.*, 1972, 1974). The World Integrated Model (WIM), a second Club of Rome model, had a similar focus, but was much larger, distinguishing between economic sectors, world regions, and resources and allowing for interregional trade and loans (Mesarovic and Pestel, 1974a, 1974b).

The Bariloche model focused on the economy–quality of life link, taking account of income and resource inequalities across world regions (Herrera *et al.*, 1976). Wassily Leontief developed an input–output model of the world economy broken down by regions for the United Nations (Leontief *et al.*, 1977), while the Future of Global Interdependence world model primarily simulated interregional and international economic linkages using a mix of input–output analysis, system dynamics, and econometrics (Kaya *et al.*, 1977). The Globus group modeled political–economic relationships among 25 countries (Bremer, 1987). The International Futures (IFs) world model built on the Leontief model, Bariloche model, WIM, and Globus, representing economic, political, social, and environmental processes (Hughes, 1999). These models formed the base of an expanding world modeling effort, which continues today.

In the 1990s and 2000s, several new world models emerged, often incorporating elements of the first wave of models. New versions of IFs, for example, involve various updates of the original model (Hughes and Hillebrand, 2006). Globesight builds on WIM, representing primarily the global economy (Mesarovic *et al.*, 1996). Other models started from scratch. G-Cubed is a multi-sector/world region applied general equilibrium economic model geared to study emission taxes, trade barriers, and fiscal and monetary policies (McKibbin and Wilcoxen, 1998). The National Institute Global Econometric Model (NIGEM) models economic interactions between countries (NIESR, 2006). The applied General Equilibrium model for Energy–Economy–Environment (GEM-E3) studies effects of the economy on the environment in the European Union or in 21 world regions, where pollution and industrial emissions such as carbon dioxide (CO_2), nitrogen oxide (NO_x), and sulfur dioxide(SO_2) gases can prompt damage reduction (GEM-E3, 2004). The Integrated Model to Assess the Global Environment (IMAGE) simulates relationships between the economy and the biosphere across world regions, focusing on energy, industrial emissions, and climate change (NEAA, 2006).

Given our interest in forecasting globalization, which of these world models should we utilize? The short answer is that none of these models fully answers our needs. On one hand, the econometric and applied general equilibrium models and the Club of Rome models generally do not model domestic and international socio-political forces. However, globalization involves many political and social interactions, not only economic and environmental interactions. On the other hand, Globus and IFs do capture international and domestic economic-socio-political relationships. Unfortunately, Globus omits the environment, the IFs system does not have an elaborate module and does not feed its outputs back into the model (Hughes, 2007, Chapter 16 of this volume), and both models include certain features that are not suited for our purpose, which will be discussed shortly.

The task of forecasting globalization then, seems to require integration of ideas, design principles, and algorithms utilized by more than one world model. We can gain insight about features of the required blend by describing some world models in greater detail. In choosing among these models, I first note that the IMAGE world model seems suited for discussing the economy–energy–environment nexus for our purpose of forecasting globalization, but it is very large and complex. For our purpose, it will suffice to focus instead on World3, which is a much smaller world model that includes some similar features.

Naturally, our next choice must involve Globus or IFs, as other world models generally do not include socio-political intrastate and interstate interactions. IFs is active today and includes 182 nations. In contrast, work on Globus stopped in the early 1990s and the model includes 25 nations, but it is more suited to serve as a vehicle for the purpose, for several reasons. IFs includes simplified political modules of Globus, and its economy is based on Globus (Hughes, 1999). IFs models trade of a country with the world (Hughes and Hillebrand, 2006), whereas Globus models bilateral trade (Pollins and Brecke, 1987), which is vital for modeling globalization. IFs also does not include effects that reduce globalization (Hughes and Hillebrand, 2006), while Globus does, and additional effects such as globalization-induced dissent over income inequality can be added to the model. Finally, IFs computes the probability of military disputes and uses it to generate a random event of dispute (Hughes and Hillebrand, 2006), while Globus models levels of conflict/cooperation, not random events (Smith, 1987). I will return to the IFs–Globus nexus in the last section.

World3 in the context of forecasting globalization

This section outlines the basic design principles of the World3 model and evaluates their applicability for forecasting globalization. Building on the work of Forrester (1971), World3 models relationships between the world economic system and the environment, assuming that the biosphere imposes physical constraints on the global economy, including certain non-renewable resource stocks, renewable resources regeneration rates, and absorption and breakdown rates of pollution (Meadows *et al.*, 1972, 1992, 2004). The base run of World3 predicts a rise in global socio-economic indicators until the mid-twenty-first century, followed by a sharp decline across the board, including industrial output, food, quality of life, life expectancy, and population size. Pollution and ecological footprint (indicating overall environmental stress) follow a similar pattern, and resources decline continuously.

The model shows that if the world economy grows too large for the biosphere, physical limits lead to economic and population collapse, unless limits are expanded considerably or removed, or technological fixes to problems are unlimited in potential, quick, errorless, and costless. These results have prompted criticisms and counter-critics. The outcome of collapse under default values was too much to bear for many. Jahoda *et al.* (1973), for example, argued that the key assumptions are too pessimistic, and that the model ignores politics, social structure, and human aspirations, which can change outcomes.

Others argued that World3 ignores national differences, and omits markets, innovation and significant resource discovery (Cole, 1977). Wallich (1972: 86) called it "a piece of irresponsible nonsense," and Nordhaus (1973, 1992) criticized the equations. In 1992, President George H.W. Bush said that in 1972 some spoke of limits to economic growth, but we now know that "growth is the friend of the environment." The Exxon–Mobil company stated in 2002 that the Club of Rome was wrong in questioning the sustainability of growth (Meadows *et al.*, 2004: 204). Judge Kozinski of the US Court of Appeals, 9th Circuit, called the model "a bunch of hooey" (Kozinski, 2002: 1743), and Marxsen (2005) wrote that "limits to growth may exist only if people buy into this wrong idea."

In the 1990s, it seemed that opinions had begun to shift. For example, Arrow *et al.* (1995: 520) argued that the Earth has a limited carrying capacity. While exact numbers are not known, estimates suggest an inverse relationship between affluence and carrying capacity (Cohen, 1995; Reuveny, 2002; Harris, 2006). Facing global warming, sea-level rise, and stronger and more frequent extreme weather events, the Kyoto Protocol (Kyoto, 1997) and Intergovernmental Panel on Climate Change (IPCC, 2001a, 2001b, 2001c) called for a considerable reduction in global greenhouse emissions, which, with the current state of technology, inevitably implies some restriction of economic growth. Almost all of the industrialized countries, with the exception of the US and Australia, ratified the Kyoto plan, further demonstrating the shift in opinions toward accepting the spirit of World3.

With these important issues discussed, let us describe the structure of World3. The model consists of about 200 ordinary, non-linear differential and algebraic equations. The model is currently coded in STELLA (a system-dynamic computer language) and includes more than 500 parameters and 300 variables, a third of which need initialization.[2] The model is solved numerically for every six-month period, creating different trajectories from 1900 to 2100, depending on the parameters and initial conditions set by the user. These trajectories are generated under the assumption of "the best of all worlds" scenario, employing the following features. Various decisions take immediate effect and exhibit no transaction costs. Natural resources are perfect substitutes for each other in production, and can therefore be represented as a single resource. There are no military or government sectors in the model. Markets clear excess demand or excess supply perfectly and instantaneously without using prices as signals. All signals in the model, including those about resource scarcity, pollution, and hunger, come from the world as a whole, without any delays. All technologies in the model are successful and have no unexpected side effects. There are no differences between rich and poor in the model. There are also no conflicts, ethnic strife, wars, terrorism, corruption, labor strikes, accidents, drug addictions, epidemics, storms, or other extreme weather events.

This best of all worlds scenario, however, faces natural limits, which may constrain economic activity. The sizes of these limits can be altered or removed by the user of the model, but Meadows *et al.* (1972, 1992, 2004) argue that their default values are reasonable. For example, the cultivatable land is capped at 3.2 billion hectares. The initial land fertility in the year 1900 was sufficient to produce 600 kg/hectare of grain-equivalent, without addition of any fertilizer. The rate of raising natural land yield is capped at 740 percent, and the non-renewable resource stock is capped at 7,000 times the extraction rate in 1900. Nature can absorb and break down pollution, but the absorption time rises with the stock of pollution. For example, nature can break down half of the 1970 pollution stock in one year, but if pollution rises 250 times, absorbing half of the pollution stock requires 10 years. Finally, unused degraded land can regain half of its natural fertility in 20 years.[3]

The model consists of five interacting sectors, each dealing with a different primary subsystem of the model. The economic subsystem produces industrial output, which is allocated to various uses. The population subsystem models fertility, mortality, and population growth. The pollution subsystem models the generation of pollution and its absorption. The non-renewable resources subsystem models resource extraction and discovery of new resource stock. The food subsystem produces food by using land and agricultural input capital. Let us discuss each of these sectors in greater detail, and consider their link to forecasting globalization.

The economic sector of World3 produces industrial output. As in the standard neoclassical economic growth model, industrial output in the model can change its nature without delay and at zero cost. The stock of industrial capital (factories and machines) increases due to investment (new capital added per year) and it declines due to depreciation (capital becoming worn out or obsolete). The rate of investment in industrial capital is given as the residual after allocating industrial output to increasing service capital (health, family planning, education) and cultivatable land, improving land fertility, agricultural capital, resource extraction capital, and capital used in producing consumer goods.

Consider next the population sector. Population dynamics are traced for the 0–14, 15–44, 45–64, and over-64 age groups. The growth rates depend on births and deaths per year. Deaths rise with population size and mortality, while mortality falls with food and health-services per capita and rises with pollution. Births rise with population size and fertility, while fertility falls with industrial output per capita and family planning and education services per capita. The model, then, assumes that society is over the hump of the demographic transition.

Production and investment in the model take place on a global scale, which is one of the increasingly important features of the global economy. The processes increasing the different capital stocks in the system are also important for our purpose, because globalization is expected to raise global industrial output and spread education, family planning, and health services throughout poor countries. Tracing populations for several age groups is also important in our context, because in the coming years rich countries may exhibit greater numbers of elderly, while poor countries may exhibit greater numbers of young people. These dynamics have implications for dissent over globalization and for migration patterns, an issue to which I will return.

The environment and non-renewable resource sectors of World3 are affected by, and affect, the economic and population sectors. Industry and agriculture in the model generate pollution, such as radioactive waste, metal waste, NO_x emissions, and SO_2 emissions for industry; and herbicides, insecticides, fungicides, and pesticides for agriculture. The two pollution stocks increase toxicity, which increases mortality and reduces food growth. Pollution stocks decline due to natural absorption and pollution control, which is introduced as output, and the stock of pollution rises. The single non-renewable resource stock of World3 is used as an input in producing industrial output. Resource extraction is costly. As the resource stock falls, extraction becomes more costly, since it is assumed that the richest and most convenient resources are extracted first. More effort is also put into discovery, and more resources are found (to a predetermined extent). At the same time, as scarcity rises, technological advance reduces the amount of resources required per unit of industrial output.

The pollution and non-renewable resource features of World3 are critical for our goal. Globalization raises world output and, with current technology, pollution, representing the "scale effect." However, it is also argued that as income per capita rises, preferences change and people use more pollution control and shift to cleaner production methods, representing the "income effect." The two effects drive an Environmental Kuznets Curve: pollution rises with income per capita up to a certain level and then declines as income continues to increase. Depending on its strength, the income effect may arguably be able to alleviate pollution autonomously, as the economy continues to grow. Regarding the non-renewable resource sector of World3, as the global economy grows and integrates, knowledge and technology flow more freely, raising resource efficiency in production and enabling discovery of stocks heretofore unknown due to their remoteness. However, a world economy growing due to globalization also requires more resources in production, raising pressures on existing resource stocks. Accounting for this tension is crucial for forecasting globalization.

