Innovation, Technology, and Knowledge Management

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Innovation and Entrepreneurship

Theory, Policy and Practice

Springer

Innovation, Technology, and Knowledge Management

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Series Foreword

The Springer book series *Innovation, Technology, and Knowledge Management* was launched in March 2008 as a forum and intellectual, scholarly "podium" for global/local, transdisciplinary, transsectoral, public–private, and leading/"bleeding" edge ideas, theories, and perspectives on these topics.

The book series is accompanied by the Springer *Journal of the Knowledge Economy*, which was launched in 2009 with the same editorial leadership.

The series showcases provocative views that diverge from the current "conventional wisdom" that are properly grounded in theory and practice, and that consider the concepts of ***robust competitiveness***,[1] ***sustainable entrepreneurship***,[2] and ***democratic capitalism***,[3] central to its philosophy and objectives. More specifically, the aim of this series is to highlight emerging research and practice at the dynamic intersection of these fields, where individuals, organizations, industries, regions, and nations are harnessing creativity and invention to achieve and sustain growth.

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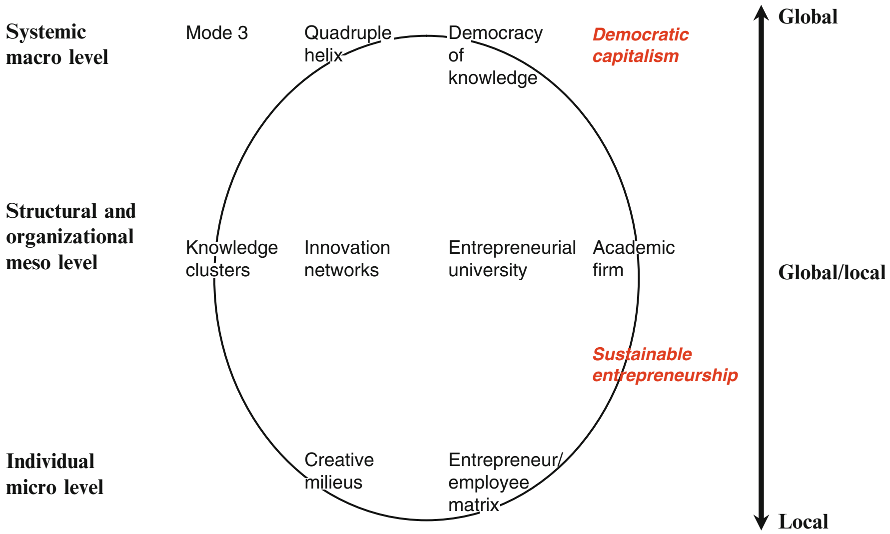
[1] We define *sustainable entrepreneurship* as the creation of viable, profitable, and scalable firms. Such firms engender the formation of self-replicating and mutually enhancing innovation networks and knowledge clusters (innovation ecosystems), leading toward robust competitiveness (E.G. Carayannis, *International Journal of Innovation and Regional Development* 1(3), 235–254, 2009).

[2] We understand *robust competitiveness* to be a state of economic being and becoming that avails systematic and defensible "unfair advantages" to the entities that are part of the economy. Such competitiveness is built on mutually complementary and reinforcing low-, medium-, and high-technology and public and private sector entities (government agencies, private firms, universities, and nongovernmental organizations) (E.G. Carayannis, *International Journal of Innovation and Regional Development* 1(3), 235–254, 2009).

[3] The concepts of *robust competitiveness and sustainable entrepreneurship* are pillars of a regime that we call "*democratic capitalism*" (as opposed to "popular or casino capitalism"), in which real opportunities for education and economic prosperity are available to all, especially—but not only—younger people. These are the direct derivatives of a collection of topdown policies as well as bottom-up initiatives (including strong research and development policies and funding, but going beyond these to include the development of innovation networks and knowledge clusters across regions and sectors) (E.G. Carayannis and A. Kaloudis, *Japan Economic Currents*, p. 6–10 January 2009).

Books that are part of the series explore the impact of innovation at the "macro" (economies, markets), "meso" (industries, firms), and "micro" levels (teams, individuals), drawing from such related disciplines as finance, organizational psychology, research and development, science policy, information systems, and strategy, with the underlying theme that for innovation to be useful it must involve the sharing and application of knowledge.

Some of the key anchoring concepts of the series are outlined in the figure below and the definitions that follow (all definitions are from E.G. Carayannis and D.F.J. Campbell, *International Journal of Technology Management*, 46, 3–4, 2009).



Conceptual profile of the series *Innovation*, *Technology*, and *Knowledge Management*

- The "Mode 3" Systems Approach for Knowledge Creation, Diffusion, and Use: "Mode 3" is a multilateral, multinodal, multimodal, and multilevel systems approach to the conceptualization, design, and management of real and virtual, "knowledge-stock" and "knowledge-flow," modalities that catalyze, accelerate, and support the creation, diffusion, sharing, absorption, and use of cospecialized knowledge assets. "Mode 3" is based on a system-theoretic perspective of socio-economic, political, technological, and cultural trends and conditions that shape the coevolution of knowledge with the "knowledge-based and knowledge-driven, global/local economy and society."
- Quadruple Helix: Quadruple helix, in this context, means to add to the triple helix of government, university, and industry a "fourth helix" that we identify as the "media-based and culture-based public." This fourth helix associates with "media," "creative industries," "culture," "values," "life styles," "art," and perhaps also the notion of the "creative class."

- Innovation Networks: Innovation networks are real and virtual infrastructures and infratechnologies that serve to nurture creativity, trigger invention, and catalyze innovation in a public and/or private domain context (for instance, government–university–industry public–private research and technology development coopetitive partnerships).
- Knowledge Clusters: Knowledge clusters are agglomerations of cospecialized, mutually complementary, and reinforcing knowledge assets in the form of "knowledge stocks" and "knowledge flows" that exhibit self-organizing, learning-driven, dynamically adaptive competences, and trends in the context of an open systems perspective.
- Twenty-First Century Innovation Ecosystem: A twenty-first century innovation ecosystem is a multilevel, multimodal, multinodal, and multiagent system of systems. The constituent systems consist of innovation metanetworks (networks of innovation networks and knowledge clusters) and knowledge metaclusters (clusters of innovation networks and knowledge clusters) as building blocks and organized in a self-referential or chaotic fractal knowledge and innovation architecture,[4] which in turn constitute agglomerations of human, social, intellectual, and financial capital stocks and flows as well as cultural and technological artifacts and modalities, continually coevolving, cospecializing, and cooperating. These innovation networks and knowledge clusters also form, reform, and dissolve within diverse institutional, political, technological, and socioeconomic domains, including government, university, industry, and nongovernmental organizations and involving information and communication technologies, biotechnologies, advanced materials, nanotechnologies, and next-generation energy technologies.

Who is this book series published for? The book series addresses a diversity of audiences in different settings:

1. *Academic communities*: Academic communities worldwide represent a core group of readers. This follows from the theoretical/conceptual interest of the book series to influence academic discourses in the fields of knowledge, also carried by the claim of a certain saturation of academia with the current concepts and the postulate of a window of opportunity for new or at least additional concepts. Thus, it represents a key challenge for the series to exercise a certain impact on discourses in academia. In principle, all academic communities that are interested in knowledge (knowledge and innovation) could be tackled by the book series. The interdisciplinary (transdisciplinary) nature of the book series underscores that the scope of the book series is not limited a priori to a specific basket of disciplines. From a radical viewpoint, one could create the hypothesis that there is no discipline where knowledge is of no importance.
2. *Decision makers—private/academic entrepreneurs and public* (*governmental*, *subgovernmental*) actors: Two different groups of decision makers are being addressed simultaneously: (1) private entrepreneurs (firms, commercial firms,

[4] E.G. Carayannis, *Strategic Management of Technological Learning*, CRC Press, 2000.

academic firms) and academic entrepreneurs (universities), interested in optimizing knowledge management and in developing heterogeneously composed knowledge-based research networks; and (2) public (governmental, subgovernmental) actors that are interested in optimizing and further developing their policies and policy strategies that target knowledge and innovation. One purpose of public *knowledge and innovation policy* is to enhance the performance and competitiveness of advanced economies.

3. *Decision makers in general*: Decision makers are systematically being supplied with crucial information, for how to optimize knowledge-referring and knowledge-enhancing decision-making. The nature of this "crucial information" is conceptual as well as empirical (case-study-based). Empirical information highlights practical examples and points toward practical solutions (perhaps remedies); conceptual information offers the advantage of further driving and further-carrying tools of understanding. Different groups of addressed decision makers could be decision makers in private firms and multinational corporations, responsible for the knowledge portfolio of companies; knowledge and knowledge management consultants; globalization experts, focusing on the internationalization of research and development, science and technology, and innovation; experts in university/business research networks; and political scientists, economists, and business professionals.
4. *Interested global readership*: Finally, the Springer book series addresses a whole global readership, composed of members who are generally interested in knowledge and innovation. The global readership could partially coincide with the communities as described above ("academic communities," "decision makers"), but could also refer to other constituencies and groups.

Elias G. Carayannis

Preface

As today's global economic landscape is changing rapidly, the ability of businesses to introduce new innovative products to the market faster than their competitors is perhaps their most distinct competitive advantage. This becomes obvious by the significant market share that the innovative companies gain while increasing profitability. Extensive research in this field has shown that companies that are constantly innovating normally double their profits compared to others.

The term innovation refers to a process that comprises three stages: the conception of a new idea, its evaluation, and, finally, its practical implementation. Thus, innovation is an important element of modern entrepreneurship. Innovation management, namely, how a new idea is created, how and by what criteria it is assessed, or how it is financed, is a very tedious and demanding process, and a component element of effective entrepreneurship.

In this context, innovation management techniques and models of increasing sophistication are being developed internationally; these, in turn, serve as a basis for the development of many methodologies of measuring innovation at the individual, national, European, and international level. It is important to mention that according to the conclusions of the European Commission, based on the European Innovation Scoreboard (EIS), Greece is last in the list of the EU-15 area countries and one of the last in the EU-27.

The weakest points of the innovation system of Greece are identified in the production of new products, risk capital, patenting, broadband penetration, lifelong training, investment in research on the part of firms, high-tech exports, and finally employment in medium-high-technology manufacturing. This has resulted in low innovativeness and competitiveness of the Greek economy. Furthermore, it is noteworthy that both the inflow of foreign capital in Greece and the Greek direct investments abroad represent a very small proportion of the total output and input of the eurozone.

The important role of innovation in firm profitability and overall sustainable economic growth, coupled with the disappointingly low yield of the Greek Economy in this field, have made the design of an effective innovation policy in Greece imperative. It is obvious that such a policy can be based on young scientists and entrepreneurs who will have a sufficiently high level of knowledge in innovation and entrepreneurship.

This book aims to meet the needs of education and training in modern techniques of innovation and entrepreneurship, and focuses on the detailed presentation of successful business practices. The contents of this book are presented initially in two parts.

The first part deals with the process of innovation and its relationship to knowledge, learning, and creativity. The second part is about entrepreneurship and its interdependencies with innovation and the various innovation systems and policies.

Chapter 1 is an Introduction to Innovation providing the basic concepts and definitions of Technology, Invention, Creativity, and Innovation with emphasis on Technological Innovation. In addition, a historical, social, and technocratic perspective of Innovation is presented, with a brief reference to the process of Innovation Measurement.

Chapter 2 deals with Innovation Management, mainly through Education and Knowledge Management. Furthermore, the role of Knowledge in Innovation and the relationship between Knowledge and Learning are analyzed, and the Knowledge Process model is presented. Finally, the difference between Innovation and Invention is clarified, and the types and characteristics of Simple Innovation and Technological Innovation are listed.

In Chap. 3, through a detailed case study of a large company, the relationship between Innovation and Competitiveness is elaborated. This chapter also presents the concepts of Creativity, Innovation, and Competitiveness in Public and Private Sectors, and makes an attempt to analyze the role of the Public Sector in promoting these concepts.

The management of Technological Innovation and the consequent challenges is the subject of Chap. 4, an issue also presented through case studies. This chapter lists the different standard models of the Innovation Process with reference to (a) Intellectual Property Rights management and (b) the concept and the practice of Knowledge Management and Intellectual Capital.

Chapter 5 deals with the study of Innovation Systems. Special emphasis is placed on the presentation of the different types of Innovation Systems and their basic principles, on the Open and Closed Innovation Systems as strategic choices, and on simulation systems. Of particular interest is the configuration of Innovation Systems with the use of Systems Dynamics and the application of these standards in Sectoral, Regional and particularly National Innovation Systems. This chapter concludes with further analysis of Open Innovation Systems, Innovation Networks, Knowledge Societies, International Research Cooperation, and Innovation Indices.

In Chap. 6, which opens the second part of this book, there is an introduction to Entrepreneurship and its relationship with Innovation. Moreover, the different types of Entrepreneurship are presented, followed by an analysis of the concepts of Sustainable Entrepreneurship, the Learning Life Cycle model, and Strategic Learning. A reference to Business Incubators and Technology Clusters versus Knowledge Clusters is also made.

Chapter 7 seeks to shed light on the practices of Entrepreneurship and Innovation, with a focus on procedures such as Technology Management and Transfer, mechanisms and models of Technology Transfer, and barriers and facilitating factors for successful Technology Transfer. Finally, there is a detailed presentation of Cooperation Research and Development Agreements (CRADAs).

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Contents

Chapter 1
Introduction to Technological Innovation

At present, the life cycle of products, i.e the time span from a product launch in the market until it becomes mature, is constantly shrinking. In fact, in some sectors, such as personal computers, the technological ageing of products takes place within just a few months. Therefore, the capacity to introduce new products in the market anticipating their competitors, earning in this way significant shares of sales, constitutes a big competitive advantage for companies. Companies, hence, should be in a position to constantly 'innovate' in order to preserve and improve their market position. Many would define innovation as 'something new, an invention, a new idea'. In reality though, innovation does not only constitute the birth of a new product or process-related idea; it does include all stages, from the design and the evaluation of the way this idea is translated into action effectively. An innovation takes effect with the first commercial transaction regarding a new or improved accessory, product, process or system. On the contrary, the invention is an idea, a design or a model of an improved or new accessory that in most of the times does not result in any commercial transaction, although it could lead to a patent. Many researches have shown that innovative enterprises, namely the ones that constantly innovate, present on average double profit compared to the rest. However, innovation management is particularly difficult, hence the failure of many new ideas to result in successful new products or services. For this reason, various innovation management models have been developed.

1.1 Basic Concepts and Definitions

> '*Imagination is more important than knowledge. To raise new questions, new possibilities, to regard old problems from a new angle, require creative imagination and marks real advance in science*'.
>
> [Albert Einstein]

E.G. Carayannis et al., *Innovation and Entrepreneurship*, Innovation, Technology, and Knowledge Management, DOI 10.1007/978-3-319-11242-8_1

1.1.1 Technology

Technology is defined as something 'allowing someone to get involved in a specific activity…with a steady qualitative outcome', or 'the art of science and the science of art' (Carayannis 2001) or 'the science of arts' (von Braun 1997). Diwan adds that the technological foundations are market size, standards, innovation, high motivation, and supply of capital (Diwan and Chakraborty 1991). The impact of innovation may be directed to multiple sectors. For example, Jonash lists product/service, process and business innovation as key impact areas. Product/service is the development and commercialization of hard goods, process refers to new ways of producing and delivering cost-time-quality advantages and business innovation is new models of conducting business for competitive advantage (Jonash and Sommerlatte 1999).

Technology is a Greek word derived from the synthesis of two words: 'techne' (i.e. art) and 'logos' (logic). Defined as such, technology means the art of logic and the logic of art. It is formally defined as 'a design for decision/action that reduces the uncertainty in the cause-effect relations in order to achieve a desired outcome'. Technology usually consists of two components: (1) a hardware aspect consisting of a tool that embodies the technology as a material or physical object, and (2) a software aspect, consisting of the information basis for the tool (Carayannis 1994a, b, c). Although technology is embodied materially in a product, it should nevertheless be viewed as a process, a dynamic and not a static one, a social rather than an intangible knowledge. It is a combination of creative and structured tangible objects, codified knowledge and unsaid know-how embedded in individuals, groups and organizational processes.

1.1.2 Technology Management

Technology Management is a set of practices and policies affecting technologies to build, maintain and strengthen the company's competitive advantage at the level of proprietary knowledge and know-how. In 1987, the American Research Council defined Management of Technology as linking "engineering, science, and management disciplines to plan, develop, and implement technological capabilities to shape and accomplish the strategic and operational objectives of an organization" (Carayannis 1994a, b, c). While technology management techniques are themselves important to an enterprise, they are most effective when they complement the overall strategic posture adopted by the enterprise. The strategic management of technology tries to 'create advantage at the level of technology' or 'to take advantage of possible technological opportunities generated by technology' (Carayannis 1994a, b, c).

1.1.3 Invention

Understanding the term of invention should take precedence over the definition of innovation. Florida considers invention as breakthrough and innovation as an actualization (Florida and Kenney 1990). In addition, Hindle defines invention as the creative origin of new process and the enabler of innovation (Hindle and Lubar 1986), which has impact on social, economic and financial processes. Therefore, invention is defined as creative process or progress, while innovation is defined as the actualization and impact of all processes–progresses on societies and markets.

1.1.4 Creativity

> *'Management is, all things considered, the most creative of all arts.' It is the art of arts. Because it is the organizer of talent'.*
>
> [Jean-Jacques Servan-Schreiber]

Starting from the individual level, creativity may be defined as the capacity to 'think out of the box', think laterally, observe, conceive and construct ideas and models that outweigh or outstrip existing items and ways of thought and perception. Creativity is associated with the capacity to imagine in the sense that it requires the creator to perceive future perspectives, not being obvious under the current circumstances. Therefore, creativity is the capacity to observe new interactions between objects and ideas. Creative types, such as artists, scientists and businessmen usually present features of **'obsessed maniacs'** and **'clairvoyant oracles'** (Carayannis 1998–2002, George Washington University Lectures on Entrepreneurship) as well as the capability and propensity for creative destruction, just as Joseph Schumpeter characterizes innovation. Albert Scentzgeorgi, Nobel Prize laureate, defined creativity as follows:

> *'seeing what everyone sees and thinking what no one has thought before'.*

1.1.4.1 When, Why and How Creativity Arises

The problem with 'creativity' is that it is indeterminate. While we generally know when something is creative, we usually don't know why. It seems particularly challenging to give a precise definition on the matter.

Aristotle for example argued that inspiration involves a form of insanity giving birth to great ideas as a result of a person's thoughts, evolving through forms of cooperation (Dacey and Lennon 1998, p. 17). This view that considered the creative individual as insane sustained throughout the nineteenth century.

Freud believed creative ability was a personality trait that tends to become fixed by experiences in the first five years of life (Dacey and Lennon 1998, p. 36). He added that creative expression constitutes a means to express internal conflicts that would otherwise lead to neuroses. Creativity was some sort of emotional purgative that kept men sane (Kneller 1965, p. 21). During the first half of the twentieth century, B. F. Skinner and other behaviorists considered creative production to be strictly the result of 'random mutation' and of appropriate society's reinforcing factors (Dacey and Lennon 1998).

Kneller (1965) argues that 'an act or idea is creative not only because it is novel but because it achieves something that is appropriate to a given situation'. We create when we discover and express being new to us. The functional phrase 'it's new to us', even if an individual has discovered something, is still creativity if we rediscover it by ourselves.

Amabile (1996) seems to be giving the most thorough definition available today. She suggests a dual definition of creativity: (1) a product or response is creative to the extent that appropriate observers independently agree it is creative. Appropriate observers are individuals with large experience in respective fields˙ and (2) a product or response will be judged as creative to the extent that it is both a novel and appropriate task at hand, and the task is heuristic rather than algorithmic. Moreover, Amabile (1996, p. 90) classifies personality traits figuring constantly in the summaries of empirical papers as the traits of creative individuals:

- High degree of self-discipline in work-related matters.
- Ability to delay gratification.
- Perseverance in the face of frustration.
- Independence of judgment.
- Tolerance for ambiguity.
- High degree of autonomy.
- Freedom from gender role stereotyping.
- Inner point of control.
- Willingness for risk taking.
- A high degree of individual, targeted *struggle for excellence.*

Amongst the aforementioned ten basic traits, it would be particularly useful to add three more: the incentive to freedom, the functional freedom and flexibility. The incentive to freedom (Getzels, Taylor, Torrance, as quoted by Dacey and Lennon 1998) appears when individuals reach the limits of rules to fulfill their needs; when the rules of a situation cause distraction from their creative ideas. Functional freedom refers to the ability to use objects for other creative or unique uses. Dacey and Lennon contend that the more education a person has, the more rigid his or her perception of function and functional freedom is likely to become. Moreover, since education tends to encourage complexity of thoughts, this could lead to a more complicated way of thinking moving against the production of simple ideas-constituting many of the greatest solutions worldwide. Flexibility is the capacity to see the whole of a situation, instead of a set of disparate details.

1.1.4.2 Creativity in an Organizational Context

> *'Culture is the invisible force behind the tangible and observable in an organization, a social energy that moves people into action. Culture is to the organization what personality is to the individual—a hidden yet unifying theme that provides meaning, direction, and mobilization'*
>
> [Killman 1985]

Many authors consider creativity in the business environment as a key element allowing changes inside the organizations. Kao (1996, p. xvii) defines creativity as: the overall process wherefrom ideas are born, developed and transformed into value. Creativity involves what people usually mean as innovation and entrepreneurship. In our discourse, creativity denotes the art of giving birth to new ideas and the method of formulating and developing such ideas into true value. Kao views creativity as 'the result of interplay among the person, the task and the organizational context' (as quoted in Gundry et al. 1994). Drazin et al. (1999) agree with this argument. They conclude that creativity constitutes an individual but also group process. The complex, creative projects observed in large organizations require the involvement of many different individuals and not just a few. In a creative effort, it is usually difficult to give credit to each individual separately (Sutton and Hargadon, as quoted in Drazin et al. 1999). Creativity, they argue, is a repetitive process whereby distinct individuals interact with the group, resolve issues on their own and they return to the group to transform and further enhance their ideas.

1.1.4.3 Environmental Effects on Creativity

> *'When I am, as it were, completely myself, entirely alone, and of good cheer . . . my ideas flow best and most abundantly. Whence and how they come, I know not; nor can I force them. Those ideas that please me I retain in memory.'*
>
> [W.A. Mozart

Woodman and Schoenfeldt (1990) highlight the importance of social environment and stress the following: 'it is clear that individual differences in creativity are a function of the rate in which social factors and contextual factors support the development of creative process'. They also add that research in creativity led to the acknowledgement of the fact that the kind of environment it is most likely to produce a well-adjusted person is not the same as the kind of environment a creative person is likely to create. Due to lack of research in the field, we shall briefly examine the factor through a continuously broadened circle of social influences-from family to culture.

Amabile (1996) reports three significant social factors for creative behavior:

- **Social facilitation (or social inhibition),** arising from the presence of others: She mentions that the presence of others may dwindle performance in projects being complex or where there is limited knowledge but could improve performance in projects where knowledge is available or in simple ones. Moreover, abundant evidence shows that individuals present worse performance in ideas production tests when they work in groups compared to individual work.

- **Modeling or imitation of observed behavior:** The research underscores that a big number of creative models of an entire generation can stimulate a creative production for the following generation (Simonton). At individual level, the type of influence seems more complex.
- **Motivational orientation or intrinsic or extrinsic approach of a person to work:** Studies show that the intrinsic orientation leads to a preference for simple, foreseeable projects.

Available data suggest that different cultures may boost or obstruct creativity. Arieti (1976) investigates the culture-bound impact on creativity and stresses that the possibility for creativity is set to be more frequent than its actual manifestation. Some cultures promote creativity more than others and named these cultures ‘creative’. He considers that individuals become creative when the following three factors are in place:

- **The culture is right.** He gives the example of airplane that could not have been invented, if gasoline had not been invented first.
- **The genes are right.** A person’s intellect, considered genetic, should be high. Creativity, possibly genetic or not, should also be high.
- **The interactions are right.** He cites the example of Freud, Jung and Adler. If Jung and Adler had not had Freud to compete with, it is questionable whether they would have been able to occupy such a significant place in modern psychology.

In a study on culture by Hofstede (1980) of forty independent nations, he found four criteria where the cultures of said nations diverged: power of distance, uncertainty avoidance, individualism–collectivism and masculinity–femininity. Such dimensions have a strong impact on the ‘collective mental planning of people for the environment’. They have also been enshrined in our collective historical culture. For example, the Americans have a tendency towards high individualism, small power of distance and low uncertainty avoidance. Such tendencies do reflect American history which has attached a high value to quality, independence and willingness to take up risks.

Such cultural impact is very much different quality wise from the social influences mentioned in previous creativity models. To use a more suitable term, we call it ‘cultural embeddedness’ because it denotes much more than a society’s standards, values and mores. It denotes what constitutes our reality. Taking into account this additional element, we put forward a new creativity model that not only does explain the elements of creativity but the process itself. Under this new model, cognitive and personality factors interplay individually and vice versa. The social environment interacts with the three factors mentioned above and conversely the individual participates in the creative process. Cultural embeddedness affects not only all creative factors but also all steps of the creative process.

1.1.5 Innovation

‘Discovery consists of looking at the same thing as everyone else and thinking something different.’

[Albert Szent-Gyorgyi-Nobel Prize Winner]

Innovation is a word deriving from Latin and means the introduction of something new to the existing world and the order of things or the improvement of resources productivity as mentioned by J. B. Say, quoted in Drucker (Drucker 1985). Many definitions of innovation are found in the literature. We report some of them:

Chris Freeman and Soete (1982) reports: *"The industrial innovation involves technical design, manufacturing, administrative and commercial activities related to the marketing of few (or improved) products or with the first commercial use of a new (or improved) process or equipment"*.

Paul Gardiner (1985) highlights the following: *"…innovation does not only mean commercialization of a significant advantage at the highest technical level (radical innovation), but it also includes taking advantage of small scale changes in the know-how (improvement or incremental innovation)…"*

Peter Drucker (1985) stresses that: *"innovation is the special tool of businessmen to utilize change as an opportunity for a different activity or service. It is possible to appear as a discipline, to be learned, to be practiced"*.

Paul Michael Porter (1990): *"enterprises acquire a competitive advantage through acts of innovation. They approach innovation in its broader sense, including new technologies and the new way to do things"*. The term Innovation may refer to the process-conversion of an idea into a merchandised product or service, a new form of business organization, a new or improved functional production method, a new product presentation way (design, marketing) or even to a new service rendering method. It may also refer to the design and construction of new industrial equipment, the implementation of a project with a new management or may refer to a new way of thinking to deal with a situation or a problem. (Green Paper of the E.U. on innovation). Technological evolution and the parallel social and economic changes take place through the realization of innovation. A society's ability to innovate largely constitutes a mechanism of renewal and development. Innovation regards every aspect of economic or productive process. At the level of an enterprise or an organization, innovation is mainly realized either by developing new products and services or by restructuring production–operation processes.

The continuous innovative effort for new products-services or new productive processes create a competitive advantage in three critical areas:

a. Evaluation of the resources involving research and development activities, application of a new technology, sales productivity, production etc, new productive investments and expansion into new markets or broadening of the customer base.
b. Development and renewal of the entity with investments and growth, professional evolution opportunities for human resources, new recruitments and optimism, high morale and spirit.
c. Business success building on the reputation and attracting new customers, image of a dynamic business, products that distinguish from the competition, ongoing development and making hard for the competition to gather pace.

1.1.6 The Concept of Technological Innovation

Innovation is often associated with the creation of a sustainable market around the launching of a new and superior product or process. In particular, in the literature of technology management, technological innovation is characterized by the introduction of a new technological product in the market:

> *'Technological innovation is defined here as a situationally new development through which people extend their control over the environment. Essentially, technology is a tool of some kind that allows an individual to do something new. So, technology transfer amounts to communication of information, usually from one organization to another'.*
>
> (Tornatzky and Fleischer 1990)

In particular, technological innovation is defined as:

> *'Introduction in the market of a technologically new or significantly improved product or the application of a technologically new or significantly improved productive process, successfully responding to market demand. It is the outcome of the interplay of market conditions on the one hand and of the possibilities to utilize the stock of technological and scientific knowledge'*
>
> (Schumpeter 1934)

Many authors acknowledge the importance of technological innovation for a company's high performance today. We report some of them:

- Technological innovation in various enterprises is one of the key reasons for industrial competitiveness and national development (Freeman and Soete 1982; Porter 1985).
- Innovation is the only special ability in the 1990s (Peters 1996).
- The key feature of a modern market is not the price, but innovation (Zaltman et al. 1973).
- Innovation is the ultimate border in the modern business world helping companies to attain better yield, new products and services at lower cost (Pospiril 1996).

Technological innovation is a new technology that creates new products, hence new opportunities for the industry. This is the basic meaning of innovation and the reason it is important for economic growth as it creates business opportunities. Technology was and will be the key incentive to drive changes in our society.

Technological innovation has turned into the largest driving force paving the way for society since 1980s. There is a constant flow of products and processes, from power engines in cars, airplanes, telecommunications and pharmaceutical preparations. All enterprises owe their existence and long standing presence to the successful application of technology in the creation of new products and improved manufacturing processes.

At present, management executives acknowledge the primordial role of technological innovation in a company's business success (Hans J. Thamhain). The enterprises that failed to keep up their innovative nature have been outstripped by younger and more active organizations. This failure is due to their weakness to see through the impact of new technology, while competitors seize the opportunity for development offered by technology. Traditionally, innovation has been linked to R&D activities and the use of technological knowledge. This could be explained by the fact that all examples outlined in the literature of businesses are taken from the pharmaceutical industry, the chemical industry or electronics, where basic research has brought about the innovation that changed the world (penicillin, nylon and microprocessors). Any industrial application of scientific knowledge is a technological innovation. It should be stressed at this point that all sectors, of high or low technology, can use technology for innovation. A case in point is EUROPASTRY-FRIPAN, a company set up in Barberà del Vallès, that managed to innovate in an existing bakery industry developing frozen bread. The possibility to have hot bread at any time of the day carrying out a simple task not requiring specialized staff at the sale point seemed impossible to many people. The company almost took a leading position in the Spanish market and set out a revolution in what was seen as a particularly traditional sector. A broader interpretation of the term 'innovation' refers to innovation as an 'idea, practice or material artifact' (Rogers and Shoemaker 1971) adopted by a person or an organization, where the artifact is 'considered new by the relevant unit of adoption' (Zaltman et al. 1973). For this reason, innovation tends to change the perceptions and the relations at organizational level but its influence is not limited at this level. Innovation in the broader socio-technical, economic and political framework could significantly affect, shape and modify the ways and the means people live, businesses are structured, compete, succeed and fail and nations prosper or decay (see Fig. 1.1). In particular, Fig. 1.1 aims to explain the nature and dynamics of an international framework where creativity and innovation could lead to competitiveness improvement and ongoing development. On the other hand, the lack of creativity and innovation is a factor of failed performance and therefore a factor of economic yield failure. In those countries where creativity and innovation are effectively realized, globalization could serve as a drive of beneficial and continuous economic integration. Nevertheless, globalization may become a powerful force leading to loss, inequality, marginalization and economic corruption in non-competitive countries. A government and market success or failure is determined by the way they make use of the four basic elements shaping creativity, innovation and competitiveness worldwide:

1. The coordination and partnership between governments, enterprises, research laboratories and other specialized bodies, universities and support services for small and medium sized enterprises (SMEs),
2. The power of information and communication technology,
3. The efficiency that can be brought about by management and organizational systems in production and trade, and
4. The international agreements, provisions and regulations. All four elements of this framework shall impact on creativity and innovation at micro-level (company level) as well as on innovation and competitiveness at macro-level (industry, national, global).

From a company's perspective, **innovation** is considered as the **fortunate ending of an invention's commercialization journey**, when such a journey is indeed

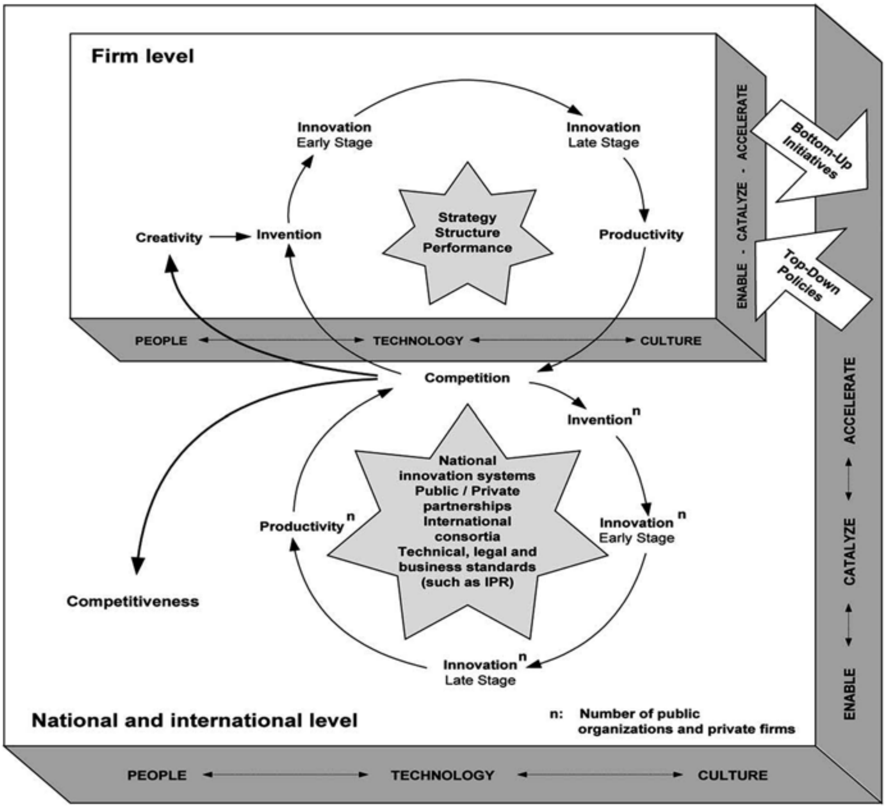

Fig. 1.1 Creativity, innovation, competitiveness

successful and results in a constantly thriving market share or a new market. In other words, a technical discovery or invention (or creation of something new) is not important for a company unless this new technology can be utilized to add value to the company through income increase, cost cutting and similar improvements in economic results. This has two important consequences for the analysis of any innovation in a business organization. Firstly, innovation should be in-built in the organization's functions and strategy in order to clearly impact on the way said organization creates value or on the type of value offered in the market by this organization. Secondly, innovation is a social process, as it is only through intervention and management of persons that an organization can actualize the benefits of innovation. The discourse around innovation leads clearly to the creation of a model for the understanding and the evolutionary nature of innovation. Innovation management deals with the activities undertaken by the enterprise in order to produce solutions for problems related to products, processes and management. Innovation involves uncertainty and dis-equilibrium. Nelson and Winter (1982) suggested that any change-however insignificant-represents an innovation. They also suggest that, considering uncertainty, innovation ends up to the emergence of new technologies and changes in relative weighting of existing technologies (ibid). This results in **the disruptive process of dis-equilibrium**. Insofar as innovation is adopted and disseminated, existing technologies become less useful (reduction of weight factors) or even useless (weight equal to "0") and are discarded. The stage of adoption is when uncertainty appears. New technologies are not adopted automatically but rather the markets influence the adoption rate (Carayannis and Alexander 1997; Carayannis and Alexander 1998a, b; Carayannis and Jorge 1998c).

It is obvious that innovative technologies put forward solutions for market problems, such as reduced cost, usefulness and productivity. Nevertheless, the markets are social structures and are subject to non-innovative criteria. For example, an invention may be very promising offering a significant reduction in product cost something which would reasonably influence the market to accept said innovation; however, asymmetry in information (or lack of knowledge in the market as regards the properties of the invention) is the reason why the invention cannot be immediately embraced by the markets. Therefore, innovation may simply remain an invention. If, though, innovation becomes accepted by the market, the results shall lead to a change in the relative weight of existing technology. This is the dis-equilibrium in effect. Taking into account the existence of uncertainty and change in the innovative process, the management should develop skills and should understand the process as a method to manage sudden change of events. The problems of managing the resulting change are strategic by nature. They can be classified in three categories, **engineering, entrepreneurial and administrative** (Drejer 2002). Such classification relates to the respective types of innovation, product, process and administrative innovation:

- The engineering problem involves selection of the suitable technologies for the correct operational performance.
- The entrepreneurial problem refers to identification of a product/service and the target markets.
- The administrative problems focus on mitigating uncertainty and risk during the previous phases.

In much of the previous discussion on innovation, a recurrent subject is that of uncertainty, leading to the conclusion that an effective innovation model should include a multi-dimensional approach:

> *'Uncertainty is defined as the unknown knowns, while risk is defined as the known unknowns'.*

A model being helpful for comprehension is the Multidimension Model of Innovation, MMI (Cooper 1998). This model tries to define the understanding of innovation by establishing three-dimensional boundaries. The levels are the following: the product–process, the additional-radical and the administrative–technological. The product–process boundary deals with the final product and its relation to the methods adopted by the companies to produce and distribute the product. The additional-radical boundary determines the degree of relative strategical change accompanying innovation dissemination. This is a measure of disruption or dis-equilibrium in the market. The technological–administrative boundaries refer to the relation of the innovative change in the operational nucleus of a company. The technological boundary refers to the influences in basic steady production whereas the administrative boundary would involve innovations that affect the relative policy factors, the resources and the social aspects of the company.

1.2 Innovation Posture, Propensity and Performance

Penrose (1959) and Barney (1991) developed the conceptual model of organizational innovation from a perspective based on company resources. In particular, they focused on the concept of knowledge that permeates all organizations as intangible resource to give new daily routines, technologies or structures that impact on future performance (Nelson and Winter 1982). In order to explain the multi-layered influence of organizational innovation, they viewed the framework of innovation routines as a procedural model. They place emphasis on intangible resources contributing as inputs to the process of innovation; they examine the capacity of an enterprise to participate in innovative activities and finally they consider the raft of organizational outputs deriving from innovation that extend from short-term outputs to long term permanent impacts.

This compilation of measures is housed within a '3P' framework for the organizational innovation. Innovation results from three critical factors at business level: **Posture, Propensity, Performance, 3P** (see Fig. 1.2) (Carayannis and Provance 2008).

Posture refers to an organization's position within the largest innovation system of its environment (i.e., region, industry, technological domain). In detail, posture encompasses the situation in a company along three dimensions: the organizational, technological and market life cycles depicting its capacity to participate and benefit from innovation (Damanpour 1996). In this way it determines the conditions affecting an enterprise within a specific technological regime serving a specific market. Every company's capacity to take part in innovative activities shall be restrained by its posture, being extrinsic to the innovation process measured. In other words, irrespective of whether and which type of innovation process is adopted, a company exists always at some point in its life cycle from its establishment until failure (organizational life cycle). The company selects the technologies to adopt in the application of its strategies and is thus subject to the life cycle of the technology regime wherein technologies exist (technological life cycle). For example, a small number of post carriage businesses kept on operating for a while after the launching of cars, so their position in the technological regime of post carriage sustained and continued being measured. Finally, the company finds itself in a competitive context within significant strategic activities in one or more markets. These markets exist in various points in its life cycle, restricting thus the company's available innovative actions.

Propensity is a company's capacity to capitalize on its posture based on the innovation's cultural acceptance. In this way, propensity is an intangible reflection of procedures, routines and capabilities established within a company. A company

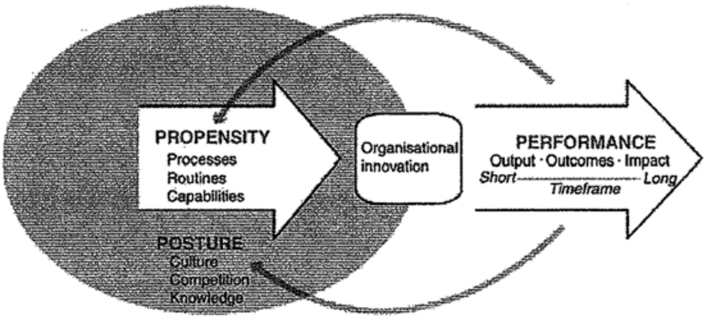

Fig. 1.2 The 3P framework: a systems view of the innovation process (Carayannis and Provance, 2008)

may have sufficient resources and therefore higher externalization of innovation, while having at the same time an underdeveloped capacity for innovation by virtue of its culture or other restrictions (Carayannis and Provance 2008).

Performance is the enduring result of innovation. This part of the framework involves three levels: **output, outcome and impact,** (Carayannis and Provance 2008). Impact appears as direct, internalized benefits of innovation. New product introduction, patents and technology transfer licenses are some examples of output arising. Outcomes encompass medium results, such as revenues from new products. Finally, impact represents lasting and long-range benefits that are injected to the company by its innovative capacity and are transformed into results for the company's environment too. All the three factors—posture, propensity and performance—are empirically conceived in the form of a combined indicator defined as **Complex Innovation Index, CII** (Carayannis and Provance 2008). This comprehensive measure denotes the superior evaluative results of innovation measurement (analyzed further down) in all aspects of the process (Damanpour 1996).

1.3 Innovation Measurement

Measurement of innovative performance at enterprise level has been less the focus point compared to project or system level. Studies at project level offer a broader understanding of the mechanisms underlying innovation and their impact on the organization in question. Most of these studies exclude the control held by managers to deal with uncertain and dynamic environments. Differences among the studies have led to a generally accepted innovation performance indicator or to a common set of indicators at organizational level. In general, the following categories of indicators related to innovation can be distinguished:

- **Input indicators** measure the available resources in the innovation process. Such inputs include the intellectual, human and technological capital (e.g. Baruk

1997; Carayannis et al. 2003; Hagedoorn and Cloodt 2003; Lansiti 1997; Leenders and Wierenga 2002; Parthsarthy and Hammond 2002).

- **Process indicators** depict the organizational systems and the management systems of innovation processes. They also integrate a company's innovation system design as well as its innovativeness (Howells 1995; Kahn 2002; Koen and Kohli 1998).
- **Output indicators** determine the results of organizational innovation. Output indicators represent the realized short-term success of innovative activity. Indicators in this group count the numbers and rates of patents, patents reports, the number of new products, innovation-related sales rate etc (Baruk 1997; Michalisin 2001). They also represent the realized, short-term success of innovative activity, e.g. profit margins or the company's medium-term and long-term market shares, the company's growth rate, the dominant designs or the technological standards formulated by business innovations, the innovations of second stage and advanced stages deriving from an initial innovation, degree of disruptiveness (Carayannis et al. 2003). Impact measures the continuous advantage enjoyed by a company as a result of innovation. Many studies utilize a single input or output indicator to define a company's innovative performance (Coombs et al. 1996; Evangelista et al. 1998; Feeny and Rogers 2003).

However, it has been ascertained that there are problems in innovation measurement, particularly with input indicators (Coombs et al. 1996). The critical issues are (1) some input measurements that do not conceive the process performance, (2) single measurements not reflecting economic or qualitative value, and (3) lack of indication of technological complexity in the inputs. Similarly, Santarelli and Piergiovanni (1996) have demonstrated that output indicators based on patents may be problematic because the technological level and the economic value of patents are particularly heterogenic; the nature of patents' content largely varies from country to country. In addition, not all innovations are patented; not all patents turn out being innovation and patenting depends largely on a company's size. Output indicators present limitations due to primary factors at industry level, when industries or enterprises with variable size are compared. Other studies have criticized the isolated measurement of innovative business operations or parts thereof (e.g. Damanpour 1996).

Adding to this criticism, we have identified three limitations of the existing literature. Emphasis is primarily placed on the manufacturing sector and on products' innovations, disregarding the process variables. Therefore, existing innovations do not take into account some significant indicators for innovative success and present restrictions in the examination of different sizes, objectives and activities of enterprises. Recent studies have presented the advantage of utilizing complex indicators to determine a company's innovativeness (e.g. Hollenstein 1996; Hagedoorn and Cloodt 2003). However, the concept of a complex indicator has not been studied in depth by the literature. Only three innovation studies use complex indicators to record the diverse determining innovation-based performance factors (Damanpour 1996; Hagedoorn and Cloodt 2003; Hollenstein 1996). Only Damanpour (1996) and Hollenstein (1996) utilize process indicators. It is therefore required to develop

Table 1.1 Measurable features of novelty

Quantitative measures		Quality measures	
Characteristic	Measurement	Characteristic	Measurement
R&D	Budget R&D	Effection	Productivity
	Patents		Development
	New products		Low cost
	Staff R&D		Flexibility
	Publications		Offer/Demand
	Initiatives R&D		Enterprise's size
	New ideas		Market's effection
	Inventions		Users' benefits
	New markets		
	Products extensions		
	Conventions	Personal	Low prices
	CRADAs	Social	Social involvement
	Cooperations		Saving time

complex indicators that would integrate the distinct approaches to measurement and would include measures of the overall innovation project (Coriat and Weinstein 2002; Hagedoorn and Cloodt 2003).

How then should innovations be measured, provided of course they are measurable? Research & Development (R&D) constitute the first measurement tools utilized (Evangelista et al. 2001). Nevertheless, research and development itself can be measured based on different characteristics. For example, in case of research and development measurement/Intellectual Property Rights, the number of patents constitutes a measurement indicator. Other characteristics are frequently measured though, such as budget for research financing, the number of researchers, the number of significant inventions, the number of new products, the number of researches published, etc. (Tidd 2001). There exist also other characteristics associated in a less apparent way, such as increased productivity and development or reduced cost (Nelson and Winter 1982). Another classification of measurable characteristics is realized on the basis of the social impact of innovations. The relevant examples include the possibility to measure the advantages, the lowest prices and time saving offered to consumers as well as other elements facilitating the members of society (Mansfield et al. 1977). A typology of measurable characteristics could be of help to collect the distinct measurable characteristics (Table 1.1).

The basic classification is between 'quantitative' and 'qualitative' measurable characteristics. Quantitative measurable characteristics are the ones directly associated with innovation process. For example, the number of patents is the direct result of the research process and it is not generally affected by external factors. On the contrary, improvement of productivity could be a direct result of innovation but the relation between the two is less clear due to other characteristics affecting it. Productivity increase could derive from a simple increase of interest in the application of innovation for productivity. This should not make us assume that innovation was not a key factor that influenced the increase of productivity but most probably that the measurement process was not accurate enough to reveal the role of different influences.

Research and development directly affect the outcome. Studies carried out in the manufacturing sector showed that the utilized financing granted for research and development (R&D) was the main explanation for the differences in productivity development among manufacturing companies compared to the entire financing for research and development in the entire sector (Nelson 1977). This could practically mean that the expenses for research and development are a direct way of measuring a company's productivity. The adoption of measures for the development and application of innovations could be influenced by a company's business and technological strategy. A company aiming at high profit may choose to measure the characteristics of innovations geared towards specific targets (Nelson 2000). This type of measurement is more useful for the characteristics being directly linked between them, i.e. for the cases of quantitative measurable characteristics.

1.4 Competitiveness

Competitiveness is people's, organizations' and nations' capacity to achieve high outputs and outcomes and in particular to add value using the same or lower input amounts (see Fig. 1.3).

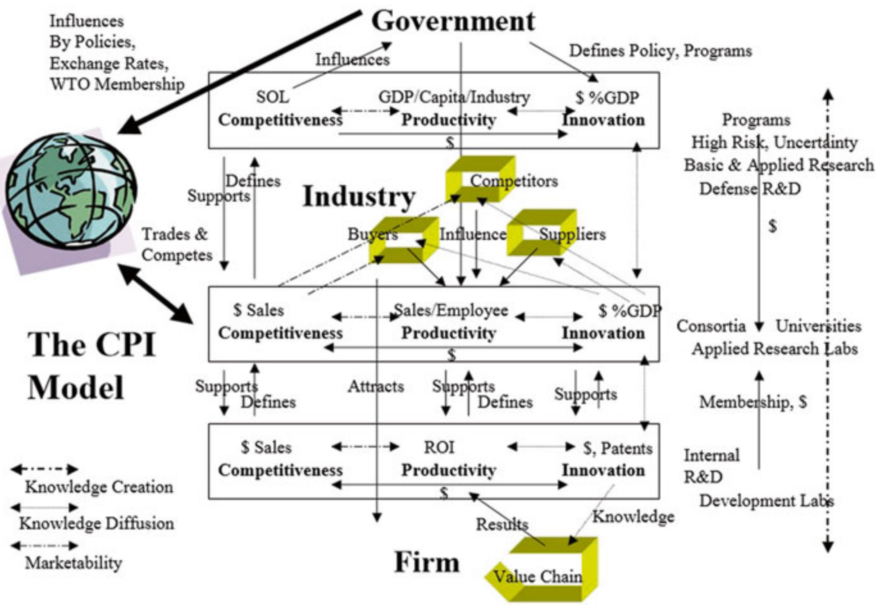

Fig. 1.3 The CPI model

In addition, the entrepreneurial addition of value and the learning from experience and failure are not solely determined by profit and non-profit organizations. The rule for the evaluation of such outcomes as 'superior' or 'better', or 'more performing' could include basic capabilities of a specific organization or nation as well as a comparison with other organizations or nations. Then the basic conclusion drawn for competitiveness is that it is attained through an organizational improvement process whereby institutions of an economy have a clout over people, knowledge and technologies, with the aim to restructure relations and achieve higher production levels.

1.5 A Historical and Socio-Technical Perspective on Innovation

> *'But in capitalist reality…, it is not price competition which counts but the competition from the new commodity, the new technology, the new source of supply, the new type of organization.... competition which....strikes not at the margins of the profits and the outputs of the existing firms but at their foundations and their very lives'*
>
> [Joseph A. Schumpeter 1942]

To understand the history of innovation, one should take a look at Schumpeter's classical papers. Schumpeter authored the 'Theory of Economic Development' in 1934 as a research focusing on profit, capital, credit, interest and cyclical economic fluctuations. His main contributions were (a) the expansion of Adam Smith's economic principles from land-labor-capital to land-labor-capital-technology-entrepreneurship and (b) the introduction of the concept of imbalance in economic discourse. It is interesting to highlight that Schumpeter was a socialist who believed that the capitalist system would eventually collapse and be replaced by a socialist system. At this point he agreed with Marx, but his interpretation on socialism was very much different on many accounts. Marx felt that the economic model he applied could determine the structure of society. The corner stone of his theoretical structure was the 'Value-Added Theory' whereby the value of a commodity, taking into account the perfect balance and the ideal competition, is proportional to introduction of labor. Schumpeter disagreed with Marx on this issue reaching the conclusion that the perfect balance and the perfect competition were problematic even in the best of cases.

Another point of discord between Schumpeter and Marx was the latter's allegation that the capitalist system shall collapse '(Zusammenbruchstheorie)' as a result of its inherent injustices. According to Schumpeter, the natural evolution of capitalism would destroy the foundations from within. In reality, he considered that the economic crisis of 1930s was an indication of paradigm shift that strengthens his convictions. Schumpeter saw capitalism in almost the same way he saw innovation process. Both were generally considered stable processes (under perfect conditions) from a theoretical model perspective. Schumpeter, however, introduced the conceptual theory of imbalance as the main powerful factor and this could be further expanded in the concept of continuous powerful disequilibrium (Carayannis 1994b) to grasp and articulate the concept of successive Fisher-Pry (S-curves) curves with discontinuous or/and disruptive innovations, inducing a change in the curve or/and the change of the 'rules of the game', as we shall see below.

Michael Tushman and Charles O'Reilly suggest that discontinuous innovation involves breaking with the past to create new technologies, processes and organizational 'S-curves', resulting in significant leaps in the value added to customers. Similarly, Clayton, Christensen, Gary Hamel, C.K. Prahalad, James Utterback describe discontinuous innovation as a mixing of 'radical technologies', 'discontinuities' or 'radical innovations' enabling entire industries and markets to set out, be transformed or be vanished (Kaplan 1999). Technological innovations helping companies to establish new rules for the enterprises or to create enterprises anew are usually considered discontinuous. With regard to the concept of 'discontinuity', the distinction is rare in the literature; the same applies with the methods of recognizing said radical innovations. For the masterminds of corporate strategies' planning, a key question remains unanswered and regards the establishment of a method for the identification of opportunities and their utilization through rational processes that lead to reliable steps (in contrast to waiting for a random appearance of opportunities) (Kaplan 1999).

Usually capitalism is referred to as 'laissez-faire' but after the Second World War capitalism is more closely related to social, political and legal models. Following Schumpeter's principle on evolutionary capitalism, we could say that capitalism in modern era is a reasonable expansion of Schumpeter's theory. The concept of innovation as a 'socio-technical' system has been fairly consolidated. Rogers (1995) for example defined innovation from the point of view of notions for people or groups adopting an innovation. The efforts to classify innovations on purely technical terms are facing the danger of depicting the outcome of a social process as something that would be totally separated from human influence.

This paper advocates an approach for the concept of innovation classification and sub-division in four basic dimensions (Carayannis 2002):

i. The process of innovation (the way innovation develops, disseminated and adopted).
ii. The content of innovation (the specific technique or social nature of innovation itself).
iii. The environment of innovation (the environment in which innovation takes place and the environmental impact on innovation).
iv. The impact of innovation (the social and technological change arising from the innovation process completion) (Carayannis 2002).

Using all these four dimensions of innovations, we could investigate deeply its social repercussions.

The key factors linking creativity and innovation are the following:

- **Environment:** The environment where the above dimensions take place.
- **Process:** What is the process actualizing all the above.
- **Content:** What is the content of the above taking into account the interaction with other factors.
- **Impact:** What is the impact of each of the above on the other factors.
- **Level:** The properties should be viewed at all levels including the company, industry, national and international levels.

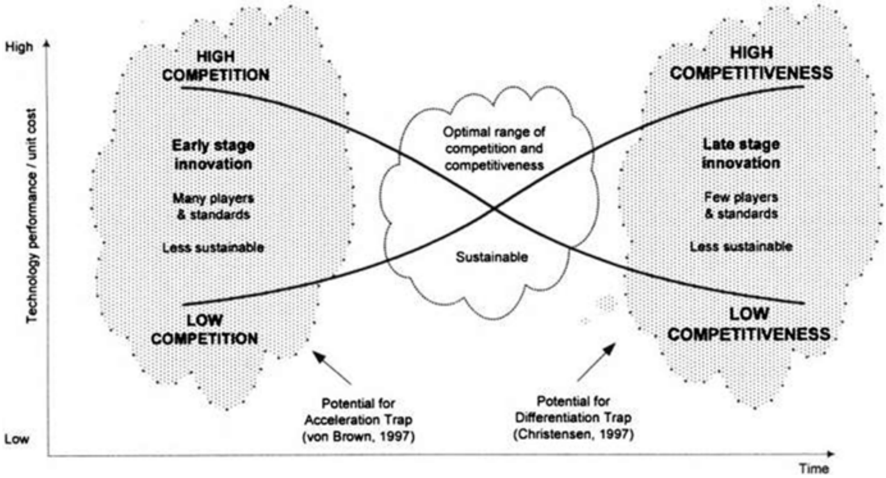

Fig. 1.4 Competitiveness vs competition trade-offs (Carayannis and Gonzalez 2003)

- **Invention:** What is being invented determines the content of innovation.
- **Mechanization:** It is a necessary but no satisfactory condition for innovation.
- **Creativity and Competition:** They may be extrinsic factors to competitiveness. Competition facilitates or inhibits competitiveness (see Fig. 1.4).
- **Stabilization:** It may reproduce satisfaction.
- **Radical technologies:** They can renew competitiveness with significant productivity profits.

Nevertheless, exaggerated competition may undermine competitiveness leading to the Acceleration Trap (von Braun 1997) and to Differentiation Trap (Christensen 1997) (see Fig. 1.4). This kind of situations lead increasingly to shorter and no continuous cycles of products and spiral cost of R & D with shrinking profit margins and market shares, resulting from exaggerated competition and reduced competitiveness. Under the circumstances, change takes place so quickly that usually companies fail to fully benefit from it and end up using resources insufficiently and declining their position in the market participating in price wars and in trivial innovation races. Companies could thus find themselves 'trapped' in a ruthless spiral of increasing competition and reduced competitiveness resulting in even fewer sustainable positions or market niches.

1.6 Common Frameworks and Typologies to Characterize Innovations

'Comforted by idols, we can lose the urge to question and thus we can willingly arrest our growth as persons: 'one must invoke tremendous counter-forces in order to cross this natural, all too natural progressus in simile, the continual development of man toward the similar, average, herdlike common!'

[Nietzsche, 58]

Innovations can be classified in three general categories, in **content innovations, process innovations and administrative innovations** (Tidd 2001). Some researchers classify innovations based on the influences per **geographical regions** (Evangelista et al. 2001) or based on **decision making criteria** (Rogers 1995), while others distinguish innovation in **incremental, generational, radical and architectural** (Cooper 1998). Another method to classify innovations in types is carried out depending on the decision making systems (Rogers 1995) and is based on the principle establishing that the adoption of some innovation be influenced both by individuals and by social systems in their entirety. Moreover, innovations are distinguished in **subversive/non subversive** and in (Christensen 1997) continuing**/discontinuing** innovations (Tushman and Anderson 1990).

- **Process innovations** regard the change in the methods adopted by a company to offer products and services. A case in point is the use of the internet to manage the supply chain, whereby ordering, pricing and monitoring are carried out through the internet.
- **Innovations of content** reflect the changes in the final products and in a company's services. Such an example is the addition of a new characteristic, i.e. remote control in TV sets to facilitate users.
- **Administrative innovations** refer to the changes in the characteristics of an organization or an institution. Such examples are the changes in policy, structure and distribution of sources.
- The classification of innovations based on the differences arising per **geographical region** is a very narrow concept being usually restricted in the comparison between specific technological innovations. One of the disadvantages of said method is the evaluation of an innovation's regional/geographical nature. For example, in cases of **research and development (R & D)**, evaluated based on the number of patents, it should be clarified that the areas where a patent was discovered may be different from the area where it was registered, particularly in the case of multinational companies. Should an invention take place in an Asian company belonging to a USA multinational, the patent registration application is most probably filed in USA; as a result, if measurements take place per geographical region, it shall be considered that the patent belongs to the USA.
- Bringing together various previous studies on technological innovations (particularly studies carried out by Abernathy, Anderson, Clark, Henderson, Tushman and Utterback) a common framework emerges that distinguishes four general types of technological innovations: **incremental**, **generational**, **radical** and **architectural innovations**.
- **Incremental** innovations exploit the potential of established designs and usually reinforce the dominance of already existing enterprises. They also enhance current operational capabilities of a technology through small scale improvements on the value of technology, adding attributes such as performance, safety, quality and cost.
- **Generational innovations** are incremental innovations resulting in the creation of a new system that does not present radical changes.
- **Radical innovations** introduce new concepts that diverge significantly from the practices of the past and contribute to the creation of products and services based

on different engineering or scientific principles and usually pave the way for new markets and possible applications. They also offer a ‘new operational capacity that constitutes a discontinuity in the current technological capabilities in effect’.

- **Architectural** innovations serve to broaden the classification of radical and incremental innovations introducing the concept of changes in the way the constituent parts of a product or system are linked together.

Another common classification is **evolutionary** innovations whereby changes seem to follow the process of ‘natural selection’ (technical improvements are the result of the ‘survival of the fittest’) and **revolutionary** innovations, whereby changes appear as disruption or non-continuing change in the course of technology. These two approaches to innovation, however, are not mutually exclusive.

Based on the aforementioned types of innovation, we could show the way these concepts relate to each other in a more integrated framework for the analyses of innovations.

Process	Content
Evolutionary innovation	Incremental innovation or Next generation innovation
Revolutionary innovation	Radical innovation or Architectural innovation

The integrated framework of our four dimensions enables us to correlate discontinuous and disruptive technologies with the following concepts.

<table>
<tr><th>Process</th><th>Content</th><th>Environment</th><th>Impact</th></tr>
<tr><td rowspan="2">Evolutionary innovation</td><td>Incremental innovation</td><td>Continuous innovation</td><td rowspan="2">Non-disruptive or Disruptive innovation</td></tr>
<tr><td>Next generation innovation</td><td>Continuous innovation</td></tr>
<tr><td>Revolutionary Innovation</td><td>Radical Innovation</td><td>Discontinuous innovation</td><td>Non-disruptive or Disruptive innovation</td></tr>
</table>

Not all innovations are discontinuous and not all discontinuous innovations are they disruptive; moreover, not all disruptive innovations are discontinuous. This is determined by Lethe innovation’s field of application, the time and its impact, while diverse strategies exist to deal with the challenges and the opportunities emerging from scheduled or random technological discontinuities and disruptions.

1.7 Innovation Process

‘The lowest form of thought is the stripped recognition of the object. The highest form is the full intuition of a man who sees everything as part of a system’

[Plato]

Defining innovation process is by nature problematic. This research field is still at its creation stage and every researcher in the field has given his own definition on innovation process. However, there is significant information available in order to have a common understanding of several points. The innovative process is determined through the correlation of its research constituent parts (Nelson 1977). Inventions can be measured, while the process of research and development can also be determined or constitute an object of research. Science and inventions can be linked between them; the sources of innovations can be further developed, the organization-bound factors can be investigated, technological evolution can be studied, diffusion of innovation can be assessed and learning phenomena can be disclosed.

'Inventions are viewed as complementary, cumulative, and leapfrog'

[Rosenberg 1982]

Complementary invention is the invention of a new process or of a new product that regards an already existing technology, such as the computer's mouse that supports the interactive relation between user and PC. Cumulative invention is the invention added to an already existing invention. For example, the improvement of a product by adding a pour spout on juice cartons is a case in point. Leap-frog inventions bring about radical changes that differ from the existing technologies and cause discontinuity in the markets.

To understand the process, one should conceive the concept of innovation urgency as a basic and guiding element (Cooper 1998). In a competitive context, managers are led to success both at individual and at organizational level. For organizations to be successful, managers should take a step further beyond development, application and approval of innovation. They need to be constantly innovative in order to reach success, driving organizations to higher levels of innovations' diffusion.

Most of innovation models are based on three basic ideas (Drejer 2002):

- Firstly, the organization can act in a suitable way in order to create or choose its environment
- Secondly, the strategic options of managers shape the structure and the processes of organizations and
- Thirdly, the selected structures and processes highlight a strategy.

It is a very interesting way to view the models of innovations. If an organization can choose its context and if this option is rational, it should be able to choose the best possible context for a successful strategy. However, there are numerous examples of strategies adopted by enterprises that did not yield the anticipated results. Is this principle belied by the bad performance of a strategy? Most probably, the selection of a context is affected by external factors. This question is indeed very interesting and it is worth being investigated; however, it does not fall under the scope of this book.

There are several recurrent basic principles pertaining to innovations. These principles are summarized as follows:

- The integrated organizational approach
- The incentives of innovations
- The systematic process to convert an invention into innovation
- Team skills

- Communications
- Learning and
- Project management.

The above principles are fundamental for the elaboration of innovation process. It is worth to underline the interdependence relations between learning and the skills possessed by the teams in relation to innovations. In a group context, individual members do not have sufficient knowledge but if the 'sum of knowledge' a group has collectively is larger than the knowledge available if team members were acting as separate individuals, then the team will become a successful carrier of innovation. A team's capacity to accumulate knowledge through effective learning methods constitutes a significant criterion for the long term success of the team, given that the usual structure of teams is subject to changes.

In general, viewing innovation as a process and not as a specific event or result is attributed to Peter Drucker (Cooper 1998; Drejer 2002). Control over the process of innovations is named also management of innovations. Management of innovations is determined by five basic activities (Drejer 2002):

- Technological integration: The technological integration regards the relation between technologies and the company's products.
- Process of innovations: The process of innovations involves functions creating and preserving innovations.
- Strategic planning: Strategic planning refers to planning of innovation-related technologies.
- Organizational change: Organizational change encompasses the disruptive nature of innovations related to requirements for knowledge and skills, new markets, new employees, etc.
- Development of an enterprise: The development of an enterprise refers to the creation of new markets for the products of innovations.

It is worthwhile stressing that innovations can lead to development of enterprises but also be driven by it. Said interaction is probably explained by the fact that during the initial stages, innovations by nature cause a disruptive change to organizations, e.g. creating new markets. As long as an enterprise evolves, the influence of technology becomes apparent.

The stronger competitors become or the more apparent their innovations become, an increasing and urgent requirement shall emerge for further innovations in order for the company to preserve its place in the market. As a result, competition drives the company to application of innovations.

Organizations are influenced by innovations in many ways. Creativity is driven by competition, change, learning, climate, communications, processes, social interaction between individuals and other external factors. Despite the fact the application of innovation constitutes an act with a predetermined purpose, uncertainty is its main attribute (Nelson 1977). This characteristic seems to influence all the guidelines exercised on the organization. In this way, as long as creativity leads to innovations, creativity itself is influenced. The influence could be either positive or negative; hence, creativity is altered and strategic plans prove to be ineffective. Stephen Kaplan (1999) dwells on the four types of discontinuities identified in Hewlett Packard and clarifies a context that could serve as a guide for managers of technologies and policy makers, as follows:

> Working in HP we discovered four types of discontinuities and elaborated a framework to help management executives recognize the opportunities to apply discontinuous innovations-i.e. to investigate the inflow of new revenue and to identify remarkable propositions for upgraded service to customers. This is the strategic objective that clarifies the new worthy business possibilities that could substantially contribute to growth.
>
> The context deals with the case of an organization wishing to explore new opportunities of discontinuous innovations and is based on three assumptions. Firstly, we believe that discontinuous innovations involve the creation of a new value for customers within existing or new markets. Secondly, seeking for discontinuous innovations, organizations create a new space for competition or modify the existing methods to deliver value to consumers. The third and last assumption regards the model's structure itself.

References

Amabile T (1996) Creativity in context: update to the social psychology of creativity. Westview Press, Boulder

Arieti S (1976) Creativity the magic synthesis. Basic Books, New York

Barney JB (1991) Firm resources and sustained competitive advantage. J Manage 17:99–120

Baruk J (1997) Innovativeness of Polish enterprises in the initial period of system transformation. Technovation 17(9):477–489

Carayannis E (1994a) A multi-national, resource-based view of training and development and the strategic management of technological learning: keys for social and corporate survival and success. In: 39th International council for small business annual world conference, Strasbourg, France, June 27–29

Carayannis E (1994b) The strategic management of technological learning from a dynamically adaptive high tech marketing perspective: sustainable competitive advantage through effective supplier-customer interfacing, University of Illinois, Chicago/American Management Association Research Symposium on Marketing and Entrepreneurship, Paris, France, June 29–30

Carayannis E (1994c) Gestion Strategique de l'Acquisition des Savoir-Faire, Le Progrès Technique, no. 1, Paris, France

Carayannis E, Alexander J (1997) The role of knowledge exchange in trust, co-opetition and post-capitalist economics, paper presented at the European Institute for the Advanced Study of Management, Belgium

Carayannis E, Alexander J (1998a) The wealth of knowledge: converting intellectual property to intellectual capital in co-opetitive research and technology management settings. Int J Technol Manag 18(3/4):326–352

Carayannis E, Alexander J (1998b) Secrets of success and failure in commercializing US government RandD Laboratories technologies: a structured case study approach. Int J Technol Manag 18(3/4):246–269

Carayannis E, Jorge J (1998c) Bridging government-university-industry technological learning disconnects: a comparative study of training and development policies and practices in the US, Japan, Germany, and France. Technovation 18(6/7):383–407 (Note: 1998 Recipient of two Emerald Management Reviews Citations - Citation of Excellence for Practical Implications and Citation of Excellence for Readability)

Carayannis E, Alexander J (2001) Virtual, wireless mannah: a co-opetitive analysis of the broadband satellite industry. Technovation 21(12):759–766

Carayannis E, Gonzalez E (2003) Creativity and innovation = competitiveness? In: Shavinina LV (ed) When, how, and why, The international handbook on innovation, part VIII, chapter 3. Elsevier

Carayannis E, Gonzalez E (2003) Creativity and Innovation = Competitiveness? When, How, and Why, The International Handbook on Innovation, Larisa V. Shavinina (ed.), Part VIII, Chapter 3, Elsevier Press, October

Carayannis E, et al (2003) A Cross-Cultural Learning Strategy for Entrepreneurship Education: Outline of Key Concepts and Lessons Learned from a Comparative Study of Entrepreneurship Students in France and the US, Technovation, 23(9): 757–771, NOTE: Recipient of Emerald Management Reviews Citation of Excellence for Research Implications

Carayannis EG, Provance M (2008) Measuring firm innovativeness. Int J Innov Regional Dev 1(1):90–107

Christensen CM (1997) The innovator's dilemma: when disruptive technologies cause great firms to fail. Harvard Business School Press, Boston

Coombs R, Narandren P, Richards A (1996) A literature-based innovation output indicator. Res Policy 25(4):403–413

Cooper JR (1998) A multidimensional approach to the adoption of innovation. Manage Decis 36(8):493–502

Coriat B, Weinstein O (2002) Organizations, firms and institutions in the generation of innovation. Res Policy 31(2):273–290

Dacey JS, Lennon KH (1998) Understanding creativity: the interplay of biological, psychological and social factors. Jossey-Bass, San Francisco

Damanpour F (1996) Organizational complexity and innovation: developing and testing multiple contingency models. Manag Sci 42(5):693–716 (Organizational innovation: a meta-analysis of effects of determinants and moderators. Acad Manag J 34(3):555–590, 1991)

Diwan RK, Chakraborty C (1991) High technology and international competitiveness. Praeger, New York

Drazin R, Glynn MA, Kazanjian RK (1999) Multilevel theorizing about creativity in organizations: A sensemaking perspective. Acad Manage Rev 42(2):125–145

Drejer A (2002) Situations for innovation management: towards a contingency model. Eur J Innovation Manage 5(1):4–17

Drucker P (1985) The discipline of innovation. Harv Bus Rev 76(6):149–157

Evangelista R, Sandven T, Sirilli G, Smith K (1998) Measuring innovation in European industry. Int J Econ Bus 5(3):311–333

Evangelista R, Iammarino S, Mastrostefano V, Silvani A (2001) Measuring the regional dimension of innovation. Lessons from the Italian innovation survey. Technovation 21:733–745

Feeny S, Rogers M (2003) Innovation and performance: benchmarking Australian firms. Aust Econ Rev 36(3):253–264

Florida RL, Kenney M (1990) The breakthrough illusion: corporate America's failure to move from innovation to mass production. Basic Books, New York

Freeman CJ, Soete L (1982) Unemployment and technical innovation: a study of long waves in economic development. Frances Pinter, London

Gundry LK, Prather CW, Kickul JR (1994) Building the creative organization. Org Dyn 22(4):22–37

Hagedoorn J, Cloodt M (2003) Measuring innovative performance: is there an advantage in using multiple indicators? Res Policy 32:1365–1379

Hindle B, Lubar SD (1986) Engines of change: the American industrial revolution, 1790–1860. Smithsonian Institution Press, Washington

Hofstede G (1980) Motivation, leadership and organization: do American theories apply abroad? Organ Dyn 9:42–63

Hollenstein H (1996) A composite indicator of a firm's innovativeness, an empirical analysis based on survey data for Swiss manufacturing. Res Policy 25:633–645

Howells J (1995) A socio-cognitive approach to innovation, Research Policy, 24(6):883–894

Jonash RS, Sommerlatte T (1999) The innovation premium. Perseus Publishing, Boston

Kahn KB (2002) An exploratory investigation of new product forecasting practices. J Product Innovation Manage 19(2):133–143
Kao J (1996) Jamming: the art and discipline of business creativity. HarperCollins, New York
Kaplan S (1999) Discontinuous innovation and the growth paradox. Strategy Leadership 27(2):16–21
Killman R (1985) Gaining control of the corporate culture. Jossey-Bass, San Francisco, pp 1–16
Kneller G (1965) The art and science of creativity. Holt, Rinehart and Winston, New York
Koen P, Kohli P (1998) Idea generation: who has the most profitable ideas. Eng Manage J 10(4):35–40
Lansiti M (1997) From technological potential to product performance: an empirical analysis. Res Policy 26(3):345–366
Leenders MAAM, Wierenga B (2002) The effectiveness of different mechanisms for integrating marketing and RandD. J Prod Innovat Manage 19(4):305–317
Mansfield E, Rapport AR, Wagner S, Beardsley G (1977) Social and private rates of return from industrial innovations. Q J Econ 91(2):221–240
Michalisin M (2001) Validity of annual report assertions about innovativeness: an empirical investigation. J Bus Res 53:151–161
Nelson RR (1977) In search of useful theory of innovation. New Holland Res Policy 6:37–76
Nelson RR, Winter SG (1982) An evolutionary theory of economic change. Belknap Press of Harvard University Press, Cambridge
Nelson RR (2000) Technology, Institutions, and Evolutionary Economic Theory, Mimeo
Parthasarthy R, Hammond J (2002) Product innovation input and outcome: moderating effects of the innovation process, Journal of Engineering and Technology Management, 19(1):75–91
Penrose ET (1959) The theory of the growth of the firm. Wiley, New York
Peters J (1996) Messung und Bewertung des Innovationsverhalten im deutschen Automobilzuliefersektor - Ergebnisse einer empirischen Untersuchung [Measurement and valuation of the innovative behavior within the German automobile supply industry - evidence of an empirical study]. Working paper series of the Department of Economics, 151, University of Augsburg Riordan, M. H., D. E. Sappin
Porter ME (1985) Competitive advantage: creating and sustaining superior performance. Free Press, New York
Porter M (1990) The competitive advantage of nations. Free Press, New York
Pospisil V (1996) New constellations. Ind Week 245(14):6
Rogers EM (1995) Diffusion of innovations. The Free Press, New York
Rogers EM, Shoemaker FF (1971) Communication of innovations: a cross-cultural approach. The Free Press, New York
Rosenberg N (1982) Inside the black box: technology and economics. Cambridge University Press, Cambridge
Santarelli E, Piergiovanni R (1996) Analyzing literature-based innovation output indicators: the Italian experience. Res Policy 25(5):698–712
Schumpeter JA (1934) Theorie der wirtschaftlichen Entwicklung. Duncker and Humblot, Berlin (reproduced 1997)
Schumpeter JA (1942) Capitalism, socialism and democracy. Harper Brothers, New York
Tidd J (2001) Innovation management in context: environment, organization and performance. Int J Manage Rev 3(3):169–183
Tornatzky LG, Fleischer M (1990) The process of technological innovation. Lexington Books, New York
Tushman M, Anderson P (1990) Technological discontinuities and dominant designs: A cyclical model of technological change, Administrative Science Quarterly 35:604–633
Von Braun C-F (1997) The innovation war. Prentice Hall, Upper Saddle River
Woodman RW, Schoenfeldt LF (1990) An interactionist model of creative Behaviour. J Creative Behav 24:10–20
Zaltman G, Duncan R, Holbek J (1973) Innovations and organizations. Wiley, New York

Chapter 2
Introduction to Innovation Management

2.1 Innovation Management Through Management of Knowledge and Education

> *'Until philosophers become kings or until kings and princes in this world acquire the spirit and power of philosophy .....states shall not be relieved from their demons-I believe the same is true for human race…'*
>
> [Plato]

Many authors have dwelled on the idea that innovation can become object of 'management'. For example, Burns and Stalker (1961) authored the book 'Management of Innovation' partly based on a previous study of a research and development laboratory of a local company.

In contrast to the past when innovations in enterprises appeared in a random and disorganized way, in the post-war period emphasis was placed on the idea that innovations could be systematized, even 'planned'. The development of organizational studies (e.g. Cyert and March 1963) and the study on management function (e.g. Barnard 1938; Drucker 1999) laid new foundations for the understanding of innovation process.

Therefore, a basis was created for a new sector of specialization and knowledge in technology and organizations. However, managers do not fully or duly comprehend the management of knowledge and in many cases, professionals and academics, when talking about knowledge management; they practically mean management of information and technologies.

In reality, knowledge management has to do more with the art of thoroughly understanding the potentials of an organizational context and with the evaluation, influence and the disclosure of tacit know how (Carayannis 2000).

A research by McKinsey in 40 companies in Europe, Japan and the USA showed that many executives believe that knowledge management starts and ends with the creation of specialized technological information systems.

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Some companies even take a step further to connect all information available and construct models that would enhance performance thanks to improved processes, products and their relations to consumers. These companies realize that the actual knowledge requires companies themselves to develop ways whereby their employees shall understand previous connections, advancing beyond infrastructure touching upon all aspects of an enterprise (Hauschild et al. 2001).

2.1.1 The Role of Knowledge in Innovation

Given that innovations do not constitute a purely technological project, the knowledge required for their successful management cannot be solely covered by science and engineering. Innovations can be divided in two sectors:

- In technical knowledge and transfer of knowledge (Bohn 1994) and
- In learning regarding administrative methods offered for technology management (Jelinek 1979).

An organization needs access to two kinds of knowledge, i.e. technical and administrative in order to enhance systematic development of innovations.

For the benefit of the entire organization and not only of isolated individuals, learning and knowledge should be accessible not only by the one who discovered them but also by all parties involved, who should be in a position to use them, apply them, modify and adopt them. Learning needs to be generalized in an organization, if it wants to be real and not be downgraded to a 'simple adjustment'. It needs to make the transition from a simple reproduction to application, change and improvement. 'Learning rules' should be included, changed and adjusted without repeating blindly older successful methods. Finally, if learning is to include innovations, it should also include an administrative system for the present and the future (Jelinek 1979).

The most demanding point in research regarding knowledge application in innovations is to sort out significant and information management-related information from the opposite. The attributes of knowledge involved in the process of innovations may present significant diversifications. Part of this knowledge will be clear and shall take the form of technical documents, drafts or other documents, it shall be codified and easy to determine; another part of knowledge shall be tacit, embedded in the established organizational projects and can only be carried over through socialization and cooperation. Therefore, the successful management of innovations may clearly benefit from the systematic approach to knowledge management. Knowledge, learning and their context of development constitute classical definitions having been redefined in the context of information technology progress and knowledge management. Knowledge management may be considered as a socio-technical system made of tacit and clear business policies and attitudes. Said attitudes and policies are facilitated through integration of information technology tools, business processes as well as of the intellectual, human and social capital. The capacity of individuals and of an organization to think rationally, to learn, express themselves/itself and have a vision on collective or individual basis can be considered as a capacity of management and cognition.

Organizational memory, intelligence and mindset are important and decisive factors for cognitive processes both at individual and organizational level. According to our opinion, the managerial and organizational part of cognitive process and knowledge management drive to superior levels of knowledge and meta-knowledge. What is knowledge really and how is it acquired?

2.1.2 *Knowledge/Meta-Knowledge*

> *'The biggest ancient-Greek breakthrough was the removal of explanations on what was happening to the world by the field of religion and magic and the creation of a new kind of explanations, i.e. rational ones being the object of a new kind of research.'*
>
> [Peter Checkland 1981, p. 32]

Many definitions have been advocated at times for knowledge and organizational knowledge. Beckman (1998) grouped a raft of remarks and drew up some useful definitions related to knowledge and organizational knowledge:

- **Knowledge** is organized information that can be utilized for problem solving (Carayannis 1999).
- **Knowledge** is information that has been organized and analyzed in order to be understood and utilized for problem solving or decision making (Turban 1992).
- **Knowledge** includes direct and indirect restrictions imposed on objects (units), functions and relations in combination with specific and general heuristic and reasoning processes that take part in the model under formation (Sowa 1999).
- **Knowledge consists of** truths and convictions, estimates and concepts, judgments and expectations, methodologies and know-how (Wiig 1993).
- **Knowledge** groups perceptions, experiences and processes considered sound and true, that direct thought, behavior and human communication (van der Spek and Spijkervet 1997).
- **Knowledge** is a rational thought on information in order to guide the implementation of projects, problem solving and decision making aimed at performance, learning and teaching (Beckman 1997).
- **Organizational knowledge** is the collective sum of human-centered assets, intellectual property assets, infrastructure assets and market assets (Brookings 1996).
- **Organizational knowledge** is processed information included in programs and processes facilitating action. Such knowledge has been acquired through systems, processes, products, regulations and the organizational context (Myers 1996).

Beckman (1997) suggests the method of **Hierarchization of Knowledge** that involves five levels and where knowledge can climb upwards from lower levels toward a superior level.

Nonaka and Takeuchi (1995) classified accessibility to knowledge in two categories, in inherent and clear, while Beckman (1997) identifies the following three stages of accessibility: tacit, implicit and explicit:

- Tacit (human mind, organization)—possibility of indirect access, always with difficulty, through knowledge elicitation and behavior observation.
- Implicit (human mind, organization)—accessible through querying and discussion, but informal knowledge must first be located and then communicated.
- Explicit (documents, computer)—directly accessible, documented into formal knowledge sources that are often well-organized.

2.1.3 Knowledge–Learning Relation

> *'Even if the first step in the course of a historic invention is the result of a conscientious decision, in this case as in any other case, the spontaneous idea-the instinct or the intuition-does play a significant role. In other words, the unconscious does take part, whose contribution is decisive. Therefore, conscious effort is not exclusively responsible for the result. The unconscious gets into the picture at some point with its almost invisible objectives and its intentions. Reason on its own is not enough'*
>
> [Carl Jung 1958]

First researches on organizational learning focused more on the effort to describe the learning process in the organizational-business environment without necessarily recognizing the regulatory role of learning (Cyert and March 1963; Nelson and Winter 1982; Levitt and March 1988). Learning, as an activity in an organization, in a business corresponds to the unification of individual efforts and of the interaction relationships in groups.

Organizational learning, therefore, is converted into a process governing the relations among individuals through mechanisms, such as disclosure of information, communication and the cognitive environment. Some authors utilize the version of 'cognitive learning', highlighting thus the actions to identify the pathways that would improve organizational learning through certain systems (Senge 1990; Ciborra and Schneider 1992). Based on this tenet, companies with better organizational learning are expected to have a better performance in the market compared to the rest of companies.

Other authors stress that learning is likely to mitigate an organization's performance. Huber (1991) reports that 'units may learn to do something right in the wrong way or may learn to do something wrong in the right way'.

Ineffective or unsuitable learning processes may deprive a company from its competitive advantage, if they contribute to the erroneous connection between management activities and company performance (Levitt and March 1988). Even the effective learning processes may be undermined by the market changes and the environmental conditions that render them non relevant or in the worst case dwindle the company's performance.

Learning activities, therefore, may turn into basic disadvantages from basic advantages. It is also probable that technological learning shall eliminate competition, inflict a short term blow on the organization's competitiveness but yield a higher performance long term, if the market adapts to new technologies (Christensen 1997). In this way, there is no linear relation between learning and an organization's performance. What is more likely happening is that improvement of performance depends on quality (and not on quantity) of cognitive learning.

2.1.3.1 Types of Learning

'Computo, ergo sum. Particeps sum, ergo sum. Cogito, ergo sum.'

[René Descartes]

We believe there are three levels of learning, taking the previous theory into consideration, regarding the impact of learning on formulating a company's potential and the change of its mode of operation (Carayannis 1994a, b, c; Carayannis and Kassicieh 1996). Three degrees of technological learning match this hierarchy:

- Functional learning
- Tactical learning
- Strategic learning

In **functional learning**, the accumulation of experience and learning takes place by learning new things (Carayannis 1994b). It is a short term to mid-term perception of learning that focuses on new or improved capabilities on the basis of knowledge offered by the organization. This type of learning contributes to managing basic organizational capacities, (Prahalad and Hamel 1990), competition strategies (Porter 1991) and resources allocation (Andrews et al. 1965).

In **tactical learning** we learn new tactics to apply the already accumulated experience and learning processes (we redefine the basic rules and the contingencies involved in our short term functional context): we create new models for eventual unexpected events pertaining to decision making, by modifying or improving the rules for decision making (Carayannis 1994b). This is the means to lead to a long term perception of learning, ending up in the company's re-establishment and re-planning. Tactical learning facilitates companies in exploring new opportunities for the organization in a more performing and effective way and to reinforce or combine the already existing basic capacities, creating innovative concepts for more competitive advantages.

With **strategic learning** we develop and learn (internalization and institutionalization) novel views in relation to the enterprise's–organization's functional environment or the view of the world (Hedberg 1981) and we therefore assimilate new learning strategies (Cole 1989). We redefine the fundamental characteristics (rules and contingencies) taken into account for decision making or the fundamental characteristics of our functional context. It is a very long term concept on learning that focuses on the reformulation of 'tools' (methods and processes) used for an organization's reestablishment and re-planning (Bartunek 1987; Bateson 1972, 1991; von Krogh and Vicari 1993; Nielsen 1993). The strategic learning degree involves the broadening and review of concepts regarding the limits and capabilities of a company's strategic environment. Strategic learning contributes to rapid progress towards a new competitive environment and to 'increasing the learning curve gradient and rate through improved and innovative projects adopted by organizations' (Carayannis 1994b, pp. 582–583). The result is what other authors call 'change of the rules of the game' (Brandenburger and Nalebuff 1996; D'Aveni 1994) or the 'creation of new ecologies for the enterprises' (Moore 1996). The company paves a new way towards a conceptual formulation of its operations, its market and the entire competitive environment, acquiring a greater strategic flexibility not only vis-à-vis the course of its works but also regarding the influence and mentoring of its remaining operations.

2.1.3.2 Learning/Meta-Learning

Learning is the first process used by companies to modify their capacities in order to better respond to the environment. In the case of learning, as it happens with the majority of basic concepts, there is no absolute matching as to what is being learned, how it happens and how it is being managed. In finance, learning refers to quantitative and measurable improvements in operations adding value. For the management, learning is the source of 'sustainable competitive performance' (Dodgson 1993) while in the literature on innovations, learning is considered a source of 'comparative innovative performance' (Dodgson 1993). According to Doz (1996), inside an organization there is a distinction between cognitive learning and behavioral learning. The process of cognitive learning arises in case the members of a company realize the need for change under certain conditions, while behavioral learning appears when the company's cognitive projects indeed change (application of cognitive learning). Broadening even more the concept of learning, we could say that the organizational learning involves a new form of behavior being reproduced in the entire company, driving towards a broad change within the organization (Teece et al. 1997).

2.1.3.3 Knowledge Management

Knowledge management is defined as the 'systematic, clear and premeditated creation, renewal and knowledge application in order to enhance as much as possible the knowledge-related company's performance and the revenues derived from the elements of knowledge' (Wiig 1993). Sveiby (1998) defines knowledge management as 'the art of creating value from an organization's intangible assets'. Sveiby (1998) distinguishes two basic kinds of activities regarding knowledge management:

- The first one refers to knowledge management as management of information and
- The second kind as management of people.

2.1.3.4 Cognitive/Meta-Cognitive Process

The cognitive capacity is people's ability to estimate, interpret and raise arguments on environmental, conceptual or organizational stimuli and the meta-cognitive capacity is the ability to 'make thought on their thoughts, just like meta-learning means learning things related to or for learning' (Carayannis 1994a).

The processes for the creation, transfer, selection, acquisition, storage and recovery of knowledge could be dealt with from an information technology (Shannon and Weaver 1949), meta-cognitive (Simon 1969; Sternberg and Frensch 1991; Halpern 1989) and linguistic perspective (Chomsky 1993).

In this context, the person who solves human problems and the manager of technologies is considered equally technician and worker (Schon 1983), at the same time 'synthetic' and 'divisive' (Mintzberg 1989). Persons, groups and organizations are based on multi-level learning and reverse learning (Carayannis 1992, 1993, 1994a, b, c; Dodgson 1993) to create, preserve and increase the ability of groups, persons and organizations to transfer and assimilate embedded and non-embedded (von Hippel 1988) technologies in the form of artifacts, convictions and evaluation programs (Garud and Rappa 1994) or in the form of inherent and explicit knowledge (Polanyi 1958, 1966; Nonaka 1988, 1994). It is also very important to understand that individual and organizational learning and knowledge are entities that complete and reinforce each other through the organizational memory. Moreover, the learning process should be supported by an accurate and specific organizational memory in order to create, preserve and constantly renew the company's stock in skills and capabilities: In case of an organization that is about to learn something new, memory allocation, memory accuracy and the conditions it is used constitute the basic characteristics of the organization (Weick 1979) (see Carayannis 1994b, 2001). It is important to remember that 'knowledge does not develop in a linear way, by collecting data and applying a method of assumptions and conclusions but it resembles more a spiral line with a rising course so that each time we reassess a previous position or opinion, it is done under a new perspective' (Carayannis 1994b). This conceptual perception lays the ground for the development of an Organizational Cognition Spiral—OCS (Carayannis 1998a, b, c), as part of a model to manage organizational knowledge. Intuition, defined by Weick as 'inherent expertise', relates to all these concepts (Davenport and Prusak 1998, p. 11) combined with meta-knowledge, which is knowledge (consciousness) over the knowledge one possesses (Carayannis 1998a, b, c).