Agricultural land in the model is used to grow food for people and to feed the animals that provide meat and dairy products. Increasing capital, fertilizers, and labor raise land productivity, while increasing pollution reduces it. If food per person falls below a predetermined critical level – representing human demand for food and growing with income per person – more inputs are allocated to agriculture. Unused degraded land is assumed to regain fertility at a given rate, which grows if investment is allocated for that purpose. The land stock rises with investment in land development, the cost of which rises with the land stock as good land is used first. Erosion, urbanization, and industrialization decrease cultivatable land, while investment reduces land erosion, increasing cultivatable land.

Finally, some technologies in World3 improve automatically in response to a problem. Examples include: when pollution rises, cleaner production kicks in; health care improves when mortality is high; as resource scarcity rises, resource efficiency in production and resource discovery improve; and agricultural fixes kick in when food per capita is too low. These fixes employ shares of output, and kick in only if they can be afforded. The user can also turn on technologies such as raising the recycling rate, reducing pollution per unit produced, raising land yields, and reducing land erosion. This is done by specifying the strength of the improvement; its rate of change from the time that it becomes available in the laboratory; and the delay between this time and use in the field.

The competing effects modeled by the agricultural sector of World3 are useful for our forecast of globalization. For example, globalization promotes urbanization and industrialization, reducing cultivatable land, but it also spreads the use of fertilizers, raising yields. At the same time, globalization homogenizes consumption tastes, raising the question of whether we will be able to provide everyone on Earth with the diet of rich nations. Turning to the technological progress embedded in World3, as global energy demand rises with economic growth and fossil fuels decline, we may move to bio-fuels, wind power, and solar radiation. These energy sources, however, have side effects. For example, as we use more land to grow plants for energy generation or for generating energy from wind power or the sun, less land will be available to grow food. At any rate, these features are also useful for our forecast, as the spread of technological progress is said to be one of the hallmarks of globalization.

More generally, the negative feedbacks from the environment to the economy included in World3 seem relevant for any forecasting analysis of globalization. In a world where climate change is gradually becoming accepted as a reality, representing a global economy that begins to be too large for its biosphere, and then ignoring the negative feedback from the environment to the economy, seems wrong. Still, socio-political human actions can make a difference. Other negative feedback is also possible. For example, as observed empirically by various scholars (see, e.g. Reuveny, 2002, for a discussion), the environment can play a role in militarized conflict, affecting both the environment and the economy. These socio-political forces are not included in the modeling structure of World3. Thus we need to bring domestic politics and international political and economic relations into the picture.

Globus in the context of forecasting globalization

The reader may recall that the Globus world model focuses on intrastate and interstate economic–socio-political processes. This section outlines the basic design principles of Globus and evaluates their applicability for forecasting globalization. Work on Globus commenced in 1977 and came to a stop in the early 1990s. Mathematically, Globus employs ordinary, non-linear differential equations, algebraic equations, and logical statements. The left sides of the differential equations (the time derivatives) depend only on variables from the previous period. As simultaneity is not present, the model can be solved recursively (equation by equation). This is done every one-tenth of a year, from 1970 to 2010. Globus is coded in Fortran 77, a computer language, including about 40,000 variables and parameters and 8,000 equations. Most parameters come from empirical estimates and some are set based on other studies. Originally, it was run on mainframe computers, but a version suitable for PCs was developed in the late 1980s.

Globus simulates political–economic forces among and within 25 countries, including the five major powers; a twenty-sixth unit in the model represents the rest of the world. Nations include six sectors: demography, domestic politics, government budget, economy, foreign relations, and international trade. Globus performs the same computations for all nations, using different parameters and initial values and accounting for East–West differences. The model first computes the growth rates of trade flows of each nation with all the others, then computes growth rates for population, economy, government budget, domestic politics, and foreign relations. Once the growth rates are computed, the differential equations are integrated numerically forward one-tenth of a year. The loop repeats until the end of the time horizon. With a preliminary description in place, let us discuss the model's parts in greater detail and the implications for forecasting globalization.

The demography module is the only part of Globus that is not affected by the other parts of the model. The population growth equations take the form:

$$\frac{dN_t}{dt} = c.N_t \tag{1}$$

where N denotes the number of people in a country, c denotes a series of national growth rates for each five-year period, which come from the United Nations population projections, and t is time. The series c in equation (1) can take on low, medium, and high values, depending on the particular population projection chosen by the user. The model traces total population, labor force, and urban population, as well as the sizes of age cohorts 0–4, 5–9, 10–14, 15–19, 20–24, and older than 65, which are assumed to be important clients of public programs (Bremer, 1987).

The demography module of Globus does not seem to be ideal for our purpose. In forecasting globalization, it seems better to model population growth as an endogenous process affected by other modules in the model, not as the exogenous process in Globus. I will return to this point in the next section. That said, Globus includes some useful features for our purpose. Tracing populations of various age groups, in addition to total population, is important for our purpose, as discussed in the previous section in the context of World3. Tracing the size of the labor force is also important. For example, labor issues stand at the core of processes involving international trade and multinational corporations. The size of the labor force affects the tax base, which affects the ability of the government to compensate the losers from globalization, while a high unemployment rate due to international competition can increase the level of domestic dissent.

The domestic economy module includes four parts. One part models the supply and demand and determines prices, quantities, and inventories for six sectors: agriculture, raw materials, energy, arms manufactures, and services. The second uses labor demand (by firms) and supply (by the public) computations to determine wages. The third computes money demand (by the public) and supply (by the state), setting the interest rate. The fourth part computes the exchange rate between the dollar and the local currency, based on the current account (trade balance), capital account (money from abroad minus money flowing abroad), and the gap between US inflation and the country's inflation. The Globus economy moves toward equilibrium, but may not be necessarily at equilibrium at any given point in time. For example, if demand is larger than supply, then the economy adjusts, but this takes time, as it does in reality, during which new adjusting forces may arise, pushing the economy toward a new potential equilibrium (Hughes, 1987).

The government budget module computes spending and taxes. The government sets budgeting goals for government consumption, social welfare, and debt servicing. Each of these goals depends on several variables. The goal for consumption depends on its past value; defense outlay based on foreign relations and vulnerabilities; education and health outlays based on the state of the economy and demography; foreign aid based on alliances; and a residual for administration. The goal for social welfare spending depends on unemployment and pensions. The goal for debt servicing depends on interest and principles due. These budgeting goals drive actual spending goals based on the relative powers of the civilian and defense sectors and fiscal authority (reflecting current budget shares). Gaps among actual spending goals and expected revenues (based on income, foreign payments, and demography) drive target revenues, while income, taxes, demography, welfare payments, and public firms' profits drive actual revenues. The gap between actual and target revenue drives the implemented budget and tax rate (Cusack, 1987).

The economic and budgeting modules are important for forecasting globalization. Decisions on trade, currency exchange, and investment or production abroad reflect expected profits across nations, which depend on the state of each economy. The economy, in turn, is affected by tax, interest rates, exchange rates, and expenditure policies. These policies are monitored by investors, who may decide to move money or production elsewhere at short notice. Defense expenditure can also affect the economy, as well as leading to an arms race, particularly when relations are strained. As conflict becomes more likely, business declines, which can affect the global economy when the nations involved are large players.

The domestic politics module computes levels of public satisfaction with the government, public protest, government repression, and violence in Western nations (democracies), former Soviet Bloc nations (autocracies) and developing nations, but these variables are not fed back into other modules in Globus. In the West, as the economy declines, public satisfaction falls and protest rises, which the regime seeks to suppress. In the former Soviet Bloc, as the economy or state spending fall, public satisfaction falls, protest rises, and repression rises relatively faster than in the West. The model for the former Soviet Bloc also includes the elite (the Communist Party). Elite satisfaction is driven by similar forces to those driving public satisfaction in the West, but also falls when repression rises (the government is less popular). In the developing countries, when the economy and government expenses do not meet basic needs, violent public protest and repression rise, which further raises violence. When the economy declines but basic needs are met, protest rises, leading to repression. The level of repression in the developing countries is modeled to be relatively lower in democracies than in autocracies (Eberwein, 1987).

Any forecast of globalization should include a model of domestic dissent and regime reaction, as in Globus, which is part of the daily reality of globalization in many countries, particularly developing countries. Yet, Globus does not feed the output of the domestic politics module back into the model. In other words, the output of this module does not affect the model, which is an assumption that is not suited for our purpose. I will return to this point in the next section. In addition, globalization puts additional strains on the domestic political system, which need to be added to the model. As examples, imports compete with local producers, reducing satisfaction and raising protest, exporters face larger markets, raising regime support, external actors may push the regime to cut welfare programs, and capital flight can cause a crisis, reducing public support and raising protest. All of these tensions may lead to regime repression.

The foreign relations module employs the following two equations for each pair of countries x and y (denoted as a dyad):

$$\frac{dS_{xy_t}}{dt} = a + bS_{yx_t} + cS_{xy_{t-1}} \tag{2}$$

$$\frac{dS_{xy_t}}{dt} = d + eS_{xy_t} + fS_{yx_{t-1}} \tag{3}$$

where S_{xy} is the conflict/cooperation level x expresses toward y, S_{yx} is the level that y expresses toward x. S spans a range of activities, from unification to war, t denotes time, and a and d are constants. The parameter c in equation (2) gives the effect of S that x expressed toward y in period $t-1$ on the rate of change of S, representing the inertia of political relations, and f in equation (3) has a similar meaning. Positive reactions b in equation (2) and e in equation (3) represent the tendency to respond in kind – conflict for conflict and peace for peace. Negative values for b and e represent appeasing a hostile partner or expressing hostility toward a friendly country. The reaction variables are modeled to depend on the military capability ratio of x and y; the shares of bilateral trade in total trade for each country; the general political climate of the relations in the particular dyad; and the political climate of East–West relations.

The international economics module computes bilateral trade flows between each country and the other 24 countries in the model, in the aforementioned six sectors. Nations are assumed to distinguish otherwise similar imports by their country of production, as in Armington (1969). For France, for example, imported Saudi oil is different than imported Norwegian oil. The export side is not modeled. Import decisions follow two stages: nation x first allocates its income to consuming domestic and imported goods, per sector, depending on relative prices; nation x then computes desired bilateral import, per sector, from each exporter. The desired import falls with the price charged and the level of conflict that the exporter nation expresses toward x, and rises with the exporter's share in world export. The gap between the desired bilateral import and the current import flow (from the previous period) drives bilateral import growth rate per sector.

The economic and political dyadic processes modeled in Globus are relevant for our purpose of forecasting globalization. International economics differs from domestic economics, as the world system is shaped by many governments, not one, giving rise to various possible outcomes that need to be modeled. For example, nations may use gains from their international trade relations to augment or acquire various military powers. In response, other nations may also do so, so as to be prepared should these military powers be directed toward them in the future, thus increasing political tensions in the world system. In another scenario, as international economic interactions intensify, nations may come into conflict over issues such as the division of the economic gains or the imposition of various economic barriers. In a third scenario, economic globalization may promote positive relations, because countries may sever their economic ties as their political relations deteriorate, losing the economic gains from these ties. The trade and conflict/cooperation modules of Globus can help in the evaluation of these futures.

Having described the very basics of the World3 and Globus world models, and evaluated the implications of their design principles for forecasting globalization, I will build on these discussions in the next and last section of this chapter.