2.1.4 The Model of Organizational Cognition Spiral

The model being suggested contributes to the comprehension of basic issues involved in organizational knowledge management. The model identifies different knowledge situations constituting the two-dimensional function: of knowledge (K) and of meta-knowledge (MK), as defined above, and includes successive 'cycles of

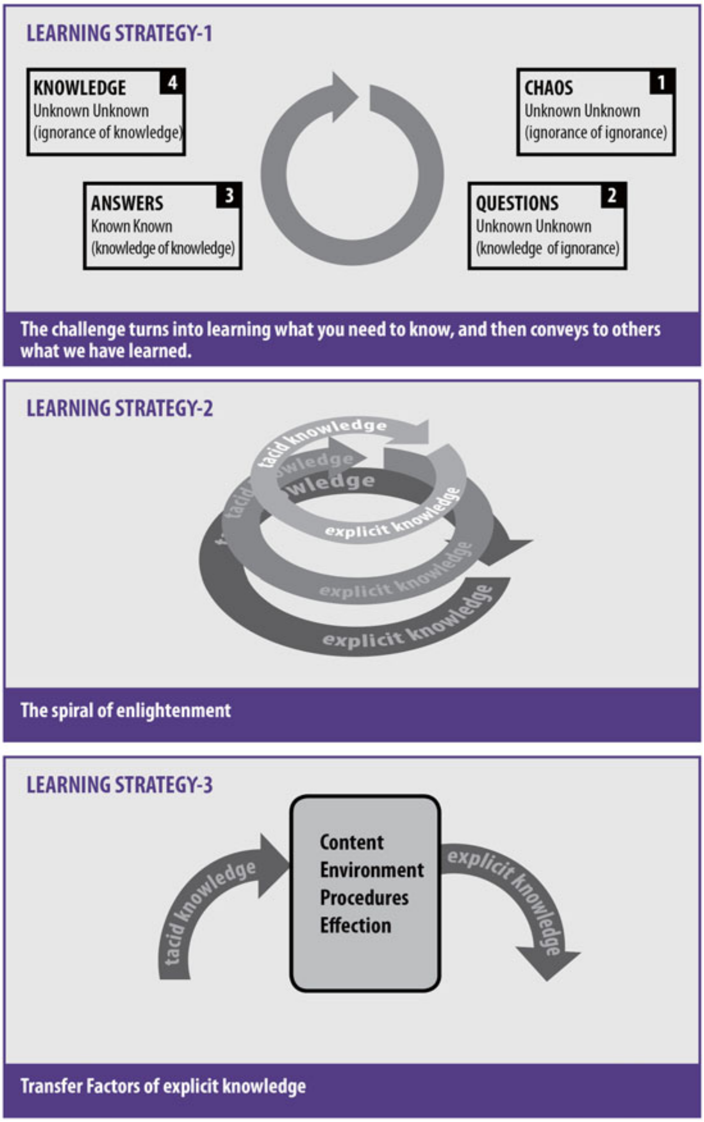


Fig. 2.1 Knowledge cycles (Carayannis, GWU lectures, 2000–2009)

knowledge' a person or organization can go through and pass from four stages of knowledge or ignorance. As we shift from one cycle to the next and to the following one, the overall level of knowledge and meta-knowledge increases (see Fig. 2.1) (Carayannis 1998a, b, c).

Usually, but not always, according to Tables 2.1 and 2.2 (end of paragraph), transition takes place from ignorance of ignorance (you do not know what you ignore) to knowledge of ignorance (you know what you do not know), to knowledge of

Table 2.1 Process and technology-available knowledge conversions

Conversion	Procedures available	Available technologies
A (III->I) From knowledge of Ignorance to knowledge from knowledge	Problem solving	Decision-making tools
	Internally motivated knowledge discovery	Interactive modeling
	Active learning	
	Focus on efficiency	
B (IV->III) From ignorance of ignorance to knowledge of ignorance	Cooperation procedures	Groupware
	Internally motivated discovery of after-knowledge	GDSS
	Value elicitation	Videoconfereding
	Target recognition	Brainstorming
	Facilitation	
	Active learning	
	Focus on efficiency	
C (IV->II) From ignorance of ignorance to ignorance of knowledge	Osmosis knowledge	Information infrastructure
	Externally motivated knowledge discovery	Access mechanisms—networks
	Knowledge creation	LANs
	Passive learning	WANs
	Focus on efficiency	Internet and Intranet
	Circumvention the paradox of knowledge and productivity of information technology	Data sources
		Data storage
		Distributed databases
D (II->I) From ignorance of knowledge to knowledge of knowledge	Protection of intellectual property	Intelligent Agent Technologies
	Outdoor motivated discovery of after-knowledge	Collaborative filters
	Management of intellectual capital	Data mining
	Passive learning	Neural networks
	Focus on efficiency	
E (III->II) From knowledge of ignorance to ignorance of knowledge	Implicit learning from top to bottom	Tools for decision making for technological infrastructure
	Internalization of knowledge/vertical planning	Access mechanisms: networks
	Externally and internally motivated emergence and crystallization of a theoretical example	LANs
	Transfer of focus from efficiency to effectiveness	WANs
	Circumvention the paradox of knowledge and productivity, technology, information	Internet and Intranet
		Data sources
		Data storage
		Distributed databases
		Groupware
		GDSS
		Videoconfereding
		Brainstorming
F (II->III) From ignorance of knowledge to knowledge of ignorance	Explicit learning from the bottom up	Groupware
	Obsolescence of knowledge/substitution	GDSS
	Externally and internally motivated theoretical examples shifts change sign reference standards ("gestalt switches")	Videoconfereding
	Cleavage of the paradox of knowledge and productivity of information technology	Brainstorming
	Transfer of focus from efficiency to effectiveness	Learning capable Intelligent agents or Interfaces

Table 2.2 Content and technology-enabled knowledge states

State	Enabling content	Enabling technologies
State I: K, MK Awareness of awareness	• Internally-driven knowledge discovery • Active learning • Focus on effectiveness	• Decision support tools • Interactive modeling
State II: K, MK Ignorance of awareness	• Collaborative processes • Internally-driven meta-knowledge discovery • Value elicitation • Objectives identification • Facilitation • Active learning • Focus on effectiveness	• Groupware • GDSS • Videoconferencing • Brainstorming
Stage III: K, MK Awareness of ignorance	• Knowledge osmosis • Externally-driven knowledge discovery • Knowledge creation • Passive learning • Focus on efficiency • Bypassing of knowledge & IT productivity paradox	• Information infrastructure • Access mechanisms: networks – LANs – WANs – Internet and intranet • Data sources – Data warehouses – Distributed databases
Stage IV: K, MK Awareness of ignorance	• Individual privacy protection • Externally-driven meta-knowledge discovery • Intellectual capital management • Passive learning • Focus on efficiency	• Intelligent Agent Technologies • Collaborative filters • Data mining • Neural networks
E (III→II) From Awareness of ignorance to Ignorance of awareness	• Top down tacit learning • Knowledge internalization/ routinization • Externally & internally-driven conceptual paradigm emergence and crystallization • Transition of focus from effectiveness to efficiency • Bypassing of knowledge & IT productivity paradox	• Tools form making technology infrastructure decisions • Access mechanisms: networks – LANs – WANs – Internet and intranet • Data sources – Data warehouses – Distributed databases • Groupware • GDSS • Videoconferencing • Brainstorming
F (II→III) From Ignorance of awareness to Awareness of ignorance	• Bottom up explicit learning • Knowledge obsolescence/ substitution • Internally & externally-driven conceptual 'gestalt switches'/ paradigm shifts • Transition of focus from efficiency to effectiveness • Resolution of knowledge & IT productivity paradox	• Groupware • GDSS • Videoconferencing • Brainstorming • Learning-capable intelligent agents or interfaces

knowledge (you know what you know: result of research, discovery and learning) and finally to ignorance of knowledge (you do not know what you know: as a result of continuing practice, knowledge become inherent (Carayannis 1998a, b, c).

For the sake of simplicity, we assume that the dimensions are at two levels and represent presence and absence of knowledge and meta-knowledge. Therefore, the levels of the two dimensions are represented as K/˜K and MK/˜MK. These two levels over the two dimensions end up in totally four states of knowledge:

1. ˜MK, ˜K (ignorance of ignorance)—[You do not know what you do not know]
2. MK, ˜K (knowledge of ignorance)—[You know what you do not know]
3. MK, K (knowledge of knowledge)—[You know what you know]
4. ˜MK, K (ignorance of knowledge)—[You do not know what you know]

Organizations may sustain any of the above situations including possibly current, desirable or intermediate levels. The situations can be represented as follows (Fig. **2.1**).

Knowledge management can be considered as the process of managing transitions between the aforementioned four situations (Carayannis 1998a, b, c).

The revolutionary transformation of knowledge is by nature **differential and thorough** (Carayannis 1992, 1993, 1994a, 1994b, 1996, 1997, 1998a, b, c, 1999, 2001, 2002), because it consists of **reverse knowledge**, **knowledge** and **meta-learning**, differentiates older from new experiences, selects and preserves the useful measures for knowledge and unifies the lessons taught (Carayannis 1998a, b, c).

This process reflects the dynamics of a complex progress, at individual and organizational level, from the information, knowledge, wisdom and intuition data. In this way, constantly broadening and increasingly deeper levels of **organizational knowledge** (Choo 1998) are attained and quantitative and qualitative modifications are in place in the stock and flow of knowledge of an organization and individuals.

2.2 Difference Between Innovation–Invention

There is a clear difference between the concepts of invention and innovation. The famous economist Joseph Schumpeter (1942) was the first to have observed and defined this difference: the 'invention' is the outflow of an applied research, while 'innovation' is the successful introduction of an invention in the market as a functional solution (product or service). Scientific discovery is also assessed on the basis of whether it has contributed to understanding natural phenomena. Due to the fact that innovation includes specialized knowledge and the latter's main attribute is its being a public good, the state enshrines legally the intellectual rights of an inventor–innovator by awarding him/her a patent, safeguarding thus for the benefit of the inventor–innovator the economic exploitation of the new product in a specific geographical region and for a specific period of time.

It would be easier to understand innovation as an entrepreneurial process evolving into a connection with scientific research, learning, market conditions and economy, if we take into account the historic examples of inventors who took a step further and proceeded to the commercial promotion of their inventions, become i.e. innovative entrepreneurs. Such examples shed light on the true nature of innovation. Until the end of the nineteenth century, scientists were not generally interested in the practical application of their discoveries. One of the first scientists who proceeded to the technological application of his scientific discoveries was Justus Liebig, who, by the middle of nineteenth century developed the first artificial fertilizer as well as a significant meat extract which constituted the only means to preserve animal proteins until the discovery of the refrigerator in 1880s. Moreover, in 1856 the English scientist Sir William Perkin discovered the first synthetic dye and established later a chemical industry to economically capitalize on his discovery.

One of the most successful, innovative inventors was the American Thomas Alva Edison, who managed to be granted exclusive rights over more than 1,000 patents throughout his life. Three of them were the light bulb, the cinema tape-film of 35 mm and the electric chair. His capacity to innovate, and not simply invent, i.e. his capacity not only to have ideas but convert them into products being sold successively in the market, helped to create a large enterprise (General Electric), with its worth standing at circa 21.6 bn $ in 1920. In other words, Edison understood correctly the two-way character of innovation requiring mobilization and coordination of two forces, the technology promise and the market demand.

According to his biographer, Mathew Josephson, Edison had no intention to dwell on organized research. He was driven to this option because he failed to manufacture electric light that could be practically used. This failure made him more determined and he decided to work on scientific research systematically. He was aware of the scientific work conducted previously by other scientists and decided to work hard to achieve what he wanted. Edison's contribution to electricity is a very good example of the ability to convert a commercial opportunity included in an idea into a practical application. In case of inventing an electric bulb, Edison understood that without an electrification point, the light bulb would be simply an idea with no practical value. Therefore, he and his research team began the creation of an electricity generation and distribution infrastructure, including even the design of switches, cables and floor lamps. Edison's contribution proved that innovation is something more than having new ideas. It is the process whereby new ideas acquire practical application. Notwithstanding the diverging definitions of innovation as regards the wording, all of them agree nevertheless that innovation is the elaboration and exploitation of new ideas and not simply their fabrication and invention. The interested reader may skim through the specialists of innovation, such as Freeman, Rothwell & Gardiner, Drucker and M. Porter, Clayton Christensen, and others.

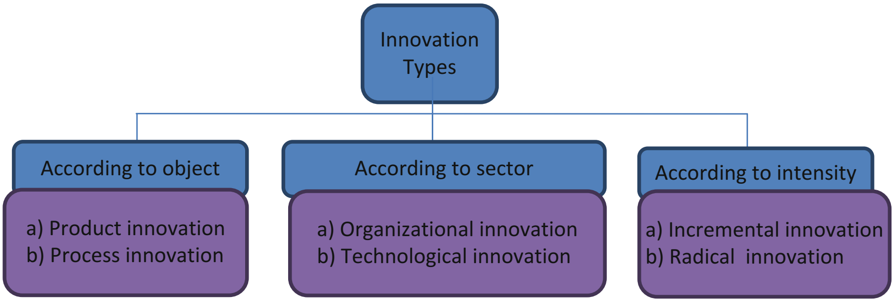
As regards invention in contrast to innovation, some of the most important inventions of the nineteenth century were invented by persons whose name was forgotten. The names we still remember are the names of entrepreneurs who transformed inventions into a commercial value. For example, the vacuum cleaner was invented by J. Murrey Spengler. However, it was W.H. Hoover, leatherwear manufacturer, who launched it in the market. Similarly, the sewing machine was invented by Elias Howe in Boston in 1846, who failed to promote it commercially, though he traveled to England for that purpose. Returning to the USA, he found Isaac Singer to have stolen his patent and having set up a thriving business of sewing machines.

Innovation is therefore the product of the nineteenth century, not of the twentieth century, while invention has existed since primitive times. The driving force was to envisage the opportunity to create new industries, such as the electric railway by Edison. In the twentieth century innovation became the heart of technological effort through systematic organization and institutionalization of applied research in laboratories of Research and Technological Development.

2.3 Types and Characteristics of Innovation

2.3.1 Types of Technological (and Non-technological) Innovation

The types of innovation vary depending on the object, the sector it refers to, the scope or its intensity. These types are not independent one from the other. There exist though some recognizable attributes, without having dividing lines. The types of innovation are classified in three groups.



In the **first group** the classification is based on the object innovation refers to:

- Product or Service Innovation and Process Innovation.

The **Product or Service Innovation** refers to the case when an enterprise introduces a new product in the market or provides a new service. **Process Innovation** is in place when an enterprise introduces new elements in its production process or its operation, being used for the production of a product or the provision of a process.

In some cases the dividing line between these two types is not clear. Separation depends on the organization involved. The emphasis placed by companies on every type of innovation differs depending on the company's stage of development. In the first stages, when the company is small, it adopts product innovations mainly. As the company grows and becomes more complex, it adopts process innovations too. The development of new products is a risky venture as it may inject big profits in an enterprise, if the venture succeeds, but it could also lead to failure.

On the contrary, process innovations, whereby higher production volume, low production cost and higher sales are sought after, are less radical, hence entailing lower risk for the enterprises adopting them.

In the **second group** the classification is based on the sector innovation refers to:

- Administrative or Organizational Innovation and Technological Innovation.

The **Administrative or Organizational Innovation** appears in the administration sector and affects the organizational system of an enterprise, consisting of business executives and the relations between them. In other words, the Administrative Innovation is the introduction of a new administrative system or a new administrative process; it does not introduce a new product or service but influences indirectly their introduction or the production process thereof.

The Technological Innovation pertains to the technological sectors of an enterprise, comprising the equipment and the procedures for raw materials and information transformation into products or services. Technological Innovation refers to the creation, improvement and expansion of the procedures sustained by the products. Technological innovation may refer to the adoption of a new idea relating to a new product or service, or the introduction of new elements in production processes or service provision of an enterprise.

Administrative Innovations are primarily adopted by large enterprises with more complex structures. These enterprises face bigger problems in auditing and coordinating various departments and try to solve such problems through administrative innovations. However, it seems that an increasing number of small enterprises implement Technological Innovations, striving in this way to gain a competitive advantage.

In the **third group** the classification is based on the intensity and scope of innovation:

- Incremental Innovation and Radical Innovation.

Incremental Innovation is the one leading to a relatively small deviation from current practices. It is introduced to improve old products or procedures, without intervening to the existing structure and strategy of the enterprise. **Radical Innovation** brings about fundamental changes in the activities of an enterprise and expresses a significant deviation from current practices. It gives momentum to new business activities, strategies and structures and introduces totally new products.

On average, Radical Innovations are adopted less frequently compared to gradual innovations. They constitute a bigger challenge for the existing structure, as regards determination of executives' duties and cause strong reactions upon the application thereof. They seem more complicated to the members of an enterprise because they are more original and they provoke a higher degree of uncertainty for their conditions of development and application. Usually large enterprises with higher success rates than smaller ones introduce Radical Innovations because the type of these innovations requires technical knowledge and stock of resources. Moreover, large enterprises possess the financial resources capable to absorb the largest part of the cost, in the event of failure and for this reason large enterprises act in a more decisive way.

2.3.2 *Characteristics of Innovation*

The characteristics of innovation are classified in three axes.

1. Product Axis: Product innovation is in place when a new or improved product is launched in the market.

   The parameters examined under this axis are the following:

- **Market demand:** Demand and acceptance of the product in the market is one of the key criteria for product innovation. It is directly linked to the company's market share and to profit margin.
- **Level of resonance:** It is the level of target-customers locally, nationally or internationally; it is the product acceptance and market penetration yardstick.
- **Optimal use of existing condition:** It is examined whether the existing technology is used in an optimal way relevant to the product and its production. It relates to updating procedures and technology forecast.
- **Price/Value:** The price and value of a product is compared with the prices of corresponding competitive products in the market.
- **Compliance with the regulations:** Compliance with the safety, health, environmental regulations, etc. It is a characteristic of innovation because compliance with the regulations could often lead to qualitative innovative changes on the product.
- **Originality:** It is examined whether the product is a new solution or encompasses changes compared to competitive products. These changes may concern the product, its package, the way it is distributed or its use. It is also a way to evaluate an enterprise's approach to innovation.
- **Offer of improvements:** The product as an evolution of an existing technology, in the sense of using new materials, the existence of new functions, the use of the product in new applications. It defines whether the product brings about changes on the basic design or its architecture.
- **Coverage of operational needs:** Coverage rate of specific operational needs, customer needs, including over-coverage offering additional functions not fully determined by customer demands. It relates to customer requirements analysis.
- **Aesthetic:** The product's outward appeal is a criterion of innovation often underestimated; it constitutes though a key success factor.
- Adherence to intellectual property rules.

2. Process Axis: Process innovation is the introduction of new processes in product development or the improvement thereof.

   The parameters examined under this axis are the following:

- **Market research:** Market research may disclose alternative solutions regarding design, price, distribution and product promotion and offers an estimate of product acceptance and image in the market.
- **Connection to target-customers:** Frequency of contact between the company and target-customers at local, national or international level. The main objective is to establish a long lasting relation mainly with large customers.

- **Access to new technology:** Frequency of the company's contact with the current technological evolutions regarding production of product. It relates directly with departments of R&D, design, cooperation with technological bodies, participation in exhibitions, etc.
- **Costing Methodology:** Costing methodology in all stages of the product development process. Analysis and accurate costing methodology is required to cut the total product production cost.
- **Compliance with the regulations:** Compliance of the product development process with the safety, health and environmental regulations, in parallel with the procedures to verify all the above. Compliance of the development process with the regulations often contributes to qualitative upgrading of the product.
- **Technique of ideas development:** The existence of specific techniques and approaches for the elaboration of new ideas is examined; such ideas affect significantly the development of a successful innovative product.
- **Improvement techniques:** The effort and the techniques to integrate new technologies and uses in the product are assessed.
- **Emphasis on fulfilling operational needs:** Focus of product development process on the specific operational need the product addresses. It involves conversion of requirements to product specifications and relates to the way the trade mark participates in product development process.
- **Focus on aesthetics in the design:** The success of products using a fixed technology and with fixed target-customers depends directly on their attractiveness and their visual diversification vis-à-vis competitive products. The aesthetic aspect of a product in combination with the analysis of its ergonomy is one of the main targets of industrial design. The use of systems and design engineers is assessed.
- **Formal procedures to protect copyright:** It is examined whether the required actions are taken to protect copyright. It is assessed whether an enterprise is geared towards protecting patents and designs and whether the above methodology constitutes its policy.

3. Management (organization) Axis: The introduction of changes in administration and organization constitutes the administrative innovation that completes the first axis.

   The parameters examined under this axis are the following:

- **Feasibility study:** It is the base (technical, economic, commercial) to decide upon an investment.
- **Formal procedures to ensure communication with target-customers:** Such procedures may include participation in exhibitions, sample distribution, meetings with groups of customers, etc.
- **Formal procedures to apply the best technology:** One of the key indications of innovation is systematic follow up of current technological evolution, the assessment of the technological level of competitors, the identification of new technologies and the correct selection of the best technology.
- **Cost control:** Control is a systematic review process applied during the design phase, in order to cut production cost, preserving at the same time the value and

the required operation specifications (value/price) and ensuring the product's sustainability and competitive price.

- **Quality control:** Formal control procedures during the design phase that include use of methods to analyze and improve innovation process quality and processes to safeguard rules applying to date.
- **Organizational culture:** Emphasis of organizational culture on innovation. It has been evidenced that organizational culture relates directly to a company's innovativeness. Some elements of organizational culture placing emphasis on innovation is the encouragement to create new ideas, the clarification of the enterprise's innovation policy to all employees, the determination of performance measurement systems, personnel training etc.
- **Quantitative controls with criteria to assess improvement of technology, new materials, functions and uses:** Introduction of controls with quantitative data and minimum acceptance values to assess improvement of technology, new materials, functions and uses. Processes for the integration and evaluation of new technologies and methods by the company.
- **Quantitative controls with criteria on the satisfaction rate of functional needs:** Introduction of controls with quantitative data and minimum acceptance values to fulfill specific functional needs.
- **Marketing and quality control processes for the aesthetic aspect of the product:** Introduction of marketing and quality control processes to assess and ensure good product aesthetic appeal. It relates directly to production and testing of originalities.
- **Formal control to protect copyright:** Formal control procedures to protect copyright are examined.

References

Andrews KE, Christensen LE et al (1965) Business policy. Text and Cases, Homewood, 111, Richard D Irwin

Barnard CI (1938) The functions of the executive, Thirtieth Anniversary Editionth edn. Harvard University Press, Cambridge

Bateson G (1972) Steps to an ecology of mind. Ballantine, New York

Bateson G (1991) Ecology of mind: the sacred. In: Donaldson R (ed) A sacred unity: further steps to an ecology of mind. Harper Collins, New York

Beckman T (1997) A methodology for knowledge management. International Association of Science and Technology for Development (IASTED) AI and Soft Computing Conference. Banff, Canada

Beckman T (1998) Knowledge management: a technical review. GWU Working Paper

Bohn RE (1994) Measuring and managing technical knowledge, Sloan Manage Rev No. Fall: 61–72

Brandenburger A, Nalebuff J (1996) Co-opetition. Currency Doubleday, New York, p 39

Brooking A (1996) Introduction to intellectual capital. The Knowledge Broker Ltd., Cambridge

Burns T, Stalker GM (1961) The management of innovation. Tavistock, London

Carayannis E (1992) An integrative framework of strategic decision making paradigms and their empirical validity: the case for strategic or active incrementalism and the import of tacit technological learning, Working Paper #131, School of Management, Rensselaer Polytechnic Institute, October

Carayannis E (1993) Incrementalisme Strategique, Le Progrès Technique, no. 2, Paris, France

Carayannis E (1994a) A multi-national, resource-based view of training and development and the strategic management of technological learning: keys for social and corporate survival and success. In: 39th International council for small business annual world conference, Strasbourg, France, June 27–29

Carayannis E (1994b) The strategic management of technological learning from a dynamically adaptive high tech marketing perspective: sustainable competitive advantage through effective supplier-customer interfacing, University of Illinois, Chicago/American Management Association Research Symposium on Marketing and Entrepreneurship, Paris, France, June 29–30

Carayannis E (1994c) Gestion Strategique de l'Acquisition des Savoir-Faire, Le Progrès Technique, no. 1, Paris, France

Carayannis E (1996) Re-engineering high risk, high complexity industries through multiple level technological learning: a case study of the world nuclear power industry. J Eng Technol Manage 12(4):301–318

Carayannis E (1997) Data Warehousing, Electronic Commerce, and Technological Learning: Successes and Failures from Government and Private Industry and Lessons Learned for 21st Century Electronic Government, Online Journal of Internet Banking and Commerce, March

Carayannis E (1998a) The strategic management of technological learning in project/program management: the role of extranets, intranets and intelligent agents in knowledge generation, diffusion, and leveraging. Technovation 18(11):697–703

Carayannis E (1998b) Higher order technological learning as determinant of market success in the multimedia arena; a success story, a failure, and a question mark: Agfa/Bayer AG, enable software, and sun microsystems. Technovation 18(10):639–653

Carayannis E (1998c–2002) George Washington University Lectures on Entrepreneurship. Carayannis, E. The Globalization of Knowledge and Information Creation and Diffusion Processes and Standards in an Emergent Trading Groups Context: EU, NAFTA, Mercosur, and APEC, Seminar on Globalization of Knowledge and Information Creation and Diffusion Processes and Standards in an Emergent Trading Groups Context: Laying the Foundations for Latin American Competitiveness in the 21st Century, University of Puerto Rico Rio Piedras, San Juan, Puerto Rico, March 14, 1997

Carayannis E (1999) Fostering synergies between information technology and managerial and organizational cognition: the role of knowledge management. Technovation 19(4):219–231

Carayannis E (2000–2009) GWU Lectures

Carayannis E (2001) Learning more, better, and faster: a multi-industry, longitudinal, empirical validation of technological learning as the key source of sustainable competitive advantage in high-technology firms. Int J Technovation

Carayannis E (2002) Is higher order technological learning a firm core competence, how, why, and when: a longitudinal, multi-industry study of firm technological learning and market performance. Int J Technovation 22:625–643

Carayannis E, Kassicieh S (1996) The relationship between market performance and higher order technological learning in high technology industries. In: Fifth international conference on management of technology, Miami, FL, 27 February–1 March, pp 309–320

Checkland P (1981) Systems thinking, systems practice

Chomsky N (1993) Language and thought. Wakefield, RI: Moyer Bell

Choo CW (1998) The knowing organization: how organizations use information to construct meaning, create knowledge and make decisions. Oxford University Press, New York

Christensen CM (1997) The innovator's dilemma: when disruptive technologies cause great firms to fail. Harvard Business School Press, Boston

Ciborra CU, Schneider LS (1992) Transforming the routines and contexts of management, work and technology. In: Adler PS (ed) Technology and the future of work. MIT Press, Cambridge, pp 269–291

Cole R (1989) Strategies for learning: small group activities in American, Japanese, and Swedish Industry. Berkeley University Press, Berkeley
Cyert RM, March JG (1963/1992/1992) A behavioral theory of the firm, 2nd edn. Prentice Hall, Englewood Cliffs
D'Aveni RD (1994) Hypercompetition: managing the dynamics of strategic. The Free Press, Manoeuvring
Davenport T, Prusak L (1998) Working knowledge: how organizations manage what they know. Harvard Business School Press, Boston
Dodgson M (1993) Organizational learning: a review of some literatures. Org Stud 14(3):375–394
Doz YL (1996) The evolution of cooperation in strategic alliances: initial conditions or learning processes? Strategic Manage J 17:55–83
Drucker PF (1999) Management challenges for the 21st century. Butterworth-Heinemann, Oxford
Garud R, Rappa M (1994) A socio-cognitive model of technology evolution: the case of cochlear implants. Org Sci 5(3):344–362
Halpern D (1989) Thought and knowledge: an introduction to critical thinking. Lawrence Erlbaum, Mahwah
Hauschild S, Licht T, Stein W (2001) Creating a knowledge culture. McKinsey Quarterly, 4:23–26
Hedberg B (1981) How organizations learn and unlearn. In: Nystrom PC, Starbuck WH (eds) Handbook of organizational design. Oxford University Press, London, pp 8–27, This article focuses on the need to unlearn, that is to remove old knowledge
Huber GP (1991) Organizational learning: the contributing processes and the literatures. Org Sci 2:88–115
Jelinek M (1979) Institutionalizing innovation: a study of organizational learning. Praeger, New York
Jung C (1958) The undiscovered self. Princeton University Press, Princeton
Levitt B, March JB (1988) Organizational Learning. Ann Rev Soc 14:319–340
Mintzberg H (1989) Mintzberg on management. The Free Press, New York
Moore LF (1996) The death of competition. HarperCollins, New York
Myers, P. ed. 1996. Knowledge management and Organizational Design. Butterworth – Heinemann
Nelson RR, Winter SG (1982) An evolutionary theory of economic change. Belknap Press of Harvard University Press, Cambridge
Nielsen R (1993) Woolman's "I Am We" triple-loop action-learning: origin and application in organization ethics. J Appl Behav Sci 29(1):7–138
Nonaka I (1988) Creating organizational order out of chaos: self-renewal in Japanese firms. Calif Manage Rev 30(2):57–73
Nonaka I (1994) The dynamic theory of organisational knowledge creation. Org Sci 5(1):14–37
Nonaka I, Takeuchi H (1995) The knowledge-creating company: how Japanese companies create the dynamic of innovation. Oxford University Press, New York
Polanyi M (1958) Personal knowledge. The University of Chicago Press, Chicago
Polanyi M (1966) The tacit dimension. Routledge, London
Porter M (1991) Towards a dynamic theory of strategy. Strategic Manage J 12:95–117
Prahalad CK, Hamel G (1990) The core competence of the corporation (1990). Harv Bus Rev 68(3):79–91
Schon D (1983) The reflective practitioner: how professionals think in action. Basic Books, New York
Schumpeter JA (1942) Capitalism, socialism and democracy. Harper Brothers, New York
Senge P (1990) The fifth discipline: the art and practice of learning organization. Doubleday, New York
Shannon CE, Weaver W (1949) The mathematical theory of communication. University of Illinois Press, Urbana
Simon H (1969) The sciences of the artificial. MIT Press, Cambridge

Sowa JF (1999) Relating templates to logic and language. In: Pazienza MT (ed) Information extraction: towards scalable, adaptable systems, Lecture notes in AI #1714, Springer, pp 76–94

Sternberg R, Frensch P (1991) Complex problem solving: principles and mechanisms. Lawrence Erlbaum, Hillsdale

Sveiby K (1998) What is knowledge management? http://www.sveiby.com.au

Teece DJ, Pisano G, Shuen A (1997) Dynamic capabilities and strategic management. Strategic Manage J 18(7):509–533

Turban E (1992) Expert systems and applied artificial intelligence. Macmillan, New York

van der Spek R, Spijkervet A (1997) Knowledge management: dealing intelligently with knowledge. In: Liebowitz J, Wilcox LC (eds) Knowledge management and its integrative elements. CRC Press, Boca Raton

von Hippel E (1988) The sources of innovation. Oxford University Press, New York

von Krogh G, Vicari S (1993) An autopoiesis approach to experimental strategic learning. In: Lorange P, Chakravarthy B, Roos JV, de Ven A (eds) Implementing strategic processes: change, learning and co-operation. Blackwell, London, pp 394–410

Weick KE (1979) The social psychology of organizing, 2nd edn. Addison-Wesley, Reading

Wiig K (1993) Knowledge management foundation. Schema Press, Arlington

Chapter 3
Innovation and Competitiveness: Case Study

3.1 Introduction

The foregoing analysis in the previous chapters of the book demonstrated that innovation constitutes the foundation and driver of competitiveness worldwide. Starting from its definition and based on a broad raft of experiences and results, innovation allows the addition of higher added value in a way that materially prevails constituting probably exclusivity (disruptive and discontinuous innovations).

For a better comprehension of all the above, it would be wise to quote a case study, for the XEROX company, where promotion and use of innovation as a recipe of corporate success and profitability has gone through a historic path. At the same time it is also interesting and enlightening to see the failure by XEROX in many occasions to commercially capitalize on the technological invention and innovation for various reasons ranging from lack of imagination or/and courage on behalf of corporate leadership up to dysfunctional corporate traditions and mindsets.

A critical issue is the presence or absence of ability and readiness for technological learning particularly at higher levels (learning new ways of learning), (Carayannis 1994a, b, c).

3.2 Innovation-Case Study XEROX

3.2.1 XEROX Background and History

In the last years many changes have been observed in what we call **old and what we call new economy**. The old, industry-based economy has been traditionally characterized by economies of scale whereas the **new knowledge-based economy** is considered as the economy of networks (Shapiro and Varian 1999). The shift from the old to the new economy could be described as a change of technological paradigm.

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According to Kuhn, a paradigm is defined as 'an object for further articulation and specification under new and more stringent conditions' 1 (Kuhn 1962). According to Moore, the traditional old economy is defined as the economy being developed against the competition, following a victory–defeat scenario (Moore 1996). The new economy paradigm is defined as the creation of a market or the co-evolution, according to a victory–victory scenario.

XEROX numbers many successes and failures in its history with regard to innovation. The successes are obvious at present in the office environment. Photocopy machineries, laser printers and network services are all around us, due to XEROX successful innovation. It is not only office equipment that made XEROX a success. Service provision (maintenance of photocopy machines) and consumables (ink cartridges, paper etc.) is very successful-similarly to support services and document processing services (solutions). XEROX innovations multiply; according to data, more than 7,000 active patents belong to its intellectual property. However, in the course of time, there were some unsuccessful innovations too.

The invention of a personal computer with a graphic imaging environment, a desktop, a mouse, Ethernet and the first document processor WYSIWYG has never been a XEROX innovation. The same is true for the first laser printer. In both cases, XEROX invented but did not innovate. It took the control of other companies and acquired their inventions to reach the stage of innovation. There are, however, three basic questions raised:

- **What criteria drove to success?**
- **What criteria drove to failure?**
- **What are the lessons to be drawn?**

These are very important questions. The answers could help us define the criteria of success, allowing for the elaboration of methodologies which would enable the creation and preservation of better innovation practices. When studying innovation, it is better to start analyzing successes and failures. This way of analysis is followed below for the example of innovation in Xerox.

On October 22, 1938, in Astoria, a suburb of New York City, Chester Carlson invented what was later called a photocopy. He considered the photocopy a revolution in the evolution of office but later he would realize that people did not view this invention in the same mood as he did. Carlson, born in 1906 and during the first steps of his career, worked as a pressman assistant; he even published a small newspaper in his hometown.

This early experience impressed him and particularly his difficulty to place words on paper and share the knowledge. He later obtained a physics diploma from the Institute of Technology of California and began to work as a researcher engineer at Bell laboratories. In an era of work slowdown, he obtained a Law diploma that led him to a second career as private practicing lawyer. As a lawyer he often faced the problem of not having enough carbon papers.

The only alternatives were to use an accurate photographic processing or to try broad patent applications. In his free time, he explored alternative technologies finding finally the study by the Hungarian physicist Paul Selenyi on photoconductivity. He made experiments in his kitchen, copying finally the image "10-22-38 ASTORIA" on a tin plate coated with sulfur. He finally concluded that innovation was not an easy process. He looked for a company that would be interested in further financing a research on his invention. For 10 years he was not successful at all.

The market was not ready for alternative solutions—the common view that prevailed was that current technology, the photocopy carbons, were sufficient and there was no need for a new technology. In 1944, the Battelle Memorial Institute, a non-profit research institute, was interested in helping Carlson to further develop his invention. In Battelle times, selenium was introduced as an improved photoconductor and a shade of dry ink was developed. Finally, in 1947, the company Haloid, a photographic paper manufacturer, obtained a license to manufacture a photocopies machine. In a year's time, the first Xerox photocopy machines began operating, heralding the era of photocopy.

The first photocopy machine had a complex operation but found a place in the production of satisfactory mechanisms with the method of printing negative film. We should remember that the printing technology at that time was with 'a printing press', printing separately images of cast metal. This was a very costly procedure. Finally, the method of negative film was utilized in printing, in cheap printing environments.

Up until 1959, Haloid improved the equipment and circulated the copy machine #914—the first real photocopy office machine. #914 was a revolutionary innovation. The competitors, the 3 M Thermo-Fax polygraph by the company AB Dick and the Kodak Verifax were outstripped in a relatively short period of time. The machine #914 was so successful that spearheaded technology and dominated the market up until 1972.

The photocopy was discovered in 1938, but it was only in 1959 that the initial discovery was applied and became an innovation. The 19-year journey from discovery to innovation was wasted in finding a financial partner to further develop the idea (1938–1947) and later in trying to determine a market (1948–1959). From the '30s to the '50s, the office technology was characterized by the carbon paper and the upcoming offset printing method.

The carbon paper allowed for the copying of a document in real time in probably more than 8 copies but the cost for 8–500 copies was prohibitive. What Chester Carlson and Haloid initially found in the market research was that there was no need for innovation. The challenge for Haloid was to develop a market.

The first reproduction machine of copies through the photocopy was presented in 1949. The market gained was in between the developing offset printing technology. In particular, the first photocopy machine by Xerox fixed as direct target to manufacture document reproduction mechanisms with the offset method (conversion). The mechanisms would be used successively in the reproduction process of identical documents, making therefore photocopies. The copies' creation mechanism by Xerox for the reproduction with the offset method was expensive and complex to operate and soon would be replaced by another one, based on photography and being less costly. As long as Haloid Company was being focused again on substituting the carbon paper technology, it fared well with the introduction in 1959 of the photocopy machine #914. This combination of market pull and technology push would generate revenue and profit in the '70s. Since the early days of Haloid unregulated innovation, Xerox has elaborated a culture for innovation organization. At the same time, in the organizational chart of Xerox, the Innovation Group refers directly to the chief executive officer. This stresses the primordial role of innovation for an organization.

Xerox kept on innovating throughout its history although it was not always successful. In 1973 the first desktop computer was presented driving the revolution of PCs. Xerox, due to its marketing strategies, to be discussed further down, did not profit from this development. For a second time in 1977, it developed the laser printer but did not move quickly to dominate the early laser printer market, as did the competitive company Hewlett-Packard.

Xerox corrected its innovation strategy when it introduced in 1990 the black-and-white high intensity printer system, DocuTech, creating thus a digital revolution in placing words on a piece of paper. Later in 2002, it introduced iGen3, a colored version of DocuTech technology, hoping that this would mark the launch of another revolution, that of digital color, and would bring Xerox the economic reward of innovation.

To fully understand Xerox, we should have a picture of the entire raft of products and services and the market share it holds. Therefore, the two main categories -products and services could be classified further (see Table 3.1):

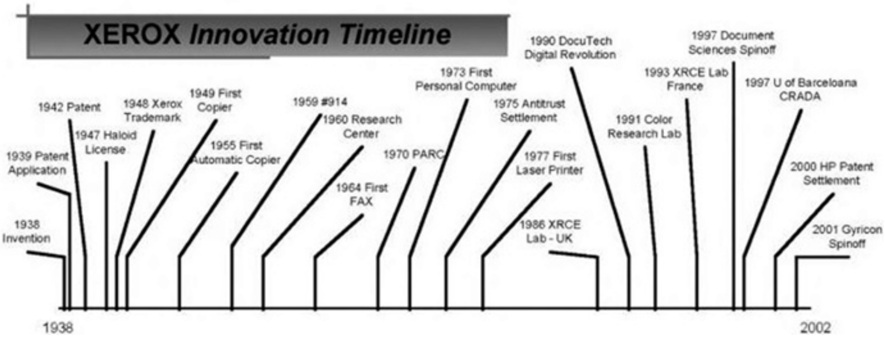
- **The products encompass office maintenance, production, equipment and**
- **The required support services and**
- **The services consist in resources, reverse engineering process, solutions**
- **(embedded services) and software applications.**

It is interesting to underline that searching for products and services on a diachronic basis revealed some interesting things, some of them being the heart of Xerox innovation portfolio—electronic typewriters, working mechanisms and computers. These do not figure in the current portfolio anymore.

Table 3.1 Innovation measures—hard vs soft

Hard Measurables		Soft Measurables	
Characteristic	Measure	Characteristic	Measure
R&D	• Patents • R&D Budget • New Products • R&D Staff • Publications • R&D Incentives • New Features • Inventions	Impact	• Productivity • Growth • Lower Costs • Flexibility • Supply/Demand • Firm Size • Market Influence
	• New Markets • Product Extensions • Conferences • CRADAs • Partnerships	Social	• User Benefits • Lower Prices • Social Enablers • Time Savers

Table 3.2 XEROX innovation timeline (Carayannis et al 2003)



Xerox sells its products through various channels-in various ways including direct selling, telemarketing, after sales services, agencies, donations and through the web. These modes of selling are managed by various organizations—see the table below. The sales organization is global and is divided in regional departments. The largest sales organization is the one in USA and is covered by North American Solutions Group (NASG).

Almost 50 % of Xerox employees are working for Xerox Services, with most of them being placed in the customer-sales store. Xerox sales and the distribution channels are displayed in Table 3.2. Business solutions are an area of understanding that many Xerox researchers found hard to grasp. Xerox defines 'Solutions' as an 'integrated proposal that includes materials, software and human-based services that solves a problem, improves a project, and creates a market or a competitive advantage'. Xerox has divided the provision of Solutions to 4 main business functions and focuses on market production (graphic arts companies), office market and services. The four groups are Documents Systems and Solutions Group (DSSG), Office Systems Group (OSG), Office Printing Business Group (OPBG) and Xerox Global Services (XGS).

3.2.2 Innovation: Sequence of Errors

In 1970, Xerox developed the Palo Alto Research Center (PARC), being famous as the center of computer revolution. PARC researchers were given the ease to conduct basic research from the beginning. This led, among other discoveries, to the first personal computer in 1973 and the first laser printer in 1977.

The personal computer was sophisticated for its era consisting of a software system, a text editor WISYWYG, a graphic environment for the user interconnected to a desktop surface, a mouse and an Ethernet connection. With this state-of-the-art discovery in its portfolio, Xerox would drive the computer revolution-but as history shows us, Xerox did not profit from this unprecedented discovery letting others lead the genesis of a new market. The question addressed to researchers of innovation is why Xerox let this happen and what could be done to avoid this type of costly mistake in the future! In other words, what is the lesson to be taught from this?

In order to understand Xerox strategies, researchers are trying to find the solution exploring the history of innovation of Xerox and taking interviews from basic players of the era. In such an interview with Mr. RT, a Xerox veteran for 30 years and business executive connected with the control center of the business in West Coast for the largest part of his career, the following information was taken.

In '70s, besides PARC, Xerox held an important control center of the business in the West Coast. You should remember that the Xerox base is in Rochester of NY, where the largest labor force worldwide is placed (16,000). The man who envisaged the 'office of the future' was Joe Wilson II, later President of Xerox. At that time, except for PARC, Xerox—West consisted of Versatec (regionally), XSoft (development of software applications), Xerox Network Services (Ethernet, networks), Sughart (construction of discs), Total Recall (scanning and retrieve applications) plus a construction capacity of photocopy machines and materials. This was a very advanced portfolio of technical capacity and technical power of those times.

PARC since the beginning of '70s was a central institution for arranging computer information. It developed a professional forum as a tool to give incentives to researchers. Every week it used to host a public event ("FORUM") to allow its researchers to present the results of their researches. "FORUM" was addressed to professionals from universities outside Xerox, engineers from the developing computer industry and others interested in research. This early contribution of knowledge helped to the birth of computer industry in the area of Silicon Valley.

When the personal computer was initially developed, Xerox strategy was to promote PC as a private tool of an enterprise. It was mostly a 'portable' computer than a 'personal' computer. The computer would comprise a 32" broad portable unit and a hard disc that could be transported and be moved from place to place, as required. The computer was placed in an interconnection terminal. The initial software, MESA, was unique. We should stress that MESA finally became the base of artificial intelligence systems of our time.

The PC was named with the code STAR and was soon introduced in the market as the mechanism 6085. Finally, a by-product was formed called Global View and the computer later became known as Global View System. Approximately 50 applications were developed, such as text editor, spreadsheets programs, graphics programs, specialized graphics (chemical and mathematical applications), messenger programs, hyperlinks, browsers, etc. It contained many particular characteristics, such as the application "CLEARINGHOUSE" (clearance application), giving users a knowledge distribution area. An application enabled users to create applications upon demand (a JAVA precursor). All applications were privately owned and could be used only in the Global View system.

In the same time, Xerox started staffing the West Coast administration with former IBM management executives, most of them with powerful activity.

It should become known that the upcoming PC market was influenced by three large players of the era, i.e. Xerox, IBM and WANG. As we may know from various IBM studies, the management's ability and experience (former IBM executives) could not be harmonized with the PC market developments. Introducing the power of experienced IBM management executives, Xerox probably made its biggest mistake. Former IBM executives did not fit in well in the existing Xerox culture and had a hard time to disseminate their ideas in Xerox management infrastructure. Xerox management executives had the right vision and lagged behind in the appropriate execution.

While Xerox nurtured the vision of 'the office of the future', it was not sure how to promote it in the market. Xerox was known for the selling of photocopy machines and it fared very well. The PC market was established–overwhelming–standardized and Xerox management had a hard time foreseeing the progress of the industry. It focused its strategy on the commercial axis 'business-to-business' (B2B) disregarding the 'personal' or amateur market (B2C), as was known. As the market target was business to business, the selection of privately-owned systems showed it was the best strategy. It was later when it became known that the PC industry development was driven by amateurism that was the bridge between the offer of in depth knowledge and the computer usefulness for personal and business use.

The market was better delimited with the rise of Apple computer. It is interesting to highlight that the main attraction of Apple computer was the common graphic surface/desktop/mouse, an idea borrowed during a visit to PARC. Another point of discussion in Xerox, narrowing down the market strategy, was the alignment of sales power. Xerox possessed a well-trained and equipped sales team aligning the photocopy machines with the provision of material (H/W) and services of added value. For Xerox to capitalize on this novel innovation, the computer, a sales labor force was required which was aligned with a different fundamental product—the software (S/W) in the sense that it had the capacity and experience to sell services (software). Xerox strategy did not take into consideration the re-alignment of its sales labor force and in particular its remuneration objectives. Xerox had a successful sales team particularly because its remuneration objectives were very liberal.

In order for the existing trade-off plans to benefit each salesperson separately, the only solution for computers' sale, being attractive from an off-setting point of view, was to sell a multi-million dollar computer.

During '70s the only customers who were able to invest millions in computers were the current powerful computer customers of IBM, WANG, Digital and others. Therefore, the computer market based on B2B axis was not sustainable. Large companies were not ready to shift from high-power computers to personal computers even if they were networked. The results were obvious. Another barrier to success was the different corporate mindset or culture: Xerox was domiciled in Rochester of NY and the computer revolution rose in the West Coast of the USA; the mentality gap between East and West Coast is significant. The subsequent clash of cultures led to a Not-Invented-Here Syndrome that worked as a hindrance to the successful transfer of technology and XEROX innovation promotion.

The new inventions originating from the West Coast were not immediately understood because the sources of knowledge and the management for innovation support were based in Rochester. A case in point is the development of network technologies by Xerox. The technology was developed in West Coast control centers and was then transferred to Rochester for further development—a clear case of cultural conflict, as Rochester owned a small infrastructure to support the upcoming internet technology. Funding and marketing decisions, being based in Rochester, lacked the strategy to be aligned with the perceptions of the upcoming market. Focus was placed on the marketing strategy of photocopy machines and the PC marketing was not aligned with the marketing strategies for photocopy machines. The object of marketing strategies for recently emerging markets was erroneously explained. Cultural differences had not been promptly identified and XEROX executives did not handle them appropriately.

Finally, XEROX traded Global View in non-privately owned environments, such as IBM 6000 and with compatible concepts in IBM / Microsoft (MS) ideas adopting the strategy of "competitive cooperation" (co-opetition) but the decision taken was delayed so it failed to ensure a share in the market of said technology. Commercial isolation was encumbered with technological inconsistencies. For example, the personal IBM computer, when it followed the MS platform, did not have sufficient memory to run the Global View of XEROX and because the sufficient memory cost was too high for the era, the overall installation cost was prohibitive.

There was an effort to utilize the products of technologically advanced organizations but organizationally cultural influences and oppositions got in the way. In the beginning of '90s, Xerox strategy showed that technological research centers in West Coast are about to shut down and to merge with the Rochester-based organizations in NY State. At present, PARC in Palo Alto of California and the research centers of Xerox in Ontario, Canada and in Grenoble, France are guided, directed and managed by Rochester technological administration, NY.

Another influence on Xerox innovation strategy was the anti-trust arrangement of 1975. According to this arrangement, Xerox agreed to open the dossier of its intellectual rights property and issue a license to use some of them previously considered technology of Xerox exclusive ownership. While the arrangement did not impact directly on Xerox culture, it finally influenced its innovation strategy, as proven, by the current Innovation Group organization.

Intellectual property became a source of revenue for Xerox. It took a generation to change this culture and become fully applicable.

As typically described in the Xerox example, the other side of success is a list of innovation's failures.

The failures of innovation are summarized as follows:

1. Management of intellectual property rights—Patenting and taking advantage of strategically corporate secrets
2. Influences of diverging mindsets and management strategies of technological and business risk
3. Strategic development of markets

One cannot accept the reasons of failure without making a valuation and assessment that would enable translating failures into successes in the future.

In the first failure, management of intellectual property rights—Patenting and taking advantage of strategically corporate secrets, the strategy used by PARC to recognize the production of researchers led to the disastrous result of exposing corporate secrets to competitors without managing exchange within certain legal boundaries—such as Credos (Cooperative Research and Development Agreement), i.e. licensing agreement or other arrangement to control the share of knowledge. Dissemination of technology needs to be safeguarded by suitable policies and practices for its protection. The creation of inventions and their commercialization via innovations is hard and should not be obstructed by uncontrolled flow of information undermining profit margins.

The second failure refers to the influences of diverging mindsets and management strategies of technological and business risk. This is a complex subject of discussion as the culture of an organization may not be directly obvious. In the case of Xerox, it can be considered that there are two distinct cultural influences.

Initially, the company was largely influenced by the aspect of creating a 'home office'. Rochester in NY was the operational center of Xerox with an employee concentration of more than 20 % of the total labor force. Rochester is also home to the historical influence of innovation up until the middle of '40s. In 1970, when the innovation center (PARC) was developed in West Coast, there was a natural reaction by Rochester group of employees against the fact that Rochester was not the innovation center's base. Moreover, the management of West Coast divisions mainly consisted of persons recently recruited by IBM. Xerox culture and IBM culture were not compatible resulting thus in an additional separation from Rochester.

The third failure, the market development strategy, is practically linked to the existing cultural influences. Since Rochester, home to the marketing department, was not culturally linked to the West Coast divisions, the marketing department failed to comprehend the essence of discoveries being made in PARC and in the West Coast divisions. This lack of understanding was deleterious for any marketing plans developed. Rochester was not grasping the real meaning of the discoveries, tending to challenge the place. The lack of understanding led to mistaken marketing plans and to underestimating market capabilities.

At the end of the day, what is the lesson drawn from XEROX case analysis study? Innovation can be considered as a coin with two different sides. On the one hand lies success—a history teeming with discoveries that can evolve into innovation. On the other hand, there is failure—either due to lack of discoveries or due to non-converting the discovery into innovation. Remember the definition of innovation given above, i.e. as a kind of implementation or application of a discovery for rendering new solutions or improving existing solutions, desires or needs of the market.

The case of Xerox provides us with examples of aspects of innovation, the rich history of successes and the disenchantment of failure. It also supports the definition given on innovation and the important criteria for the distinction between innovation and invention.

3.3 Creativity, Innovation and Competitiveness (CIC) in Public and Private Sectors

This section, combining sources of literature (including authors), interview fields with thorough knowledge by academics and professionals, attempts to go deeper into the practices and consequences of creativity and innovation on competition.

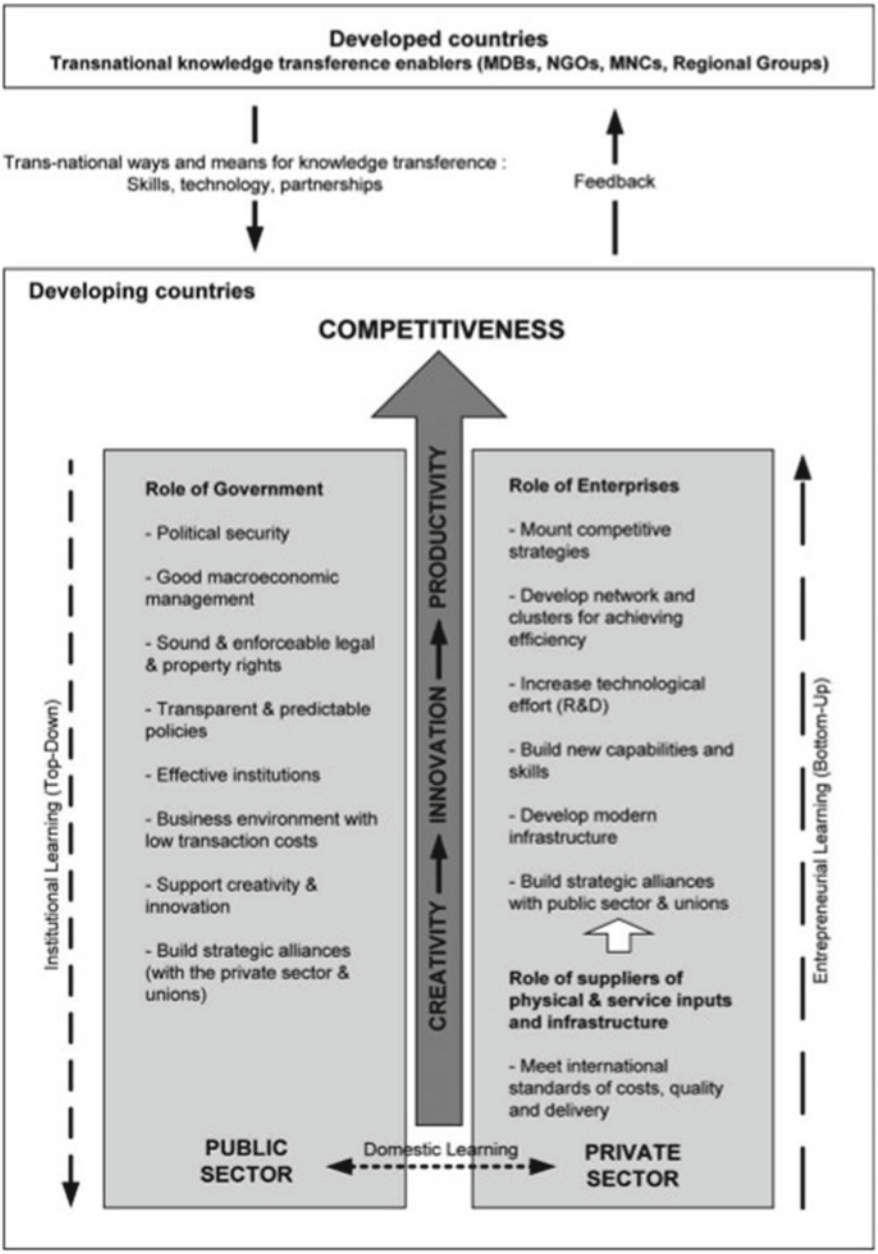
We believe that competitiveness is a product and a function of creativity and innovation reserves and supply, being determined and modified through various types, ways and kinds of knowledge (up to bottom and bottom up, acting proportionately, succeeding or failing through the exchange of capabilities, cooperatives, technological activity, supranational knowledge, domestic knowledge as well as through special knowledge and inventiveness **(the 'when', 'how' and 'why' of creativity and innovation)** (see Figs. 3.1, 3.2, 3.3, 3.4, 3.5, and 3.6) (Carayannis et al. 2003a, b).

In Fig. 3.1, we see the co-operative interaction between the public, private sector and the main institutions of cooperation, such as universities, research institutes and non-governmental organizations (NGOs) in order to establish strategic alliances aiming at higher levels of competitiveness in developed and developing countries.

In this context:

- Governments are in charge of creating a stable and foreseeable political and macroeconomic environment using transparent policies, reinforcing their legitimate rights and property rights, facilitating the specialized development, creating a business environment with low transaction costs and offering sufficient incentives for creativity and innovation.
- Enterprises should use competition strategies developing specialized networks to achieve performance (social profit), increase of technological effort intensity (more sources for R&D), building of new capacities and skills (human and intellectual profit) and development of a modern infrastructure. Suppliers and importers of services, materials and infrastructure should be harmonized with the international standards of quality, distribution and cost.
- Universities and research institutes should be aligned with the development policies and innovation priorities of the public sector as well as the strategies of the private sector to offer crucial and critical new capabilities and skills to public and private bodies through appropriately targeted research. Non-governmental organizations (NGO) should serve as empowering agents, catalysts and accelerators of activities of public and private cooperatives.

Fig. 3.1 Interactions of knowledge and institutional interactions of CIC (Carayannis and Gonzalez 2003)



Universities & Research Institutes	Non Govermental organisations
Biography alignment to the business needs Creating private and public cooperation for the development of new capacity and capability	Functioning as intermediaries, catalysts and accelerators of private and public cooperation
Institutes for cooperation	
< - - - - - - - - - inter-organizational learning - - - - - - - - - - >	

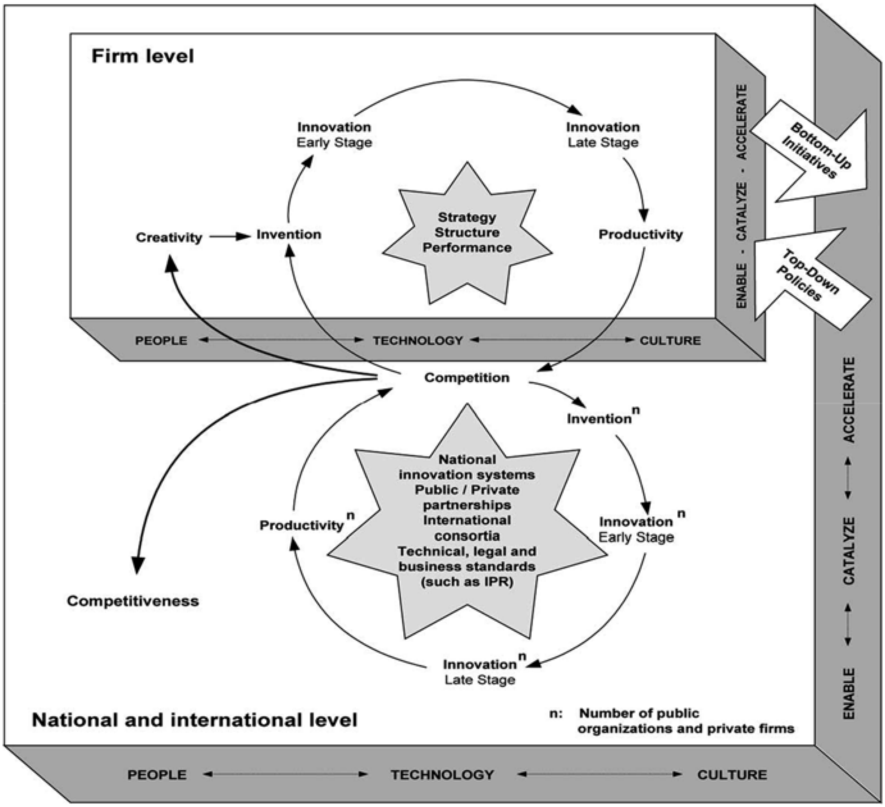


Fig. 3.2 Interactions of CIC: an approach with system dynamics

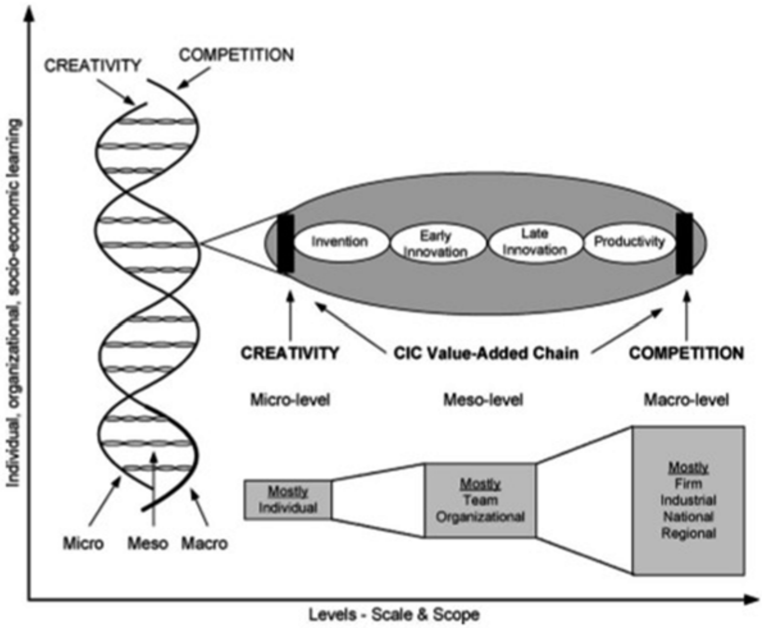


Fig. 3.3 The CIC spiral and the value chain (Carayannis and Gonzalez 2003)

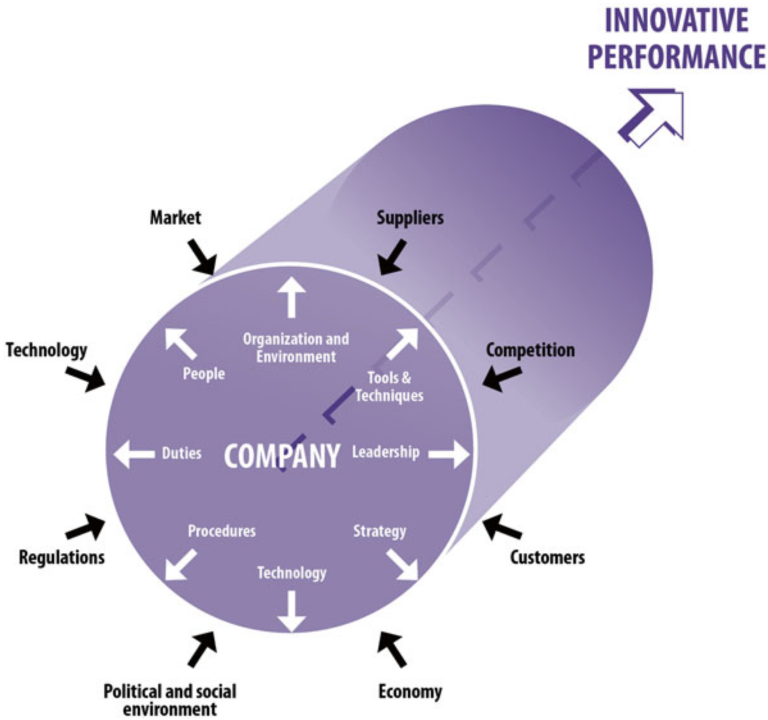


Fig. 3.4 Factors influencing innovative performance (Carayannis and Gonzalez 2003)

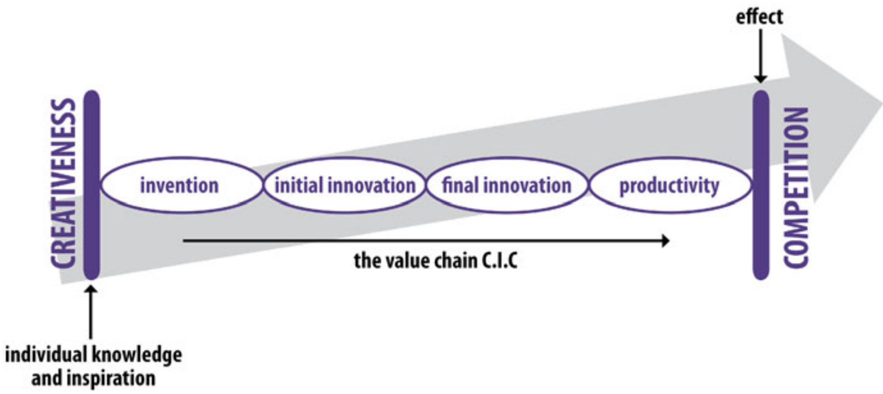


Fig. 3.5 The value chain of CIC (Carayannis et al. 2003a, b)

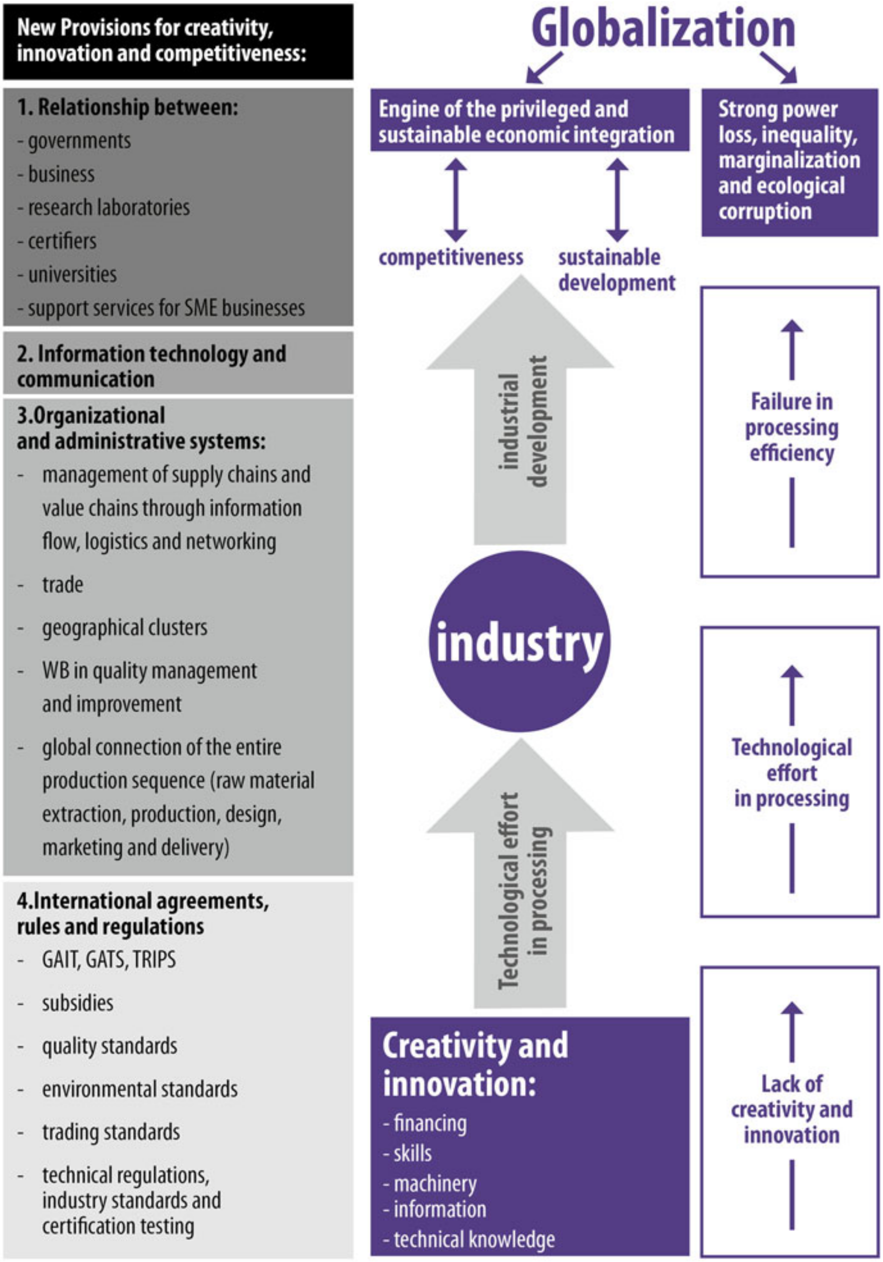


Fig. 3.6 The value chain of CIC-Global and local perspectives (Carayannis et al. 2003a, b)

The **institutional high level knowledge** completing the **business knowledge as it evolves** serves as a catalyst and accelerator of economic growth. It contributes to the convergence of developed and developing countries as well as to technology transfer from the developed to the developing countries and between public sectors, private sectors, universities, research institutes and non-governmental organizations (see Figs. 3.2 and 3.6) (Carayannis et al. 2003a, b).

Research found that innovation and creativity become all the more important in the public sector and in the survival and flourishing of the private sector, determining modern requirements and capabilities in public and private sectors worldwide (Carayannis et al. 2003a, b).

Some of the requirements and capabilities of the public sector impacting heavily on the private sector are described below:

(a) **Shrinking of budget and demographic movements with advanced-aged population groups**
(b) **Higher required production of knowledge by employees achieving enhanced mobility**
(c) **Increased pressures for responsibility and transparency guided by privatization, globalization and by an increasingly informed and experienced voters' base**
(d) **Increased pressure to and by the private sector to become more competitive requiring the comeback of a more competitive public sector**
(e) **and last, but not least, the Multilateral Development Banks and particularly the International Monetary Fund that encourage and require increase in productivity and transparency in public and private sector policies, practices and structures.**

Competitiveness is also a means to go back to the past as it reflects past creative breakthroughs of clever and innovative activities as well as the shaping of the future, ensuring the foundation and the frame of upcoming efforts of the public and private sector. Moreover, at present, the implementation of a creative and innovative effort heralds the upcoming horizons of a knowledge-based economy and society. These interact with individual knowledge and creativity in an ongoing emerging cyclical procedure (see Figs. 3.3, 3.4 and 3.5) (Carayannis et al. 2003a, b).

We also found that creativity and innovation do not always lead to boosting of competitiveness (at least on a short term to midterm basis) (Carayannis 2001, 2002). In other words, too high competition levels and a lack of competition in the form of trusts or monopoly conditions contribute to decrease of competitiveness at least long term (Carayannis et al. 2003a, b).

Summarizing our indulgence in the field of creativity and innovation, as these are related and affect competitiveness, we can identify many areas of interest that justify an additional focus on research aimed at better understanding. The key determining factors and the dimensions (content, process, context, impact) of creativity and innovation and the role of knowledge in this process come into sight (Carayannis 2002). We deem useful to map empirically the natural characteristics and the dynamics of knowledge and meta-knowledge, in accordance with CIC2Helix (Fig. 3.3) as regards public and private sectors and Fig. 3.4 (Carayannis et al. 2003a, b).

A better understanding of these procedures could yield results, enriching and promoting the effectiveness of the knowledge produced and the efficacy of transmitting and assimilating knowledge. In this way, the cognitive economies of scale and the attitudes may be attained at increasingly higher levels allowing for more, faster, cheaper and better things (Carayannis 1998a, b, c, 1999, 2001, 2002).

These benefits can be manifested in various ways at micro-medium and macro levels (see Fig. 3.3), namely higher living standards, more competitive companies, more robust economies, fast and sustainable growth rates (see Figs. 3.3, 3.4 and 3.5). Indeed someone can identify a challenge and an opportunity, for policy makers and administrators in the private and particularly public sector, taking into account the risks and possibilities available in the three figures mentioned. *In particular, Figs. 3.3, 3.4 and 3.5 conceive and display a combination of dynamics, complex and powerful forces in the game: human knowledge, individual creativity, organizational productivity and national competitiveness, along with institutional inertia, politically weak foresight and market and governmental failures* (Carayannis et al. 2003a, b).

By understanding how to better manage these forces, we could end up in impressive results (to some extent, successful examples of social and economic growth, such as Singapore, South Korea), while trying to work against these forces and trying to stop them we could be driven towards hazardous and non-tolerated poverty and totalitarian regimes. Ensuring rewards and stimuli to cultivate creativity and innovation, it could serve as a catalyst and accelerator for creativity and competitiveness.

3.4 Concepts and Empirical Observations: Case Studies

> *'Leaders in knowledge organizations have the capacity to perceive strategic deep knowledge so that they can evolve into public knowledge open to dialogue and improvement'*
>
> [Peter Senge 1990]

Creativity is the result of inspiration and knowledge, the release of talent in a demanding environment; it is primarily a strongly private and individualistic process—it operates at the small (individual) level (Fig. 3.3). Innovation is a team effort and takes place at the medium (group/organization) level, as it requires a combination of the gift of creativity with the fruit of discovery and favorable market conditions. Synchronization, option and impact are important along with 'divine providence', passion and inspiration. Competitiveness is the foundation of creativity, discovery, innovation and is realized at macro (industry, market, state, local) level (Carayannis et al. 2003a, b).

We are inspired by the double helix discovery that won the Nobel Prize and was a fundamental and evolutionary discovery in order to clarify and articulate the nature and dynamics of the interconnection between creativity, innovation and competitiveness but also the evolution paths thereof. We attempt to do this through **Creativity, Innovation and Competitiveness Double Helix (CIC2Helix)** (Fig. 3.3) whereby an element represents the flow and the recording of creativity and competitiveness (Carayannis et al. 2003a, b).

In every point of their evolution, such elements are linked in a chain adding the values of creativity, discovery, early innovation, late innovation, productivity and competitiveness **(CI3PC chain of added value, Fig.** 3.5**)** (Carayannis et al. 2003a, b). This element serves as catalyst and accelerator of social, economic, organizational and individual knowledge and meta-knowledge allowing the helix CI2C to keep on evolving, enriching and promoting the effectiveness of produced knowledge and the knowledge transfer and dissemination capacity.

In this way, the cognitive economies of scale and diversity may be attained at increasingly higher levels allowing for more, faster, cheaper and better things (Carayannis 1998a, b, c, 1999, 2001, 2002). These benefits can be manifested in various ways at micro-medium and macro levels, namely higher living standards, more competitive companies, more robust economies, fast and sustainable growth rates (see Figs. 3.3, 3.4 and 3.5) (Carayannis et al. 2003a, b).

We also try to formulate and confirm our perspectives with a research on questionnaires being answered by public and private sector managers from a number of countries all over the world, facing issues related to leaders, critical success, factors of failure and criteria for creativity, innovation and competitiveness. Our general findings arising from discussions with specialized executives in the public and private sector lead to the following conclusions:

- **Lack of imagination** (when creators and managers of technology and innovation fail to envision the future and only face the present).
- **Lack of courage** (when decision makers are too afraid to deal with the real requirements and avoid critical reality checks).
- **Fear of success** (when decision makers hesitate or are unable to embrace the pledge to success-either consciously or unconsciously-and therefore debilitate or undermine their efforts).
- **Fear of failure** (when decision makers and those who manage decisions are overwhelmed by the fear of failure and fail to realize that someone cannot avoid the risk but can only manage it in the best possible way. They thus mismanage technological or business risk and create processes and tendencies that drive to failure even when it is not necessary).
- **Short term focus on profit** (the narrow-sighted way of dealing with profit usually speeds up decisions being problematic from a mid-long term point of view and serves only short term interests). In the case of public sector, the equivalent case is that of politicians who only care or are forced to focus on how to win the next elections.
- **Strategy versus tactical options and actions** (as a result of all above ailments in relation to decision making, the options of tactic provoke actions that usually anticipate or impede the strategic options and actions).

In addition, the findings of the research can be organized and presented in three basic issues:

Subject 1: Key figures of Innovation and Creativity
Subject 2: Drivers of Innovation-Catalysts and Prohibitive Factors
Subject 3: A brief review of the current state of play in various countries-Challenges and Opportunities

3.4.1 Subject 1: Key Figures of Innovation and Creativity

In public and private sectors, innovation can be understood as a way to re-examine and reorganize the government, updating—replacing public services/public organizations, managing/guiding the change of the process, modifying the structure of programs and the distribution service, re-designing and improving the distribution service for the citizens, re-planning the responsibility of the working framework and measures performance, strengthening the suppliers of public services and private companies.

Extrapolating the answers we took by those who ply the trade in the public and private sector in various countries, innovation is recognized describing the following characteristics with the most important being the following by priority:

- **Discovering something new**
- **Seeing something from a different view**
- **Introducing changes**
- **Improving something that already exists**
- **Transmitting new ideas**
- **Implementing an existing work in a new way**
- **Producing only new ideas**
- **Following the market leader**
- **Adopting something that has already been tested elsewhere**
- **Attracting innovative people.**

3.4.2 Subject 2: Drivers of Innovation-Catalysts and Prohibitive Factors

Based on our empirical findings, there exist factors acting in a catalytic or prohibitive manner to creativity, innovation and competitiveness in the public and private sector.

Catalysts:

1. **Political guidance, far-sightedness, strategic plan (with the right objectives). Relative organizational autonomy and firm willingness on behalf of leadership for innovation.**
2. **Innovation/creativity rewards the system in the right position.**
3. **Protection of intellectual property rights.**
4. **Favorable organizational environment for the conversion of tacit ideas and knowledge into clear proposals for improvement: Open and frequent communication and dialogue, strategic interchange among various functions and technologies and access to information (Nonaka and Takeuchi 1995).**
5. **Correct mix of people and team spirit are manifested in well functioning groups.**

6. **Feeling of pressure (if you feel that you are against it, as it usually happens in the private sector, you become more innovative and competitive).**
7. **Someone innovates when being in a state of need, 'necessity is the mother of discovery': a recap in the experiences of innovation in governments over the last 25 years shows that innovation arises in almost all cases amid an environment of economic crisis.**
8. **Willingness of governments to innovate-this is why it is required to mobilize central government and first line officials and as well as administration officials.**
9. **In the private sector, the supportive management is willing to take up risks and encourage new opinions. Public sector executives and private sector managers with sufficient time to formulate and implement innovation initiatives.**
10. **Governmental support for Research and Development (R&D) and incentives to invest in R&D.**
11. **Availability for capital risk including investment and capital for innovation.**
12. **Commitment by political and economic forces and existence of public control.**
13. **Networks and innovation units such as: existence of educational institutes of advanced knowledge, 'think tanks', training programs and technical groups, institutions acting as a framework of internet activities, such as the cooperation of various countries in international programs of Research and Technological Development.**
14. **Variety of people and free flow of ideas (genesis of a variety of ideas, requiring assumptions, testing assumptions, rehabilitation for cultural and spiritual short-sightedness).**

Barriers:

1. **Reactions coming from elected or appointed experts who are predisposed to 'thoroughly examine'-in order to delay-innovations.**
2. **Innovation fails due to resistance to change: the failure of courage and imagination may prove to be significant barriers to innovation.**
3. **Feeling of 'comfort': Why should I press myself and disrupt my comfortable habits? Conservatism in multiple forms, e.g. 'do not change the status quo' syndrome, 'no risk policy', 'lack of no certified alternative solutions', 'do not omit the pre-determined course'.**
4. **Lack of courage by government executives to deal with the challenges and the problems, fear of losing the support of voters accompanied by a lack of long term vision (focus only on short term benefits), instability and widespread re-shuffling of executives in their positions.**
5. **Lack of courage by general managers and the team of heads of directorates in the private sector to accept change and make a long term estimate-pressure by those having interests to increase their benefits per share on a short term basis-fear of losing support by individuals harboring high interests if they do not respond positively to their pressure for short term results-**

frequent restructuring for a short time to make up and execute initiatives for long term development (Perel 2002).

6. **The way innovation is introduced is a decisive factor and a message heralding its success rate: innovations of gradual change have lower impact on hierarchy relations and as a result, are treated with a more moderate reaction and inertia compared to the more radical ones. The 'hazardous innovations' resisting the most are the ones with a dividing nature and have the tendency to change structure, in order to affect only positively the system's functionality.**
7. **Rigid hierarchy structures and lack of results management. Instability in the roles of the game (bias), corruption and lack of transparency. Poverty and political struggle. Central red tape, prosperity-decay policies and governmental control for the sake of control.**

3.4.3 Subject 3: A Quick Look at the Current State of Play in Various Countries-Challenges and Opportunities

Our findings show that there are various basic requirements and possible opportunities associated with innovation and creativity underpinned on initiatives and tactics. This is practically the role of the Multilateral Development Banks (MDBs). There are also opportunities and requirements being faced with the private sector, resulting from the high and increasing rates of technological change, globalization and competition intensity.

1. **There is a large potential for creativity, innovation, competitiveness at individual level but there is a shortage of public tactics to cultivate and capitalize on the advantages of this potential.**
2. **In some countries, the government's tactics, while ensuring indirect economic assistance, are unable to guarantee a market for product development and hence sales opportunities.**
3. **Often in developing countries, disintegration plans see the light of day lacking consensus, dialogue or agreement with local communities. The main emphasis is control. There are no channels for participation and for structuring a prosperity plan.**
4. **In some European countries, there is an urgent need for research and education to forge strong ties with the real economy; there is also need for the European Research Area and the innovation system to be unified.**
5. **In many countries the private sector is considered more capable as regards creativity, innovation and competitiveness compared to the public sector. The public sector seems inert due to formalities and regulations inhibiting growth. Political indecisiveness and opportunism influence all economic activities and render economy a slow developing one.**
6. **In some countries, universities—in contrast to the majority of them—are wonderful, illustrative examples of the public and private sector being sources of creativity and innovation.**

7. **Many countries have not been fully equipped somehow with tactics and practices merging in one simple, unified outcome. Most of the aforementioned results, in relation to this type of cooperation, are found under the authority of the public sector with the initiative having been taken by persons and not through an organized project.**
8. **A higher requirement involves less developed countries due to lack of sufficient potential and necessary infrastructure to convert the vision into action and of continuing and stable potential to cultivate creativity, innovation and competitiveness.**
9. **Most of developing countries still believe in concentrated type agreements. The public sector is predisposed to arbitrariness for political or even personal reasons. Private sectors are disorganized. Companies are mismanaged and lack strategic planning abilities. Public and private sectors do not cooperate enough and fear responsibilities.**
10. **In general, it seems that non-specific, unclear and non-systematic measurements of creativity, innovation and competitiveness are being attempted in developing and developed countries. Usually, economic and social performance indicators are considered as proxies to measure performance in the field.**
11. **The Multilateral Development Banks (MDBs), though traditionally teeming with examples and ideologies that resist dialogue and change, and, therefore, creativity and innovation, have been involved, either independently or via cooperation, in a large number of initiatives to promote competitiveness and higher growth levels in borrowing member-states through pilot programs and projects.**

Recently, the technological progress on the Internet and the high connection speeds have allowed member states to exchange substantial information with the participants in various programs and works, promoting knowledge from a distance in a modern, cost-effective way . However, MDBs are required to work harder in order to measure their effectiveness in periods when creativity, innovation and competitiveness are brewing at national and local level.

3.5 The Role of the Public Sector in Promoting Creativity, Innovation and Competitiveness (CIC)

'To learn one must be humble'

[James Joyce, Ulysses]

Further down we analyze and classify thematically the reactions by public and private sector executives that we collected through the field research in order to consolidate proposals to executives and create a map of the progress of future research.

Innovation plays a decisive role in the public sector serving as a catalyst and accelerator of social and economic growth. Promoting CIC in the public sector could lead to better, more performing management at a lower operational cost for public sector enterprises and social prosperity functions.

The occasional cost for the public sector when not promoting the creation of a competitive environment is enormous, since the economic and social cost linked to obsolete and outdated ways of guidance and business administration is significant particularly in less developed countries.

The role of the government in a developing country is much more critical since usually the private sector does lack the means and the ways to increase the capital for innovation. Therefore, if the government does not intervene, there is a slight possibility of innovations seeing the light of day.

Usually, the less developed countries have a shortage of sufficient labor force and necessary infrastructure in order to convert vision into action, while in industrial countries, these conditions are largely met. The public sector may act as a catalyst for CIC in developing countries and this is the reason why it can promote and take up works in areas where the private sector does not find sufficient profit incentives to carry out works.

The procedural method can be a function of the market development rate and of the requirement for public/private sector services. A well-developed public infrastructure could ideally allow for promotion of CIC in the public and private sector.

The active support of innovations by the government is required in developing countries due to the insufficiency of the political and economic system that can disrupt initiatives of technological innovation in the public or private sector.

Science, being developed in the public sector, should be reasonably turned into a guaranteed commercialization without the public sector becoming dramatically competitive to the private sector. The public sector should not operate as a competitor to the private sector collecting business initiatives.

The public sector requires more aggressive policies to cultivate creativity within its own administration, to promote innovation inside the government and gradually increase its own competitiveness. The public sector may promote CIC in various ways:

1. **Creating an environment that supports CIC.** It involves successive policies, regulations and provisions that strengthen CIC. Rewarding and granting incentives, such as tax rebates, security and other favorable requirements benefiting from the international experience. Ensuring performing incentives for research and scientific growth, investing in adequate resources.
2. **Utilizing the government's purchasing power** (approximately 30 % of the national gross product in the Latin America countries) to boost competitiveness (along with effectiveness and transparency).
3. **Building social security safeguards** for those who fail when seeking for discovery and support mechanisms for those who need additional support to discover/innovate.
4. **Acting beyond market failures**, when the private sector cannot act on its own due to lack/asymmetry of information or due to scale problems. Taking all this into account, the promotion of non-traditional exports or grants for technological innovation in small or medium-sized enterprises are some examples.

5. **Trying to merchandise research** that was produced by the public sector, e.g. federal laboratories, Ministry of Defense, Administration of the National Aeronautics Center.
6. **Building an adequate innovation system.** The main focus areas relate to research and innovation networks, technology transfer and innovation programs (scientific and technological parks).
7. **Offering the available resources for basic research.** These resources could create an environment that would be less prone to applied research and more inclined to 'theoretical' research.

3.5.1 Public–Private Partnerships Promoting CIC

In developed countries, when markets operate more effectively with the private sector participation for CIC development they are more sustainable. The public–private sector partnerships (PPPs) are realized to allow a higher level of private sector participation in predetermined enterprises/areas despite the relatively higher level of competition and the lower profit margin. In these countries, private companies have the incentive to get involved in partnerships with the government for other reasons, such as to obtain a larger market share or simply for reasons of marketing, advertising and promotion. Moreover, developing countries with a less stable social structure and economy and political structures inextricably linked with the government's reliability often present a hindrance in the private sector's participation.

Some areas of the private sector need support by the public sector to improve innovation, competitiveness and creativity. In addition, the support of new ideas and initiatives is required (research of applied sciences or construction of technological breakthroughs). In this last case, there is a possibility of public and private sector partnership but only in those areas where the private sector is deprived of the innovation and creation ability and particularly for those areas where discontinuous innovations are the main pursuit.

Summarizing the description of recognition criteria of possible initiatives/ideas to conclude cooperatives between public/private sector, criteria and processes for the selection of private sector objectives and conditions, the following could be put forward:

1. **Priority of governmental areas**
2. **Possible practical application and gain for society or economy too**
3. **Low cost or profitable venture**
4. **Long term venture**
5. **Candidates with integrity and sufficient economic resources**
6. **Willingness for change**
7. **Competitive spirit**
8. **Vision for the future**
9. **Additional experience and resources**

10. **A good record of achievements**
11. **Contribution to innovation**
12. **Experience and access to the market.**

(Carayannis et al. 2003a, b)

It is a significant but nevertheless paradox procedure. There is a risk factor when choosing a winner; the public sector, however, is responsible vis-à-vis society not to risk using public funds.

The process requires connecting society with the business sector in order to ensure transparency. The rules and procedures should be crystal clear as well as the involvement of any public sector official. This is very significant when taking the product a step further to the chapter of innovation.

An 'Experts committee' should be set up for selection, supervision and assessment. A 'quality guarantee' committee needs to complete the functions of the 'Experts committee' in order to supervise quality/evolution to a following stage every time the relevant works begin. Economic arrangements are always available particularly to ailing enterprises.

3.5.2 The Role of Multilateral Development Banks (MDBs), such as the World Bank in Promoting CIC

The role of Multilateral Development Banks (MDBs) that support innovation in the public and private sectors is decisive. MDBs may:

- Promote the consolidation of national policies and action plans for CIC, with long term and short term objectives, but calling for existing pursuits. Train and mobilize the personnel being in charge of works and activities execution in public and private organizations. Allocate the necessary resources and tools for the execution of the appropriate actions and make available ongoing technical assistance and supervision.
- Create favorable conditions where innovations in developing countries can bear fruit.
- Assist developing countries in properly following the fundamental regulatory and economic policies so that the conditions that encourage new ventures and innovation be able to function within the private sector.
- Disseminate worldwide the best practices in developing nations, reinforcing the private sector institutions so that an enterprise can largely contribute to political decision making.
- Contribute to eliminating commercial barriers that affect developing countries and destroy the possibility of innovative growth.
- Spread information, knowledge and successful CIC experiences among member states.
- Promote CIC through agreements, contracts and integrate it in growth policies.

For Multilateral Development Banks (MDBs) to be capable to contribute more effectively to CIC promotion, they should:

- Merge CIC in their administration. The Multilateral Development Banks (MDBs) should assume joint responsibility (with the countries) for the merger results. This joint responsibility should be defined at the level of national growth and good living standards of citizens in the target countries.
- Be more creative, innovative organizations, less rigid and less bureaucratic.
- Support governmental projects whose leadership and ownership are held by the government. In other words, no economic assistance shall be ensured to the government not enjoying independent ownership of ideas development or certified leadership.
- Give more flexibility to countries in their effort to find the best way to growth (not pre-fixed 'magic formulas')
- Be more accountable for their breakthroughs as regards national productivity and competitiveness (Carayannis et al. 2003a, b).