Questions on possible futures

This chapter argues that forecasting globalization requires the use of a world model, because the processes involved are both highly complex and interdependent. The very basic nature of these complexities and interdependencies was illustrated by outlining the design principles of two existing world models – World3 and Globus. Taken together, we can see that the involved interdependencies and complexities cut across these models. It follows that our world model should include as few exogenous variables as possible, and as many endogenous processes as possible, and our modeling framework should cut across the economic–socio-political–environmental lines of demarcation at the national and international levels.

This section outlines globalization-related questions to be potentially answered by our world model. In this preliminary stage, the modeling apparatus cannot be discussed at length. Suffice it to say that it is probably not a good idea to develop our model by adding processes to the Globus model. As noted, work on this world model stopped in the early 1990s, and by now some of the specific modeling knowledge is probably lost. For our purposes, it is much more practical to augment the International Futures (IFs) world model, which builds to some extent on Globus, particularly the Globus economic module. IFs employs state-of-the-art software design principles and a user–machine interface, includes some political and social processes, and, most importantly for a very large project such as ours, work on IFs has continued throughout the years and its specific modeling knowledge base is still intact.

With this important issue clarified, let us now turn to some topics that our modeling apparatus would need to confront. Beginning with the economic arena, our questions may focus on the scope of economic globalization. For example, will the thrust of international trade expand globally in the future, or will it follow regional patterns? Can trade flows shrink globally as they did during the 1930s? Similar questions naturally apply for the extent and global distribution of foreign direct investments (FDI) and financial capital flows. In answering these questions, we should model the behavior of all relevant actors. For example, bilateral trade flows depend on the behavior of importers, exporters, and governments; and FDI depends on the behavior of investors, workers, and governments. We may also ask questions about communication links. For example, will they aid in the spread of terrorism and/or the spread of innovation and knowledge?

Economic globalization strains societies by creating winners and losers. For example, local producers may face foreign competition. Exporters, in contrast, may face larger markets. Foreign businesses may pressure the government to cut spending, eliminating welfare programs. This may benefit companies, cutting their participation in these programs, but hurt the public. Capital flight may cause financial crises, hurting the poor, while benefiting speculators. All of these forces can affect income inequality within and across nations. How will they evolve in the future? Will they promote protests, political instability, and regime repression? Even though Globus does not feed the effects of protests and repression back to the model, will these forces hurt the economy, reduce the tax rate, and further shrink public spending, intensifying the cycle of repression and economic decline? Will these forces be most prevalent in developing countries, reducing the standard of living?

Economic performance not only affects the standard of living, but can also affect population growth by changing variables such as income per capita and the levels of education, public health, and family planning. Modeling population growth as an exogenous process, as in Globus but unlike in World3, precludes the possibility of population being affected by the outputs of other parts of the model, "throwing the baby out with the bath water," or, in other words, defeating the purpose of capturing population–globalization interdependencies. The size of national populations may also change due to migration. Will the current migration from developing to developed countries expand in the future? Will these migrants consist mainly of educated people relocating legally from poor to rich nations, or will they consist mainly of poor people entering the rich world illegally to work in labor-intensive jobs? What will be the effect of the out-migration on the countries that they leave?

Another issue of population dynamics has to do with the fact that today the share of elderly people in rich countries is on the rise – a so-called population implosion. Will the rich nations face labor shortages and growing dependency ratios in the future? What will be the effects on the required spending on health care and welfare services? In poor countries, in contrast, the population is both growing and much younger on average. Will the population implosion in rich countries and the population explosion in the poor countries intensify migration of young people from poor nations to rich nations? What will be the effects on the poor nations?

Consider next the environment and its potential interaction with globalization in the future. World3, we recall, suggests that the environment will play a critical role in the future, which raises a number of questions. For example, how will the state of the environment vary across nations as globalization expands? Will the global environment deteriorate overall, as the economic system continues to grow due to globalization? The state of the environment may also affect the economy itself. World3 predicted a global economic collapse in this century, illustrating the possibility of limits to economic growth for a system facing a finite carrying capacity. However, perhaps globalization will alleviate these limits by raising incomes following the logic of the environmental Kuznets curve, according to which richer people prefer to live in a cleaner environment. Must the effects of rising pollution and land degradation on agriculture, and the effects of declining resources on industry be as bad as in World3?

The environment may also be a factor in the global distribution of industries and wastes that damage the environment. Industries such as mining; paper and pulp; chemicals; cement; and quarrying, are notorious polluters. There are reasons to believe that at least some of the more damaging industries are migrating to poor countries. Will this tendency grow in the future, or will the distribution of clean industries become less skewed? A related question can be asked about toxic waste: how will the distribution of these materials evolve over time? Will the rich nations send their toxic wastes to poor nations?

Issues involving food, water, and energy seem particularly vexing, and they raise many questions. Much of the water that we return to the biosphere is polluted, and many aquifers are used unsustainably. Will the price of water rise sharply in the future, as demand outstrips supply, making desalinization of sea-water economical? Will all nations be able to afford this expense?

Observing that even diets based on meat and dairy are based on the environment, since domestic animals eat grain; and noting that poor nations seek to grow economically, will there be enough food to feed the world the American diet if other countries begin to demand it? Much will depend on technological innovation, particularly for energy. The coming years will probably exhibit a transition from fossil fuels to alternative energy sources. Will energy prices rise sharply as the supply of fossil fuels diminishes, or will the transition to alternative sources be smooth? One may also wonder whether the new energy sources can carry the day for the world economy. If bio-fuels, wind power, and solar radiation become our major energy sources and their utilization requires large areas of land, what will be the effect on agriculture?

Deteriorating environments may also have socio-political effects. For example, economies may decline because of depletion of critical non-renewable resources such as oil or iron if innovation and substitution fall behind. Will nations work together to manage the shortages, or will they resort to force in order to obtain scarce resources? Abundant resources may also promote conflict, serving as a source of income. Will political conflicts intensify if the global economy falters due to climate change, and, if they do, what will be their geographic distribution? Severely degraded environments may also cause out-migration, particularly when people depend on the environment for their livelihoods. Will such migration intensify in the future due to climate change? Can it lead to conflict between migrants and residents in the host area? Will most of these movements involve people in poor countries? At the same time, perhaps globalization will alleviate pressures. For example, globalization may promote industrialization, reducing dependencies on the environment.

Democracy is yet another force to consider. We know that democracy promotes bilateral trade and FDI flows, but its role in economic growth is not clear. It is clear, however, that economic development promotes democracy. As globalization progresses and income increases, will the spread of democracy slow down environmental degradation? For example, people may elect leaders that favor environmental quality even at the expense of economic slowdown. Alternatively, will democracy expand as people demand to have a larger say in managing impending environmental crises, or will the level of democracy shrink as people direct their energies to surviving in a deteriorating environment?

The interaction of economic and socio-political forces raises additional questions. For example, will the people whose standard of living declines because of globalization organize politically within and across nations and demand the slowdown of globalization? Can the level of democracy decline because the winners from globalization try to forcefully prevent such a move? Will international and intrastate relations improve as economic globalization expands, leading, for example, to global disarmament and reducing the incidence of civil wars? Or, alternatively, will nations and societies try to channel economic gains from globalization to acquiring arms, prompting others to do so as well, increasing tension and the likelihood of war?

Since the gains from globalization may vary, the global distribution of power may also change. Will the future world system be unipolar, bipolar, or multipolar? What will be the effect of radical technological innovation in China, for example, energizing the already bustling Chinese economy? Will the US leadership decline, giving way to a rising China? Will the transition be violent? What will be the implications for democracy and economic openness? Will the new Chinese knowledge diffuse to other nations, or will China guard it closely, seeking to maintain its advantage? If the innovation diffuses, will it reach only the rich countries? Still the future may not exhibit a radical breakthrough, but rather the incremental improvements envisioned by neoclassical economics. What are the implications of this scenario for systemic leadership?

We have accumulated many difficult questions for our world model, but even more questions could be raised. No one really knows the future; no matter how detailed our world model, it still will be a model reflecting our interpretation of history and the assumption that it can tell us something about the future. However, world models can offer more than forecasting. They can also provide us alternative scenarios, depending on the assumptions we are willing to make, and allow us to evaluate interdependencies, given these assumptions. In fact, given the complexities of globalization, it would be next to impossible to say anything about these interdependencies without a world model, unless one is willing to approach the problem by parts, employing the synthetic principle of *ceteris paribus* (all things being equal). This principle, however, is not useful when interdependence is the defining characteristic of the system to be modeled.

Should we decide to answer these questions and others by way of developing a world model, we will likely not be able to capture all of these processes correctly at first, and we may well require much iteration before concluding that we got it right. A project focusing on forecasting globalization by means of developing a world model is better thought of as a long-term investment, which improves the model based on the endless unfolding of history. As the famous Niels Bohr saying goes, "prediction is always very difficult, especially about the future."

Acknowledgment

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Notes

1 For additional definitions of the meaning of globalization, see, for example, Sklair (1999), Woods (1998), and Farazmand (2006).

2 World3/91, the model version used in Meadows *et al.* (1992), has 149 equations, 272 variables (of which 96 need initialization), and 508 parameters.

3 Meadows *et al.* (1974) explain the considerations driving each equation, and the default values chosen for the model's physical limits, initial conditions, and parameters.

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18 Evolution, modernization, and globalization

A theoretical and mathematical model

Jürgen Klüver and Christina Klüver

Introduction

Marx and Weber founded the classical universalistic theory of modernization, which postulates that processes of modernization will become a global phenomenon as a result of the universal distribution of industrial capitalism. Marx, as is well known, explained this process as the result of the development of the forces of production as the driving factor of the emergence of bourgeois societies. Weber described the same process as being that of secularization and rationalization. He did not deny the important role of the forces of production, but he assumed a more complex process, i.e. a interdependency between the basis and the superstructure of societies (cf. for example his analysis of the influence of Protestantism on modern capitalism in his famous work *The Protestant ethics*). Despite the theoretical differences between these viewpoints, they and their followers held a common assumption, namely that the processes are universal, i.e. they will assimilate all other non-Western societies into the same evolutionary pattern.

In a strict sense, Weber and Marx did not invent that assumption, but inherited it from the European Enlightenment (Trigger, 1998). The theorists of this epoch claimed that the specifically European form of development was a model for all other societies, in the sense that sooner or later all non-European societies would develop in basically the same way as European ones. Therefore, the Europe of the Enlightenment could be considered as some sort of paradigm for all other societies, which accordingly could be characterized as earlier and less-developed phases of the European Modernity.

Of course, this point of view, which may be recognized as one of the first formulations of Eurocentrism, was soon opposed, mainly by the philosophers of history from the Romantic period, such as Herder. These philosophers assumed that each culture can be understood only as a unique form of human achievement, and that it is impossible to compare different cultures. In particular, it is not possible to understand different cultures as earlier or later manifestations of the same universal evolutionary schema. This dichotomy of "universalistic" evolutionary thinking versus a more "particularistic" one, is still important for contemporary views on human history.

In this chapter it will not be possible to analyze the arguments for and against these opposing schools of thought (cf. Klüver, 2002). Yet, when we discuss the logic of sociocultural evolution, and accordingly propose a theory, formulated in terms of a specific algorithmic schema, we must take into account the undeniable fact that the process of globalization is certainly an immediate result of the development of European Modernity: at that time only Europe was experiencing the emergence of those societies that are characterized by capitalism, modern science, and a particular form of parliamentary democracy, based on the *political* declaration of human rights. One may call this kind of society "modern," "capitalistic" in the tradition of Marx, or "functionally differentiated" in terms of social systems theory (Habermas, 1981; Luhmann, 1984). Therefore, modern Western culture as a product of European development must be seen as the driving force of globalization. An acceptance of this fact is unbiased by Eurocentrism.

Although the roots of contemporary globalization processes are indisputable, the specific ways in which different cultures will be affected by them are the subject of many arguments. The universalistic theory of Marx and Weber assumes that all cultures will go the Western way, with the emergence of an autonomous capitalistic subsystem, Western political institutions, and the like. We shall present some opposing theories below. But, in order to deal with the question of how globalization will probably manifest itself in political, economic, and other social fields in different cultures, we have first to ask how sociocultural evolution, i.e. human history, can be analyzed in a *scientific* way, which means basically a mathematical one. Only if it is possible to detect some evolutionary logic in historical processes will speculations on the future become more than pure guesswork. Accordingly, we shall start with the question of how the general logic of theories of sociocultural evolution must be characterized; subsequently, a general theory of sociocultural evolution will be presented. Finally, in the last section of this chapter, we will ask whether this theoretical model is capable of even very preliminary and cautious speculation about the future of globalization.

The logic of evolutionary theories

In a general sense, human history is nothing other than a special kind of evolutionary process, although an extremely complex one. Therefore, the logic of theories that intend to explain general features of historical processes should be of the same kind as that of evolutionary theories in general. In particular, if such historical theories are to have some explanatory power, then the approach of time-series analysis will not be sufficient, because such an approach remains, by necessity, at a phenomenological level. Hence, the task of constructing theories to explain historical processes is twofold: on the one hand one has to look for the level on which causes for historical phenomena may be found, and on the other hand one has to decide by which logical and/or mathematical structure such theories must be characterized. In this section we shall first deal with the second question and then with the first one. Subsequently, in the next section we will present an appropriate theory, based on a specific mathematical model, called the "Socio-Cultural Algorithm" (SCA).

The physicist John Barrow (Barrow, 1991) once asked whether "the Universe is a structure or a program." As was to be expected, his answer is "both": "Structure" refers to universal and time-independent characteristics of the universe, usually represented by general equations in a time-invariant form. "Program" refers to the evolutionary aspect of the universe, i.e. the question not only of its origins, but also of the driving forces of its evolutionary development. As "program" in a mathematical sense means "algorithm," Barrow's question is whether mathematical theories of the universe should be represented as general systems of equations, or by equally general algorithms. Obviously, this depends on the particular *Erkenntnisinteresse* (Habermas), i.e. the specific questions that one wants to answer using a mathematical theory. Therefore, it is not by chance that in theoretical physics, and in particular in cosmology, the use of computer programs, i.e. the algorithmic formulation of physical processes, has become much common.

Evolutionary theories hence can be best mathematically formulated by the characterization of the specific algorithms that represent the driving forces of the developmental processes. The most famous example of such evolutionary algorithms is the modern synthesis of biological evolution, with its "genetic algorithm" of variation and selection (cf. Dennett, 1996). Accordingly the basic logic of this evolutionary process soon became the paradigm for a mathematical model, namely the well-known genetic algorithm of John Holland (Holland, 1975). Other prominent examples are Marx's theory of historical materialism, i.e. the driving force of the development of the forces of production (*Produktivkräfte)*, and the developmental theory of Piaget, i.e. the mechanisms of assimilation and accommodation (cf. Klüver, 2003).[1] A mathematical theory of human history, which means a theory of sociocultural evolution, should contain at its core an appropriate algorithm.

When defining the basic level of theories of sociocultural evolution, one has to remember the truism that history is produced by human beings. Yet they do so not as specific individuals but as *social beings*, i.e. as social actors who occupy a certain social role. In this fundamental sense, the level on which causes for social processes must be looked for is the level of social actors and their actions according to their specific social roles. A social role can be understood as a pair (r, k), if r means the social rules by which the role is characterized and k means the role-specific knowledge. A medical doctor, for example, must obey specific social rules, defined in the famous oath of Hippocrates, and has at his disposal the medical knowledge concerning certain diseases and the according therapies. More general, if we define a society as a pair (S, C), consisting of a certain social structure S and a certain culture C as the set of all accepted knowledge, then a particular social role is a subset of the pair (S, C). Thus, we obtain an explanatory definition of sociocultural evolution: It is the changing and creation of social rules by means of changing and enlarging the role-specific knowledge and the corresponding sets of social rules (cf. Klüver, 2002), which on a macro-sociological level means the variation and enlargement of (S, C). The driving force of sociocultural evolution, therefore, is the enlargement of knowledge and the corresponding variation of social structure, i.e. social rules, by the creative thinking and actions of social actors. The fundamental assumption behind these definitions is the fact that the emergence of social roles increases the efficiency of a society via specialization with regard to certain tasks. In the words of Habermas (Habermas, 1981), the generation of new social roles increases the steering capacity of a social system.

By defining "social role" as the conceptual unit of theories of sociocultural evolution, one has to take into account an important distinction: on the one hand there are "creative" or "technical" roles, respectively, and those who occupy these roles are responsible for the cultural development. Such roles are, for example, those of technicians, artisans, artists, merchants, and scientists. On the other hand, there are "cultural" roles, like those of priests and politicians. The corresponding "occupants" of these roles are responsible for the maintenance of culture, from Parsons' famous definition of the L-subsystem, and they operate in a more conservative way. It seems rather obvious that the developmental chances available to a society depend on the sociocultural relationships between those two types of roles. If, for example, the cultural roles inhibit the occupants of creative roles in a strict fashion, then no permanent sociocultural evolution is possible. If, on the other hand, the occupants of creative roles are rather autonomous with respect to the influence of the cultural roles, then a continuous cultural development is possible. The first case is characteristic, e.g. for feudal Chinese society or the Islamic societies during the Middle Ages – i.e. both cultures grew and "blossomed" for a certain time, before they stagnated and ceased to evolve. The second case is the main feature of Europe after the Reformation and Enlightenment, that is after phases where the occupants of creative roles managed to obtain more freedom from the Catholic Church and the feudal political powers. The famous case of Galileo and the attempts of the church to oppress his scientific ideas was just one example of the difficulties of these processes.

A sociocultural algorithm

On the basis of the above-mentioned considerations we, together with Jörn Schmidt, constructed an appropriate simulation program, whose theoretical and mathematical core is the so-called sociocultural algorithm (SCA). The occupants of certain roles are represented by cells on a grid. These artificial actors can learn from one another and can also generate new ideas. However, the occupants of cultural roles can inhibit the production of new ideas, for example, they can forbid the creation of new world views or of new technical inventions, as the ruling Mandarins did in feudal China. Therefore, the decisive evolutionary factor in our model is the so-called EP-value: EP means the "evolutionary parameter," which is computed by the ratio of the cultural and creative roles. Roughly speaking, the computation is done in the following way: the artificial occupants of certain social roles are connected on the grid via "weighted" connections, comparable with the structural logic of artificial neural nets. If, for example, an occupant A of a creative role has the connection value $w(A, B) = k$ to the occupant of a cultural role, if $w(B, A) = m$, and if $k < m$, then B has influence on A, but not vice versa, or respectively A cannot influence B to the same degree as B influences A. In this case, B hinders the ability of A to create new ideas, i.e. to enlarge the culture of the respective society. The whole EP-value of the artificial society is given by the arithmetical mean of all connection values $w(B, A)/w(A, B)$, if A is an occupant of a creative role and B of a cultural one. If EP is small, then the occupants of creative roles are free to produce new ideas and vice versa. More details concerning this model and the historical arguments supporting it can be found in Klüver (2002).

The driving force of cultural development in this model is, therefore, the possible enlargement of role-specific knowledge and hence the enlargement of the whole culture; or stagnation because of overly strong inhibitory factors coming from the occupants of cultural roles. Moreover, the larger the increase in knowledge accorded to the creative roles, the smaller the inhibitory forces exerted by the occupants of the cultural roles. In other words, a certain social structure, represented by the values of the evolutionary parameter, determines the cultural development; conversely, the development of the culture determines the changes in the social structure, which will in turn again determine the development of the culture, and so forth.

A historical comparison between, for example, feudal China and the Islamic societies at the Middle Ages on the one hand, and medieval Europe on the other hand, confirms that general assumption: Both China and the Islamic societies were much more developed than medieval Europe. Yet both cultures stagnated, i.e. they became caught in a "cultural attractor," whereas Europe, in the process of the Reformation and Enlightenment, unfolded an evolutionary force that lead to the emergence of modern Western culture. The explanation is that in China the ruling Mandarins (cultural roles) successfully hindered the activities of the artisans and early scientists (creative roles) (cf. Needham, 1970); in a similar sense the homogeneity of Islamic culture stalled cultural development, due to the dominant role afforded to Islam (Klüver, 2002). In contrast to that, even medieval Europe was characterized by a rather high degree of autonomy for the creative roles, an autonomy which was politically established by the relative freedom of the large trading towns, organized, for example, in the Northern *Hanse* or the league of the Flemish cities.

The evolutionary parameter EP has another important characteristic. Even in medieval Europe the degree of role-autonomy, measured by the according EP-value, was initially not small enough to generate the sociocultural evolution that in the end led to European modernity and contemporary Western culture. The specific European development can only be explained by assuming that the initially favorable EP-values started an evolutionary process that caused a variation in the initial EP-values themselves. In other words, initially favorable EP-values generate a process by which the EP-values decrease. This logic of evolutionary processes may be called "an evolution of evolution."

We were able to confirm these theoretical hypotheses concerning the relationship between different types of social roles by demonstrating that in most of the simulation runs of the SCA-model the evolutionary process stagnated because of unfavorable initial EP-values. That is indeed the case in human history, as the great British historian Toynbee noted in his monumental work (1934–61). Only in the few cases with favorable EP-values did the process of cultural development continue. Figure 18.1 shows a typical "Toynbee development," and Figure 18.2 a development that is characteristic of the evolution of modern Western culture.

Note that neither process is a linear one. The second picture demonstrates an expected occurrence of part-time regressions and stagnation (see below). However, with respect to the evolutionary parameter, there is a certain caveat to take into account. Favorable EP-values are necessary *per se*, but not always sufficient for unhindered evolutionary development. The evolutionary parameter characterizes an *internal* driving force, which under "normal" environmental conditions enables a society to evolve in the way just described. Yet external causes like wars, climate change or the exhaustion of material resources may nevertheless hinder or stop evolutionary processes. In our simulation runs, we assumed normal environmental conditions, in the sense that only the internal social factors should be taken into account. The history of development from medieval Europe to Western Modernity shows that this assumption is also valid for the only historical case where the sociocultural evolution to modern societies took place. It is a question for historical research

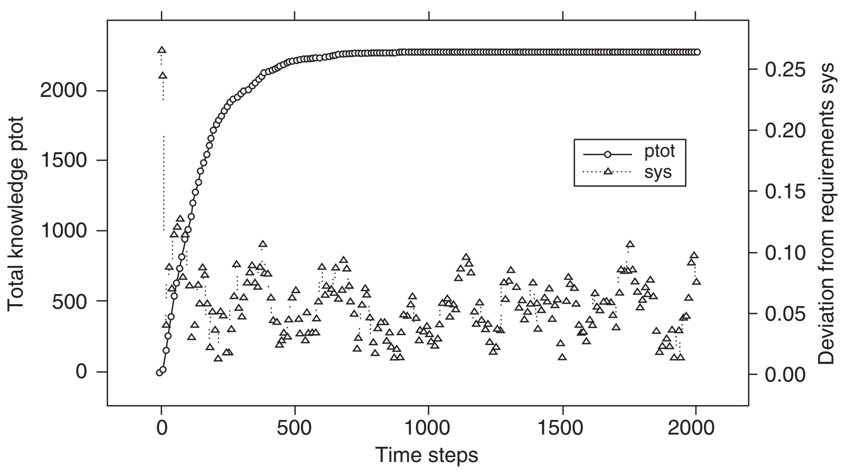

Figure 18.1 A Toynbee development.