References

Carayannis E (1994a) A multi-national, resource-based view of training and development and the strategic management of technological learning: keys for social and corporate survival and success. In: 39th International council for small business annual world conference, Strasbourg, France, June 27–29

Carayannis E (1994b) The strategic management of technological learning from a dynamically adaptive high tech marketing perspective: sustainable competitive advantage through effective supplier-customer interfacing, University of Illinois, Chicago/American Management Association Research Symposium on Marketing and Entrepreneurship, Paris, France, June 29–30

Carayannis E (1994c) Gestion Strategique de l'Acquisition des Savoir-Faire, Le Progrès Technique, no. 1, Paris, France

Carayannis E (1998a) The strategic management of technological learning in project/program management: the role of extranets, intranets and intelligent agents in knowledge generation, diffusion, and leveraging. Technovation 18(11):697–703

Carayannis E (1998b) Higher order technological learning as determinant of market success in the multimedia arena; a success story, a failure, and a question mark: Agfa/Bayer AG, enable software, and sun microsystems. Technovation 18(10):639–653

Carayannis E (1998c–2002) George Washington University Lectures on Entrepreneurship. Carayannis, E. The Globalization of Knowledge and Information Creation and Diffusion Processes and Standards in an Emergent Trading Groups Context: EU, NAFTA, Mercosur, and APEC, Seminar on Globalization of Knowledge and Information Creation and Diffusion Processes and Standards in an Emergent Trading Groups Context: Laying the Foundations for Latin American Competitiveness in the 21st Century, University of Puerto Rico Rio Piedras, San Juan, Puerto Rico, March 14, 1997

Carayannis E (1999) Fostering synergies between information technology and managerial and organizational cognition: the role of knowledge management. Technovation 19(4):219–231

Carayannis E (2001) Learning More, Better, and Faster: A Multi-Industry, Longitudinal, Empirical Validation of Technological Learning as the Key Source of Sustainable Competitive Advantage in High-Technology Firms, International Journal of Technovation, May

Carayannis E (2002) Is higher order technological learning a firm core competence, how, why, and when: a longitudinal, multi-industry study of firm technological learning and market performance. Int J Technovation 22:625–643

Carayannis E, Gonzalez E (2003) Creativity and innovation = competitiveness? When, how, and why. In: Shavinina LV (ed) The international handbook on innovation, Part VIII, Chapter 3. Elsevier Press, Oxford

Carayannis E et al (2003a) A cross-cultural learning strategy for entrepreneurship education: outline of key concepts and lessons learned from a comparative study of entrepreneurship students in France and the US. Technovation 23(9):757–771, September 2003. NOTE: Recipient of Emerald Management Reviews Citation of Excellence for Research Implications

Carayannis E, Gonzalez E, Wetter J (2003b) Nature and dynamics of discontinuous and disruptive innovations from a learning and knowledge management perspective. In: Shavinina LV (ed) The international handbook on innovation, Part II, Chapter 7. Elsevier Press, Oxford

Kuhn TS (1962) The structure of scientific revolutions. University of Chicago Press, Chicago

Moore LF (1996) The death of competition. HarperCollins, New York

Nonaka I, Takeuchi H (1995) The knowledge-creating company: how Japanese companies create the dynamic of innovation. Oxford University Press, New York

Perel M (2002) Corporate courage: breaking the barrier to innovation. Res Technol Manage 45(3):9–17

Senge P (1990) The fifth discipline: the art and practice of learning organization. Doubleday, New York

Shapiro C, Varian H (1999) Information rules. Harvard Business School Press, Boston

Chapter 4
Innovation as a Management Process

4.1 Introduction to Technological Innovation Management

The management of innovation is a highly interactive process. It is the result of an ongoing transfer of knowledge among various points-entities where the participation of every team member could influence the final outcome (Cooke et al. 1998).

Many a time, innovation seems successful short term but appears not so successful on a long-term basis. The main reasons for this are frequently the non-realistic expectations in the future evolution of technologies and the lack of insight in unexpected influences. A second observation is that in only a few cases the basic barriers are the scientific or technological problems. Usually, organizational, administrative and institutional problems get in the way.

Innovation management is complex and risky. A failure analysis of companies does reveal inter alia a significant number of innovative companies that failed to translate their technological creativity into profitable business operations. The challenge therefore is not only the creation of innovation but of its appropriate management to generate profit in the company. As the role of innovation management in the performance of an enterprise is clear, the process of its management should be standardized and used to attain a sound business operation.

According to Roberts (1987), the management of technological innovation (as defined in Chap. 1) refers to the organization and orientation of human and financial resources in a performing way, geared towards:

- Advanced knowledge acquisition
- Emergence of technical ideas aimed at new or improved products
- Procedures and services
- The development of applicable standards
- The transmission of these ideas in production, distribution and use.

E.G. Carayannis et al., *Innovation and Entrepreneurship*, Innovation, Technology, and Knowledge Management, DOI 10.1007/978-3-319-11242-8_4

4.1.1 How Could a Company Enhance Its Capacity for Innovation

A company needs sufficient resources, capable and suitable personnel for correct management of innovation in order to enhance its capacity for innovation. In reality, innovation relates to various sectors of knowledge such as the creation of new ideas and concepts, the design and development of models, the industrial development, Research & Development, the re-design of a business's process, marketing etc. All the above shall adhere to the most recent theories of business organization whereby the operational structure of a business should not necessarily comply with the traditional, operational plan (production, marketing, financing etc.); instead, it should be divided in a series of business processes. A procedure could be defined as a reasonable sequence that covers all the activities adding value for customers and carried out aiming at the success of a specific outcome. In general, all these activities cover a big variety of functional areas.

Any organization, of any size, could be divided in a series of procedures. The first group of procedures refers to a business's strategic activities (strategic procedures), while the second group underlines all these activities involving customers directly (basic procedures). The third group of procedures, supporting the other two, takes into account the suppliers (support procedures).

The innovation process includes activities related to the creation of new products (designing and developing new products) with the capacity to make things differently in order to enhance the value of products (re-designing the procedures of a business).

Moreover, the innovation process should be guided by a well-defined market based not only on market launching, consisting of identifying opportunities and not satisfied needs but also on the creation of market and customer satisfaction with the new product or service.

The innovation process should be guided by the clearly delimited market focus and involves 4 basic activities:

1. **Creation of new Ideas:**
   - Determination of new ideas of products and services.
   - Customer needs forecast with the analysis of market trends and competitors' successes.
   - Encouragement of new ideas and creativity among the personnel.
   - Determination of the mechanisms and the criteria used for the selection of ideas being developed.
   - Programming the creation of new products.
2. **Re-design of production processes:**
   - Re-design of production processes in order to achieve higher flexibility or productivity, along with higher quality and reduced production costs.
   - Changes in production processes to allow changes in the products.

- Evaluation of the introduction of new technologies and management of organizational tools in production processes in order to increase the value of products.

3. **Knowledge Management:**

- Innovation as a result of technology and know-how.
- The way and the procedures whereby enterprises decide what technologies to develop internally (current training, set up of an R & D department, etc.).
- The extent to which enterprises are supplied with technology or make available technology in external centers, as it happens with the subcontracting of Research & Development programs to other businesses, research centers and universities.

4. **Products development:**

- How enterprises are driven from an idea to the launching of a new product or service in the market? This process requires a detailed description of operations and product specifications, such as the description of the parts and the systems it contains and it should be taken into consideration in the production and distribution process as well as in the product's after-sale services.
- How do enterprises develop a new product as soon as possible?
- How do enterprises coordinate the internal personnel and the external teams?
- What kind of management methods shall be applied by enterprises?

5. **Re-design of market processes:**

- The changes in the marketing processes contribute to the increase of products' value or to the creation of new products and services.
- Use of the modern information technology to redefine the market's product.

4.2 What Is the Management of Technological Innovation and Why Is It Important?

Among the challenges faced today by management executives, the management of technological innovation is one of the most demanding ones. If done correctly, the companies create value and profit, develop a sustainable competitiveness, become lively, entertaining work places, attracting and preserving the most productive and creative personnel. If the technological innovation management is done in the wrong way, the companies may face serious and probably determining problems by losing money, employees and reputation. In the vast majority of business segments, if companies do not innovate, their competitors will catch up and in any case, the former will find them outside the labor market.

The primordial objectives of the management are to improve performance and enhance viable competitiveness in their organizations. Successful management of technological innovation is achieved when the broad range of innovative elements and activities within an organization is being managed properly and is effectively combined with an innovation strategy. This allows companies to fulfill their general purpose-generation of profit, development, delivery of better quality and larger variety, larger market share, or increasing remuneration of employees, safety, satisfaction.

The management of technological innovation involves all the aspects of companies where the development and the use of technological innovation enable companies to attain their targets. It also encompasses elements such as the management of strategic innovation, the teams and networks of innovation, the research and development, the design and elaboration of new products and services. However, notwithstanding the numerous incentives to innovation, there are special barriers to its success.

The management of technological innovation is usually required under circumstances with increased vagueness, uncertainty and risk. Given that technological innovation is for many companies a primary way of competition in the twenty-first century, its management is an activity of vital importance.

As already mentioned in the first chapter, technology constitutes a product that can be copied with practical application and knowledge allowing it to develop and to be used. Technology is presented in the new products, in the processes and the systems and includes knowledge and skills required for its operation, being reproductive.

Innovation is something much more than invention–creation of a new idea and its application; it encompasses all activities required for the commercialization of new technologies (Freeman and Soete 1997). Practically, innovation is the successful commercial exploitation of new ideas. It includes the scientific, technological, organizational, economic and business activities that lead to the commercial launching of a new (or improved) product or service.

Companies compete successfully when they offer new, better or/and more cost-effective products and services that can be used by customers for their benefit and that they cannot be offered by competitors. Therefore, their competitive advantage derives from the capacity to do better and cheaper things, or to do new things. We should highlight at this point that there is a relative dimension because the advantage lies in the activities of companies versus their competitors. There is also an absolute dimension because a market is required for what the company is producing.

Technological innovation plays a primary role in providing comparative and absolute advantages. Although it may seem crystal clear what technological innovation is—a new computer, an automated transactions machine (ATM), or pharmaceutical products—the scope of the definition of technology and innovation is in reality broad. This illustrates that technological innovation may arise in many, often unexpected sectors, as shown in our case studies; take, for example, innovation in foodstuffs, cruise ships and car insurance. Innovation is involved in many more company departments compared to ‘technology’.

Decisions pertaining to the strategy, organization, marketing and the position of an enterprise are made in parallel with the ones being relevant to research, design and processes. The challenge for an enterprise is effective decision making for each one of such sectors and this usually should take place simultaneously. These features display the complexity of technological innovation and therefore the challenge for the management thereof.

Technological innovation is something much more than the successful application of new ideas in products and services. It often requires changes in the organization and the strategies supporting it. Technological innovation involves dealing with a raft of issues and activities that constitute a challenge as to its management; they add to the risk and uncertainty and render cumbersome the elaboration of general recipes for its success.

It is though the difficulty itself in the management of technological innovation that renders it a valuable source of competitive advantage. If every company were able to do this successfully, it would not offer a source of relative competitive advantage. As stated in 1912 by Frederick Gardner Cottrell, from the University of California and one of the founders of the American Society of Research, 'many praiseworthy patents offered by their inventors to the public totally free, have not been launched to the labor market, primarily because 'what is everyone's business is no one's business' (Cottrell 1912; he refers to Mowery 2005).

Technological innovation appears rarely through activities of individual companies-organizations. It is more often the result of input by various organizations and enterprises, of cooperation between customers and suppliers, of various groups and networks and official technological forms of cooperation. The Management of Technological Innovation involves therefore alliances, technological cooperation and networks.

The management of Research and Development (R&D) is significant as it provides an organized source for the production of an idea and improves the capacity of companies to absorb useful information from outside. The Management of Technological Innovation encompasses issues ranging from technology forecast and evaluation techniques up to organizational issues, such as the extent of concentration or decentralization of research and development, the degree in which research and development are internationalized and the ways whereby internal capabilities are linked to external sources of research–development–universities, research centers and other enterprises. It includes balancing the short term applied research and development and the more long term, theoretical basic research. It includes management of creative and productive researchers and research teams.

The Management of Technological Innovation entails the management of products and services innovation. This includes performance factors, encouraged through various systems of administration and programs. The management of design is a significant constituent for the development of new products and services. Design entails selection of elegant and performing options in order to find solutions. It covers the options made in relation to aesthetic appeal, impact, operation and reliability.

The management of innovation operations and processes includes the way operations and production complete existing activities and offers options for new innovation activities. It is interested in a broad range of entrepreneurial and organizational issues. The final objective of the Technological Innovation Management is the process of commercialization—meaning revenue from investments in innovation.

The appropriation of value from the investments of companies in technological innovation involves intellectual property rights, granting of licenses, creation of technical standards, speed, secrecy and ownership of additional advantages.

The so-called 'regime of intellectual property expropriation' (the possibility, the tendency of a private good being converted into a public one) determines the extent in which companies can ensure receiving sufficient revenue from their investment. Commercialization may not be direct; companies may extend their options for the future, through the process of innovation and this should be examined upon evaluation of their commercial profits.

Innovation in the processing industry and services is particularly interesting because the boundary between services and processing industry becomes increasingly vague (Quinn 1992). A company designing car engines is it a processing company or a service rendering one? Could IBM be considered a processing company when its strategy is to supply customers with solutions rather than with products? Do Software plants using particularly automated writing tools manufacture products? Many significant activities carried out by processing companies, marketing, distribution, applied engineering, design, maintenance, accounting would be described as services if they were offered externally. Many services such as bank telling are offered now electromechanically and the value of processing products is now found in intangible properties, such as fast delivery, easy use, brand and reliability that would have been considered as services had they not been embedded in the products. Many service rendering companies describe their offers as products. In addition, many products are packaged with intangible services.

Such an example is the service package by Ericsson and Nokia for their products. Given that service companies create capacities based on Research and Development—in order to increase diversification of their products, cut development cost and service rendering and protect their owned technology—dwell on many issues relevant to the ones of processing companies. The majority of issues therefore being discussed for the Management of Technological Innovation are equally valid for the services and processing issues. Examples will be given both from processing and service rendering companies.

The ways in which technological innovations are developed and used keep on changing and the Management of Technological Innovation is a dynamic and evolving sector of practice. New challenges arise as regards technology-based competition, the role of the government, the contribution of basic research, the evolving innovation process and the environmental concerns.

The management of information technologies (IT) and information systems is embedded therein and is not considered as a distinct area in the Management of Technological Innovation. Many strategic and organizational issues, such as the development of new information technology and software products and the use of information technology and information systems in Research and Development and its operations are included in the definition of the Management of Technological Innovation.

The **importance of the Management of Technological Innovation** is being investigated under a corporate, national, theoretical and individual perspective.

4.2.1 A Corporate Perspective

The Management of Technological Innovation is important for the growth, effectiveness and survival of companies. History is teeming with examples of enterprises that were not able to survive because they failed to abide by innovation's requirements. Each of the sectors of Technological Innovation Management is significant but some are critical for specific companies. For example, the capacity for competition of pharmaceutical and electronics companies depends on their ability to manage Research and Development. It is Research and Development that offers the opportunities to create separately new products and markets. Pharmaceutical companies, such as GSK, Pfizer, and Merck, are based on research to create particularly profitable drugs to treat ulcer or to manufacture AIDS inhibitors.

Companies, such as Sony in consumer electronics, Samsung in DRAM semiconductors, BMW in cars, HSBC with online economic services and Google in search engines depend on new products and services to offer the means to compete with and such innovations largely determine their enterprises.

Boldness as regards the processes enables companies, such as Toyota to produce better and cheaper cars compared to their competitors and allows companies of electronics, such as Acer in Taiwan to effectively produce for important customers in the USA, Europe and Japan. The success of supermarkets, such as Wal-Mart and Tesco, largely depends on their particularly innovative procedures.

When NEC decided it wanted to acquire experience in semi-conductors, something it perceived as a key strategy for its competition with various industries, it used more than one hundred technological alliances to do so. The strong technological enterprises, such as Boeing, very much depend on their teams and networks. Boeing operates at present in the production of aircraft in cooperation with associates in charge of design and the manufacturing of important spare parts, such as engines, shaft and steering-paddles. Boeing can no longer design and construct aircrafts itself.

Enterprises usually fail to acquire value from their technological innovations. Ampex failed to see the real market as regards its evolution in video recording. RCA did not make the business transition from vacuum tubes into transistors. The effectiveness and the quality of commercialization process determine the outcome of technological innovation. The Betamax video system by Sony was technically better that the competitor VHS system by Matsushita, but failed to win the competition in the consumer market. The personal computer PC by IBM was in many respects inferior to other competitive products but met huge success. The ability of Matsushita and IBM to commercialize their innovations more effectively compared to their rivals offered them their competitive advantage.

Out of all aspects of Technological Innovation Management, the innovation strategy was the most demanding. Very few enterprises are steadily in a position to develop and apply innovation strategies. The adoption of dominant positions in technology could offer a significant competitive advantage. SAP, the German software applications company, benefited significantly from the forecast of the significance of using Unix systems and later on Microsoft NT systems. Similarly, when market evaluations are accurate making forecasts—as when Matsushita saw the market in relation to recording videos—leaders can largely benefit as regards innovation.

At the same time, leaders may fail to capitalize on new ideas, allowing product innovation fans, such as Dell to succeed. Companies in the same industry follow different strategies, based on their resources, abilities and ambitions. When these strategies are correct, the significant benefits increase. For example, the Italian clothing company Benetton and the Spanish company Zara have been particularly effective in integrating innovation in their products, processes, marketing and sales, being thus able to achieve their competitive targets, i.e. fast delivery of fashion products being constantly changing to the market. They can deliver 'quick fashion', making sure that what Madonna was wearing at the Saturday concert will be available at the stores by next Wednesday.

4.2.2 A National Perspective

he possibility to manage innovation impacts at national, regional and local level because it affects the levels of employment, the kinds of work and the ways whereby countries, areas and cities prosper or decline. The globalization of production and markets, along with the increased use of digital communications and services have driven to a significant restructuring of entire economies and of the ways innovation processes are regulated at local and international scale. Nevertheless, a strong spatial dimension prevails in the management of innovation processes. Nations are still interested in innovation.

Some empirical research conclusions are mentioned below illustrating the significance of technological innovation:

- High-technology industries grew two and a half times faster compared to construction industries from 1980 up to 2003.
- The commerce of cutting-edge technology goods (requiring high levels of Research and Development) doubled from 1994 up to 2003.
- High technology industries in the USA grew from 11 % in 1980 to 13.5 % in 1990 and 34 % in 2003.
- Innovative countries and regions present higher productivity and revenue compared to less innovative ones (Fagerberg 2004).
- The benefits from investments in Research and Development from a 'social' aspect (in society in general) and from a 'private' aspect are steadily estimated at high levels. In a study regarding 17 innovations, Mansfield et al. (1977), found that the social 'revenue' from investments in Research and Development were 56 % and private revenue stood at 25 %.
- Technological innovation has played a key role in the economic reform of Eastern Asian economies.

- Entire industries, such as the Swiss watch industry and geographical regions such as Silicon Valley in California can be strengthened or weakened by technological change (Saxenian 1994; Utterback and Suarez 1994).
- At corporate level, the new products, of less than 5 years old, are set to yield 30 % of profit in American companies and almost half of sales and profits in high performance companies (Cooper and Edgett 2004).
- Credit and easy access to financing is more likely to be granted to innovative companies compared to not innovative ones (Czarnitzki and Kraft 2004).
- In the United Kingdom, innovators in construction and services industries present higher productivity and increase of productivity compared to non-innovators (Criscuolo et al. 2005).
- Payments for the granting of licenses and the right to technology increased at constant prices from $7bn in 1976 to over $120 bn in 2004.

4.2.3 A Theoretical Perspective-Evolutionary Economy

The empirical conclusions on the effect of technological innovation are enhanced by new theoretical approaches that unveil the significance of innovation, evolutionary economic and new or inherent growth theory.

The importance of technology for economic growth has been understood by political economists, (Adam Smith, Karl Marx, Alfred Marshall), but it was Joseph Schumpeter the first who placed innovation at the center of his economic analysis. For Schumpeter, innovation refers to new products, production methods, supply sources, markets and modes of organization. He explained how economies grow:

> *'Nothing can be more plain or even more trite common sense than the fact that innovation lies at the heart of almost all phenomena, difficulties, and problems of economic life in capitalist society'*
>
> [Schumpeter]

Evolutionary economics view capitalism as a system that constantly creates variety of ideas, companies and technologies created by entrepreneurs and innovative activities of large research groups (Nelson and Winter 1982; Dosi 1988; Nelson 1995). Decisions lead to choices out of this variety regarding companies, consumers and governments.

Some of these market choices are successfully disseminated and are fully developed in the new activities of companies and in technologies that provide the foundation for future investment in creating variety. A big part of the variety and the options made is disorganized or fails to be disseminated; therefore, the significant uncertainty, the disruption and the failure constitute features of the evolutionary economic growth. From the perspective of evolutionary economics, success in innovation explains the different performance of nations, regions and enterprises.

Modern economic evolutionary theory (Frenken 2000) keeps on advocating that economic growth and development are first and foremost a result of innovation, bringing in more insight through the theory of complexity. Economic development is a very complex process involving many constituents, in open systems, with unpredictable outcomes. Innovation yields profit, but also brings about a structural change (Schumpeter' creative destruction), uncertainty and 'useless' investments.

The importance of evolutionary economics in the Management of Technological Innovation lies in the way it helps to explain the primary importance of innovation; however, they do illustrate that innovation is complex and uncertain and sometimes unsuccessful. Emphasis is placed on the central paradox of innovation: it is substantial, however continuously problematic.

4.2.4 Significant Characteristics of the New Growth Theory

Technology is 'endogenous'-a central part of the economic system, a key factor of production along with capital and work.

- Although any important technological discovery may arise randomly, technology is rising as a whole, depending on the resources dedicated thereto.
- Technology generates 'positive revenue'. The traditional theory forecasts shrinking revenue in investments; however, a big increase can be attained by technological investment.
- The investment may render technology precious and technology may make investment even more precious-a circle that can permanently increase an economy's growth rate.
- Monopolistic power is useful in granting incentives for technological research.
- The emerging global economy is mostly based on ideas rather than objects. This requires different institutional arrangements and pricing systems, taking into account for example that the prices depend on the time of development, cost and risk and not on plants' production costs.
- The capabilities for discovery and ongoing improvements are immense.

Traditional neoclassical economic theories view technology as an 'exogenous' factor in explaining economic growth. This form of analysis considers that productivity and growth represent a function resulting from the combination of the three factors of production: land, work and capital with a big unexplained balance in the calculations. Based on this theory, technological innovation may be a part of the explanation for this balance but unfortunately so far there is little interest in investigating and establishing its importance. The sources of technology and the characteristic and idiosyncratic ways whereby innovation is being used in individual companies to generate growth are disregarded. Moreover, technological investments, like all capital investments, were supposedly generating reduced revenue with the lapse of time (Verspagen 1993).

On the contrary, the new growth theory supports that technology is a significant 'endogenous' factor that explains the growth and the understanding of the necessity of the way technology flows among companies and industries (Romer 1990).

Moreover, contrary to conventional investments in installations and equipment bringing in reduced revenue as times goes by, technological investments are set to 'produce' positive revenue through the creation of new knowledge, options and opportunities (Arthur 1991).

4.2.5 An Individual Perspective

The contribution to society by advanced and recent innovators, such as Edison, Marconi, Steve Jobs in Apple and Bill Gates in Microsoft, is well known. Innovations, however, do not simply arise through the heroic efforts of some persons. They usually arise from combined activities of human groups and organizations that build on the other's knowledge and experience. The work undertaken may mostly result in '99 % of Edison's toil from 1 % of his inspiration' and indeed, occasionally it may be, as Nathan Rosenberg (1976) put it, 'polluting and uninspiring'. Innovation is though the result of the application of innate human inventiveness and wit. Creativity is something that we are all capable of and the application of innovation capacity constitutes a source of enthusiasm, challenge, satisfaction and happiness.

4.3 Challenges in Technological Innovation Management

The more innovation activity focus shifts from the simple incremental improvements towards more demanding changes and the higher the number of bodies participating in its creation, the more Technological Innovation Management involves the effort to manage something complex and hazardous. Besides the inherent complexity of many products and services, a key view on complexity rests in the systemic nature of a modern enterprise. In this respect, complexity is a characteristic of systems having multiple contributors and unexpected outcomes. Moreover, technology-based innovations, such as airplanes, cars, buildings, banking operations or mobile phones, comprise various systems. Computers for example include central processing units, software systems, applications programs, disc units, memory chips, power supply and communication devices, keyboards and screens. The integration of all above complex systems is a key objective of the Technological Innovation Management.

Some of these complex systems have been described as a particular form of industrial production requiring different administrative approaches (Hobday 1998).

Therefore, for complex products and systems (including products of high value, basic goods, control systems, networks and constructions of applied engineering, electronic aircraft systems, coastal oil equipment and smart buildings), there are special demands in the design, program management, applied engineering and integration of systems (Brusoni et al. 2001).

Risk levels are determined by various factors, including the degree in which innovation results are unpredictable, costly and non-assignable. The innovative activities of companies clash with the overall business uncertainty of future decisions relevant to the investment, the technical uncertainty for future technological developments and the parameters of technological performance and cost, with the market uncertainty for the commercial sustainability of specific new products or processes (Freeman and Soete 1997). With the high degree of risk and uncertainty of investments in technological innovation and the very high investment levels therein (some companies spend billions of dollars annually and some industrial sectors, such as electronics and pharmaceutics spend more than 10 % of their annual revenue in Research and Development), huge pressure is placed on companies worldwide to cut the expenses of technological innovation or obtain higher revenue therefrom.

There are challenges linked to all the methods used to ensure desired revenue from investments in innovation, such as whether for example intellectual property protection is subsidized and can be preserved, or whether secrets can be kept. They explain why innovators fail so often to have the suitable return on their efforts. An additional estimate is the issue of speed: how fast can innovation be protected and returns be incurred? New markets can develop very quickly, based on the new technology. Within a decade since its development, it is estimated that electronic commerce has turned into a business of trillions of dollars. In such swiftly evolving environments many challenges arise for many companies and opportunities for others.

Whether it has to do with the development or with the improvement of new products, processes and services, the Management of Technological Innovation requires the organizational capacity to learn fast and move quickly when issues of competition arise. As we shall see in the following chapters, companies may develop organizational rigidness opposing innovation and the external sources of ideas.

4.4 Case Study in Technological Innovation Management

Some of the issues and the common problems faced in the Management of Technological Innovation are briefly presented in the following short case studies, being complex descriptions of actual businesses and placing emphasis on the opportunities and the issues such are facing.

4.4.1 Biotechnology Company

The Biotechnology Company arose towards the end of '70s in the USA. These companies started as vehicles of transmission of new scientific discoveries in genetic applied engineering and immunization, in the industry, by research laboratories and universities.

Some companies were initially expected to follow the model of information technology industry and reproduce the remarkable growth of companies such as

Apple, Intel and Microsoft. Few biotechnology companies, though, have reached a similar for the sector size. Many of them have been acquired by large pharmaceutical companies and those that remained independent have primarily focused on product development rather than on becoming producers and distributors.

Sidmuth Genes Technology (SGT) is an example of an American biotechnology company that seeks the optimal way to obtain value from its intellectual property. The business is located in Cambridge, Massachusetts and employs 45 people including 20 scientists holding a PhD, in the elaboration of gene technology that inhibits liver cancer development.

SGT started from two scientists, Elaine Weissman and Peter Georgiou a capital investor, Jenny Kuper, on the basis of a scientific discovery with two possible market applications. Laboratory tests proved very successful and Weissman and Georgiou consider that their discovery would contribute to overcoming liver cancer, a disease of a multi-million dollar market in USA.

The challenges faced by SGT are significant. They include the management of the regulatory process required to first protect and then develop its discovery. The company patented its discovery (being the basis of Jenny Kuper initial investment) but there were various technical aspects associated with the important discovery that were not fully patented. This was due to carelessness on behalf of managers of the new enterprise and to a concern to deal with the patents cost.

Subsequently, SGT discovered that the true commercial added value of its discovery lies not in the substance itself (a complex protein), but in the product growth and manufacturing process per scale. This is a delicate process as it includes product development in quantities of some grams utilizing a specific animal gene. Significant intellectual capital was invested in the manufacturing process but was not patented and competitive companies obtained the technology because Weismann and Georgiou kept on their academic tradition to publish and discuss their research results. Although the company knew it was a matter of knowledge sale, it failed to acknowledge which aspect of knowledge had the highest value.

A second problem faced by SGT was the time span and the money required to gain the approval for a new drug development. Under the American regulatory system, it could take between 4 and 14 years involving more than 750 million dollars to ensure approval for a new drug by virtue of the rigorously controlled testing and approval process.

The company discovered however that although the new product functioned, it did not yield evidently better results than the existing products in the market. As a result, it shifted its attention towards the second application and this meant delay and cost increase.

SGT could not afford to proceed through the drug approval regulatory process, nor attempt to develop the marketing and distribution effort required to launch its products in the market. Initially, it considered that its eventual product would be so effective that it would be sold with prescription in the drug stores but then decided that higher supervision of use was required. It investigated the possibility of targeting specialized treatments at hospitals. Weissman and Georgiou thought that while in the first case SGT would have to sell the product's rights to a large company that would be able to assume the cost for marketing and distribution; in the second case it would be in a position to preserve some rights to the product. However, in this case, the product's commercialization cost proved equally prohibitively costly. To improve its economics, it had started offering research and services to other enterprises using the experience of its personnel and its scientific equipment in order to analyze and place consecutively the various genetic materials.

Following a long discussion and with some reluctance, it forged a strategic alliance with an important American pharmaceutical industry, receiving in exchange a high investment capital for all the rights of the developed product.

In the case of SGT, the administrative challenges faced by the three biotechnology company managers are important. The two scientists, instead of conducting a research, spend their time in communication with regulation-related organizations; they work on patent rights infringement and with the drug approval process of the American Food and Drug Administration (FDA); they execute stereotypical procedures to improve the company's financials and manage the cumbersome and demanding relations with associated large pharmaceuticals. Weissman and Georgiou wish to maintain the momentum and eagerness for discovery and encourage the creativity needed to continue developing new products and to build on the company's base of knowledge. Jenny Kuper had registered a success in computer industry but had limited experience in pharmaceutical companies. Her expectations for quick profit have not been fulfilled and she is undecided as to the strategy to be followed. She could keep on financing the company into a joint venture until other products are developed or almost developed and then sell the business making possibly significant profit. Or she could keep on encouraging SGT to sell its intellectual property at much lower price to a large pharmaceutical company, exposing thus herself to a lower risk.

The enterprise has important decisions to make for its future. Could it become an enterprise for rendering research services but where would be the pleasant part for creative scientists like themselves? The enterprise needs to decide whether it shall continue financing its own expensive research to develop a series of new products, or whether it shall become ambitious and try to develop and commercialize its products, probably in cooperation with other companies. It should be examined whether it shall sell out to a pharmaceutical company, and if yes, at what point should it be attempted.

4.5 Innovation Management Techniques (IMTs)

Today, product life cycles become gradually smaller. Actually in some sectors such as the computer sector, technological devaluation of the products occurs within a few months. Therefore it is a great competitive advantage for the companies to be able to introduce new products to the market before their competitors, gaining in this way significant sale shares. Today companies must be able to be constantly innovative in order to maintain or improve their position in the market.

Many people would reply to that question by saying that 'innovation is something new, an invention, a new idea'. However, in reality innovation is not just the generation of a fresh idea for a new product or process, but also includes all the stages from design and efficiency evaluation to the idea's implementation.

The implementation of an innovation is basically carried out with the first transaction regarding a new or improved part, product, process or system. On the contrary, an invention is a concept, a plan or a model of a new and improved part, product, process or system, which although it can lead to a patent certificate, in the majority of the cases does not result in a transaction and therefore in the end the innovation is not implemented.

Many surveys have shown that innovative companies—ones that constantly innovate—are, on the average, twice as profitable than other companies. However, managing innovation is extremely difficult and, as a result, the majority of new ideas do not turn into new successful products or services.

If innovation is to be successfully managed the firm needs a number of things which can be quite easily specified, and which it may well make sense to acquire from external sources. These may include:

- Information on what can be done;
- Information on how to do it;
- Help in ensuring the firm makes the right decision on what to do and how to implement it;
- Assistance with planning and implementation;
- Money, to finance the necessary developments, together with advice on appropriate sources including grants and loans;
- Some way of ensuring the firm does not get unduly side—tracked by short term pressures and emergencies;
- Specific expertise on technological, marketing, management or organizational matters;
- Training and skills development at various levels.

Successful innovation management is difficult for smaller firms, but with some simple, structured techniques and a good facilitator the chances of success can be greatly increased. The difficulty arises for several reasons, among them access to information, short timescales, a necessary aversion to risk, reluctance to engage outside help, and financial constraints.

While there is a wealth of research on innovation in large firms and high tech small firms, the processes of innovation in most SMEs are not well understood. What is clear is that creating an innovative enterprise is not primary about technology: it is about people, culture and communication. These "softer" factors, together with the technology itself and the business processes within the firm, must be taken into account in an integrated approach to innovation management. The aim is a dual perspective: a technologically informed view of business strategy combined with a strategic view of technological development.

Many methodologies and techniques have been employed in managing innovation, which are implemented at every stage of the innovation process in order to make it smoother and more efficient; they are called Innovation Management Tools/Techniques (IMTs) and each has its own characteristics, its own way of implementation and, depending on its special features, is applied at different stages of the innovation process.

Structured IMTs facilitate a rapid, wide ranging appraisal and encourage strategic thinking. They allow the consultant to highlight and probe areas of weakness and those where there is a difference in perception among staff. They help to alert the company to strengths, weaknesses and opportunities, and emphasize important human issues. Above all, they stimulate the firm to action. They can start a process in which early tangible benefits will build confidence for achieving long term change.

The key to success lies in achieving a "best fit" between the consultant, the technique used, and the firm. Some principles of good practice are listed in Fig. 4.1. The consultant adds value by ensuring that management and staff take the assignment seriously; forcing issues into the open; promoting wide staff involvement; interpreting findings; and moving the firm on to action planning and implementation. A good analogy is that of a "business doctor". Some principles of good practice for the consultant can also be identified.

In recent years decades, a multitude of Innovation Management Tools has been developed. Evaluations show that many of them work well and often lead to successful results. The same evaluations, not surprisingly, also reveal that factors outside the IMTs themselves are crucial in determining how successful the results will be. Based on observations, it seems sensible to argue that a competent consultant working together with a strongly committed top management can make good use of most modern IMTs, and that no IMT can compensate for the absence of management commitment and the lack of general consultancy competence. In order to select the most suitable IMT for a specific task, it is necessary to know the areas it

- Simplicity and clarity in presentation & data collection
- Founded on an open, objective model
- Seeks best fit to company situation, with clear objectives
- Compares with best practice in & beyond industry sector
- Flexible – complements and does not stifle creativity
- Collects basic information / expectations beforehand
- Includes time perspective
- Balances comprehensiveness + time (e.g. via suitable software)
- Consults cross –section on firm
- Uses discrepancy information (differences in perception among staff)
- Includes action planning step
- Linkages to other tools / steps
- Sets success criteria
- Facilitates learning by firm
- Provides for mandatory follow - up

Fig. 4.1 Principles for IMT design

focuses on. It is equally important, of course, to know the needs of the enterprise in question in order to make a proper match.

In order to select the most suitable IMT for a specific task, it is necessary to know the areas it focuses on. It is equally important, of course, to know the needs of the enterprise in question in order to make a proper match.

4.5.1 Examples of IMTs

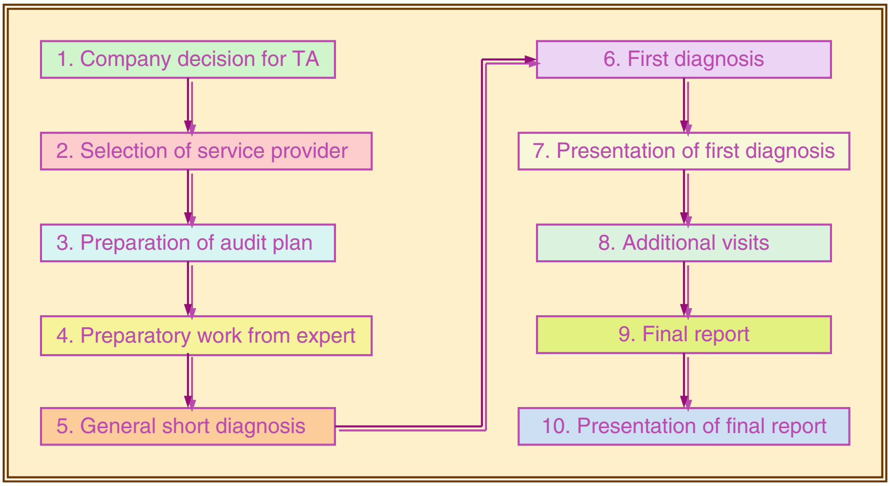
4.5.1.1 Technology Audit

The Technology Audit is a method for identifying through a short interview-visit to a company, the major company requirements, needs, weaknesses and strengths on both human resources and infrastructure. The Technology Audit is a technique that enables the auditor to determine and identify in a very short meeting session, the management's view of how the company performs as well as strong indications of what the company really needs. The Technology Audit technique examines concurrently the external and internal environment of the company and identifies the human resources relation to company's performance.

The objective of Technology Audit is to provide the auditor with a clear identification of company's first priority needs as well as strengths and opportunities that should be taken under consideration. It also assists the auditor to identify the more significant actions that the company should adopt.

The technology audit is equally applicable to manufacturing and service firms. The firms should be wishing to create new products, incorporate new processes, diversify their activities and be with growth potential. They should have capacity to survive and innovate and an aptitude for international cooperation.

The main steps of a technology audit process are shown in figure and are described below.



1. Step 1: Company decision for Technology Audit
   The starting point of the technology audit process, is the desire or wish of a firm to carry out a technology audit.
2. Step 2: Selection of service provider
   The firm selects the intermediary organization or expert to carry out the technology audit.
3. Step 3: Preparation of audit plan
   The expert visits the firm and discusses the audit details with the manager. The expert should have a brochure/flow diagram of the steps to follow, a list of benefits, a list of other companies that carried out technology audits etc. The audit plan is devised together with top management. It establishes issues to investigate, how to collect data and from whom, in what time span and at what cost etc.

The psychology of the interviewed person is the main obstacle of technology audit. The psychological factor that is of major importance in the outcome of any interview.

The objective is to elaborate a reasonable diagnosis of what might be in need of improvement within the company under consideration within a short period of time. It is thus important to extract all necessary information under a friendly discussion that would flow smoothly and would thus allow the persons interviewed to open up and mention what they really believe or understand about how things are running within their company.

For this reason all subjects should be tackled randomly and repeated through questions that are raising a different point of view of the same subject, so that the auditor is helped to understand and feel where there might be a problem. The auditor in such cases should not insist to find out the truth immediately but will have to bring the issue up for discussion several times within the interview but each time from a different point of view.

The auditors should always understand when the person interviewed is not feeling right, either because he does not know the answer or because he is not able to provide his own opinion or answer due to the presence of other company colleagues. In all such cases the discussion should immediately change and through a reminder by either of the auditors, the subject should be tackled at some later stage.

4.5.1.2 SWOT Analysis

SWOT analysis is another tool for auditing an organisation and its environment. It is the first stage of planning and helps markets to focus on key issues.

A scan of the internal and external environment is an important part of the strategic planning process. Environmental factors internal to the firm can usually be classified as strengths (S) or weaknesses (W) and those external to the firm can be classified as opportunities (O) and threats (T). Such an analysis of the strategic environment is referred to as a SWOT analysis.

SWOT analysis provides information that is helpful in matching the firm's resources and capabilities to the competitive environment in which it operates.

SWOT analysis is a business tool by which, a firm wishing to implement a strategic analysis, analyses and recognises its corporate Strengths and Weaknesses as well as the existed or forthcoming Opportunities and Threats from its external environment. Only when these four critical information elements are well elaborated and known, the enterprise is able to formulate and implement the strategy leading to its business aims.

The role of SWOT analysis is to take the information from the environmental analysis and separate it into internal issues (strengths and weaknesses) and external issues (opportunities and threats). Once this is completed, SWOT analysis determines if the information indicates something that will assist the firm in accomplishing its objectives (a strength or opportunity), or if it indicates an obstacle that must be overcome or minimised to achieve desired results (weakness or threat).

When doing SWOT analysis, remember that the S and W are INTERNAL and the O and T are External.

SWOT analysis is an extremely useful tool for understanding and decision-making for all sorts of situations in business and organisations.

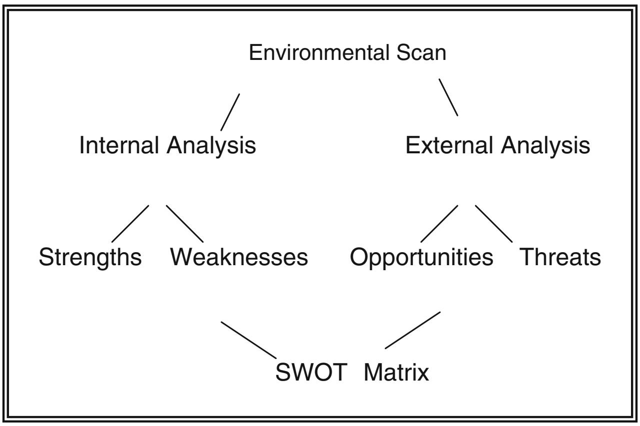
SWOT Analysis is a very effective way of identifying your Strengths and Weaknesses, and of examining the Opportunities and Threats you face. Carrying out an analysis using the SWOT framework helps you to focus your activities on areas where you are strong and where the greatest opportunities lie.

By creating a SWOT analysis, you can see all the important factors affecting your business together in one place. It's easy to create, easy to read, and easy to communicate.

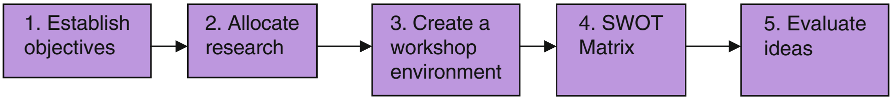
A company can use the SWOT analysis:

- While developing a strategic plan or planning a solution to a problem.
- In order to develop a plan that takes into consideration many different internal and external factors, and maximises the potential of the strengths and opportunities while minimising the impact of the weaknesses and threats.

SWOT Analysis Framework



Action Checklist



1. Establish the objectives
   The first key step in any project is to be clear about what you are doing and why. The purpose of conducting SWOT analysis may be wide or narrow, general or specific.
2. Allocate research and information-gathering tasks
   Background preparation is a vital stage for the subsequent analysis to be effective, and should be divided among the SWOT participants. This preparation can be carried out in two stages:

   - Exploratory, followed by data collection.
   - Detailed, followed by a focused analysis.

   Gathering information on Strengths and Weaknesses should focus on the internal factors of skills, resources and assets, or lack of them. Gathering information on Opportunities and Threats should focus on the external factors.
3. Create a workshop environment
   If compiling and recording the SWOT lists takes place in meetings, then do exploit the benefits of workshop sessions. Encourage an atmosphere conducive to the free flow of information and to participants saying what they feel to be appropriate, free from blame. The leader/facilitator has a key role and should allow time for free flow of thought, but not too much. Half an hour is often enough to spend on Strengths, for example, before moving on. It is important to be specific, evaluative and analytical at the stage of compiling and recording the SWOT lists.
4. List Strengths, Weaknesses, Opportunities, Threats in the SWOT Matrix
5. Evaluate listed ideas against objectives

With the lists compiled, sort and group facts and ideas in relation to the objectives. It may be necessary for the SWOT participants to select their five most important items from the list in order to gain a wider view. Clarity of objectives is key to this process, as evaluation and elimination will be necessary to separate the wheat from the chaff.

The SWOT analysis template is normally presented as a grid, comprising four sections, one for each of the SWOT headings: Strengths, Weaknesses, Opportunities, and Threats. The SWOT template below includes sample questions, whose answers are inserted into the relevant section of the SWOT grid. The questions are examples, or discussion points, and obviously can be altered depending on the subject of the SWOT analysis.

Strengths	**Weaknesses**
Advantages of proposition? Capabilities? Competitive advantages? USP's (unique selling points)? Resources, Assets, People? Experience, knowledge, data? Financial reserves, likely returns? Marketing—reach, distribution, awareness? Innovative aspects? Location and geographical? Price, value, quality? Accréditations, qualifications, certifications? Processes, systems, IT, communications? Cultural, attitudinal, behavioural? Management cover, succession?	Disadvantages of proposition? Gaps in capabilities? Lack of competitive strength? Reputation, presence and reach? Financials? Own known vulnerabilities? Timescales deadlines and pressures? Cash flow, start-up cash-drain? Continuity, supply chain robustness? Effects on core activities, distraction? Reliability of data, plan predictability? Morale, commitment, leadership? Accreditations, etc.? Processes and systems, etc.? Management cover, succession?
Opportunities	**Threats**
Market developments? Competitors' vulnerabilities? Industry or lifestyle trends? Technology development and innovation? Global influences? New markets, vertical, horizontal? Niche target markets? Geographical, export, import? New USP's? Tactics—surprise, major contracts, etc.? Business and product development? Information and research? Partnerships, agencies, distribution? Volumes, production, economies? Seasonal, weather, fashion influences?	Political effects? Legislative effects? Environmental effects? IT developments? Competitor intentions—various? Market demand? New technologies, services, ideas? Vital contracts and partners? Sustaining internal capabilities? Obstacles faced? Insurmountable weaknesses? Loss of key staff? Sustainable financial backing? Economy—home, abroad? Seasonality, weather effects?