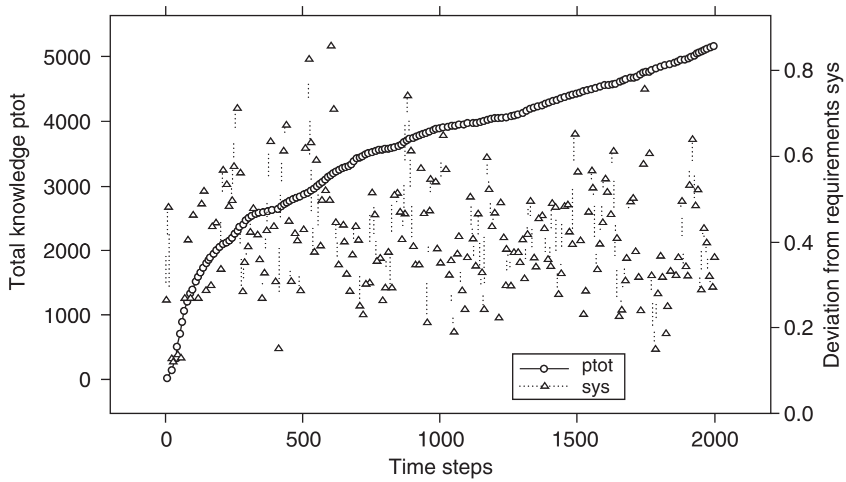

Figure 18.2 Development that is characteristic of the European Modernity.

whether perhaps the stagnation of cultures like feudal Japan was due to certain external factors, although we doubt it.

To be sure, simulations *per se* are not sufficient to prove the final truth of a theory on sociocultural evolution. Yet our sociocultural algorithm demonstrates not only the satisfactory possibility of applying mathematical tools to historical processes, but also the soundness of the above-mentioned theoretical and meta-theoretical considerations.

Although the basis of the theoretical considerations and the model is at the level of social roles, which means a micro-sociological level, the SCA model is still a certain form of macro-model. The artificial role occupants are modeled as "finite state automata," which means that they are defined by certain states and the changing of these states. That is in particular the logic of cellular automata (CA), and the SCA is mathematically a generalized CA. To overcome this deficiency, we have enlarged the SCA by adding another level to it, namely the level of *cognitive development of the artificial actors*. By this enlargement the SCA becomes a "sociocultural cognitive algorithm" (SCCA).

We can, of course, only give a rough sketch of this enlargement (cf. for more details Klüver *et al.*, 2003). The individual actors as role occupants now consist of a combination of two different kinds of artificial neural nets, namely so-called bi-directional associative nets (BAM), and a self-organizing map or Kohonen feature map respectively. The task of the BAMs is to receive certain characteristics of objects from their physical and/or social environment, that is from other more experienced actors, and to associate these environmental signals with the corresponding concepts. For example, if a child sees a small animal that has four legs, a furry coat and makes a meowing sound, it has to learn that the name or concept respectively for this object is "cat." The same learning process is valid for the neural nets. After certain training runs the BAMs are able to recognize signals that they have already learned some simulation steps ago, and are able to associate them with the corresponding concepts. Conversely, the BAMS are also able to associate the initial signals when they obtain the corresponding concepts from their environment.[2]

The task of the Kohonen map is the ordering of the different learned concepts into a semantic net. Kohonen maps belong to the type of so-called non-supervised learning neural nets, and learn according to a certain interior logic. To put it into a nutshell, Kohonen maps transfer semantic relations between concepts, characterized by the characteristics of the according objects, into geometric ones. In other words, the concepts will be clustered by the map, with certain key concepts as the center of the clusters. If, for example, a child has learned to associate "cat" with characteristics like "small, meowing, four legs, furry," and to associate "dog" with "large, furry, four legs," then the child as well as the Kohonen map will cluster "cat" and "dog" together, in contrast to "bird" which has characteristics like "feathers, two legs, wings." Readers who are acquainted with the cognitive theory of prototypes (cf. Lakoff, 1987) will immediately perceive the similarity between this theory and the procedure of the Kohonen map.

For visualization purposes, we show two figures (Figures 18.3 and 18.4) that give an impression of the operations of the SCCA; the transition rules of this enlarged model are basically the same as in the simpler version of the SCA.

Figure 18.3 shows the transition of the initial cellular automaton grid into the grid of a Boolean network. This transition represents the development of an initially homogeneous social structure, i.e. the principal social equality of all members of the society, into a stratified social structure. Social actors become different because some actors acquire more knowledge in a certain time. In addition, actors have only a finite life span, which means that "dying" and being newly "born" generate "young" actors who are socially inferior to

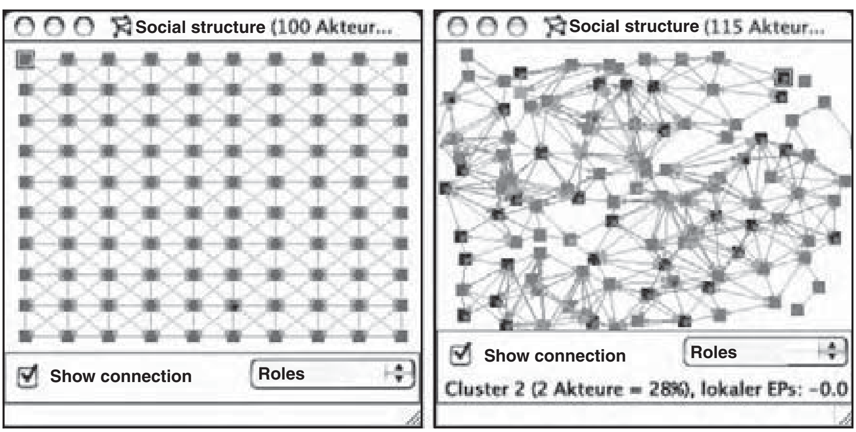

Figure 18.3 Transition of a cellular automaton into a Boolean net.

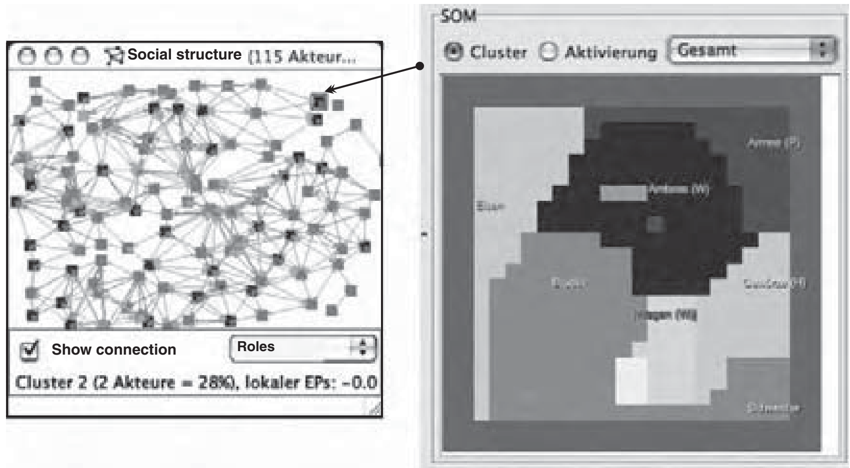

Figure 18.4 The "inner state" of an artificial actor.

the older ones because of their superior knowledge. A Boolean network is able to model such processes of social differentiation.

Figure 18.4 shows the cognitive state of a specific actor, i.e. the actor who is marked on the left side (the grid of the Boolean net). The actor has obtained some knowledge in the form of different concepts, and has clustered these concepts, that is, he/she has generated a certain form of semantic order. It is interesting to note that results of the model runs show negative consequences for a culture where much of the knowledge is already at the younger actors' disposal. If that is the case, then the younger actors only take over knowledge that the culture has already acquired, and they do not become creative, i.e. they have no time to invent new ideas. As a general result, the culture becomes static and stagnates.

The simulation runs of the SCCA were performed with different numbers of artificial actors – remember that each actor consists of several BAMs and at least one Kohonen map. It is worthwhile noting that the simulation results were basically the same with about 100 actors and with about 10^6, i.e. a million actors. Because the developmental paths of the different artificial societies are the same as in the simulation runs with the SCA, we do not provide any new pictures. Yet the fact that the results of the SCA are the same as those with the enlarged model is a strong indicator of the validity of our models.

Rivals to the universalistic theory of modernization

At the beginning of this chapter we mentioned that the classical universalistic theory of modernization is by no means undisputed. On the contrary, in the last decades several competing theories have emerged and gained popularity among sociologists who deny the postulate of a uniform path to modernization as a consequence of globalization processes. We will present just a few of these and discuss their advantages and deficiencies.

Most prominent, particularly outside the scientific world, is the *culturalistic* theory of Huntington's *Clash of civilizations* (Huntington, 1996): At its core, this theory has the postulate that cultural factors, in particular religious ones, hinder the ability of traditional, e.g. Islamic or Hindu, cultures to evolve like the Western model. These societies stop modernization processes before all the important social domains are modernized, and thus remain in a state of partial modernization. In other words, such societies will become cultures consisting of a mixture of components that are modernized according to the Western tradition and traditional components where the pre-modern world-views, i.e. religions, still dominate social life. Huntington's famous consequence is that, as a result of these only partial modernization processes, the different civilizations will "clash."

Recent global terrorism, as far as it is inspired by religious causes, and in particular the destruction of the World Trade Center on 11 September 2001, are strong arguments for Huntington's analysis and predictions. Yet the main problem with this approach is that it almost totally neglects the role of economic factors and the resulting social developments. After all, globalization is not only an economic process, and neither Islamic nor Hindu societies will be able to escape the consequences of the emergence of a global world economy. In addition, even if the thesis of partial modernization is correct, the interaction between different civilizations will not necessarily be an aggressive one. The weakness of Huntington's theory is the concentration on purely cultural factors, and in particular on the role of religion. Yet the whole theory is not validated by other factors, and it neglects the development of different societies with respect to other important social domains outside religion (see below). From an empirical point of view, Huntington's theory is not much more than an educated guess.

Another well-known example is Eisenstadt's *theory of multiple modernities* (Eisenstadt, 1987). According to such theories, industrial capitalism may indeed become the dominating form of economy, but this purely economic globalization process does not necessarily lead to sociocultural development like that of Western modernization. On the contrary, each specific culture will develop a special form of modernity that will differ from the Western model in particular aspects.

To be sure, if one looks at the numerous countries and cultures that recently have been affected by globalization processes, one will find rather different developmental processes and, in addition, one has to admit that the specific cultural and political traditions of a country generate rather different roads to modernization. In this sense, the theory of multiple modernities can cite a lot of single examples in its favor. Yet the main problem with this approach is a conceptual one: it is very difficult to define the term "multiple" in an operationalized sense so that all scholars could agree when a specific modernized culture is "really" different from the Western model or when it is nothing other than a variant – i.e. different but still orientated toward the Western paradigm. In other words, what are the crucial factors that enable us to distinguish between important and unimportant differences?

Sometimes the proponents of the multiple modernities theory seem to overlook the fact that even in Europe the modernization processes did not occur simultaneously or in the same way. For example, in England the modernization process started much earlier and took a specific path. However, the same processes started much later in SW Europe, hindered by the strong influence of the Catholic Church, and they were even stopped by the emergence of fascist regimes. The same can be said about the modernization process of Germany.[3] The uniform character of contemporary Western modernity is the result of rather different paths that in the long run converged. Yet, even today, modernity in the different European countries and the North American ones is not literally the same. Therefore, the different paths of development that one can observe in the different countries of the world may indeed obtain the same result in the end: forms of modernity that are of course not literally the same everywhere but that are variants of the Western model.

We will omit the discussion of *racist theories*, like, for example, Sarich and Miele (2004), which claim that cultural differences have their roots in biological differences between the various human "races." Genetic biology has for some time proven the genetic homogeneity of humankind, which makes it quite absurd to speak of different human *races* at all.

What all of these different theories of modernization have in common is that they deny the probability of a uniform result of modernization. This is true even with respect to racist theories: biological differences, if they exist at all, do not vanish or only disappear in the long term. Therefore, the emergence of different cultures is a biological necessity. In contrast to such views, the universalistic theory of modernization assumes, as we have emphasized, that by the universal export of capitalistic forms of economy, sociocultural changes will occur in literally all countries after the paradigm of Western modernity. The main question, therefore, is whether globalization means just adopting capitalist forms, or whether the respective societies will be also be changed at the level of their cultural and social "superstructure" – to quote the famous term coined by Marx.

Of courses, at the moment no one is able to predict the final future of globalization and modernization. Predictions are always difficult, in particular if they refer to the future, as the great physicist Niels Bohr once remarked. Yet it is possible to look for indicators and theoretical arguments that favor one of the competing theories. We shall first give some empirical data and will subsequently introduce a methodical proposal.

Data and methodical procedures

The European and finally Western process of modernization is characterized by certain criteria that are all indicators of the unfolding of modern development.

If one takes the same criteria and observes the corresponding developmental processes in different countries, one can detect interesting similarities. Here we will present only some of these criteria; a more detailed and comprehensive analysis of these data can be found in, for example, Oesterdiekhoff (2003).

Among other factors, the Western modernization process was and is characterized by certain processes of change in the sectors of economic, political, educational, and gender equality. If one looks at the corresponding developments in countries on the path to some form of modernization, one can detect astonishing parallels to Western history:

- The economic relevance of the agrarian sector decreases in all developing countries, even in Africa; while the industry-based economy increases in importance. It is a truism that the rise of industrial capitalism in Europe and North America means just this.
- The same trend is valid for urbanization processes: in all developing countries the percentage of the rural population decreases, in contrast to the emergence of very large cities. That of course was the same in Europe and North America.
- Despite the problem of overpopulation in most of the developing countries, birth rates nearly everywhere are steadily declining – the same effect has been observed in the West since the nineteenth century.
- The mean age of women at marriage is continuously increasing, which is certainly one cause of the decline of the birth rates. This situation is the same as in Western countries. In particular, it is an indicator of an increasing degree of female autonomy, because women are less dependent on marriage policies by their respective families.
- Despite some permanent setbacks to the democratic development process, on average the number of democratic or "semi-democratic" societies is increasing. As "democratic" mostly means an orientation toward the Western form of parliamentary democracy, such countries apparently follow the Western model.
- The degree of literacy and the numbers of participants in higher education are increasing in most countries. It is superfluous to emphasize the importance of such achievements to Western modernization.

All of these trends refer to the last 50 years. To be sure, other factors could and should be mentioned, but even this selection gives a fairly clear picture. Even politically regressive processes like, for example, the rise of Islamic theocracies are predictable. One needs only to remember the equally regressive fascist movements in Europe or the periods of stagnation in SW Europe.

As a preliminary summary, we may state that these data indicate that Marx, Weber and the other proponents of the universal modernization theory were right. At least, the data are more compatible with the universalistic theory of modernization than with its rivals.

The theoretical foundation of our mathematical models, as we have explained, is the assumption that sociocultural evolution is dependent on an increasing degree of role-autonomy in the important societal domains. In particular, this assumption can easily explain why the processes of modernization only emerged in Europe, before becoming the core of Western culture, and before the resulting globalization processes affected practically all non-Western countries. If these theoretical and mathematical assumptions at the heart of the SCA are correct, then the question of the validity of the universalistic theory of modernization, i.e. the question of the final sociocultural character of globalization processes, can be analyzed in a twofold manner.

On the one hand, empirical investigations should be carried out with regard to the degree of role-autonomy in the respective developing countries. The numerous empirical data available indicate that there is indeed a growing trend in favor of increasing role-autonomy. As an example we refer once again to the data about gender roles and the rise of higher education. The first set of data indicates that the social role of women becomes more autonomous, and the second set of data indicates that education emancipates itself from traditional ties like religion and pre-modern political dependencies. In this context, we need only note the importance of women's rights and the introduction of universal education for all children in Western countries.

On the other hand, such data can be inserted into simulation programs like SCA or SCCA, in order to give some rough predictions about the probable development of these countries. To be sure, even such micro-sociologically based simulation programs can give little more than predictions about probable developments. However, this is still more than pure guesswork and/or wishful thinking, determined by emotional biases.

Notes

1 Readers who are acquainted with the usual description of the theories of Marx and Piaget may find it a little strange that we call these theories "algorithmic." Yet both theories stress the factor of evolution and the driving forces of these evolutionary processes. In a mathematical way, which of course was beyond the range of both theorists, this fact means that they are as algorithmic as the theory of biological evolution. It is certainly not by chance that Marx (as a contemporary of Darwin) and Piaget (as a trained biologist) both chose the same form of theory construction.

2 Because the BAMs can associate in two directions, they are called *bi*-directional.

3 We are reminded of our mathematical model, where the developmental curve also shows phases of stagnation and even slight regression. Such non-linear paths are probably a necessary aspect of complex dynamical systems.

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Part V

Assessment

19 Assessment

What have we learnt?

George Modelski, Tessaleno Devezas, and William R. Thompson

"That's a no-brainer!" Johan Goudsblom declared in our meeting at IIASA, in Laxenburg, Austria, in 2006, when at the opening session he pondered the inquiry that lies at the heart of our concerns: "Is globalization an evolutionary process?"

Indeed, if you come to think of it, such a conclusion might appear to be obvious. We know that humanity is much more numerous, and also more productive than it was, say 1,000 years ago; and it is also more densely connected than it was then, as well as more fully institutionalized, particularly at the global level. In other words, it is also significantly more "globalized." It is therefore a seemingly straightforward conjecture that such a condition might well be the result of a process that could be described as evolutionary. But that is easier said than conclusively demonstrated, and it is much less obvious how we might sustain such an argument so that it satisfies all its proponents and detractors, and so that it shows how the search and selection processes were carried out. What has the search been about? What was being selected? These remain the central questions. At this point the inquiry turns out to be more complicated, and becomes important to compare our models with other models of global change. The present collection of studies in this volume is an elaboration on that theme.

A scholarly meeting is a structured encounter lasting a few days, in the course of which views are exchanged, and it may last just a few days (no more than four days of contact in our case), but such a conference is the focal point of a web of activities that might extend over three years or more: from the conception and formulation of the problem, and the writing of a grant proposal; through to the invitations to the prospective participants; meeting briefly, but intensively selecting the best ideas; and then dispersing again to finish writing up the work (which might differ significantly from what was originally proposed), with the refined ideas ending up in a book that embodies the results of this learning process.

We shall review the results of this learning process in three parts: the first will define the distinguishing characteristics of our approach to globalization; the second will present an overview of the contributions, and in the third we will ask: what have we contributed to the understanding of this complex process?

Is it different?

Over the past decade, globalization has been a rapidly expanding field of thought and action. Scholars analyze it, and political leaders and commentators employ its terms in their arguments. We wish to emphasize two distinguishing features of the present venture as compared with the literature: its multidisciplinary scope, and the attention that it pays to the spirit and the methods of the social sciences.

Globalization is multidimensional, and approaches to its study must cast a similarly wide net among the social and allied sciences. This means that authors come from a variety of disciplines, and a number of regional contexts. We have definitely avoided the economists' tendency to view globalization primarily through the prisms of trade or finance. We also have a strong group of political scientists, but all of them approach their topic in a multidisciplinary spirit. Neither do we neglect the world economy, seeing that the information sectors are a primary driver of recent developments. Anthropology, sociology, and history are also represented. All contributors show a strong interest in the long-range study of global change.

Second, our approaches have been basically social-scientific in method. We are self-conscious about the theoretical issues that have been raised in the literature, and we try to deal with them (e.g. **Modelski**, in Chapter 2 and **Attinà**, in Chapter 6). We are sensitive to conceptual issues, but we also lay emphasis on data (e.g. **Thompson**, in Chapter 4 and **Hughes**, in Chapter 16), and the need to test theories against these data (e.g. **Turchin**, in Chapter 8). In one instance, we even reproduce an entire data set used in our analysis (**Devezas and Modelski**, in Chapter 3). We cultivate models, and we even aspire to simulating these processes (e.g. **Hughes**, in Chapter 16 and **Reuveny**, in Chapter 17) and we appreciate being able to try out new mathematical models (e.g. **Korotayev**, in Chapter 7 and **White** *et al.* in Chapter 9). World system theories in particular need to be confronted with the reality of earthly processes, and we lay great stress upon our need to do that.

A notable strength of our volume is the use of modeling. Most of the chapters use some degree of formal representation of the process that we are investigating (one contributor, **Hakken**, in Chapter 15, has expressed reservations about it). Most of these are also models of long-range processes (global political evolution, world population growth, and the shape of the world city system) hence they do have implications for simulation and forecasting. But we have less to say in those fields than we had hoped.

The unit of this analysis has been almost uniformly global (concerning the planetary or interregional interactions among humans). It might be global political institutions, world trade, world population, world models, or the Internet. In all such cases the vision is broad, and it is cast in earth-spanning ways.

And what is substantively new?

Our substantive findings lend themselves to the following two conclusions:

1 globalization is a powerful, long-range trend that is not easily reversed or aborted; and
2 explanations of globalization are far from settled, but an explanation based on evolutionary learning appears to be plausible.

A powerful trend

Globalization has been the formative process of the modern age, and it is unsurprising that we have no trouble confirming that it has been a powerful trend, or "mega-trend," and that is likely to continue well into the future. It is a millennial process that has been the modern face of world system evolution, and as **Modelski** argues in Chapter 2, it now has 1,000 years of experience behind it. It first became evident in the early success, and rapid collapse, of the experiment of the Mongol world empire and, ever since, one of its main themes has remained what Barry Gills (2005) recently called "the clash of globalizations": the competition between empire and the idea of a world democratic organization (that he refers to as a "cosmopolis"). His 1,000-year concept of globalization is not contradicted by most of the contributions, even though the actual construction of the global system that is the foundation of the contemporary structure is widely thought to have taken off seriously only around 1500, as documented *inter alia* in **Devezas and Modelski** (Chapter 3), and **Thompson** (Chapter 4). A trend of such durability cannot be anything but powerful.

The second reason for taking it seriously is its hold in the world of ideas, and world opinion. What is still the best source for the events of the Mongol enterprise, *History of the World Conqueror*, by the Persian historian Juvaini writing in *c*.1260, demonstrates how one idea of world organization was taking on one particular stage. Maybe it was the construction of the first (known) globe (made by Martin Behaim in Nürnberg in 1492) that served as the conceptual underpinning for an alternative global system. Or maybe it was attributable to Flemish mapmakers following the lead of Mercator. Competing ideas of world order have continued to shape the course of global organization.