- Tips for successful SWOT analysis

	Top tips	But remember …
1	Never copy an existing SWOT analysis; it will influence your thinking. Start with a fresh piece of paper every time	*You could use a standard template to help the ideas flow*
2	Set aside enough time to complete it	*You may need to come back to it several times before you are happy*
3	The SWOT analysis itself is NOT the result. It's only a tool to help you analyse your business	*Before you begin any analysis, you should know what you intend to do with the results*
4	A SWOT analysis is not a business school fad. It is a proven technique used throughout the business community	*You need to be comfortable working with it in your business*
5	Keep your SWOT analysis simple, readable, short and sharp	*It needs to make sense to outsiders (e.g. bank managers or investors) so don't use phrases or acronyms that only you understand*

6	Make sure you create an action plan based on your SWOT analysis	*You need to communicate this clearly to everyone involved*
7	A SWOT analysis only gives you insight at a single point in time	*You need to review it—probably quarterly—to see how the situation has changed*
8	Don't over-analyse. Try not to worry if it isn't perfect, just get the analysis done	*If you are going to act on the results, it needs to be accurate in all the important areas*

- SWOT analysis example

Subject of SWOT analysis example: the achievement of a health centre's mission.

The scenario is based on the SWOT analysis, which has been performed by a health centre in order to determine the forces that promoted or hindered the achievement of its mission.

Starting position of the health centre:

– The staff's lack of motivation
– The building was really small
– The facilities was old
– There was a lot of paper work and bureaucracy

Those characteristics resulted in this health center facing up to a lot of problems with the accommodation of the patients. Moreover, the establishment of a new advanced hospital in the city made the situation even worse. Therefore, they decided to perform a SWOT analysis in order to perform the best decision-making for all the problems that they faced.

Step 1: Purpose of conducting SWOT analysis—the achievement of a health center's mission.
Step 2: The gathering of information on Strengths and Weaknesses focused on the internal factors of skills, resources and assets, or lack of them. The gathering information on Opportunities and Threats should focus on the external factors.
Step 3: The manager of the health center encouraged all the members of staff to freely express their opinions about what they felt to be appropriate.
Step 4: SWOT matrix

Strengths: • Willingness of staff to change • Good location of the health centre • Perception of quality services	**Weaknesses**: • Staff lack of motivation • Building was really small • Paper work and bureaucracy • Cultural differences with users
Opportunities: • Support of local government • Highly felt need of users • Internationally funded projects	**Threats**: • Low income of users • Bad roads • Low salaries • Lack of budget • Paradigms of providers • High competition

Step 5: After completing the SWOT matrix, the SWOT participants had a wider view of the situation at the centre, so they were able to propose the alternatives that helped considerably in the operation of the health centre.

The alternatives where:

- Training of the staff in interactive techniques of quality improvement
- Coordination with other providers to cover all user needs
- Remodelling of the facility with local government funds and international help
- Cost recovery of drugs and lab supplies with user fees
- Payment of incentives to staff based on performance
- Review of procedures for decreasing costs and waiting times and increasing perceived quality.

This strategic analysis and planning of the health centre had the below results:

- 27 % increase of patients
- Reduction of waiting times to 15 min
- 20 % increase of staff performance
- Remodelling of the facility

4.5.1.3 The Black Box Method

Two of the most important tools, which can be used to define the innovation needs of a business problem, are the Black Box Method and the System and Process analysis. Black Box is a method of a process in which we have no knowledge of the inner workings of the process being tested. We might know what the input is and what the expected outcome is, but not **how the results are achieved.** The method aims at:

- Either a formal description of the transformation rules linking inputs and outputs
- Or the construction of a model exhibiting a behavior that approximates what is observable from **the outside of the "black box"**

See below the definition of the Black Box method according to Principia Cybernetica:

http://pespmc1.vub.ac.be/ASC/Black_metho.html

The Black Box Approach to Problem Solving is a simple but powerful and significant method of dealing with complex problems. Its main advantage arises from the fact that it makes us differentiate clearly between:

- The preconditions for solutions or success
- The inputs (or resources we need—and/or dispose)
- The desired goals (for instance Design Goals) and
- The processes needed to build a bridge between the inputs and outputs

Having mastered this very simple technique we can:

- Start to define new possibilities, potentials and systems, whereas we may have relatively little information of what is or could be in the box

Using only plain logical thinking we can often:

– See a logical bridge between the input and the output (or present state and goals) and thus realise new possibilities whereas a completely overall consideration of the box would confuse us and make us focus too hard on not-as yet developed processes, which could easily result (if overdone) in feelings of impossibility.

Using the black box method we will realise logical possibilities that may or may not be realisable by existing processes—but we will become far more sensitive to new opportunities and potentials by doing this.

SO: The BB method is in a sense a very effective eye-opener as regards innovation!

Even in fields where we do not understand the transformative processes completely, the only thing we have to understand is that there can be a logical connection between the input and the output.

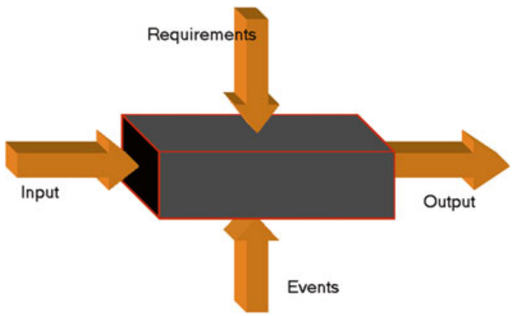
The Black Box method is typically used by:

– Researchers/statistics
– Project management
– Manufacturing
– Change management
– Engineering

In order to perform the black box method black box testing is used. The test cases in a black box test case design are deviated from the requirements or the specifications respectively. The object to be assessed is considered as a black box, i.e. the assessor is not interested in the internal structure and the behavior of the object to be assessed.

Black-Box Testing

The functionality of each module is tested with regards to its specifications (requirements) and its context (events). Only the correct input/output relationship is scrutinised.



Other names for black box testing include: *specifications* testing, *behavioral* testing, *data-driven* testing, *functional* testing, and *input/output-driven* testing. In general, every combination of input and output would require an infinite number of test cases. Consequently, exhaustive black-box testing is usually either impossible or unreasonable. The art of testing is to design a small, manageable set of test cases so as to maximise the chances of detecting a fault whilst minimising the redundancy amongst the other cases.

Equivalence Testing and Boundary Value Analysis

Equivalence testing, combined with boundary value analysis, is a black-box technique of selecting test cases in such a way that new cases are chosen to detect previously undetected faults. An *equivalence class* is a set of test cases such that any one member of the class is representative of any other member of the class.

The principle of the generation of equivalence classes is to group all input data of a program into a finite number of equivalence classes so it can be assumed that with any representative of a class it is possible to detect the same errors as with any other representative of this class.

The definition of test cases via equivalence classes is realised by means of the following steps:

– Analysis of the input data requirements, the output data requirements, and the conditions according to the specifications
– Definition of the equivalence classes by setting up the ranges for input and output data
– Definition of the test cases by means of selecting values for each class

Example Suppose the specifications for a database product state that the product must be able to handle any number of records from 1 through to 16,383. If the product can handle 34 records and 14,870 records, then the chances are good that it will work fine for, say, 8534 records. If the product works correctly for any one test case in the range from 1 to 16,383, then it will probably work for any other test case in the range. The range from 1 to 16,383 constitutes an *equivalence class*. For this product, there are three equivalence classes:

Equivalence class 1: less then one record.
Equivalence class 2: from 1 to 16,383 records.
Equivalence class 3: more than 16,383 records.

Testing the database product then requires that one test class from each equivalence class be selected.

A successful test case is one that detects a previously undetected fault. In order to maximise the chances of finding a new fault, a high-payoff technique is *boundary-value analysis*. Experience has shown that when a test case on or just to one side of a boundary of an equivalence class is selected, the probability of detecting a fault increases. Thus, when testing the database product, the following cases should be selected:

Test case 1:	0 records	Member of equivalence class 1 and adjacent to boundary value
Test case 2	1 record	Boundary value
Test case 3	2 records	Adjacent to boundary value
Test case 4	723 records	Member of equivalence class 2
Test case 5	16,382 records	Adjacent to boundary value
Test case 6	16,383 records	Boundary value
Test case 7	16,384 records	Member of equivalence class 3 and adjacent to boundary value

This example applies to the input specifications; the same technique should be applied to the output specifications. The use of equivalence classes, together with boundary value analysis, is a valuable technique for generating a relatively small set of test data with a high probability of uncovering most faults.

Functional Testing

1. *Objective and Purpose*
   An alternative form of black-box testing is to base the test data on the functionality of the module. It is the purpose of the *functional testing* to identify test cases that can be used to prove that the corresponding function is available and can be executed as well. In this connection the test case concentrates on the normal behavior and the exceptional behavior of the object to be assessed.
2. *Operational Sequence*
   Based on the defined requirements, the functions to be tested must be identified. Then the test cases for the identified functions can be defined.
3. *Recommendation*
   With the help of a test case matrix it is possible to check if functions are covered by several test cases. In order to improve the efficiency of the tests, redundant test cases ought to be deleted.

4.5.1.4 System and Process Analysis

System and process analysis are the other tools available to define the innovation needs of a business problem. System analysis is a method that helps the businesses pinpoint where changes need to be made in the system, so that limited resources can be focused on those areas. Process analysis, determines what steps within a task are required to create a measurable output. Process analysis provides an opportunity to identify problem points in a workflow, understand the factors that affect performance, and question why certain actions are taken.

The process analysis helps to trace the source of variation and is, therefore, a useful method to identify root causes of a problem. Process analysis is typically performed using an activity—level process flowchart and by asking a series of questions to explore or justify excessive cycle time, approvals, improper sequence, delays, and other process deficiencies. System analysis is an explicit formal inquiry carried out to help the decision—makers identify a better course of action and make a better decision than they might otherwise have made.

The typical use of systems analysis is to guide decisions on issues such as national or corporate plans and programs, resource use and protection policies, research and development in technology, regional and urban development, educational systems, and other social services. System analysis is performed using a system analysis diagram which is a tool that systematically illustrates the process flow from the supply side (or input of resources), to the transformation of throughput of product or services, to the output side for final quality verification and release to the customer. This diagram helps to identify interrelationships of major tasks, work phases, and opportunities for improvements through the use of feedback loops at the organization and the customer levels.

- Typical application of the process analysis technique
  - To review, analyze, and improve an existing process
  - To identify process improvement opportunities
  - To fine-tune processes in an organizational change project
- Typical application of the system analysis diagram
  - To overview the sequential production or service processes, lines of communication, and quality feedback loops
  - To reach a common understanding using the systems approach
  - To clarify roles, task responsibilities, and system requirements
- The system and process analysis are typically used by:
  - Research/statistics
  - Creativity/innovation
  - Engineering
  - Project management
  - Manufacturing
  - Marketing/sales
  - Administration/documentation
  - Servicing/support
  - Customer quality metrics
  - Change management

Problem Solving Phase

- The problem solving phase encompasses the below steps:
  1. Select and define problem or opportunity
  2. Identify and analyze causes or potential change

3. Develop and plan possible solutions or change
4. Implement and evaluate solution or change
5. Measure and resort solution or change results
6. Recognize and reward team efforts

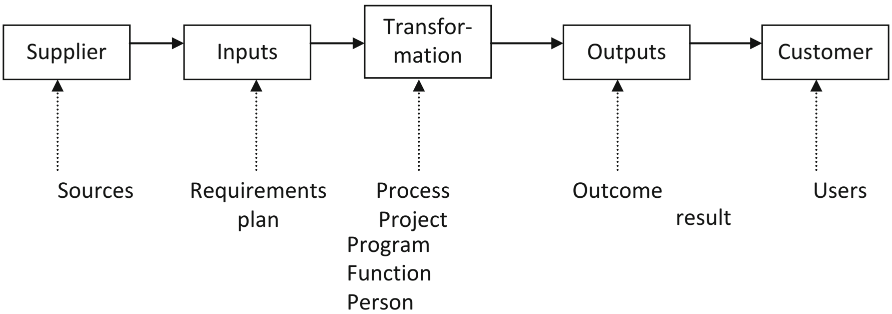
- Notes and key point for process analysis

  – To construct a process flow, several tools are available:
  – Process flowchart
  – Symbolic flowchart
  – Process mapping
  – Cycle time flowchart
  – Activity analysis

Using any one of these will allow a process improvement team to achieve established team goals.

– The given list of ten process analysis questions (see in the example) is optional. The number and content of questions may change in accordance with the complexity of any given process.

- Notes and key point for system analysis
  Below, in the boxes, we are presenting the major steps of the diagram and outside them we give some other headings or designations that can be submitted for the generic system analysis diagram headings:



- Step-by-step procedure of the process analysis by using the tool of symbolic flowchart

  1. As a prerequisite activity, a facilitated team develops a process flowchart at the activity-level for the process selected. In order to create a process flowchart the below steps need to be followed:

     - The team facilitator assembles a team whose participants thoroughly understand all aspects of the process.
     - The overall scope of the process flowchart is determined. A starting and stopping point is identified.

  - Next, participants identify all major process steps and the sequence of completion. Symbols and connecting flow lines are used to show process activity and sequence.
  - The facilitator uses a whiteboard to start drawing the flowchart. The participants assist the facilitator in drawing and connecting all process steps in the correct sequence.
  - Finally, the symbolic flowchart is verified for accuracy and dated.

2. The facilitator displays a set of standard process analysis questions. The team reviews the questions, adds, deletes, or revises questions to fully cover the process to be analyzed.

3. Using the finalized list of questions, the team discusses all activities in the process and provides responses to the questions.

4. Finally, the facilitator asks participants to recheck all responses, makes final revisions, and dates the list.

5. The information serves as an input to a variance process, a logical next step for the team.

- Step-by-step procedure of the system analysis

  1. The team develops a system analysis diagram consisting of five blocks, interconnected, and with internal and external feedback loops added.

  2. The blocks are designated to contain processing or requirements information.

  3. Using the completed System Analysis Diagram as a guide, the team explores potential problem areas and process improvement opportunities.

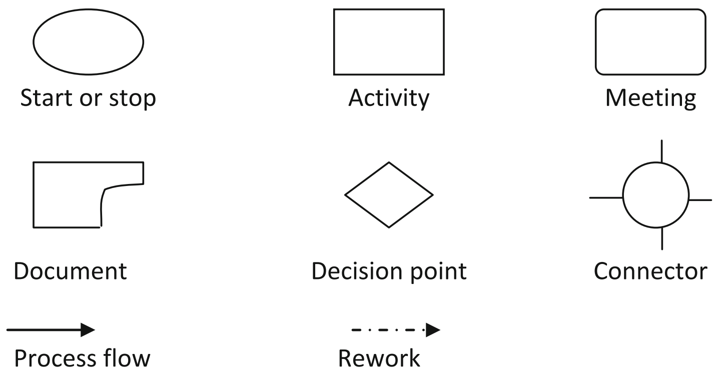
- Example of process analysis application
  In the example below we will present the method of process analysis in the facilitation of the process of a student's workshop that takes place in a university. The first step was the assembly of a team that knew everything about the process of the workshop. The second step was the construction of the symbolic flowchart that would portray the process (see the flowchart below). After the flowchart the

facilitators displayed a set of questions that fully covered the process of the workshop. In the table below you can see the questions and the responses to them.

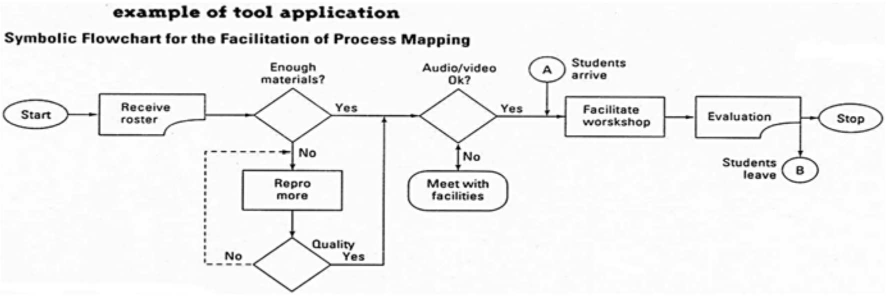
Typical Process Analysis Questions
Are the connected tasks performed in a logical sequence? *No, materials check should have been done earlier*
Does the defined process show more than two loopbacks? *Yes*
Do individual tasks have relatively long cycle times? *No*
Does every task add value to the process? *No, audio-visual check does not add value to this process*
Are there redundant tasks? *No*
Does the process reflect excessive delays? *No*
Does the process contain sources of key variance? *No*
Are there more than two approval requirements? *No*
Can the process flow be changed to reduce tasks? *Yes, remove A/V checks*
Does this process have a high level of consistency? *Yes*

From the above responses the facilitators decided that the materials check should be done earlier in order to avoid delays. They noticed that the rosters of the students were most of the times sent very late, so there wasn't enough time to prepare the materials needed to be given to the students who attended the workshop. Moreover, they observed that they could change the process flow, by removing A/V checks in order to reduce the tasks.

Standard symbols:

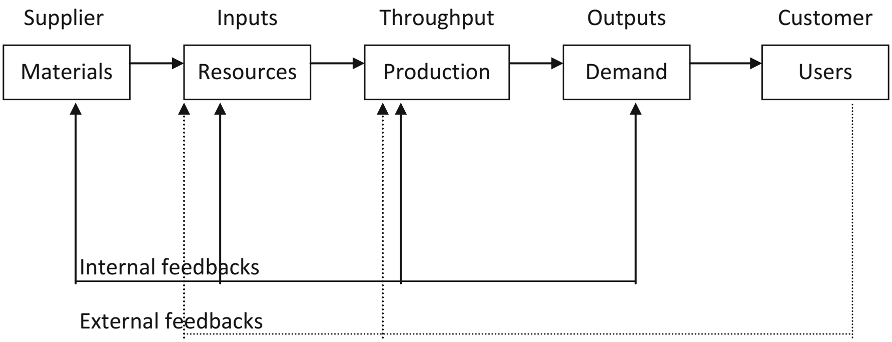


A flowchart is drawn from top to bottom and reflects left to right directionality. Avoid crossing flow lines within the chart; use connectors within and from page to page.



In the below addresses you can find examples of some other process flowcharts.

- Example of system analysis application



The above diagram represents the production system of a factory. By constructing this system with its major five blocks and by finding the feedbacks that affect its function the team of the factory can explore potential problem areas, such as:

- Bad quality of resources have a negative impact on the demand
- A market analysis is very important to decide what resources should be used to answer the good quality of the products that the customers want
- Not taking into consideration the internal feedback of demand to production will result either in the production of more products than are demanded, by increasing the storage cost, or in the production of less products, by increasing the deficiency cost.
- …

References

Arthur WB (1991) Increasing returns and the new world of business. Harv Bus Rev 100–109

Brusoni S, Prencipe A, Pavitt K (2001) Knowledge specialization, organizational coupling, and the boundaries of the firm: why do firms know more than they make. Admin Sci Q 46:597–621

Cooke H-K, Braczyk P, Heidenreich M (eds) (1998) Regional innovation systems. UCL Press, London

Cooper RG, Edgett SJ, Kleinschmidt EJ (2004) Benchmarking best NPD practices – II. Res Technol Manag 47(3):50–59

Criscuolo C, Haskel J, Slaughter M (2005) Why are some firms more innovative? Knowledge inputs, knowledge stocks and the role of global engagement. NBER Working Paper No. 11479

Czarnitzki D, Kraft K (2004) Firm leadership and innovative performance: evidence from seven EU countries. Small Bus Econ 22(5):325–332

Dosi G (1988) Sources, procedures and microeconomic effects of innovation. J Econ Lit 26:1120–1171

Fagerberg J (2004) The oxford handbook of innovation. Oxford University Press, Oxford/New York

Freeman C, Soete L (1997) The economics of industrial innovation, 3rd edn. Pinter, London

Frenken K (2000) Fitness landscapes, heuristics and technological paradigms: a critique on random search models in evolutionary economics. In: Dubois D (ed) Computing anticipatory systems. American Institute of Physics, Woodbury

Hobday M (1998) Product complexity, innovation and industrial organisation. Res Policy 26(6):689–710.

Mansfield E, Rapport AR, Wagner S, Beardsley G (1977) Social and private rates of return from industrial innovations. Q J Econ 91(2):221–240

Mowery D (1995) The practice of technology In: Stoneman P (ed) Handbook of the economics of innovation and technological change. Basil Blackwell, Oxford, pp 513–557

Nelson RR (1995) Co-evolution of industry structure, technology and supporting institutions, and the making of comparative advantage. Int J Bus Econ 2:171–184

Nelson RR (2000) Technology, institutions, and evolutionary economic theory, mimeo

Nelson RR, Winter SG (1982) An evolutionary theory of economic change. Belknap Press of Harvard University Press, Cambridge

Quinn JB (1992) The intelligent enterprise: a new paradigm. The Free Press, New York

Roberts EB (ed) (1987) Stimulating technological innovation. Oxford University Press, London

Romer P (1990) Endogenous technological change. J Polit Econ 98:S71–S102

Rosenberg N (1976) Perspectives on technology. Cambridge University Press, Cambridge

Saxenian AL (1994) Regional advantage: culture and competition in silicon valley and route 128. Harvard University Press, Cambridge

Utterback JM, Suarez FF (1994) Innovation, competition, and industry structure. Res Policy 22(1):1–21

Verspagen B (1993) 'Endogene Technologische Innovatie in Neo-Klassieke Groeitheorie. Een Overzicht' (Endogenous innovation in neo-classical growth theory. A survey, in Dutch), Tijdschrift voor Politieke Economie, 16 (2), pp. 39–55

Chapter 5
Innovation Systems

5.1 What Is a System?

Systems engineers define the term system as a set of interrelated components working towards a common goal. Systems consist of **elements, relationships and attributes.**

Components are the operating parts of a system. They can be of various types: (1) **natural persons or organizations** such as individuals, companies, banks, universities, research centers, and policy making and implementation agencies (2) **natural objects or technological artifacts** such as turbine generators, transformers and transmission lines in electric power systems, and biomedical devices, diagnostic techniques and medications within the biomedical/biotechnology system, and (3) **institutions** in the form of **legislative structures** such as regulatory laws, and social rules and traditions.

Relationships are the connections between components: The properties and behavior of each component influences the properties and behavior of the set as a whole. At the same time, each component depends on the properties and behavior of at least one other component in the set. Therefore, because of this interdependence, components cannot be divided into independent subsets. The system is more than the sum of its parts (Blanchard and Fabrycky 1990). Moreover, if one component is removed from a system, or its characteristics are changed, the other objects in the system will change their characteristics accordingly (Hughes 1987), and the relationships among them may also be changed, provided that the system is **robust**. A **non-robust** system would simply collapse if just one essential component were removed. Consequently, a function, (for example venture capital financing) conducted by a particular set of actors, in specific forms may be performed by a different set of actors, using different framework agreements in a similar system, at a different time or in a different location.

E.G. Carayannis et al., *Innovation and Entrepreneurship*, Innovation, Technology, and Knowledge Management, DOI 10.1007/978-3-319-11242-8_5

Relationships also include market links as well as non-market connections. **Feedback** (interaction) is what makes systems dynamic; without such feedback, the system is static. To state this in a different manner, the greater the interaction among the components of a system, the more dynamic this system is.

One of the major types of relationships in innovation systems includes technology transfer or acquisition, either through markets or through non-commercial interactions. As a matter of fact, it could be argued that technology transfer is the key activity in an innovation system. In cases where certain technologies are transferred unintentionally or accidentally, the term ‘technology spillovers’ may be appropriate. In other cases, technology transfer is clearly intentional for both technology supplier and technology recipient. In any case, however, the transfer cannot be successful if the receiver does not make considerable investment in time and effort, in order to achieve the capacity needed for the successful integration of the new technology. An outcome of the interaction (feedback) among actors is that the capabilities of the system components evolve over time, exhibiting change and growth, and thus changing the structure of the system.

Attributes are the properties of the components and the relationships between them: They characterize the system. “Because the components of a technological system interact, their characteristics derive from the system”, (Hughes 1987). Strictly speaking, the characteristic features which are critical for the understanding of the system are associated with the function or purpose served by the system, as well as with the dimensions in which it is analyzed. The function of an innovation system is to generate, diffuse, and utilize technology. Consequently, the main features of the system are the capabilities (which together represent the economic capacity) of the actors to generate, disseminate, and use technologies (natural artifacts as well as technical know-how) that have economic value.

5.2 The Concept of Innovation Systems

There may be various definitions of innovation systems, but they all have common features.

According to Edquist (1997, p. 14) an innovation system is defined as: “***all important economic, social, political, organizational, and other factors that influence the development, diffusion, and use of innovations”.***

Gregersen and Johnson (1998, p. 105) agree that it is likely to “regard a system of innovation as a system of actor (firms, organizations and government agencies) who interact which each other in ways which influence the innovation performance of the economy as a whole”.

Edquist (2001) presents a similar approach to innovation systems. He considers that the components of an innovation system are organizations (i.e., formal structures that have an explicit purpose and have been consciously created) and institutions (sets of common habits, routines, established practices, rules or laws that regulate the interactions among individuals, groups, and organizations).

Generally, there is a complicated bidirectional relationship between organizations and institutions that influences both innovation processes and performance, and changes innovation systems (Edquist and Johnson 1997).

According to the above definitions we can conclude that Innovation Systems are regarded as being open, dynamic, and social (Lundvall 1992a, b), implying that innovations are produced as the result of social interaction among economic actors (Olazarán and Gómez Uranga 2000). This means that they are systems that interact with their surrounding environment.

The theory of innovation systems has emerged from studies of technological systems at the micro level, from studies on innovation systems and innovation through interactive learning at the meso-and macro-level (Freeman 1987; Lundvall 1992a, b; Nelson 1993; Edquist 1997) and through many EU and OECD publications (OECD 1999), thus promoting the NIS concept. An important and comprehensive review of this literature is available in a recent publication by Miettinen (2002). Despite the fact that for the last 10 years everybody has been talking about 'innovation systems', the term 'system' is often used in a heuristic tone the literature. For Lundvall (1992a, b), the term 'system' simply explains interactivity as opposed to the linear knowledge transfer. Schienstock and Hämäläinen (2001) identify 'innovation systems' referring to the process of knowledge management, namely the creation, dissemination, and utilization of new knowledge. In other words, reference is made to the path followed by knowledge (see also Carayannis and Campbell 2006).

Bauwhof has argued that Hughes and Latour, by taking into account the process of invention–innovation, identified a method of communication (i.e. interactive learning) where different forms of knowledge were integrated through transformation processes, promoting new combinations of knowledge. At this early stage of inventions, the product (innovation) was an abstract concept, which was then redefined and transformed by actors who were looking for a way into the market. The 'invention system' was 'open' as different options were being tested. In contrast to the phase of the invention, the mature product appears in a technological model with a fixed set of different forms of knowledge, in a particular structure. In this case, the innovation system's internal complexity may be greater than the complexity during the invention stages, but the 'weak-tie' prospects are not the same as before. In the learning economy this occurs during the formation of a new species. In nature, a part of the population that has carved a different path sooner or later will probably realize that they can no longer mate with members of the population from which they have originated. This very weakness marks the birth of a new kind.

According to Carayannis and Campbell (2009), in order to perceive the importance of systems (and systems theory) one should clearly demonstrate that a system model can coexist with various other concepts, such as innovation networks and knowledge clusters. Networks focus on interaction, connectivity, and mutual complementarity and reinforcement. Networks, for instance, can be seen as the internal formation that unifies and determines a cluster.

Innovation systems approaches are built on institutional approaches, which are based on the observation that markets do not exist or do not work outside the rules and institutions that establish them. Countries, being characterized by different institutional arrangements, could be distinguished according to how they contribute to the development of technologies and the role they play in the entire system. The different institutional arrangements, which characterize countries, could be distinguished according to how they contribute to the development of technologies and the role they play in the entire system (Cimoli 1998). The institutional structure of economy creates a distinct pattern of constraints and incentives determining the interest of the actors, while shaping and channeling their behaviors at the same time. The innovation systems approach is certainly not an official theory. However, its development has been influenced by different theories of innovation, such as the theories of dialogic learning and the evolutionary theories (Edquist 1997). Concerning innovation systems Carlsson and Stankiewicz (1995) and Galli and Teubal (1997) have stated:

The goal of an innovation system may be said to be the creation, diffusion and exploitation of innovation.

5.2.1 Types of Innovation Systems

To understand the nature of innovation systems, it is important to take into consideration the various types of innovation systems appearing in the relevant literature. The most thoroughly studied form of innovation systems is the **national innovation system** (Freeman, Lundvall, and Nelson). In this approach, the state is treated as the primary unit of analysis and national differences, in institutional structures as well as in the structure of production and consumption, are factors explaining why some countries succeed in creating economic growth through innovation while others do not (Freeman 1987; Lundvall 1992a, b; Nelson 1993). This approach is now being widely adopted by bodies of transnational governance (OECD, EU, UN etc.) aiming to analyze and build political initiatives.

Others scholars focus on parts of the National Innovation System such as the regional innovation systems (Saxenian 1994, Cooke et al. Braczyk et al. De la Mothe and Paquet) and the sectoral innovation systems (Malerba 2002). Local cultures and sectoral characteristics contribute to differences in the structure, dynamics, and performance of innovation systems. Finally, some authors concentrate on the so called technological systems, which are innovation systems focusing on technology (Carlsson et al. 1992; Carlsson and Stankiewicz 1995; Jacobsson and Johnson 2000; Carlsson 2002). The aforementioned supports the notion that there are many innovation systems in a country that are focused on technology and that any technological system is unique, in its ability to develop and diffuse the new technology (Jacobsson and Johnson 2000). Thus, competition between emerging and established technologies embedded in innovation systems is understood better by using this concept. A technological system is defined by (Carlsson and Stankiewicz 1995) as:

'…a network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure or set of infrastructures and involved in the generation, diffu-

sion, and utilization of technology. Technological systems are defined in terms of knowledge and competence flows rather than flows of ordinary goods and services. They consist of knowledge and competence networks. (See also, Carayannis 2003, 2005, 2007)'

5.3 Basic Principles of Innovation Systems

Innovation is not just an isolated act of learning by a company or another entity; it is rather integrated into a larger system that both triggers innovation and allows innovation processes to run smoothly. Therefore, an innovation system includes all major actors and institutions that contribute to the creation, development, diffusion, and use of innovations, as well as interconnections and interactions among all these actors and institutions (Fig. 5.1).

An innovation system can be analyzed at **national, regional, sectoral** as well as at **international** level. The analysis of actors and institutions of each level is complementary to the analysis of innovation actors at the other levels.

Lundvall notes that innovative systems are both social and dynamic (Lundvall 2000). They are social in the sense that they are "based on an institutional context… constituted by laws, social rules, cultural norms, routines, habits, technical standards, etc." (Lundvall 2000). They are dynamic because of "financial flows between government and private organizations…human flows between universities, firms, and government laboratories, regulation flows emanating from government agencies towards innovation organizations, and knowledge flows (spillovers) among these institutions." (Niosi 2002), (see also, Carayannis 2003)

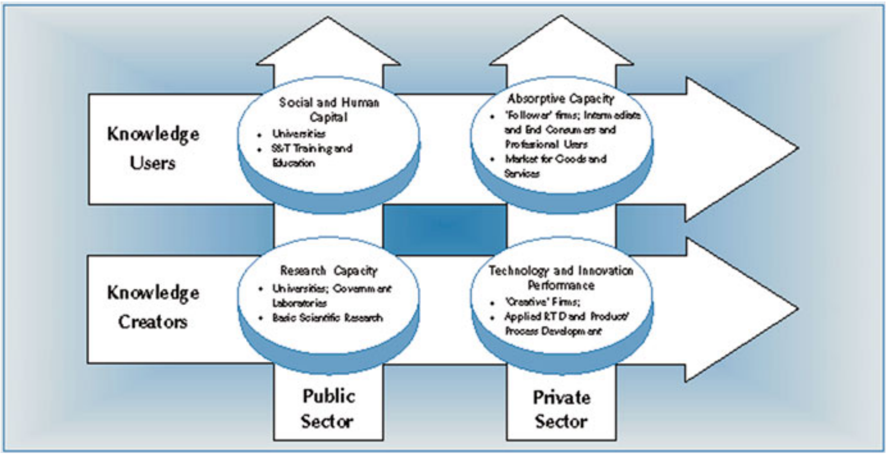


Fig. 5.1 Actors and activities in a system of science, technology and innovation (Claire Nauwelaers)

5.4 Innovation Systems and Simulation Systems

System dynamics is based on the theory of non-linear dynamics and feedback control developed in mathematics, physics, and applied mechanics. Applying these tools to human behavior as well as natural and artificial systems, system dynamics draws attention to cognitive and social psychology, economics and other social systems (Forrester 1961).

5.5 System Dynamics as a Concept, Tool, and Process

Although there are considerable differences between the above definitions, they all converge in that:

> *'System Dynamics addresses the creation of models used to describe, to a satisfactory approximation, the function of real systems providing the ability to study dynamic behavior.'*

5.5.1 Building a System Dynamics Model

5.5.1.1 System Dynamics Models

The System Dynamics methodological approach presupposes the formation of dynamic models**.** Models are simplified representations of the real system and, in general, can be classified in various ways. In the relevant literature, models are classified in three categories: natural, analogical, and mathematical. In system dynamics we use the mathematical models, as physical models often have high manufacturing costs and analogical models do not provide a satisfactory representation of the system. In mathematical model, we use mathematical symbols and equations to represent the relations between the elements of the system we wish to simulate. When using mathematical models, repetitive calculations are performed in the context of various equations, in fixed time steps. The completion of these calculations is impossible without using a computer and, therefore, special simulation programming languages have been created to facilitate the process.

According to Georgiadis, in order to comprehend the structure of mathematical models, it is considered appropriate to present concisely all the views on the classification of mathematical models, encountered in the relevant literature. Therefore, there are:

- **Dynamic or Static mathematical models, depending on whether model characteristics change or not, as a function of time. A model is classified as dynamic, when at least one of its variables is a function of time**
- **Stochastic or Deterministic, depending on whether we describe model characteristics using distribution functions or not. A model is characterized as stochastic when at least one variable is stochastic**

- **Continuous or Discrete, depending on the way a time variable changes its value**
- **Analytical Solution or Simulation, depending on the way the model is solved, and**
- **Linear or nonlinear, depending on the type of mathematical relationships they include. A model is classified as nonlinear when at least the mathematical relationship of one variable is nonlinear.**

The models we create with system dynamics are dynamic, stochastic or deterministic, continuous, simulation and, finally, linear or nonlinear (Georgiadis 2006) (see Fig. 5.2).

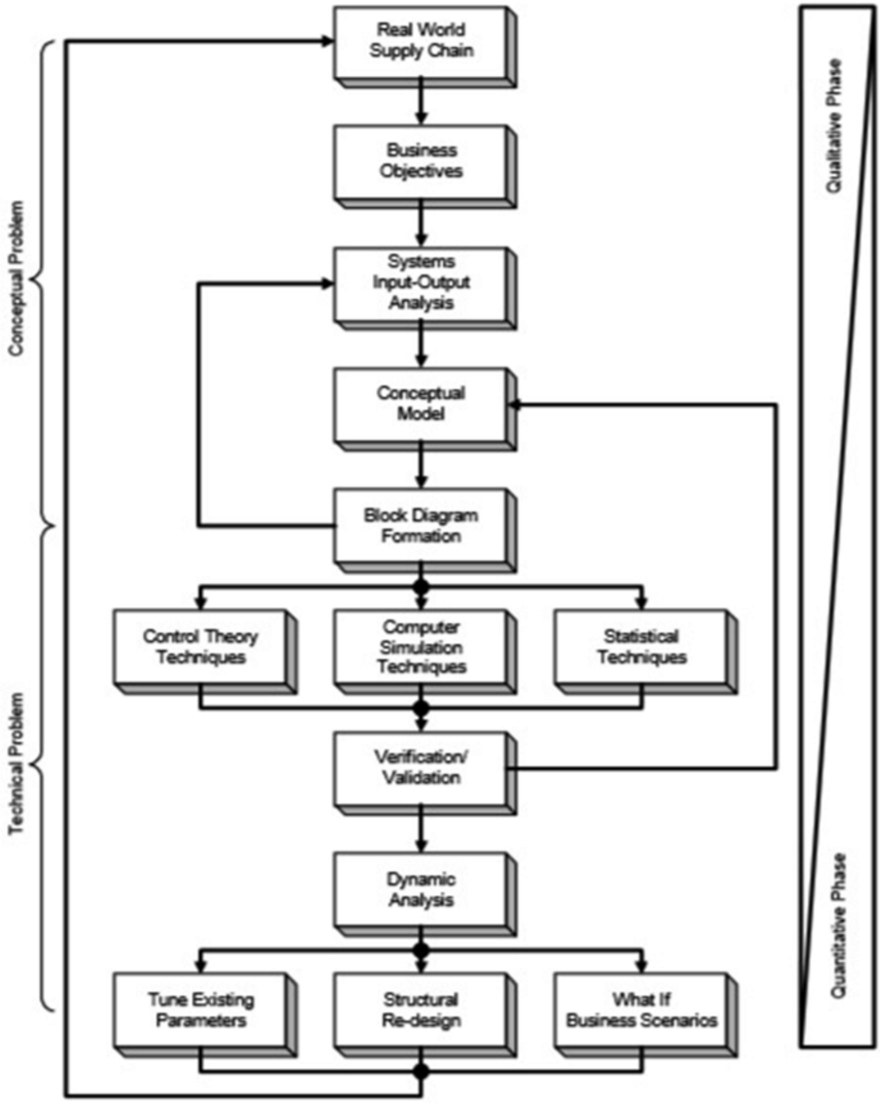


Fig. 5.2 The structure of the approach with system dynamics (Towill 1995)

5.6 Innovation Systems: Sectoral, Regional, National—Case Studies

5.6.1 Sectoral Innovation Systems

In the analysis of sectoral innovation systems, knowledge interactions between companies and organizations are mainly due to technological interrelationships. These systems emphasize the economic dynamics of technological development and the importance of technology flow within industry. Carlsson and Stankiewicz (1991a, b) define sectoral systems as a "… network of agents interacting in a specific technology area under a particular institutional infrastructure and involved in the generation, diffusion and utilization of technology" (Carayannis 1998a, b; Carayannis et al. 2003; Carayannis and Sipp 2006; Carayannis and Alexander 2006; Carayannis and Campbell 2005, 2009). They state that the basic elements of a sectoral system are:

- **Economic competence**: the total ability of a company for the creation and exploitation of business opportunities
- **Business clusters and innovation networks**: a successful innovation seems to require the interaction of agents with different specialties. Furthermore, the nature of innovation is uncertain and complex; consequently networks provide other alternative solutions for managing innovation
- **Institutional infrastructure**: a set of institutional arrangements that directly or indirectly support, stimulate, and regulate the processes of innovation and technology diffusion, and
- **Development blocks**: the development block is dynamic in nature, incorporating characteristics of disproportion. It definitely creates tension within the technological system varying in strength and composition over time and generates development potential for the system.

Breschi and Malerba (1997) define the **sectoral innovation systems** (SIS) as "the specific clusters of the firms, technologies, and industries involved in the generation and diffusion of new technologies and in the knowledge flows that take place amongst them". The cross-industry relationship is important in the analysis of SIS. It consists of one or more discrete elements of industry that are closely associated with each other. The interdependence of industries mainly comes from increasing returns provided by the continuous accumulation of knowledge over time and the interdependence between technologies and industries. An SIS is, thus, a system composed mainly of the actors in a particular area and the interactions between them. Moreover, the majority of the functions of innovation systems are fulfilled by actors in the field.

The SIS approach examines issues at the company level, intercompany issues as well as issues raised in the context of institutional relationships and focuses on the differences between the types of sectoral innovation systems. The main features of this approach are the differences and the importance of the knowledge base and the learning process, the role of non-corporate bodies and institutions, and the co-evolutionary process of change in the sector (Malerba 2004). The agents in SIS are individuals and organizations. These organizations can be businesses and non-corporate organizations, such as universities, government agencies, etc., and other individuals or organizations, such as consumers, research and development departments or industry associations. These **innovation agents** are characterized by a specific learning process, competence, structures, and behavior (Breschi and Malerba 1997; Carayannis et al. 2008; Carayannis and Formica 2008). The SIS approach, according to Breschi and Malerba (1997), distinguishes five major types: SIS in traditional sectors, mechanical industries, automotive industries, server and software industry. The SIS in traditional or 'mature' sectors often supports process innovations more than product innovations. More specifically, opportunities for importing innovations that lower production costs are being followed.

As far as the interrelation among industries is concerned, Pavitt (1984) concludes that there is a strong interdependent relationship among certain industry taxonomies that he studied. This signifies that innovation in one industry can provide the inputs into production processes in other industries. Pavitt (1984) further notes that there is a strong relationship both between 'specialized equipment suppliers' and 'science-based companies' and between 'scale-intensive firms' and 'specialized equipment suppliers'. Well-planned infrastructure and well-organized networks are not enough to build development blocks. Furthermore, competent users and suppliers as well as entrepreneurs, who develop the ability to identify, expand, and exploit business opportunities, are critical in order to transform an industrial network into a development matrix/block.

The **sectoral innovation systems approach** provides an analytical framework in order for us to recognize the performance of the system, with regard to how well it supports innovation in a particular sector (Malerba 2004).

5.6.1.1 Sectoral Specificity

The SIS approach contributes the critical idea that it is dangerous to regard all technological or sectoral systems as homogeneous. Moreover, this approach considers that the SIS approach must be based on a clear understanding of the nature of technology (for instance, tacit or codified) and the relationship between science and technology. Archibugi and Michie (1997) argue that sectors and technologies play a role and do have their own dynamics. In addition, differences of technical change among industrial sectors vary in relation to sources of technology, involvement of user needs, and means of appropriate benefit.

Pavitt (1984) presents an industrial taxonomy in the industrial sector. He identifies four main industries, namely: (a) supplier-dominated firms, such as agriculture and housing, (b) scale-intensive firms, such as bulk material and assembly, (c) specialized suppliers firms, such as machinery and instruments, and (d) science-based firms, such as electronic companies and chemical companies. Breschi and Malerba (1997) also explore the concept of 'technological regime': technological opportunities, suitability of scientific basis and knowledge accumulation for the analysis of the specificity of the sector. Studies on SIS have shown that some industries are characterized by various companies located in specific geographical areas, in which they cooperate in innovation processes but compete with other regions within countries. In other industries, some large companies compete internationally but collaborate extensively at the local level with some specialized producers. The SIS approach suggests that different industries may have different competitive, interactive, and organizational boundaries extending beyond national borders. SIS consider not only country-specific factors but also incorporate the impact of the globalization of technology. In other words, the SIS approach examines the cross-industry, interdependent relationship not only at a local and national level but also in the broader global systems.

5.6.2 Regional Innovation Systems

Towards the end of the nineties, studies on regional innovation systems (RIS) appeared simultaneously with research in fields such as industrial economics, regional economics, and economic geography. The terms used, explicitly or implicitly, to explain RIS vary among these fields but the concept of RIS can be traced back to Marshall's (1932) industrial district, the economics spaces by Perroux (1950), Dahmen's (1988) development blocks, Camagni's (1991) innovative milieu, and regional innovation systems (Cooke et al. 1997; De la Mothe et al. 1996). The emergence of RIS is a response to the perceived importance of the local supply of managerial and technical skills, accumulated tacit knowledge and knowledge spillover benefits. Although Saxenian (1991) does not specifically use the notion of RIS, she implicitly uses the term RIS expressing the existing concept of regional systems of innovation. The aim is to show how the dynamics of production networks or intercompany partnerships have helped prosperous regional economies, such as the case of Silicon Valley (Silicon Valley), California. Her study shows how to allocate the costs and risks of developing new technologies and how to encourage reciprocal innovation, among the companies involved. Through inter-company collaboration, technology transfer is remarkable in forms of informal information exchange, human resource development and mobility, and networking within the region. A new institutional innovation, represented by the intercompany network, has produced a successful and dynamic relationship with technological innovation.

Camagni (1991) defines an innovative environment as the whole set or the complex network of mainly informal social relationships, on a bounded geographical area. These relationships often determine a particular external image as well as a specific internal representation and sense of belonging, which enhance the local innovative capability through a synergetic and collective learning process. There are two important elements in the definition: (a) the importance of informal relationships in a connected innovative network and (b) the collective learning process boosting local capacity for innovation.

Cooke et al. (1997) instead of a clear definition of RIS, use three basic institutional forms:

(a) Financial capacity
(b) Institutional learning, and
(c) Productive culture.

The above institutional forms facilitate systemic innovation at the regional level. RIS are closely related to the exchange of tacit knowledge and their boundaries depend on the range of interdependence. Consequently, the size and boundaries of RIS are unclear. The RIS approach emphasizes that a successful regional innovation system needs to develop a collective identity. The regional identity acts as a critical vehicle for social capital and regional innovation capacity. This would be difficult to achieve at a distance, thus making regional clusters or agglomeration such a valuable feature of competitive advantage based on innovation.

The approaches of regional innovation systems are based on a territorial dimension and examine the innovation process at regional level. Similar to the SIS approach, even though without an explicit focus on the level of the company, most of the contributions to the nature of innovation in the RIS context refer to an innovative policy, which is based on technological change, organizational learning, and path dependence. It is expressly recognized that learning and technological change are characterized by regional peculiarities. They are entrenched in the economic structure and the cultural heritage including strong elements of path dependency (Carlson and Jacobson 1997). RIS are therefore mainly characterized by entities located in a specific region, rather than a specific sector, and by the interactions between them. Moreover, the majority of the innovation system functions are fulfilled by regional actors.

5.6.2.1 The Importance of Proximity

Regional innovation systems also emphasize the fact that geographical and cultural proximity to advanced users, and a network of institutionalized relations are important sources of innovation. Regions evolve along different paths through the combination of political, cultural, and economic forces. Network systems reflect their distinctive national and regional institutions, local histories, and social and productive interactions among the various regional development projects. Saxenian (1991) compares two distinct industrial systems, one in Silicon Valley, California and another along Route 128 in Boston, trying to explain why the former surpassed the latter in the 90s. In Silicon Valley, the industrial structure was dominated by many small companies. In contrast, some large companies dominated Route 128. Her research found that the innovative capacity of regions can be affected by industrial structure, intercompany communication, and the organizational behavior of companies.

Cooke (1997) and his colleagues provide some cultural features critical for successful RIS. These are:

(a) **A culture of collaboration**
(b) **An associative culture**

(c) **The ability and experience to achieve institutional change**
(d) **Coordination and public/private consensus**
(e) **A productive culture with sub-elements of labor relations, cooperation at work, corporate social responsibility, productive specialization and**
(f) **Existing interface mechanisms found in scientific, technological, productive and economic sectors.**

5.6.3 National Innovation Systems

The origin of the NIS concept is often associated with the work of Friedrich List (1841), a German economist and economic politician. There are two questions that need further study. The first question is: why do some economists now interpret the economic thought of List as a forerunner of the systemic nature of economic processes? And the second: is it justified to connect List's work with the NIS concept?

Starting from the second question, Freeman (1995) explains the reasons why we can associate List's work with the NIS concept: "not only did List analyze many features of the national innovation system which are at the heart of contemporary studies …he also puts great emphasis on the role of the state in coordinating and carrying through long-term policies for industry and the economy".[1] Moreover, Elam (1997, p. 158) equally considers List as an "inspirational figure for the research of national innovation systems".[2]

Indeed, List examines the concept of national system in order to include the relations between government and industry for the promotion of economic development. More specifically, he focuses on the important role of government in order to create the institutional framework for innovation and hence economic growth. For him, framework conditions include the existence of a basic education system and the provision of basic public goods, such as the development of physical infrastructure (see for example, Cantner 2000, pp. 78–79). In particular, this perception of the importance of the linkages between the educational system (mainly the existence of conditions for human resource development of the national labor force), the economic policy and success in business activity[3] is a key piece of List's work.

Taking the above into consideration, regarding the first question it is obvious that we can connect List's systemic thinking with the systemic approach to innovative activity. Nevertheless, it would be misleading to focus on more similarities between

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[1] Other scholars, e.g. Cantner (2000) or Niosi et al. (1993), also make references to List in order to clarify the NIS concept.

[2] An analytical and critical examination of List's work and its relation to NIS research can be found in Elam (1997).

[3] See the original quote in Hankel (1996).

the two approaches because we take into account that List did not aim to study different models of innovation among nations. On the contrary, the aim was to highlight the need of basic and extended public liabilities in an economy characterized by a low tech base and a weak financial system.

Starting from the idea of the national production system we proceed with the introduction of the concept of national innovation system, which made its appearance in the late '80s with the studies of Nelson, Freeman, Lundvall and others. Although it is quite difficult to give an accurate answer about the exact time the concept appeared, it is safe to say that the term 'national innovation system' was marked by the research activity of Chris Freeman (1987). In this study concerning the organization of national innovation processes in Japan, it seems that the interactions between political objectives and measures, industrial transformations and social changes describe a national innovation system par excellence. Obviously, one of the main objectives behind Freeman's in-depth study of the Japanese NIS was to explain the technological leadership of Japan at that time. To do this he identified the basic elements of Japanese NIS and refers to the most important, partly political, institutional and organizational changes in the country until the late nineteenth century (Balzat 2006).

A theoretical approach to the NIS concept was made by Andersen and Lundvall (1988). In essence, special emphasis was given on the types and the importance of interactions, mainly between users and producers, which lead the learning and innovative processes to success in a national innovation system. Given that these interactions are essential for the innovativeness and the outcome of a production system, the system can be studied as a learning and research system as well. Moreover, Andersen and Lundvall (1988) report that the national level pushes these relations through various mechanisms[4] and may thus be a logical analytical framework for user–producer interaction. In the heart of Gregersen's study (1988) there is a detailed discussion of the policies open to a national government in order to stimulate knowledge, research and innovation.

In 1988, the idea of the systemic approach to NIS was also considered by Dosi et al. (1988).[5] While Bengt-Ake Lundvall (1988) focuses on a theoretical report on the feedback between users and producers in innovative procedures, Freeman (1988) summarizes the initial findings from the Japanese NIS and emphasizes the important role of the Ministry of International Trade and Industry in steering and empowering national research activities and technical progress. In Nelson (1988), several related issues are listed focusing on specific organizational and institutional structures that occur in an NIS in capitalist countries, mainly the US. Finally,

[4] More specifically, Andersen and Lundvall claim that "At national level we can find the most efficient mechanism in the regulation, a closed market and a possibly closed capital market. Moreover, the producer–user relations are facilitated by language, culture, national standardization and a large set of formal and informal institutions".

[5] The title of Part V in Dosi et al. (1988) is 'National Innovation Systems'. Contributions to this study were made by Nelson, Lundvall, Freeman and Pelikan.

Pelikan (1988) brings up the issue of whether a capitalist market economy or a socialist machine can give a more advantageous structure for a successful NIS.

Considering the wide collection of contributions to the NIS concept contained in Dosi et al. (1988), it is no exaggeration to say that this study is the keystone for the introduction and development of the NIS approach but also of the alternative systemic approaches to innovation.

5.6.3.1 Determination of the NIS Actors

Once the concept of National Innovation System is determined the components of which it consists should be studied. Generally speaking, these systems consist of various components, of the linkages between them and of their environment. This basic systemic structure can be applied to national innovation systems too. According to the systemic theory it is implied that the concept of national innovation systems can theoretically be distinguished into the national organizations, the different types of interactions between the components[6] and the national institutional conditions that surround them. Making the above classification we can achieve a very good illustration of national innovation systems. This structure gives us the general guidelines for the study of national innovation systems, because, basically, the NIS concept is a descriptive conceptual model that still leaves plenty of room for different interpretations. The literature review, however, shows that the conceptual classification of a NIS in institutions, organizations and interactions is generally considered broad (Balzat 2006). For this reason, it may be required, in empirical applications of the NIS concept, to define and implement a different structure of the NIS concept, which will depend on the specific research questions as well as technical issues, such as the availability of relevant data.

- **The NIS framework: institutions**

Considering everything stated in Sect. 2.3, generally in line with Knight (1992), institutions can be defined as "*systems of established social rules that structure social interaction*" (Hodgson 2006). The institutions ensure, determine and guide the operation of the activities not only of the market. At national level, innovative activity being a determining factor of structural change and economic development is built by national characteristics of institutional conditions. At the same time, technological and innovative activities define the institutional conditions of the environment. Because of these independent and dynamic relations, it has been accepted that institutions evolve simultaneously with technologies.[7]

[6] The NIS are in fact associated with other subsystems of the economy. For this reason, and considering that there are many subsystems in the economy different from the PES, which also influence innovative behavior, Nelson (1993b, p. 518) has put great emphasis on the fact that innovation systems cannot be analyzed exclusively. In addition to the subsystems there are also international relations in an NIS.

[7] Perez (1983), McKelvey (1997), Nelson (1994, 1998, 2002) or Nelson and Sampat (2001).

Examples of institutions are laws, regulations, contracts, rules of market exchange, shared values and codes of conduct. A particularly useful classification for different types of institutions was developed by Edquist and Johnson (1997, pp. 49–51), distinguishing them between formal and informal, basic and supporting and between hard and soft institutions.

Two of the main elements of institutions, as perceived in the NIS concept are institutional change and path dependence. The first of the elements indicates that institutions evolve and do not remain static. The second means that the established formal and political rules, laws and models, together with informal institutions that exist today, are very closely connected with those that existed previously.

The nature of institutions to depend on the chosen route, in conjunction with the national environment, leads to the conclusion that there is not an optimal institutional setting for an innovation system. The above are closely linked to issues of technology policy and have important implications for the design and selection of national policy measures which aim at improving the institutional conditions of the environment or the success of innovative action.

- The actors in an NIS: organizations

Organizations, which represent another important component of national innovation systems, can be defined as structural and institutionalized systems that were created in order to accomplish specific missions. To do this, members of an organization operate independently as well as in collaboration (Balzat 2006). Given that institutions are social rule systems, organizations are a particular form or subset of institutions.[8] As Hodgson (2006) points out, a key difference between organizations and institutions is that organizations have more features, "*criteria to establish their boundaries and to distinguish their members from non-members …principles of sovereignty concerning who is in charge and … chains of command delineating responsibilities within the organization*" The issue that membership is a separate element of organizations has also been stressed by Reimann (1991, p. 169).

An additional central difference between the institutions and organizations concerns their appearance. These organizations have as a key feature the fact "*that they are being created all the time. They are players or actors. In contrast, institutions may develop spontaneously and are not always characterized by a specific purpose*" (Edquist and Johnson 1997, p. 47).

The most important types of organizations are businesses, private and public research centers and universities.

[8] Noteboom (2000, p. 92) argues that organizations "are not institutions but players confronted with institutions".

5.6.3.2 Types of Interactions in an NIS

Interactions between components are an important element of any system and, hence, of national innovation systems. Regarding innovation systems, the relationships between their components contribute to the emergence and diffusion of innovations. Considering that the creation and diffusion of technological knowledge and innovation are important processes in an NIS, interactions contribute to the functioning of the system as a whole. Moreover, creating relationships with others, the actors related to the processes of learning and innovative activities are trying to develop their skills.

There are many channels through which knowledge can flow between the actors, as well as a variety of approaches to measure these flows. Below we explain four types of knowledge or information flows between the agencies of an NIS developed in this dissertation.

1. Interactions Between Firms

The business sector is the main R&D performer and the source of innovation in many countries worldwide. So, one of the most important knowledge flow in an NIS is obtained from: (a) formal partnerships between businesses, such as technical cooperation and cooperation in R&D and (b) from informal interactions and interconnections, which are as important as the formal. These interfaces include the user–technology producer relationships and the role of competitors as sources for innovation. (c) Also, very important, in addition to the collaborations and interactions between firms, are intra-business interactions, i.e. information and knowledge sharing within the range of different business departments.

With these joint business activities, a two-way flow of knowledge and technology is carried out in organization, administration, production and marketing. Companies work together in order to participate jointly in technical resources, achieve consecutively growing economies and gain human and technical resources they do not have, through cooperation. So, subsequently, the innovative performance of firms is higher, since there are significant indirect effects regarding 'complementarity of behavior', which means an increase in skills that positively affect the company's ability to innovate, to engage in networking and to recognize and adopt useful technology (Samara et al. 2012).

2. Interaction Between the Private and Public Research Sector

Another important knowledge flow in the NIS is the linkages between public and private sector. These interactions succeed in linking science with technology that is essential for an NIS, in order to create long-term technological opportunities and to coordinate the research field with economic and social requirements, contributing this way to the technical progress and economic performance of countries.

Public infrastructure consists mainly of higher education institutions (universities) and research and technology organizations (public research institutes). On the other hand there is the private sector (private companies and research laboratories), which mainly funds and implements R&D. The interactions between these actors can take mainly the form of:

- Industry–university–research center collaboration for R&D,
- Patents from the industry and universities/research institutes cooperation,
- Publishing and publications after the industry–university–research institute cooperation,
- The use the patent industry makes of universities/research institutes,
- The distribution of information between industry and universities/research institutes.

What is important for this type of knowledge flow is the effectiveness and quality of private and public sector linkages for the distribution power in an NIS. Furthermore, in these partnerships the role of location should be emphasized as well, since knowledge flows from the public sector to industry may be more important in a particular location or region. High-tech, territorial and foreign capital companies as well as research institutes tend to be found in areas where major universities, active in specific technologies such telecommunications, computer software etc., are located, in order to gain access to direct and indirect networks. To effectively link the public institutional structures of R&D, many countries (e.g. Germany, the Netherlands) have implemented measures like the creation of bridging institutions.

3. Technology Diffusion

Technology diffusion is another important success factor for some countries.[9] Indeed, studies have made it obvious that knowledge flow through technology diffusion is as important as R&D investment aiming at higher innovative performance in many cases.[10] Also, the diffusion of technology is especially important for traditional manufacturing sectors and service industries that are non-R&D performers themselves or for countries which are mostly technology and innovations users rather than producers.

[9] Does Technology Policy Matters, Ergas (1986).

[10] For example, technology diffusion was found to have greater influence on productivity in Japan than direct investment in research and development in the period 1970–93 (OECD 1996a).

The format in which this knowledge flow can be realized is generally through the use of technologies coming from industry and the diffusion of embedded technology. More specifically, technology diffusion may be carried out primarily in the following ways:

- Through intermediate and capital goods (equipment, materials and products such as high tech), etc.,
- Through embedded technology and tacit knowledge in human resources (scientific and technological staff or students) meaning that technology is transferred through staff training, informal and formal networks, people etc.,
- Using encoded technology (documents, publications, scientific publications, electronic databases) and technology embedded in patents and licenses,
- In addition, knowledge of technologies may come from customers and suppliers, as well as from competitors and public agencies.

The most well established formula from the above is the buying and selling and, in general, the dissemination of technology as new equipment and new machinery, i.e., as capital goods. The capital goods sector is central to technological acquisition, competition and the relationship between user and supplier, as it is the area that requires a more intensive user–producer interactive learning.

Typically, the diffusion of innovations is a slow process that takes place over the years. The rate of technology uptake varies significantly from sector to sector and according to the national environment and the diversification of the company characteristics. However, the innovative performance of companies depends increasingly on the application of technology by adopting and using innovations and products developed elsewhere (OECD 1996).

Countries differ significantly with each other regarding the importance of different channels of indirect knowledge flow. In large economies, such as Japan and the US, the percentage of imported technology is small, however, it is an increasing fraction of total R&D, while in smaller countries imported technology is about 40–50 % of the total volume. It is a remarkable fact that technology is supplied mainly by few high-tech industries, while the use of embedded technology is global and increases the technological content of low and medium tech industries.

Among the most important factors identified as responsible for the failure of technology assimilation by companies are lack of information, lack of funding and lack of technical expertise, as well as the general organizational and managerial deficiencies. Companies need a wide range of appropriate skills and their combination for technology assimilation to be successful. The most innovative companies are those who manage to have access to knowledge from external sources and to relate to knowledge networks, encompassing informal collaborations, supplier–user relationships and technical cooperation. Additionally, it is necessary to adopt technology and knowledge according to their own needs, since the innovation process, through which technologies are developed and used, is an increasingly selective endeavor, shaped by institutional systems and knowledge distribution systems.

Essential elements for enhancing technology diffusion in a country are the improvement of the mechanisms via which it takes place and the orientation of the government towards a wide range of companies, from high growth companies to the ones with limited capability, as well as from companies belonging to traditional sectors to those belonging to the emerging fields. Also, the government should support companies at different stages of their life cycle, as well as the service sector which is constantly developing. Finally, governments should encourage linkages between either people or bodies in an NIS, as this is the key to tacit knowledge transfer.

4. Staff Mobility

This flow concerns researchers, technicians, engineers and skilled workers, as well as people with administrative and organizational skills. The movement of technical personnel between industry, universities and research centers, their personal interactions, whether on a formal or informal basis, and generally the movement of people and the knowledge they carry with them (often referred to as 'tacit knowledge') is the most basic knowledge transfer mechanism in an NIS. As it is shown in most studies, skills and networking capabilities of the staff is the key to implementing successful transfer and diffusion of technology. Investments in advanced technology must be accompanied by 'adaptability' which is mainly determined by qualifications, tacit knowledge in general and staff mobility.

Knowledge flows through personnel may take place mainly in the following ways:

- Movement of scientists and skilled personnel to other firms in the market,
- Movement of graduates from universities to industry and research institutes, as well as movement of university researchers and staff from research institutes to industry,
- Through researchers following the business sector, who do not continue with their research but engage in other activities within their company,
- Movement of technical and qualified personnel from research centers to universities,
- Informal networks among researchers (business relations, conferences, meetings, etc.), difficult to measure though.

In a country, flow levels through human mobility can be increased, if the following steps are taken:

1. The education policy emphasizes the multidimensional and lifelong learning and new skills such as teamwork, maintaining personal relationships, effective communication and adaptability to change,
2. There are flexible labor markets,
3. There is a focus on incentives for further education of the workforce.

5.6.3.3 Empirical Basis for Focusing on National Level

The first group of critics brings up a number of questions that are empirical and relate to the degree to which national systems differ in what they do and the way in which they achieve it. The other group deals with the extent to which innovation is a domestic or an international process.

Recently a number of empirical studies analyzed these issues using data from trade and patent databases (see for example articles Archibugi & Michie; Patel & Cantwell at No. 19, 1995 in Cambridge Journal of Economics). These studies do not stop the debate but the following conclusions are very logically arranged:

1. There is no doubt that national innovation systems are specialized and there is evidence of convergence in this perception.
2. International businesses tend to set some of their development goals abroad, but the trend is not particularly strong.
3. The diffusion of innovations and new technology has become very international.
4. Domestic markets play a significant role in promoting innovation.

Showing the differences in institutional characteristics is more difficult, because here it is not easy to find international statistics to illustrate the relative sizes. To clarify this issue we rely on the comparison of two economies made by Edquist and Lundvall (1997). These are the economies of Denmark and Sweden, which are very close in terms of culture, history, geography, etc. Nevertheless, it was proved that even in these countries institutional differences significantly affect how innovation is achieved. Studies in America and France (Dertoutzos et al. 1989; Coriat and Taddei 1993) also show the same thing. Recently, a broader analysis on how globalization affects institutional convergence came to the fore, the conclusions of which are quite controversial (Berger and Dore 1996; Boyer 1996). Considering all the above, it seems reasonable to conclude that national differences are substantial and have a specific systemic nature.[11]

– **The juxtaposition of policies for the analysis of innovation at national level**

According to Lundvall (1997) the analysis of national systems is important, even though the trend towards globalization of innovative activities was more pronounced, for the following reasons:

- The systems in which innovation can be analyzed (international, regional or local), whether limited within the borders of a state or not, are heavily influenced and shaped by national characteristics and contexts.
- Many of the obstacles to development concern (and are justified by) national borders and strong correlations which have been observed between poverty and geographic location.[12]

[11] Ernst and Lundvall (1997), stress the importance of how different systems use explicit and tacit knowledge in knowledge creation as the basis for systemic differences in other issues.

[12] Sachs et al. (2001).

- The idea of innovation systems is primarily associated with knowledge flow (and especially tacit) and its impact on economic growth. Subsequently, their analysis will focus on the national level, which appears to be more centrally involved in managing and controlling these flows.
- The least mobile actors of production and the most crucial for innovation (human capital, government regulations, public and semi-public institutions and natural resources) are related to a particular national environment.
- The predominant route concerning policies, including also the monetary and liquidity policy as well as the business market and social policy, is to examine the issue at national level.
- Without studying an innovation system at national level it is, it is difficult to understand what type of international institutional structures are required for the replacement of the old systems of innovation, when they are weakened by current strengths and challenges such as globalization, for example.

It is a fact that globalization and European integration are historically known to have an important influence on the creation of national states and the existing national systems of innovation. But it is quite difficult to see how these effects can be understood if we do not take the national level as a starting point for study. It is also difficult without such an analysis to identify the international institutions that are needed as substitutes for the old national systems, when these are undermined. The more powerful the forces that seek to undermine national systems are, the stronger is the need for understanding the historical role of a nation.

The above mentioned are not arguments against the analysis of innovation systems at regional level or at technological, sectoral or company levels. On the contrary, according to the literature as well, if we break down the national systems into their constituent subsystems (Chung 2001) we can understand how they develop. So, according to the opinion of the writer it is important and well-aimed to deepen the analysis of national innovation systems.

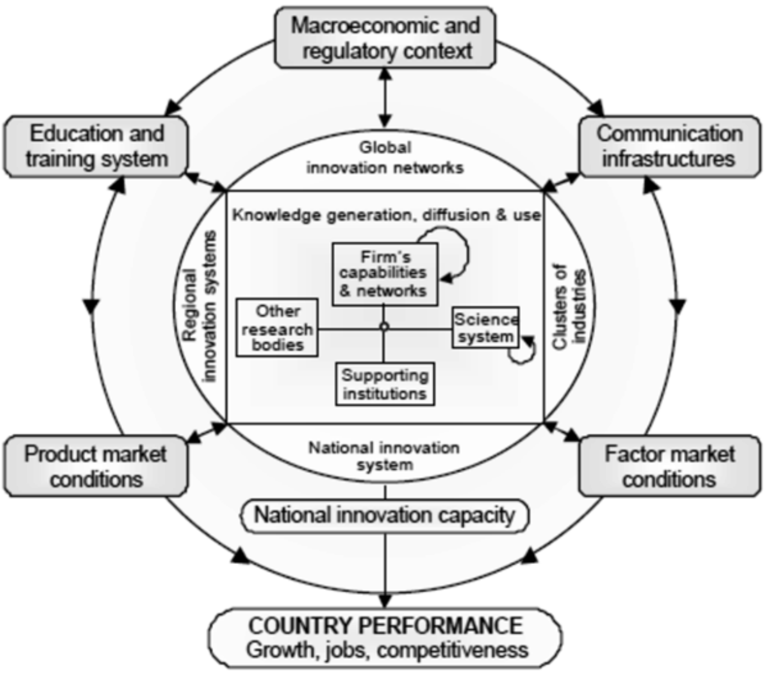
5.6.3.4 Distinction of the National Innovation System

National Innovation Systems can be divided into the following two broad categories based on the range of institutions, including:

(1) **The 'Narrow' National Innovation System (narrow NIS)**, which is a system that focuses on institutional agents "directly promoting the creation and use of innovation in a national economy" (Adeoti 2002). The 'narrow' NIS approach generally examines the following actors engaging in innovation (OECD 1999):
    - Governments (local, regional, national)
    - Bridging institutions (supporting and intermediary)
    - Private companies and research institutes financed by the former
    - Universities and other knowledge creators such as research institutes, research centers etc., and
    - Other private and non-private organizations playing a role in a NIS.

(2) **The 'Broad' National Innovation System (Broad NIS)**, which includes, additionally to the components discussed in the 'narrow' NIS, the overall economic, cultural, institutional, social and political environment of the country concerned. This environment affects innovation and comprises the national financial system, the economic policy, the internal organization of private companies, the educational system, labor markets, regulatory policies and institutions, etc. In conclusion, a 'wide' NIS and in general an innovation system (regional, global, sectoral) is a dynamic and complex system. This means that an NIS essentially depends on:

(a) **The interaction network (micro-economic environment) and the actors themselves associated with innovation (companies, research organizations, bridging actors, universities, etc.) and**
(b) **The general environment of a country, which comprises factors such as the macroeconomic and regulatory environment, the education system, market conditions, factors of production, communication infrastructures etc.**



Source: OECD, Managing National Innovation Systems, 1999

Fig. 5.3 Actors and linkages in the innovation system

Furthermore, an NIS is always in dynamic relationship with other innovation systems: it both exerts influence and is affected by them at the same time. Figure 5.3 shows the main factors and links that formulate an NIS.

5.6.3.5 Examples of National Innovation Systems

As mentioned in Sect. 5.6.3.4, the broad NIS includes, additionally to the components discussed in the 'narrow' NIS, the overall economic, cultural, institutional, social and political environment of the country concerned. This environment affects innovation and comprises the national financial system, the economic policy, the internal organization of private companies, the educational system, labor markets, regulatory policies and institutions, etc.

While individual institutions that constitute the broad and narrow innovation systems are important, "the intensity and variability of knowledge flows among the components of a national system are critical determinants of power distribution. According to these lines, it has been suggested that policy makers should shift their interest from fixed structures and absolute measures of innovative activities … to different types of interactions between actors, within and beyond the boundaries of a national system" (Caloghirou et al. 2001, p. 14). One specific example of efforts to reflect the national innovation systems are found in Norwegian system below (Fig. **5.4**).

In recent years Greece has shown an increasing growth rate, belonging to the category of countries that want to become more innovative (Moderate Innovators)[13] (Fig. 5.5). The Greek innovation system is gradually being shaped and strengthened, mainly through interventions of the state which, following the EU guidelines, deals with the creation of a favourable environment for innovation in a more systematic way.

The Greek innovation system is shaped and it is progressively strengthened, mainly with the intervention of the government which constitutes an active catalyser of decisions favouring innovation. In order to do so the government followed the lines of the EU, facing with a more systematic way the creation of an environment favourable for innovation.

In this effort to strengthen the system, it is very important to involve all key actors and to develop an appropriate culture in the Greek society in order to promote general knowledge and thus innovation (Bakouros and Samara 2010).

Greece has one of the higher growth rates between the 15 fundamental EU members (EIS 2010). Precisely, from the decade of '90 the annual growth rate of GDP was continuously higher than the medium rate of the 15 of the EU (3 % on 1991–2004 compared with the 2 % of EU-15). In 2010, according to the Hellenic National Statistical Service, the GDP was increased at 5,9 % despite the high prices of the oil. However, its classification to the competitiveness indicators between 80 countries according to the WEF (World Economic Forum) in 2009–2010 shows clearly that its innovative activity is low and that it is an imitative economy, which constitutes importer of innovations, while the technologies are only adopted by its institutions, when they

[13] Greece is showing high growth rates in GDP and GDP per capita (European Innovation Scoreboard 2010).

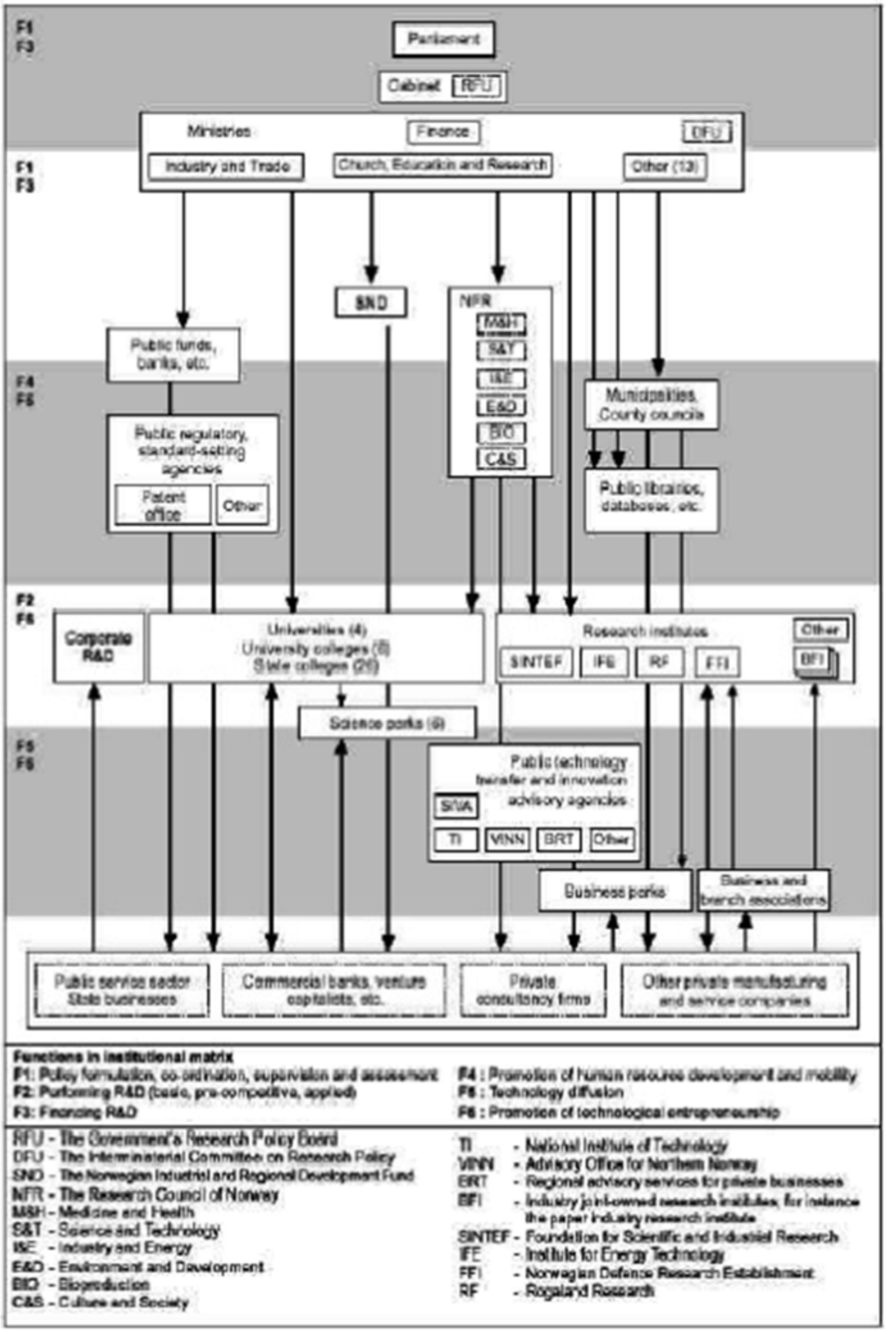


Fig. 5.4 The Norwegian system of innovation–organizational structure

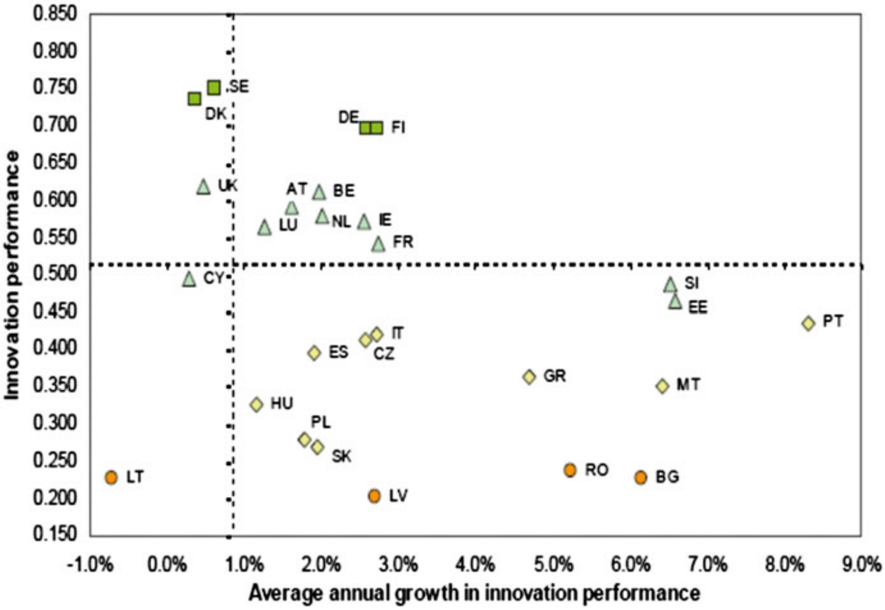


Fig. 5.5 Innovation Performance, *Source*: *European Innovation Scoreboard (2010), Comparative Analysis of Innovation Performance*

are checked and applied in advanced countries or simply are incorporated in equipment and products (Komninos and Tsamis 2008). Arundel and Hollanders (2005) agree that Greece's economic strategy does not appear to be related to innovation.

The fact that Greece is only an innovation importer and makes use of innovative technologies rather than being their creator is due, inter alia, to the following elements:

- The national infrastructure which is not developed far enough to support innovation activities,
- The dominance of R&D as a public sector activity over the private sector,
- The concentration trends of Greek industries in traditional low and medium technology sectors and
- An imbalance between knowledge creation and application in order to extract innovative results.

Also, the Greek innovation system consists of a few key 'players' who actually create its main features (Fig. 5.6). From these players, the government and public agencies play a key role, as they are the bodies that shape policy and are the key contributor to strengthening the system.

The majority of Greek firms are SME's, on the other hand, belonging mainly to the SME category, are unable to play a leading role for the national innovation system. The relations and the interactions between the actors can be considered as satisfactory. However the dependency of the firms to a great degree from the government owned financing constitutes a barrier for increased innovative efforts.

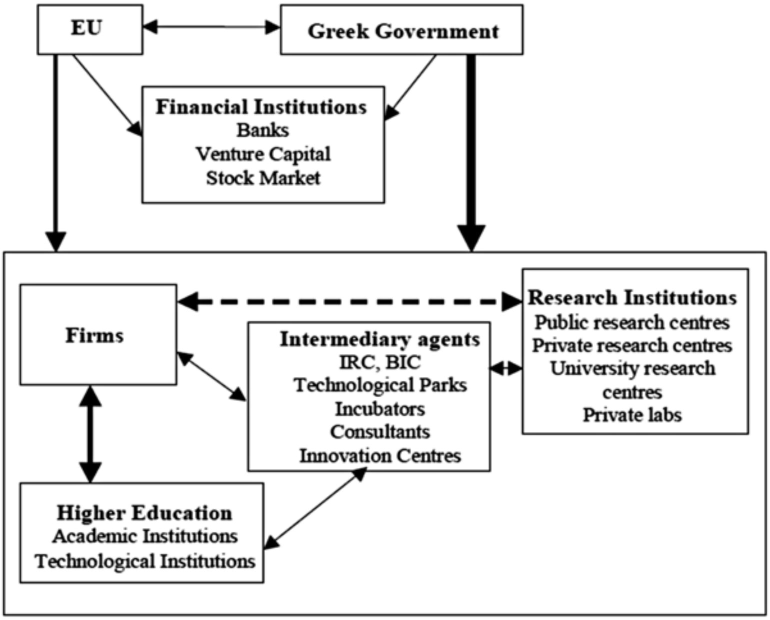


Fig. 5.6 The Greek Innovation System, *Source: General Secretariat of Research and Technology*

A general observation that has been made—see the 2010 Scoreboard Report (EC, 2007)—was that in Greece there is a general tendency to show best performance in indicators measuring the input to the innovation process and worst performance in indicators measuring the outcome of the innovation, an image showing that there is a possible lack of suitable interfaces and beneficial interactions between the system elements that create knowledge and those that apply it. Despite the negatives of the innovation system, Greece has a quite strong scientific and research potential for R&D (Tsipouri and Papadakou 2005).

Finally, the Greek policy is guided by the general principles of EU for innovation. The Greek Government is slowly 'building' an economy based on knowledge, focusing on correcting the shortcomings of the Greek system, which are the reduced participation of Greek enterprises in R&D and the development of the appropriate infrastructure and the favourable environment for the promotion of innovative activities.

5.7 Application of System Dynamics in the Study of National Innovation Systems

There are several studies in the literature on National Innovation Systems. One such category of studies relating to the creation of mathematical models for the NIS of a country trying not to compare the innovation performance with that of any other country, but with the development of policy options for further improvement, for this country. To do so, the methodology of dynamic simulation is being using. Here are two key studies in this direction. The first is the study of Janszen and Degenaars (1997) which held a dynamic analysis of the relationships between the structure and the process of NIS using the computational simulation. In this study special emphasis is given on the dynamic nature of the NIS. NIS consists of various actors that interact. Through these interactions, the technologies, products and markets evolve (Levinthal and Myatt, 1994; Nelson, 1995). This development is due to the existence of positive feedbacks linking the development of technology, products and markets with the development of industries and organizations. However, these organizations can also delay the development of new technology based products and markets by the existence of negative feedbacks. When the relationship between the different actors of the innovation system are affected by a number of positive and negative feedbacks, the dynamics of the process is evident. This study therefore describes a computer model of NIS with the approach of system dynamics. The aim is to study the dynamic relationships between components of an NIS and innovative performance. The model generated is very simplified and consists of nine functions: (a) the presence of scientific subsystem (b) the presence of technology suppliers (c) the presence of venture capital market (d) the presence of the internal market (e) the presence of rapid acceptance by consumers of innovative products (f) the creation of consumer aversion to innovation (h) grants from the government (g) the governmental requirements and (i) the laws on patents.

Another study in this direction is that of Lee and Tunzelmann (2005). In this study a mathematical model of the NIS of Taiwan has been constructed with the help of system dynamics. This study identified two subsystems, the technological system, which is responsible for the production of technological developments and the industrial system, which is responsible for converting these technologies into products. According to the strict meaning of the NIS this is associated only with the first subsystem. For the construction of the model, the NIS is analyzed in five actors: (a) in the financial sector (b) in the field of human resources (c) in the field of technology transfer (d) in the field of innovation and commercialization (e) in the market. This system does not take into account the macroeconomic policies of the government and the financial system. All these actors interact to form positive and negative feedbacks. The application of the model is to simulate the integrated circuit industry. Three sensitivity analyses take place, in the time response of the model, in political science and in technology policies and R&D.

A third study is the doctoral thesis of E. Samara, where macroeconomic conditions and the financial system are key elements of the NIS model developed. In this thesis, in order to study the NIS concept we need to separate it into the different parts-subsystems it is composed of. This is because there are various activities taking place within an NIS and all these activities are performed by different actors. These actors are the government, companies, research institutes and universities. The properties and behavior of each actor, in turn, influence all the others. In this thesis, the national innovation system is broken down into seven parts-subsystems. These parts-subsystems aim to describe the central points of NIS. The parts-subsystems that constitute our model provide a complex network of interactions. The system under study includes the following subsystems:

a. Human Capital and Knowledge
b. Innovative Activities
c. Innovation Process
d. Market Conditions
e. Institutional Environment
f. Financial System, and
g. Technological Performance.

This model is applied to the Greek NIS and several government policy scenarios are being developed to assess their impact on the innovation performance of the country (see Fig. 5.7).

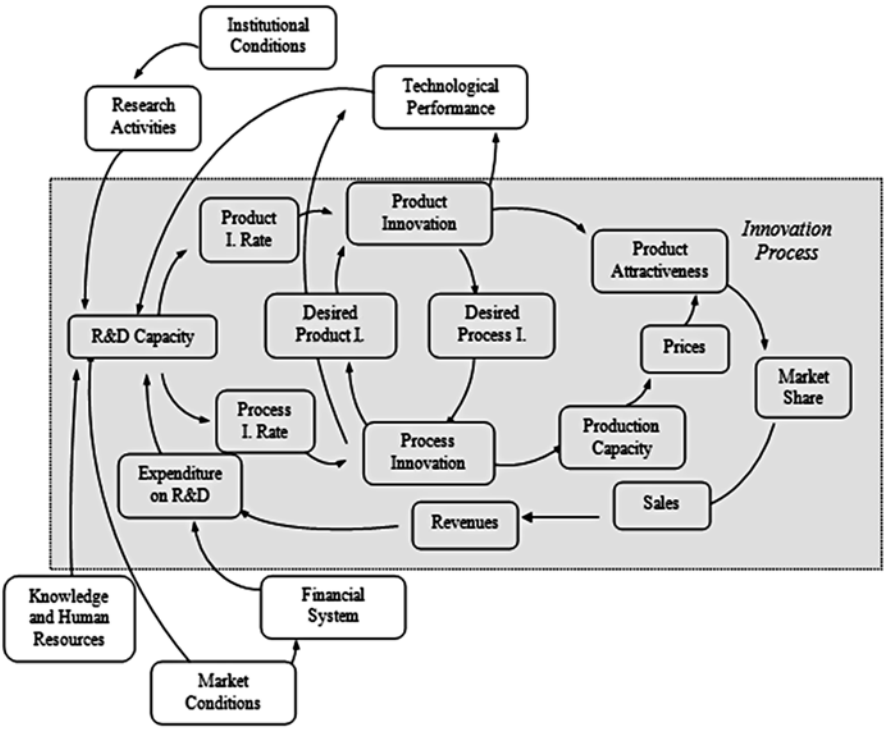


Fig. 5.7 The generic structure of NIS (Samara et al. 2012)

References

Acs Z, de la Mothe J, Paquet G (1996) Local systems of innovation: in search of an enabling strategy. In: Howett P (ed) The implications of knowledge-based growth for micro-economic policies. University of Calgary Press, Calgary, pp 339–360

Adeoti J (2002) Building technological capability in the less developed countries: the role of national systems of innovation. Sci Public Policy

Andersen ES, Lundvall B-A (1988) Small national systems of innovation, facing technological revolutions: an analytical framework. In: Freeman C, Lundvall B-A (eds) Small countries facing the technological revolution. Pinter, London, pp 9–31

Archibugi D, Michie J (eds) (1997) Technology, globalisation, and economic performance. Cambridge University Press, Cambridge

Arundel A, Hollanders H (2005) Innovation strengths and weaknesses. MERIT European Trend Chart on Innovation

Bakouros Y, Samara E (2010) Innovation management techniques: a strategic tool for SMEs in an innovative region. Int J Innov Sci 2(2):81–90

Balzat M (2006) Economic analysis of innovation extending the concept of national innovation systems. MPG Books Ltd, Printer, Bodmin, Cornwall

Berger S, Dore R (eds) (1996) National diversity and global capitalism. Cornell University Press, Ithaca and London

Blanchard BS, Fabrycky WJ (1990) Systems engineering and analysis, 2nd edn. Prentice-Hall, Inc., Englewood Cliffs

Boyer R (1996) The convergence hypothesis revisited: globalisation but still the century of nations? In: Berger S, Dore R (eds) National diversity and global capitalism. Cornell University Press, Ithaca and London

Breschi S, Malerba F (1997) Sectoral systems of innovation: technological regimes, Schumpeterian dynamics and spatial boundaries. In: Edquist C (ed) Systems of innovation. F Pinter, London

Camagni R (1991) Local milieu, uncertainty and innovation networks: towards a dynamic theory of economic space. In: Camagni R (ed) Innovation networks: spatial perspectives. Belhaven-Pinter, London, pp 121–144

Cantner U (2000) Die Bedeutung von Innovationssystemen für die internationale Wettbewerbsfähigkeit. In: Staroske U et al (eds) Innovation als Schlüsselfaktor eines erfolgreichen Wirtschaftsstandortes: Nationale und regionale Innovation ssysteme im globalen Wettbewerb. LIT

Carayannis E (1998a) The strategic management of technological learning in project/program management: the role of extranets, intranets and intelligent agents in knowledge generation, diffusion, and leveraging. Technovation 18(11):697–703

Carayannis E (1998b) Higher order technological learning as determinant of market success in the multimedia arena; a success story, a failure, and a question mark: Agfa/Bayer AG, enable software, and sun microsystems. Technovation 18(10):639–653

Carayannis EG, Alexander JM (2006) International Public/Private R and D Collaborations: Focus on EU/US Government–University–Industry Research and Technology Development Partnerships, Palgrave Macmillan

Carayannis EG, Campbell DFJ (2005) Co-Editors, Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters: A Comparative Systems Approach Across the United States, Europe, and Asia, Praeger Books/Greenwood Press, December

Carayannis EG, Campbell DFJ (2006) A "'Mode 3' Systems Approach for Knowledge Creation, Diffusion and Use: Towards a 21dt Century Fractal Innovation Ecosystem", re-discovering schumpeter: creative destruction evolving into 'Mode 3'. In: Carayannis EG, Ziemnowicz C (Co-Editors) Chapter 7, Palgrave Macmillan

Carayannis E, Campbell D (2009) "Mode 3" and "Quadruple Helix": towards a 21st century fractal innovation ecosystem. Int J Technol Manage 46(3/4):201–234

Carayannis EG, Sipp M (2006) e-Development Towards The Knowledge Economy: Leveraging Technology, Innovation and Entrepreneurship for “Smart” Development, Palgrave Macmillan
Carayannis EG, Assimakopoulos D, Kondo M (Co-editors) (2008) Innovation networks and knowledge clusters: findings and insights from the US, EU and Japan. Palgrave Macmillan
Carlsson B (ed) (2002) New technological systems in the bio industries – an international study. Kluwer Academic Publishers, Boston
Carlsson B, Jacobsson St (1997) Diversity creation and technological systems: a technology policy perspective. In: Edquist Ch (ed)
Carlsson B, Stankiewicz R (1991a) On the nature, function, and composition of technological systems. J Evol Econ 1(2):93–118
Carlsson B, Stankiewicz R (1991b) On the nature, function and composition of technological systems. JEvol Econ 1:93–118
Carlsson B, Stankiewicz R (1995) On the Nature, Function and Composition of Technological Systems, in Carlsson, B, (ed.) Technological systems and economic performance: the case of factory automation, Boston, Dordrecht and London, Kluwer Academic Publishers
Carlsson B, E.son G, Tayzmaz E (1992) The macroeconomic effects of technological systems: micro–macro simulations. Paper presented at the 20th annual conference of the European association for research in industrial economics (EARIE), Sent 4–7, Israel
Chung SC (2001) The research, development and innovation system in Korea. In: Laredo P, Mustar P (eds) Research and innovation policies in the new global economy. Economica, Paris
Cimoli M (1998) Methodologies for the studies of NIS: a cluster based approach for the Mexican case. Presented at the OECD workshop on cluster analysis and cluster-based policies, October, Amsterdam, proceedings, 1997
Cooke P, Uranga M, Etxebarria G (1997) Regional innovation systems: institutional and organizational dimensions. Res Policy 26:475–491
Coriat B, Taddei D (1993) Made in France – L’ industrie francaise dans la competition mondiale. Hachette, Paris
Dertoutzos ML, Lester RK, Solow RM (1989) Made in America: regaining the productivity edge. MIT Press, Cambridge, MA
Dosi G, Freeman C, Nelson R, Silverberg G, Soete L (eds) (1988) Technical change and economic theory. Pinter Publishers, London
Edquist C (ed) (1997) Systems of innovation; technologies, institutions, and organizations. Pinter, London
Edquist C (2001) The systems of innovation approach and innovation policy: an account of the state of the art. Lead paper presented at the DRUID conference, Aalborg, June 12–15, 2001, under theme F: ‘National Systems of Innovation, Institutions and Public Policies’. Draft
Elam M (1997) National Imaginations and Systems of Innovation, in Edquist, C. (ed.), Systems of Innovation: Technologies, Institutions and Organizations, London: Printer, pp. 157–173.
Ergas H (1986) Does technology policy matter?
Forrester JW (1961) Industrial dynamics. MIT Press, Cambridge, Massachusetts
Freeman C (1987) Technology policy and economic performance: lessons from Japan. Pinter, London
Freeman C (1988) Japan: a new national system of innovation? In: Dosi G et al (eds) Technical change and economic theory. Pinter, London, pp 330–348
Freeman C (1995) The national system of innovation in historical perspective. Camb J Econ 19(1)
Galli R, Teubal M (1997) Paradigmatic shifts in national innovation systems. In: Edquist C (ed) Systems of innovation: technologies, institutions and organizations. Pinter Publishers, London, pp 342–370
Georgiadis P (2006) Theory of system dynamics with applications in the designing and functioning of production systems. Sofia publishing, Thessaloniki
Gregersen B (1988) The public sector as a pacer in national systems of innovation. In: Lundvall B-A (ed) National systems of innovation – towards a theory of innovation and interactive learning. Pinter, London, pp 129–145
Hodgson GM (2006) What are institutions? J Econ Press

Hughes JR (1987) The evolution of large technological systems. In: Bijker WE, Hughes JR, Pinch TR (eds) The social construction of technological systems: new directions in the sociology and history of technology. MIT Press, Cambridge, pp 51–82

Jacobsson S, Johnson A (2000) The diffusion of renewable energy technology: an analytical framework and key issues for research. Energy Policy 28:625–640

Johnson B (1997) Systems of innovation: overview and basic concepts – introduction. In: Edquist C (ed) Systems of innovation: technologies, institutions and organisations. Pinter Publishers, London, pp 36–40

Komninos N, Tsamis A (2008) The system of innovation in Greece: structural asymmetries and policy failure. Int J Innovation Regional Develop 1(1):1–23

List F (1841) The national system of political economy, English edition. Longman, London, 1904

Lundvall B-A (ed) (1992a) Introduction. In: Lundvall B-A (ed) National systems of innovation – towards a theory of innovation and interactive learning. Pinter, London, pp 1–19

Lundvall B-A (ed) (1992b) National systems of innovation – towards a theory of innovation and interactive learning. Pinter, London

Lundvall B-A (1997) National systems and national styles of innovation. Paper presented at the fourth international ASEAT conference, differences in 'styles' of technological innovation, Manchester, September 1997

Lundvall B-Å, Maskell P (2000) Nation states and economic development – from national systems of production to national systems of knowledge creation and learning. In: Clark GL, Feldmann MP, Gertler MS (eds) Handbook of economic geography, chapter 10. Oxford University Press

Malerba F (2002) Sectoral systems of innovation and production. Res Policy 31(2):247–264

Malerba F (2004) Sectoral systems of innovation: concepts, issues, and analysis of six major sectors in Europe. Cambridge University Press, Cambridge

Nelson RR (ed) (1993) National innovation systems: a comparative analysis. Oxford University Press, Oxford

Niosi J (2002) National systems of innovations are "x-efficient" (and x-effective): why some are slow learners. Res Policy 31:291–302

Niosi J, Saviotti PP, Bellon B, Crow M (1993) National systems of innovation: in search of a workable concept. Technol Soc 15(2):207–227

OECD (1996) Measuring what people know: human capital accounting for the knowledge economy. OECD, Paris

OECD (1999) Managing national innovation systems. OECD, Paris

Olazarán M, Gómez Uranga M (eds) (2000) Sistemas Regionales de Innovación. Servicio Editorial de la Universidad del País Vasco, Bilbao

Pavitt K (1984) Sectoral patterns of technological change: towards a taxonomy and a theory. Res Policy 13:343–373

Pelikan P (1988) Can the imperfect innovation systems of capitalism be outperformed? In: Dosi G et al (eds) Technical change and economic theory. Pinter, London, pp 370–398

Reimann H (1991) Institutionen. In: Reimann H (ed) Basale Soziologie: Hauptprobleme. Westdeutscher Verlag, Opladen, pp 159–177

Sachs J, Mellinger A, Gallup J (2001) The geography of poverty and wealth. Sci Am 284(3):70–75

Samara E, Patroklos G, Bakouros Y (2012) The impact of innovation policies on the performance of national innovation systems: a system dynamics analysis. Technovation 32:624–638

Saxenian A (1991) The origins and dynamics of production: networks in Silicon Valley. Res Policy 20:423–437

Saxenian AL (1994) Regional advantage: culture and competition in silicon valley and route 128. Harvard University Press, Cambridge

Towill DR (1995) Time compression and supply chain management – a guided tour. Logist Inf Manage 9(6):41–53

Tsipouri L, Papadakou M (2005) Profiling and assessing innovation governance in Greece: do increased funding and the modernisation of governance co-evolve? In: OECD (ed) Governance of innovation systems: case studies in innovation policy, pp 13–42

Verlag Münster, Nelson R (1988) Institutions supporting technical change in the united states. Technical change and Economic Theory. Pinter, London

Chapter 6
Introduction to Technological Entrepreneurship

6.1 Introduction–Definitions

Adam Smith (1776) defined Land, Labor and Capital as the key input factors of the eighteenth century economy. Joseph Schumpeter (1934) added Technology and Entrepreneurship as two more key input factors in the early twentieth century. The role and dynamic nature of technological change and innovation, as well as their interdependencies, were thus acknowledged as main factors shaping the world economy's future. The static approach of the Neoclassical Economic Theory was eventually abandoned.