Lastly, the trend is powerful because it expresses and summarizes in a nutshell much of the innovative thrust that has characterized the modern world, including the emergence of a global economy, the evolution of global politics, and the rise of a potential for a global community. Moreover, as **Rennstich** argues in Chapter 5 of this volume, that trend is firmly founded upon a generational cycle. **White *et al.*** in Chapter 9 show that

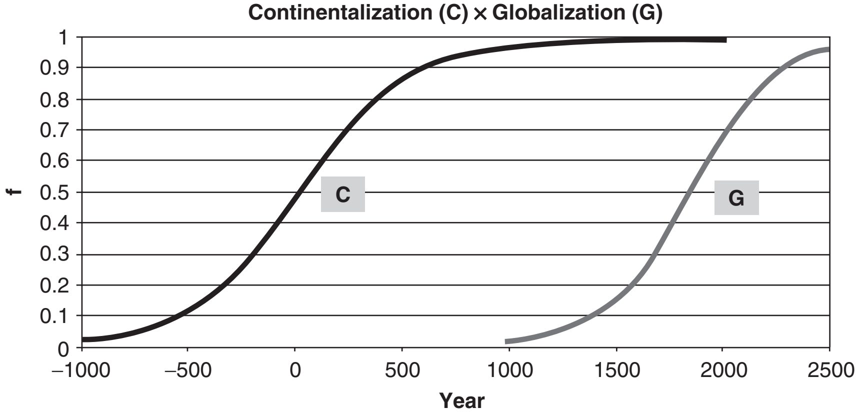

Figure 19.1 The overlap between the processes of continentalization and globalization.

major urbanization is also related to these processes. That convergence of ideas, organization, resources, cities, and biology makes for an impressive strength.

All this makes plain that globalization is a long-term process, which may have its ups and its downs that extend for decades or more, but that also exerts continuous influence. But it is not really an instance of discontinuity in world development. Rather, as it becomes apparent from Turchin's contribution, the globalization of the modern age would seem to have had an antecedent in the classical era, which saw the integration of Eurasia, in a process that might also be referred to as "*continentalization*."[1] The two processes overlapped for much of the modern era.[2]

Some have in fact argued that globalization could be traced as far back as the emergence of *Homo sapiens*, say 70,000 or 80,000 years ago, about to set out from Africa to populate the earth in what over tens of thousands of years ultimately became a world-wide movement. But that would stretch the term beyond its theoretical or practical usefulness. If the evolution of the world system started say 5,000 ago, then globalization is the world-wide process that is located in the modern era of that evolution, in the second millennium of our era and beyond. Even that might trouble some imaginations, but it does have sound reasoning behind it, because that is when *organized planetary organization* first began to take shape.

We see globalization as a world-wide trend in a more specific sense, in that it is not the special product or province of one particular group, nation, or empire, but rather the joint product of the total experience of humankind, one in which for a time some sub-set of it may come to play an innovative role, but in which all are and have been actual or potential actors. Thus, for instance, the continental integration that we noted earlier was an enterprise in which both Asia and Europe actively participated.

An evolutionary process

"A statement asserting the existence of a trend is existential, not universal" declared Karl Popper (1957), in his classic analysis of 'laws of development."[3] The several aspects of globalization that we have reviewed as evidence for a long-term trend, however powerful, were "existential" in his terms, and basically descriptive in character. "A trend, as opposed to a law, must not in general be used as basis for scientific predictions" (Popper, 1957: 120).

We have so far discussed globalization as a trend – that means, basically, in a descriptive mode. If our aspirations extend to producing explanations, and assembling material suitable for prediction and forecasting, then we need to look beyond trends to "universal" formulations (in Popper's sense), that is to scientific generalizations that can power theories and formal models.

We are agreed that globalization is best understood as a process – that is as a sequence of events (one longer, Webster-dictionary, definition defines "process" as a sequence of related changes by which one thing gradually becomes another). That is why its explanation would naturally be of a process-type. Globalization obviously is also a process of global change, that is change that affects social (world system) and natural (earth system) phenomena of a planetary scope. **Pirages**' Chapter 10 is a study of world system interaction with the forces of nature.

An evolutionary process model has two characteristics that distinguish it from other social–evolutionary approaches: first it takes humanity as a whole to be the unit of evolution, with the human species being the proper object of evolutionary theory, of search and selection. Societies are not the units of evolution: they do vary and some become, at times, centers of innovation, but they play out their role in a global context. Second, it sees social evolution not as a unitary phenomenon, but as a cascade of processes (such as global economic, political, social, cultural, etc.), closely and systematically related but also each tracing their individual trajectories and periodicities.[4]

Modelski, in Chapter 2, proposes that globalization is an evolutionary process of the world system, actuated by Darwinian-type mechanisms of search and selection, acting upon humankind, and producing institutional change of global scope. More precisely, it is a spectrum of processes that actuate, at the global level, institutional change over the entire range of economic, political, social, and cultural affairs. The processes are not cyclical, but periodic – and each of their periods constitutes a learning process that may be represented by a logistic function. Globalization may therefore be portrayed as an array of logistic processes of varying but related periods.

The **Devezas–Modelski** study of Portuguese system-building in Chapter 3 analyzes a clear example of early institutional change at the global level. Using as a basis a data set on Portuguese activities in the fifteenth and sixteenth centuries (which is presented in the Appendix of that chapter), it depicts two sets of processes – economic (two K-waves) and political (the Portuguese long cycle[5]) – whose periods are related in a proportion 2:1, and that are the drivers of global economic and political evolution upon a common foundation of technological change.

Rennstich (Chapter 5) covers the entire modern period as part of a self-organizing process that is essentially an evolutionary one. Departing from the major premise that complex systems have the capacity for self-organization, and adopting, as the minor premise, the proposition that the global system is indeed a complex system, he argues that globalization is in fact a process that has that character. He supports his argument by bringing out the role of generational turnover.

The Linstone–Devezas–Santos study in effect adds empirical content to the notion of evolutionary process. It analyzes the growth of the Internet, which is an important feature of the contemporary period of global economic evolution, the Information Age. It exhibits the same type of characteristics that have been documented for the earlier Portuguese system, and in particular a logistic structure.

These are some of the studies that support an evolutionary process explanation of globalization that is ongoing and seemingly regular, albeit punctuated by a series of logistic surges. As an alternative to this "logistic" perspective, we have **Korotayev**'s (Chapter 7) presentation of world population growth, and what he calls world system development, as a "hyperbolic" process. He traces it over 40,000 years, and displays evidence based on historical estimates that show a fine fit between historical and predicted trends. Until about the 1960s, world population appeared to be on a course of hyperbolic growth that would produce "infinite" numbers – a "singularity" – in the 2020s. We know, however, that the growth rate of world population has been declining for the past five decades.[6] But **Heylighen**'s model in Chapter 13 endorses the concept of singularity, views it as "accelerating evolution," basically in respect of technological progress and the information revolution, and sees it as approaching in the coming decades.

What does this tell us about globalization? For Korotayev, the study of long-term population trends reveals the dynamics of a world system over the past ten millennia (a more conservative version would put it at five thousand years). **Heylighen,** in Chapter 13, highlights the speed of technological and informational change (as does the **Devezas *et al.*** study of the Internet in Chapter 14, a study that does not endorse singularity). But is that a reason to extrapolate a trend in one sector of global development (K19 and beyond) in order to predict an acceleration of a more general process that has been ongoing for all of the modern era? Would it be a world "where wholly different laws apply" "in a global system … changed beyond recognition" (as Heylighen maintains)? The problem with "accelerated evolution" (as a unitary process) (as with hyperbolic growth) is that it cannot go on for ever, but must lead to a mysterious and unknowable singularity; yet the evolutionary processes postulated earlier are all based on a generational cycle whose length remains largely standard.[7] Since the evolution of humankind remains rooted in the process of generational turnover, the assumption of "accelerating evolution" needs to be carefully scrutinized. The other problem with a hyperbolic growth model of the world system that extends over ten or 40 millennia is that it is quite insensitive to fluctuations of the order of a decade, generation, or even centuries, time scales that are the principal interests of social scientists and the general public.

That is why we prefer logistic models of evolutionary processes to hyperbolic ones. Logistic processes are a bridge to learning models, and hence a direct link to human behavior; hyperbolic models (also known as "blow-up regimes") have no obvious anchor in modes of human organization. Overall, our work suggests that evolutionary process models are gathering increasing support, but that they also are a "work in progress" that calls for much additional thought and research.

Overview

We may round out this review with a brief assessment of the book as a whole. As noted, it comprises four main parts, and we might consider each one in turn, bearing in mind, in particular, the extent to which they confirm our expectations animating this project. We proposed in Chapter 1 that we can contribute to this "burgeoning" field by spurring on the construction of models of globalization; exploring the possibilities of simulation; and essaying methods of forecasting.

Evolutionary models

We do, indeed, bring to the table a number of distinct models. In Part I, "Evolutionary Models" we add some basic considerations, animating that particular approach to globalization, to the "map" of our knowledge. **Modelski** (Chapter 2) aims to clear the theoretical decks by answering Karl Popper's and Anthony Giddens' doubts about the validity of an evolutionary theory for the social sciences. These were critical arguments, whose principal target was historical materialism (Marxism) and its "laws of history," arguments that do not extend to the carefully constructed and rigorously tested theories of the twenty-first century. He then proposes an institutional (rather than connectivist), four-process model of globalization that is driven by self-similar, agent-level, processes. This is a fuller elaboration of models earlier advanced in several contexts.[8]

Chapter 3, "The Portuguese as System-builders" (**Devezas and Modelski**) explores the role of technology in early (pre-Industrial Revolution) globalization, but it also offers a strict test of the Modelski–Thompson 1996 study in respect of Portugal. It depicts a process that led to the creation of the first truly global political and economic system, and supports, with historical evidence drawn from the fifteenth and sixteenth centuries – some of which is laid out in the Appendix – the notion of K-waves and long cycles as logistic learning processes activating economic and political evolution.

Thompson (Chapter 4) inventories data sets and measurements that are needed for modeling globalization, and political globalization in particular. His focus is on the period since about 1494, and covers both the "global leadership" and "the emerging "global organization" periods of that process (see Chapter 1, Table 1.1). A number of significant time series for the past 500 years are now available, in particular on the resources and activities of global powers and the major conflicts that they engaged in; on world economic growth, much of it spurred by such powers; and trends in international organization. These are important drivers of global political evolution that may lend themselves to representation as elements of processes of political globalization.

Rennstich (Chapter 5) supplies a generational perspective on processes of globalization that elaborates on work by Devezas and Corredine (2001). He argues that the relatively stable pattern of global system development in the modern era can be traced and analyzed by means of the concept of a Buddenbrook cycle: a four-generational cohort pattern, first described in Thomas Mann's account of the experience of a leading merchant family. He applies a statistical (Shapiro–Wilk) test that confirms the stability of this development: the measured waves (socio-biological in character) follow a normal distribution and do not appear to be moving either in one or the other direction, hence contradicting the notion of change accelerating toward singularity. This stability seems to account for what appears to be the self-organizing feature of world system development. Further empirical grounding of these concepts and examples drawn from world system history will strengthen this line of inquiry.

Attinà (Chapter 6) places the evolutionary learning approach in context by comparing it with three others: the structural–economic, the "common" ("orthodox"?), and the organizational–teleological one. He lays emphasis upon long-term change in global political institutions, and the problem of reforming them, and approves the power of the evolutionary approach to draw on the experience of the past for highlighting the problems of the future.

Models of global change

Studies pursuing an evolutionary approach may be contrasted with models of global processes that build upon connectivity and/or institutionalization in the global system, and that may have a bearing on globalization. In the first of these, noted earlier, **Korotayev** (Chapter 7) shows that world population has followed a hyperbolic pattern for the past 40,000 years. It is his claim that for several millennia before the present era the majority of humans must have been connected, because they already functioned as a "world system" (that is, their total number was growing at a rate predicted by the equation) and that they therefore were "globalized" earlier than we might tend to think. We have earlier questioned the value of the hyperbolic conception, but Korotayev's argument could serve to remind us that the human species as a whole might have been subject to social evolutionary pressures even earlier than currently believed.

Another model of an early period is **Turchin**'s (Chapter 8) study of Afro-Eurasian ("Old World") forces of "integration," or what he calls globalization on a lesser – continental – scale (and that we earlier described as continentalization (see Note 2 in this chapter) of the classical era. He sees that process as producing pulsations typically of the order of two to three centuries, and describes these as (four-phased) secular cycles animating large agrarian empires, driven both by (internal) structural demographic factors, and interstate relations, but also by exogenous factors such as climate and epidemics that may synchronize state-based oscillations and produce periods of heightened East–West connectivity. Trade is seen to flourish in particular in the stagflation phase of the secular cycle. This is a report on a work in progress, but we might note that, unlike our conception of globalization, this "integration" is not actuated by a changing set of agents launching and diffusing major structural innovations.

The world system is most often thought of as an ensemble of countries, or nations. Yet it might just as well be seen as a huge yet ordered network of cities, a world city-system. Connectivity is a primary characteristic of that structured web, and its movement through time is a product of complex dynamics. Searching for valid comparative measurements of such large-scale movements, **White, Kejzar, and Tambayong** (Chapter 9) have engaged in a highly sophisticated project to gage and systematically compare the shapes of modern-era city-size distribution curves, in a Zipfian mode. Their findings basically revolve around systematic departures from the Zipfian distribution in distinct historical periods. Their "startling" finding is that of very long oscillations between steeper city hierarchies and more egalitarian city distributions. They hypothesize an embedding of dynamical processes that runs from trading zone network sizes and city-size distributions that cycle roughly every 200, 400, and 800 years.

Another powerful dynamic, one that engages **Pirages**' Chapter 10, operates between nature and humankind, between the earth system and the world system. Forces of nature have consistently been instrumental in shaping the prospects for human societies, an early spectacular instance being the Toba (Indonesia) volcanic eruption 74,000 years ago, that may have pared back the numbers of humans to 10,000. While the probability of a similar explosion is low, three other sets of threats to growing social complexity are climate change, resource exhaustion, and "the most imminent" – infectious disease. In the past, several transformational epochs have tended to disturb the normal equilibrium between humans and pathogens. These included the onset of sedentary, agrarian, and city life, and the other, the increasing contacts following upon "continentalization." Deepening globalization makes contemporary society increasingly vulnerable to similar problems, and in particular to a serious influenza epidemic.

Set against the background of a review of what she calls (unsuccessful) attempts to write "total history," **Antunes**' Chapter 11 is an account and a test of the Held *et al.* (1999) model of globalization. She sets out the model in both its spatio-temporal and organizational dimensions, and the types of globalization that they generate. Her particular focus is the transition from the "thin" globalization of the medieval period (she views the pre-medieval period as "diffused" globalization) to the "expansive" globalization of the early modern period, with emphasis on world economic developments: ports, trade networks, merchants, and capital. The description is qualitative, but concepts such as thin and thick globalization do cry out for quantitative treatment.

The Information Age

The Information Age forms a distinct period of the evolution of the global economy, and its high point (selection phase) has been the contemporary computer–Internet wave. The origin, and the major weight of it, has been in the economy, but its impact on the rest of society has been profound, and is likely to be lasting, such that some would call it the defining element of the organization of today's world. Indeed, **Kumon and Yamanouchi** (Chapter 12) conceptualize the "globalizing modernity" of the past half-millennium as the product of three superimposed and overlapping S-shaped processes (or phases of globalization), of which the last is the information revolution. They call the first phase (that of emergence), nation-state–international society, a phase that relied on a balance of power. They recognize the second phase (breakthrough), as one of Industrial Revolution, with industrial enterprises operating in a world market-place. The third (maturation) phase of "globalizing modernity" is that of informatization, in which "intelprises" function in the global "intelplace" (or knowledge framework).

Heylighen (Chapter 13) presents an "evolutionary–cybernetic model" that shares this expansive conception of the influence of information technology on social organization. Technology brings about emphemeralization that is producing more for less, generally leading to greater efficiency and a loss of friction, and the lowering of the costs of transport, communications, and information processing. Analogous dynamics apply to social evolution, in which the emergence of a new medium leads to stigmergy, which is implicit collaboration, even in the absence of rationality, and that leads to the collective production of new knowledge. The intelligent management of communication via the medium brings about collective intelligence that, world-spanning, becomes the Global Brain directing a global superorganism (a new form of organization for humanity). The Internet is currently the nearest approximation to it. A major effect of stigmergy is the acceleration of evolution that could lead to a "singularity" (a point at which the speed of innovation becomes infinite), a momentous change that makes traditional forms of prediction irrelevant.

This is a strong argument, which treats social evolution as single process propelled by information. But, if we view globalization as a bunch of processes, each with its own speed, then the impressive rates recorded in the current, steeply rising, curve of the Information Age may not transfer automatically to the several other processes that drive globalization – political, social, and cultural – at varying rates. Change there will be, but we might strive to understand it better by looking at one process at a time, and that is what **Devezas, Linstone, and Santos** are doing in their Chapter 14, which subjects the Internet to both a historical and a quantitative analysis. They observe that the creation of the Internet was an instance of serendipitous creation, a matter of self-organization, and that the web grew along two dimensions: a rise in the number of hosts (computers), and the development of software linking them (the Internet). A superlogistic sums these two processes, as a classic learning process, and it forecasts a maturation phase up to the 2020s. They see no singularity, but rather regard K-waves (including the Internet) as a normal part of the functioning of the capitalist world economy.

The perceived impact of information technologies, not least on globalization, has given birth to a new academic profession, that of Informatics (defined as the solution of problems with or caused by ACIT (automated information and/or communication technologies). In turn, that new profession calls for the training of people with a globalizing perspective.

Hakken's Chapter 15 recounts the experience of a cultural anthropologist who is teaching and researching that field. He asks the question: how useful is an evolutionary perspective to globalizing Informatics, and his attitude is generally positive to thinking about globalization as an evolutionary process, and to viewing it as a distinct stage in cultural evolution. But, in part on the basis of personal experience, he remains unconvinced about the value of simulation, or of formal modeling that might entail universals (such as laws of nature, and presumably evolutionary learning).

Forecasting and simulating globalization

The early design for this project, as reflected in Chapter 1, foresaw an important role for exploring ways of forecasting and simulating globalization. The actual results, as reflected in this book, fall short of our expectations. Maybe Hakken is right in his doubts about simulation, or modeling future worlds. Or perhaps the time is not yet ripe for such ambitious undertakings.

Fully aware of such caveats, **Hughes** (Chapter 16) gives a full exploration of the possibilities of forecasting globalization (measured by means of a refinement of the Kearney/*Foreign policy* index, for 182 countries). He does so both generally and with respect to a particular forecasting system, the International Futures (IFs) model, and conceptualizes globalization in terms of explicit positive- and negative-feedback loops (but basically without the aid of evolutionary theory), employing driver variables that are difficult but not impossible to operationalize and represent. He concedes that the varying strengths of the dynamics over time are unlikely to be represented very adequately in any current forecasting system. The short answer to the question: "Can we forecast globalization?" is "yes" and "no": we can represent more of the long-term growth in globalization in ways that provide important insights and facilitate thinking about alternative futures, but we cannot probably forecast the specifics of the processes such as oscillations or systemic crises with any great confidence. The "base case" of globalization rising in the twenty-first century represents "only one of an infinite number of possible futures," probably a "low-probability future," with a "Security First" scenario in particular indicating a stabilization of globalization in mid-century.

Reuveny (Chapter 17) describes three prominent world models of the past few decades, with a view to determining their usefulness for forecasting globalization, which he defines expansively as connectivity and interdependence within all the key domains of human activity. The World3 model of the Club of Rome–Forrester–Meadows' tradition predicts in its base run a rise in the economy until the mid-twenty-first century, followed by a sharp decline, when the economy hits natural limits. The Globus model (now discontinued) simulated political and economic forces in the 25 largest countries. For our purposes, the best path might be to augment the International Futures world model that embodies the continuing growth over the past two to three decades. Many difficult questions might be asked of such a complex model but the reward is uncertain. Maybe the range of questions needs to be narrowed, or more strictly theorized.

Klüver and Klüver (Chapter 18) describe a theory designed to show that the universal export of capitalistic forms of economy has led, in all countries, to changes that follow the paradigm of Western modernity. If history is a special kind of evolutionary process, then the logic explaining general features of that process should be the same as that of evolutionary theories that have the character of a "program." The relevant program, in their view, is the "socio-cultural algorithm" (SCA) that focuses on the higher degree of role-autonomy (determined by the relative weight of creative, and cultural, roles) in medieval Europe, as compared with China or the Moslem world. In China, the power of the mandarinate – and in Islam, that of the clergy – suppressed creativity, and led to stagnation. This hypothesis is supported by a report of a computer simulation (with cellular automata). So, is globalization a way of remaking the societies of the world in Europe's image? That is an attribution error that an evolutionary process approach is designed to avoid.

What have we learnt?

We have learnt most of all that much work remains to be done. Even though an evolutionary concept of a globalization may be a no-brainer, and basically common sense, working out that conception in practice and to the satisfaction of a wider audience requires sturdy concepts, sound method, solid data, and also work. This book presents a good case in favor of that notion – and more is already on the table – but we need even more than that.

We have not spent much time on definitions, and we have no aspirations for writing "total history," but we did take care to work out ways in which connectivity works in the social world to produce the necessary common institutions. That requires delving into the record of the past, but we do not regard history as such as an evolutionary process but rather as accommodating a set of processes that continue to this day and will likely extend into the future.

A reasoned outline of an evolutionary process model of globalization is now at hand, even though more work remains to be done. We have identified a point at which debate has commenced regarding the shape of the process and the best ways of representing it: should it be modeled as a logistic, or a hyperbolic process, and we believe that the logistic offers greater promise. The debate continues, and echoes wider concerns.

Finally, we have come to better appreciate the problems of forecasting and simulating the complex processes of globalization. Despite the natural proclivity of an evolutionary approach toward illuminating processes in time, we have yet to marry that idea with practical procedures for looking toward the future.

Washington DC, Covilhã, and Bloomington,
4 April 2007

Notes

1 And that William McNeill (1963) called "the closure of the Eurasian ecumene."

2 That overlap between the two processes, those of continentalization, and globalization, may be represented in Figure 19.1. This graph, in a schematic form, depicts the area of overlap between continentalization, and globalization, and extending from about CE 1000 to the 1800s. In empirical terms, it means that institutions that evolved in the classic era (say 1000 BCE to CE 1000) continued their sway right into modernity, even while the seeds of new institutional formations were taking root in the active zones of the planet. In particular, the Eurasian trading system of the Silk Roads continued until the 1500s, and beyond, even while new transoceanic forms of global exchange had been taking shape since the early centuries of the millennium. The imperial form of large-scale political organization held sway right into the nineteenth century, just as modern communications of the cable, telephone, and wireless variety did not set in until that time. The graph illustrates just one instance of how one innovative surge sequences into the next – globalization in all its forms is a cluster of overlapping logistic surges.

3 "A universal law, on the other hand, does not assert existence … it asserts the impossibility of something or other." We take it that "universal" basically refers to (law-like) "scientific generalization."

4 For the concept of cascade of evolutionary process, see Devezas and Modelski (2003).

5 The Portuguese "cycle" is, of course, best represented as a logistic process (as shown in Devezas and Modelski, 2003). The term "cycle" used in this case is a conventional designation suggesting process regularity, but it is not to be taken too literally.

Processes have periods, and are therefore periodic processes, but that does not make them cyclic.

6 There is evidence that world population growth has slowed at least once if not twice before in the course of world system evolution (cf. Modelski, 2003, pp. 89–92).

7 While human life-expectancy has indeed expanded dramatically during the twentieth century, generational turnover (the time taken by one generation to reproduce itself) has remained relatively stable – in the 25–30-year range.

8 In particular in Modelski and Thompson (1996), Modelski (2000), and Devezas and Modelski (2003).

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