In the late twentieth and the beginning of the twenty-first century, a large number of scholars and practitioners such as Peter Drucker (1998) identified Knowledge as the sixth and perhaps most important key input–output (I/O) factor of economic activity. We would also like to emphasize the role and importance of Technological Learning as a potentially seventh factor and driver of productivity gains, as well as an accelerator of economic growth and prosperity (Carayannis 1993, 1994a, b, c, 1998a, b, 1999, 2000, 2008, 2009).

On this basis, we believe that there is a clear role, opportunity and challenge for entrepreneurs around the world to accelerate and affect economic growth, and leverage the Digital Divide through business initiatives in the private sector. As said by, innovation is related to shifting resources to areas of higher yield. Therefore, knowledge-based and knowledge-supported entrepreneurship will be the pre-eminent driver of innovation in the twenty-first century, via real/virtual and global/local infrastructures such as the incubator networks listed below. This vision is particularly promising and appealing in the context of e-Development towards the Knowledge Economy.

E.G. Carayannis et al., *Innovation and Entrepreneurship*, Innovation, Technology, and Knowledge Management, DOI 10.1007/978-3-319-11242-8_6

The lack of formal definitions for the terms e-Development or Knowledge Economy has often been a cause of confusion:

- ***Knowledge-based economies*** are defined as "economies which are directly based on the production, distribution and use of knowledge and information" (OECD 1996).
- A ***knowledge driven economy*** is "one in which the generation and the exploitation of knowledge has come to play the predominant part in the creation of wealth".
- "For countries in the vanguard of the world economy, the balance between knowledge and resources has shifted so far towards the former that ***knowledge has become perhaps the most important factor determining the standard of living*****—**more than land, than tools, than labor. Today's most technologically advanced economies are truly knowledge-based".

In this book the working definition for **Knowledge Economy** is as follows:

'The Knowledge Economy is a state of economic being and a process of economic becoming that leverages intensively and extensively knowledge assets and competencies as well as economic learning to catalyze and accelerate sustainable and robust economic growth (Carayannis 2001, 2002, 2008, 2009).'

There has been a lot of talk in Greece lately, albeit with some delay, about the need to strengthen the spirit of entrepreneurship and stimulate self-employment in increasingly younger age groups of the working population.

Before proceeding to our analysis, the key concepts of Entrepreneurship should be clarified so that the general content of the analysis does not lead to misunderstanding and wrong estimations.

In Economic Theory, Entrepreneurship is regarded as **the fourth factor of production** after capital, labor and land. The term entrepreneurship comes from the French verb "entreprendre" which means to do something new, to create and innovate, without being absolutely sure about the result of the final effort. The existence of uncertainty over the final outcome eventually leads to the inclusion of the risk of failure in our analysis. The "entrepreneur" plays a central role in the understanding of entrepreneurship: an entrepreneur is considered to be someone who finds an opportunity and exploits it productively, in order to create and develop a new business. This is not necessarily equivalent to being an owner-manager of a small firm that does not have development as a target. Other views on the role and activity of the entrepreneur are:

Hunt and Murray (1800) explain the origin of the word:

'The word entrepreneur was used by the French in the fifteenth century to describe a military governor, who leads his troops into battle. Gradually, this concept was expanded to the marketplace and businesses. However, the interpretation of the original military meaning of the term is accurate for the market environment as well. It refers to entrepreneurs of all ages who seek to govern forces they have not created themselves, under conditions they have not chosen themselves and with outcomes that cannot be predicted.'

The Entrepreneur therefore, with the help of a decision-making grid, takes the following actions:

- **Makes decisions and takes risks**
- **Organizes factors of production in the most efficient way aiming to achieve the best possible result**
- **Uses innovations and monitors pioneering entrepreneurial initiatives in order to draw ideas**
- **Seeks profit opportunities and adopts clever strategies.**

6.2 Types of Entrepreneurship

A first attempt to classify types of entrepreneurship distinguishes between **mixed and pure entrepreneurship**. However, in the case of mixed entrepreneurship a further distinction is made between employee entrepreneurship and **capitalist entrepreneurship**. The distinction between mixed and pure entrepreneurship is made mainly for reasons of theoretical analysis and research.

6.2.1 Mixed Entrepreneurship

6.2.1.1 Employee Entrepreneurship

The term employee entrepreneurship implies that the entrepreneur undertakes activities, which could be conducted by leased employees or workers without reducing the overall labor productivity. So we understand that entrepreneurship is not an exclusive responsibility of the entrepreneur, but can be conducted by an employee as well. Entrepreneurship can be performed by an executive director of the company, who uses pioneering methods to approach his subordinates attempting to increase their interest in the enterprise. Entrepreneurship can also be accomplished by an executive, who proposes to the administration several innovations in order to improve products or services.

This type of entrepreneurship is also called **"internal entrepreneurship" or "intra-preneurship)**. In mixed entrepreneurship, the entrepreneur starting a business is often compelled to play roles that could be performed by other people. A few years ago most entrepreneurs, due to lack of specially trained workforce, were obliged to perform common tasks and direct supervision, administration and control in all the operating phases of the enterprise. As a result, the entrepreneur was burdened with more workload and his real entrepreneurial activity was hindered. But that kind of entrepreneurship tends to disappear today, since the specialized knowledge needed to operate a business is increasing and it is not necessary for the entrepreneur himself to possess that knowledge. In most of the cases, however, it would be more fruitful for the entrepreneur to dedicate time to the discovery of a new profit opportunity, rather than perform tasks that can be assigned to others.

6.2.1.2 Capitalist Entrepreneurship

Capitalist Entrepreneurship is conducted by an individual who is an owner of capital with an active and established business presence. When the entrepreneur captures an idea for the creation and exploitation of a new profit opportunity, he should either already possess some form of capital or have the opportunity to borrow money to put the idea into practice. With its startup capital raised, the newly formed company proceeds to the exploitation of this idea, acting as a capitalist–investor and believing that the best course of action would be the placement of its money on the company itself. This role of the capitalist entrepreneur tends to be limited, because of the increasing possibilities to raise funds from the financial system and various forms of business cooperation.

6.2.2 Pure Entrepreneurship

Pure entrepreneurship comprises activities that cannot be performed by salaried employees, or exclusively by other agents, as effectively as they are accomplished by the entrepreneur. Pure entrepreneurship includes all the activities identified by the entrepreneur as high efficiency actions, which would not have the same profitable results, if performed by other entities or individuals. The pure entrepreneurial function does not necessarily demand the ownership of factors of production on the part of the prospective entrepreneur. He is only required to take advantage of the key traits of his entrepreneurial personality that are important in the conception and implementation of a fruitful idea.

Entrepreneurship, however, has also been categorized into two other types, social and collaborative, that are discussed below.

6.2.3 Social Entrepreneurship

Social entrepreneurship is called the entrepreneurial activity that aims to meet social and humanitarian needs. Its goals are usually actions for humanitarian purposes that can be achieved through effective operation of its components.

6.2.4 Collaborative Entrepreneurship

The development of collaborative entrepreneurship aims mainly to the benefits of cooperative entities, with key implementation areas in specific economic sectors and production branches of agricultural products.

Another categorization of entrepreneurship distinguishes two types of entrepreneurship: **internal and external**.

6.2.5 Internal Entrepreneurship

The term Internal Entrepreneurship is used to describe the existence of inherent entrepreneurial tendencies of big company employees. Internal Entrepreneurship can be cultivated by rendering the senior staff personally responsible either for the preparation of a budget corresponding to their tasks, or for managing their departments as independent self-managed companies, regarding budget preparation and control.

Internal Entrepreneurship focuses on initiative and spirit of enterprise: an executive possessing internal entrepreneurship behaves as if he owns the company. Consequently, internal entrepreneurship is a cognitive state which exhibits the following distinct characteristics:

- **Persistence and determination manifesting themselves in the desire for very hard work**
- **Willingness to take risks but only after careful research about the chances of success**
- **Understanding, mainly based on how the market functions, particularly in relation to identifying new opportunities**
- **Reluctance to be trapped in conventionality and the gears of bureaucracy, with an aversion to restrictive regulations**
- **Enthusiasm for exercising entrepreneurial activities, emotional commitment to an organization, ability to inspire confidence in subordinates, and self-confidence to external suppliers, customers and other third parties**.

6.2.6 External Entrepreneurship

External entrepreneurship includes elements of external business environment affecting a company, either directly or indirectly. External entrepreneurship is divided into **general and specific.**

General entrepreneurship deals with sizes and forces which somehow affect the life and work of the agencies mentioned above. These elements, however, cannot be specifically identified, nor can the degree of their influence on the company be assessed with certainty and precision. One main characteristic of general entrepreneurship is that the situations prevailing and the driving forces developing in its context affect each and every business.

The main factors of general external entrepreneurship are:

- **The general economic situation—**The economic situation of the geographical area where the company is activated is reflected by the levels of wealth and overall prosperity of the area. The economic fundamentals that determine the quality of the prevailing economic situation and affect businesses are inflation rate, capital remuneration, unemployment rate, and demand. High interest rates create business financing problems, thus increasing their function costs. Similarly, high interest rates lead to demand reduction because they make consumers reluctant to take out loans for the purchase of equipment goods or of various other goods.

Increased unemployment appears to favor companies that have the opportunity to find cheap labor. On the other hand, however, it reduces the purchasing power of consumers.

- **Technology—**Technology is a wide body of knowledge, methods and techniques used in the production and distribution of goods. The rapid progress of technology is an object of attention and vigilance on the part of the executives of the company. The new methods and techniques have resulted in quality and cost improvements, and the creation of new goods flooding the market. Technological progress also implies corresponding changes in consumer preferences and ultimately contributes to the continuous rearrangement of competitive correlations in business relationships.
- **Moral conventions and social values—**Social culture, as it is expressed by the set of unwritten rules that govern the behavior of individuals, constitutes an important factor of the general business environment. Manners, customs and social values determine to a significant degree the sensitivity of ordinary people, and influence them in the selection of goods and services, as well as of behavior patterns. Social values and beliefs also influence employee attitudes towards the company.
- **Political climate—**The degree of political stability prevailing in a place has a significant effect on business activity. The frequent changes in government, especially when they occur under abnormal political conditions, result in social and economic unrest. Political instability and uncertainty interposes serious obstacles to the process of entrepreneurial programming. Programming is based on predicting the future, but under conditions of uncertainty any prediction becomes extremely difficult, if not impossible.
- **Laws** and **Constitution—**The Constitution, as the supreme law of any country, sets the general operating rules for the three branches of government (legislative, executive, judicial) and enshrines the fundamental civil rights. The rule of law is a system that governs social coexistence and determines the behavior and relationships of members of society. It also largely determines what may or may not affect businesses, as well as the course of action to be imposed. The formation of the upper administrative organs of the company, its tax liabilities, its relationship with the staff and, in many cases, the quality of goods or services offered as well as their prices constitute an object of legislative regulation.
- **Population—**The population of the area where the company has facilities and operations directly affects its survival and development. The company size is decisively influenced by the population size. Apart from the overall population size, another element, which should be investigated and taken into account by the company, is the population structure based on socio-demographic variables such as age, sex and social class.
- **Natural wealth—**The abundance of natural wealth in a country also determines economic growth and prosperity to a significant degree. Natural wealth mainly includes iron ore stocks, petroleum, forest wealth, fertile soil, rich fishing, etc; it constitutes the basis for the development of primary production. The primary production boom in one particular region creates optimal conditions for the

development of businesses belonging to the two other types of production, namely, the secondary and tertiary production.

The effects of general entrepreneurship in the long term cannot be doubted, while on a short-term basis the degree of their influence is not easy to determine. That is why the attention of executives should, in principle, be focused on the identification and evaluation of factors constituting general entrepreneurship.

The basic factors that constitute general entrepreneurship are the following:

- **Competitors—**For every business all other companies- or not- whose interests conflict with its own are competitors. There are also cases where competitors have converging interests: this phenomenon has been called **cooperative competition** (co-opetition) (Brandenburger et al. 1996; Carayannis and Alexander 1999a, b). The executives involved in competition matters should carefully evaluate all relevant information gathered. The most obvious field favoring the development of competition is the effort to attract consumers. Information on methods used and measures taken by the competitors to attract clients is fairly easy to assemble: a high percentage is by rule included in advertising spots. Competition also occurs in other sectors of activity such as sourcing raw materials that are insufficient, used technology, and conducting scientific research. Information gathering about these areas is far more difficult.
- **Customers—**The sound of the word "customer" brings to mind the person using the company's products to meet their needs. However, in reality, a chain of intermediaries intervene between a particular firm and the end consumer of its products. The gathering of information, aiming at obtaining and maintaining clientele, is sought in various ways. The most common are: market research, using various lists of organizations or individuals (who use specific goods because of occupation or profession) and periodic reports submitted to the company by specialized partners. Client handling is considered as one of the most serious problems of modern business. Some businesses are forced to establish special promotional programs addressed to customer categories. Nevertheless, consumer demand for greater convenience and better service makes the problem even harder.
- **Suppliers—**The term supplier in its broadest sense includes any other firm, organization or individual from which the company obtains everything it needs for its business: banks and credit institutions supplying capital, providers of maintenance and repairs services for buildings and mechanical installations, employment offices for personnel search services, magazine publishers, professional information providers, etc. The structuring and proper functioning of a system, ensuring the uninterrupted flow of the constituent elements mentioned above, has significant direct effects on its success. It is Important to avoid reliance on sole or single source suppliers of materials or services. The initially "good" supplier may stop being cooperative at any time, making the existence of an alternative plan necessary.
- **Professional associations—**This type of associations exercises control or regulatory influence on the company's activity. Examples of such associations are trade associations as well as associations of doctors, pharmacists, insurance

companies, landlords, etc. These associations are legislated to protect consumers from infractions and exaggerations of businesses, but also to ensure harmonious coexistence between companies.

- **Pressure groups—**These groups are composed of people with shared sensibilities and common interests and seek to impose restraints on illegal or unethical business activity. The anti-smoking movement, associations for the protection of the environment, for the equality of the sexes and for the protection against arbitrariness of public bodies could be examples of such pressure groups.
- **Unions of employees—**These unions are associations of employees, established as a body that operates legally and has negotiating rights with the leadership of a company, on issues concerning their members. But even their informal setup and presence is powerful and influential.
- **Partner Enterprises—**Businesses often work together to pursue targets that cannot be achieved by individual companies. In these cases additional problems are created, related to organization and coordination of the joint effort, use of equipment, individual costs, preservation of industrial secrets, etc.

6.3 Sustainable Entrepreneurship

Sustainable Entrepreneurship is defined as:

> *'The creation of viable, profitable and scalable firms that engender the formation of Innovation Networks and self-replicating and mutually enhancing Knowledge Clusters leading towards the so-called Robust Competitiveness (Carayannis 2005, 2006, 2007, 2008, 2009, 2010).'*

Robust Competitiveness is understood as "a state of economic being and becoming that avails systematic and defensible **unfair advantage** to the entities that are part of the economy. Such competitiveness is built on mutually complementary and reinforcing low, medium and high technology, public and private sector entities (government agencies, private firms, universities and non-governmental organizations)" (Carayannis and Campbell 2009) in the contexts of the **Quadruple Helix**, Innovation and Entrepreneurship.

In other words, robust competitiveness results from an emerging twenty-first-century **Fractal Innovation Ecosystem** (it is also called "Mode 3" Innovation Ecosystem, in juxtaposition with Knowledge Production Systems "Mode1" and "Mode2") (Carayannis and von Zedtwitz 2005; Carayannis and Campbell 2006; Carayannis and Ziemnowicz 2007; Carayannis 2008; Carayannis and Campbell 2009), which is defined as follows:

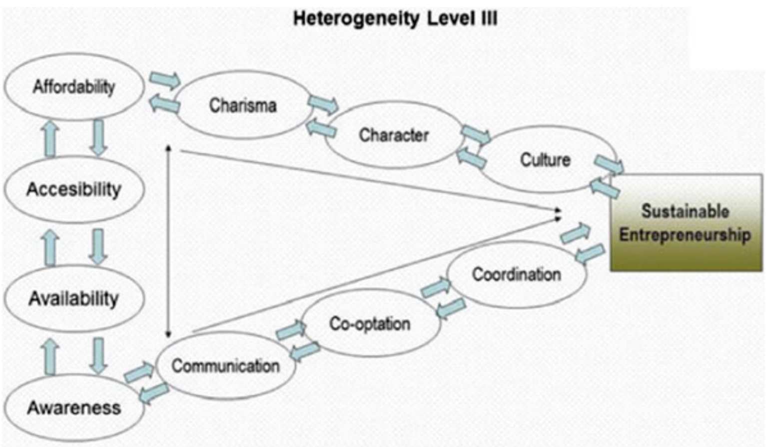
> *'A twenty-first-century innovation ecosystem is a multilevel, multimodal, multimodal and multiagent system of systems. The constituent systems consist of innovation meta-networks (networks of innovation networks and knowledge clusters) and knowledge meta-clusters (clusters of innovation networks and knowledge clusters) as building blocks and are organized in a self-referential or chaotic/fractal knowledge and innovation architecture, which in turn constitutes agglomerations of human, social, intellectual, and financial capital*

stocks and flows, as well as cultural and technological artifacts and modalities, continually coevolving, cospecializing and cooperating. These innovation networks and knowledge clusters also form, reform, and dissolve within diverse institutional, political, technological, and socioeconomic domains including government, university, industry, nongovernmental organizations and involve information and communication technologies, biotechnologies, advanced materials, nanotechnologies, and next generation energy technologies (Carayannis and Campbell 2006, 2009; Carayannis 2008).'

In Fig. 6.1 we present the major success factors for sustainable entrepreneurship, which is one of the key pillars of robust competitiveness, as discussed earlier. In particular, in Fig. 6.1 we see the strategic integration of **entrepreneurial attributes** (culture, character and charisma), **entrepreneurial skills** (coordination, persuasiveness, communication) as well as **essential components of continuous and sustainable innovation** (awareness, availability, accessibility, affordability). Lack of the above parameters should be considered as a failure factor.

Figure 6.2 depicts Schumpeter's so-called process of **Creative Destruction** and its complements (creative creation, destructive creation, destructive destruction) reciprocally substituting each other onto the **technology life-cycle curve (S-curve)**. At the same time, there is mention of Horizon and Memory as elements of a system's lifecycle to be discussed later.

Mode3 Fractal Innovation Ecosystem includes real and virtual, as well as implicit and explicit elements or knowledge nuggets (Carayannis and Gonzalez 2003). As these elements are strategically integrating and developing, they promote sustainable entrepreneurship resulting in local innovation networks and **knowledge clusters** with traits of robust competitiveness (Carayannis 2008, 2009). The elements of this system exist as substantial entities in three levels, namely, micro-, meso- and macro- levels corresponding to company, sector and economy levels.



Reprinted from Carayannis (2008b, 2009)

Fig. 6.1 Factors of success and failure for the business process (Carayannis and Kaloudis, 2008)

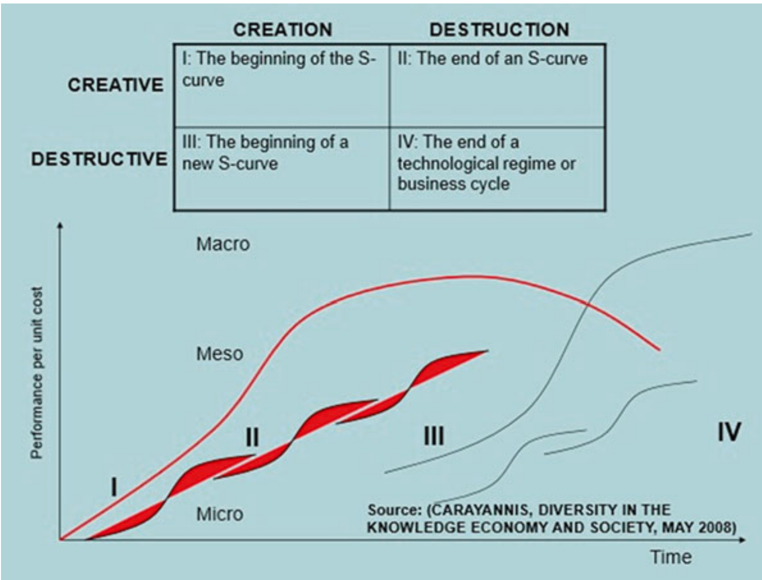


Fig. 6.2 The four types of dynamics for the evolution of business (Carayannis et al. 2008)

The structure of "MODE 3" Ecosystems for knowledge creation, diffusion and exploitation is multilateral, multimodal, multilevel and multinodal. It constitutes the basis of the conceptual determination, design and management of the real and intangible knowledge processes, namely, **knowledge-stock** and **knowledge-flow**. These concepts control, accelerate and support the creation, diffusion, sharing, absorption and use of co-specialized knowledge assets. Mode 3 is based on a theoretical systems methodology. In this methodological context, the socioeconomic, political, technological, and cultural trends and conditions lead to the creation of knowledge evolution, in parallel with the evolution of the so called "gloCal"-both global and local-knowledge economy and knowledge society.

The abovementioned is also made clear by all four types of dynamical evolution of companies, as determined by Schumpeter and mentioned in Fig. 6.2. In other words, not only creative destruction, referring to the birth, death and renewal cycle of businesses according to Schumpeter, but also the three other types, namely, destructive creation, creative creation and destructive destruction, all play an equally important role (Carayannis et al. 2008). Destructive creation represents the unsustainable business replacement. Creative creation reflects the intense and, therefore, short-lived and less sustainable form of business creation. Destructive destruction indicates the end of a specific technological paradigm, also causing the end of the company representing the technology in question. This company finds itself in a hostage situation, due to, for example, switching costs, exit barriers, or the influence exerted by powerful standards or technological legacies.

As formulated above, the **entrepreneurship career path** pursued by an individual entrepreneur can be decomposed into five unique stages:

- **Foundation—The creation and reinforcement of "entrepreneurial values" for the individual and for society as a whole.**
- **Awakening—The individual is confronted with the entrepreneurial spirit as a viable alternative among other forms of career paths.**
- **Specialization—The initial skills required for business creation are acquired and the individual is identified as being entrepreneurial.**
- **Creation—The individual moves from knowledge and learning to action. The creation of an enterprise or other valorization of entrepreneurial skills (e.g. internal entrepreneurship) is achieved.**
- **Maturation—The individual builds on his experience and advances his career through knowledge-based development and networking, as well as through external validation and valorization of his chosen career.**

An additional characteristic feature of the diagram is its self-reinforcing feedback mechanism, which underlines the fact that there is constant interaction between the entrepreneur and his environment. This interaction is temporal, as it is the case, for example, between "mature" and young potential entrepreneurs.

This framework corresponds to what has recently been suggested by Albert and Marion (1997) in the diagram below, with the stages of foundation and maturation having been added. It reflects our conviction that **entrepreneurial education** is involved not only with the individual but with society as a whole. The analysis offered by Albert and Marion is adapted to a society in which entrepreneurial values are well entrenched. For instance, the awareness phase is being described taking into account questions of the type "why should I be an entrepreneur?" However, in some cultures, this question is not examined at all. Moreover, the maturation phase introduces the concept of lifelong learning, as well as of the fact that the process of education should reinforce the value of entrepreneurial spirit (see Table 6.1).

Table 6.1 Training in entrepreneurship (Albert and Marion 1997)

Action	Level	Goals	Teaching methods
Awareness	Primary Secondary University	Developing autonomy and initiative Answer to the question: why should I become an entrepreneur?	Microprograms, case studies, interviews with entrepreneurs, industrial simulations, business-plan-competitions
Specialization	Secondary University	Understanding of entrepreneurial diversity Answer to the question: what should I do to become a successful entrepreneur?	Specialized courses, real case examples, business programs
Experimentation	Secondary University	Give students permission to work on their own programs or inactive enterprise projects	Realization of a program

Some additional issues of interest for the entrepreneur are discussed below.

- **Risk taking—**In general, an individual is discouraged or prevented from risk taking. Hofstede's well-known and widely cited articles, on aspects of culture influencing business behavior, suggest that the French culture for instance, is a culture of uncertainty avoidance with high levels of risk aversion. The reaction of the French government to this attitude is not to encourage a slow paced engagement in risk taking, but to reduce the risk associated with entrepreneurial creation. This is achieved by giving the entrepreneur additional benefits and guarantees that substantially reduce entrepreneurial risk. As stated by Marc Giget, "… risk taking by an entrepreneur, who is certainly naively optimistic, is discouraged by family and social environment."
- **Failure—**As most entrepreneurs know, failure is a prerequisite to success. If you want to succeed, you need to fail. However, acceptance of failure is not always the "norm" in the French, or even more widely, in the Mediterranean culture: a start-up failure can have severely negative effects on an individual's future.

This lack of acceptance of failure in these cultures prevents people from becoming entrepreneurs. In order to change the attitude of the entrepreneur towards failure, the social opportunity cost (SOC) of job creation should be taken into account while evaluating the wide range of business and job creation strategies. This would be of utmost importance as the SOC of job creation is highly dependent on the economic values in a given labor market. These values are, in turn, influenced by labor market distortions, which are caused by unavoidable fluctuations in the tax systems, unemployment insurance benefits, etc. Consequently, if aspiring entrepreneurs assume that there is really no economic form, and, hence, no labor market completely free of distortions, then they are far more open minded and disposed to handle failure in general, or expect a reduction in future income flows caused by existing distortions.

- **Motivation—**In North America, most entrepreneurs are very goal oriented, meaning that they are internally motivated rather than externally motivated. This is a prevailing incentive in the United States and Canada, where individual integration is encouraged. However, this is not true in France or in other European countries, where more emphasis is given to the community and the group. Therefore, there is a strong need for individuals in these areas to feel that they belong to a group with a good outer image. It is hard to imagine that there are many French people who would like to have a single goal achievement in business. Especially when one considers that money is not the most important thing. According to François Hurel, the general representative of APCE, "The higher the ranks of a person, the less are the possibilities for them to start a business. This situation has been proven throughout history. For a long time, business creation had the purpose of creating general public benefit. From the nineties onwards, we have discovered the economic advantages."

Therefore, if business activity is to grow in France, it is important to emphasize the collective benefits of this activity: the growth of a business should go hand

Table 6.2 Trust in the workplace (Schindler and Thomas)

Dimensions of trust	Description
Integrity	Honesty and truthfulness
Competence	Technical expertise, knowledge and interpersonal skills
Consistency	Credibility, good judgment in handling situations and operating with a degree of predictability
Loyalty	Willingness to protect and save face for others
Openness	Willingness to share ideas and information freely and openly

in hand with the growth of general welfare. The development of associations and networks that can work together is equally important for an entrepreneur, in order to be part of a group and meet the cultural need to belong to a team. But who will have the responsibility to ensure that this marketing and business networking actually takes place in a collective society, the answer may seem obvious, but is it?

- **Trust and relationships—**The differences between entrepreneurship in France and businesses in America reflect the great difference between these two cultures, concerning the conceptualization of the element of trust as a social construct. Schindler and Thomas identified five dimensions of trust in their work "The Structure of Interpersonal Trust in the Workplace", Psychological Reports, October 1993. These five major components based on the North American value system are listed in Table 6.2 in order of importance. In other words, Integrity is considered the most important dimension of the element of trust, considering that the other four dimensions were worthless without this first component. Openness is important, however not to the same degree as the other four.

6.4 The Model of the Learning Lifecycle and the Learning Strategy

'Qu'est-ce qu'apprendre? En francais, le mot ap-prendre signifie à la fois 's'instruire' (learning, lernen) et 'instruire' (teaching, lehren)… L' ambiguite est par elle-meme significative: en effet, il n'y a peut-être pas d'opposition absolue entre celui qui instruit et celui qui s'instruit; parfois, c'est le meme homme'

'What is learning? In French, the word "learning" means both "teach" and "learn". This ambiguity is important in itself: in fact, maybe the difference between teacher and student is very little, if any'.

[Olivier Reboul 1999]

The learning strategy suggested for entrepreneurship is designed to positively influence the effectiveness of knowledge transfer and maximize the cognitive absorptive capacity and peer-to-peer knowledge and experience transfer. It will also highlight the many aspects of active and experiential learning as well as its dimensions (process, context, content, impact) (Carayannis et al. 1998, 2000, 2001). Moreover, the nature, dynamics, and impact of relationships such as **master-apprentice** and

mentor-protégé as well as of peer learning will be empirically explored and inserted in the suggested **Model of the Learning Life Cycle (LLM)** (Carayannis et al. 2001). This model consists of the cognitive, behavioral and physical development stages of the human lifecycle, namely, **Fetal, Growth, Maturation, and Stagnation/Fall**. A precondition for the design of our Learning Strategy is that the different approaches to learning are not best suited to each and every stage of the LLM. Therefore, learning among peers may be more appropriate for the initial and advanced stages: people at these stages appear to be more receptive to their peers, maybe because they have either too little or too much experience and cognitive, behavioral, and physical maturity. In the middle stages, the master- apprentice approach may be best suited for the growth stage. In this stage, maturity occurs but is not yet sufficient or enough to allow for a more laissez-faire policy, like the mentor-protégé approach, which matches better with the maturation stage. In short, LLM depicts estimations of learning requirements and the constraints imposed by pedagogical principles and human upbringing.

6.4.1 Environmental Context

If you talk to French people about entrepreneurship in their country, you quickly realize that positive entrepreneurial values are missing in France. Where does this negative view come from? How likely is it for this perception of entrepreneurship to change in France, as well as in other European countries?

The lack of interest in entrepreneurship in the Schools of Economics in France is evident. In the Entrepreneurship Center of ESCEM (Ecole Supérieure de Commerce Et Management—School of Business and Management) in Paris, just a handful of the two thousand students are really specializing in entrepreneurship. A situation like this is fairly typical in Schools of Economics in France.

We interviewed students there and discussed the reason for this lack of interest with them. One of the most common answers was the attitude of society towards the entrepreneur. The entrepreneur is seen as greedy and selfish with the ultimate goal to make money at the expense of others. Instead of seeing business startup activities as beneficial for society, a French student may suggest that when entrepreneurs start new businesses, they take customers and sales of existing firms for granted. Another reason given is that entrepreneurship is too risky. In France, individuals who fail as entrepreneurs are stigmatized as mega-losers for the rest of their lives. Moreover, entrepreneurship offers a ‘real ‘job to those who have failed elsewhere. The young business students also consider that entrepreneurship is for those who already have a great experience in business and not for someone who is just starting a company. Furthermore, students find it very difficult to raise **seed capitals** for a new business: would a bank or an investor lend money to a young business graduate with little work experience? In addition, bureaucracy is a serious hindrance to starting new businesses and, last but not least, high taxes and bankruptcy risks are also responsible for the lack of interest in entrepreneurship.

6.4.2 Learning Strategy

While analyzing the LLM above, we discussed environmental, guiding and inhibiting factors influencing entrepreneurship. In this context, it is suggested that the 'specialization stage' would be more beneficial for tertiary education students and would definitely reinforce their entrepreneurial values, if positive values were taught at a younger age, that is, in the elementary or secondary school (see Fig. 6.3 and Table 6.3).

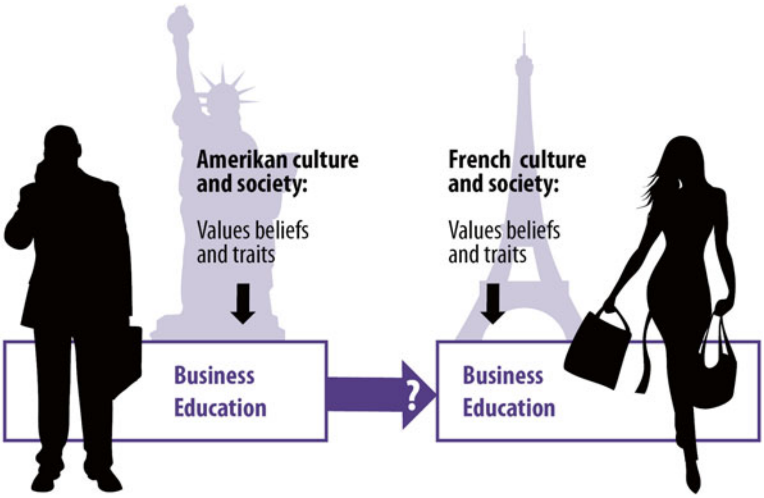


Fig. 6.3 Effect of entrepreneurial learning environment of America in France (Carayannis 2002, Cross-culture)

Table 6.3 Factors influencing entrepreneurship (Carayannis 2002)

FACTORS		COUNTRY	
		Entrepreneurship of North America	Business in France
	Private	Independent	Independent
		Same-start	Same-start
		Internally Driven	Internally Driven
		Honestly	Relative
	Environmental	Independent	Considers Community (property)
		Same-start	Does the control
		Internally Driven	Risk-averse
		Honestly	Industrial laws discourage business
			Does faith in relationships

As a result, young students would develop and consolidate a more positive attitude towards the value of entrepreneurship for society and the individual. In general, the learning strategy should move beyond traditional educational models allowing students to be active participants in their learning and lead the way or, in other words, become teachers, when necessity calls.

6.5 Incubators

6.5.1 What is a Business Incubator (BI)?

Business Incubators are organizations that provide protective environments and support for business start-ups. There is competition both among incubators and against consulting firms or real estate consultants. All of them strive for the highest ranking of the toplist, based on the value of the companies they host: the higher the equity valuation of an incubatee that exits an incubator's programs, the hotter the emerging startup and the higher the rank for the incubator in question.

Incubators vary and may be differentiated based on the different fields of their activity, which lead to different competitive scope, and different strategic objectives and services offered. According to Porter (1986), we distinguish four different fields of incubator activity or elements of competitive scope:

Vertical scope—Along with venture capitalists, business angels, consulting firms and institutional investors, incubators provide financial and administrative support for startups. Incubators try to differentiate themselves from business angels concerning guidance services offered. Although they target early startup stages, they are unlikely to focus on day-old entrepreneurs. Venture Capitalists are often external partners or customers of successfully built start-ups that participate in incubation programs. Taking the above into consideration, incubators serve as startup handling agencies for venture capitalists and institutional investors.

Segment scope—The actual source of start-ups may constitute another direction and scope for incubators. University Incubators, for instance, typically prefer faculty students and staff entrepreneurs from their host university to outsiders. Company-internal incubators would prefer company employees to outside entrepreneurs, like the Brightstar (BT) Incubator that offers its services to employees of BT only. Some independent commercial incubators rely on incubator people, a team of idea generators for startups, but this model depends highly on the creativity of the minds behind the incubator. Other incubators tend to keep their doors open to a variety of sources.

Geographical scope—Geographic focus is a natural competitive factor for regional business incubators, since their mission is to support new businesses locally. Network access is a critical element of successful budding and, given the fact that networks are usually limited to a certain region, many incubators are trying to establish a strong local presence. The exceptions here are some home company-internal incubators, where networking among tenant companies is more important than the regional network and many virtual incubators, which structure their business models based on the variety of start-ups, rather than on a particular geographical focus (Carayannis and von Zedwitz 2005).

Industry focus—Information technology, internet software and biotechnology services are typical examples of industries for hot startups in incubators. Incubator programs are focused on industries that are big enough to make the effort and expense worthwhile. In most of the cases, the selection of a particular industry niche or sector focus area depends on the professional abilities and preferences of incubator managers and aims to create partnerships between budding entrepreneurs. The chosen focus area may be another differentiating factor resulting to competitiveness of incubators. University incubators also focus on specific technologies, but their choices are determined by the size of the infrastructure investment or the reputation of academic departments. The Boston University international incubator program for instance, which focuses on the photon and optoelectronics, has invested approximately one hundred million dollars to install cutting-edge infrastructure for research and experimentation.

The four dimensions of competitive scope elaborated above help us explain not only how incubators differ from other startup "supporters", but also how to differentiate among them. Therefore, an important distinction can be made based on strategic objectives of incubators, regarding their attitude towards sponsoring startups: is it for-profit or non-profit? This differentiation is more accurate than any superficial academic distinction, as it has full repercussions on the definition of the incubator's operational model and the implementation of the entrepreneurial plan. The wide range of competitive foci and strategic objective has led to many types of incubators that offer clients specific benefits. Most common incubator archetypes are:

1. Regional Business Incubators
2. University Incubators
3. Independent Commercial Incubators
4. Company-Internal Incubators
5. Virtual Incubators

A report of these archetypes and a more complete analysis in Carayannis and von Zedwitz (2005). The first two types are generally non-profit oriented, while the last three have **strong profit motives**. All types have differences in competitive focus, options or opportunities. Figure 6.4 illustrates the correlations of competitive scope and strategic objective on the basis of incubator archetypes. The competitive focus axis includes the three competitive scopes: industry, geography and segment. The strategic objective axis differentiates between the specialisms of incubators as reflected in their profit orientation: for- profit incubators give priority to efficiency, setting it as their initial strategic objective; non-profit incubators usually set the fulfillment of a public mission as an initial goal. Regional incubators engage in setting and planning goals only indirectly connected to operating profits, such as employee retention, innovation capacity building, or stock assessments. Although the strategic goals of a non-profit incubator are also profit-seeking on the long run, profits are often concentrated outside the incubator by a parent company or a sponsor, and the

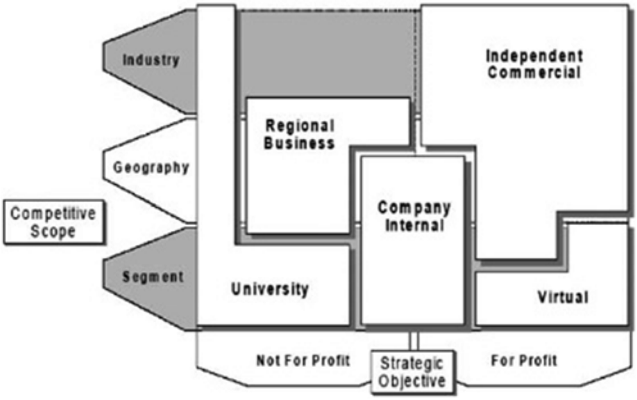


Fig. 6.4 Different strategic objectives and competitive arenas defined five incubator archetypes (Carayannis and von Zedwitz 2005)

contributions of the incubator are difficult, if not impossible to calculate. Internal sustainability goals are relatively recent trends for most non-profit incubators.

Most incubators can be connected to one of the five archetypes, although some incorporate the elements of two or even three incubator archetypes. University incubators usually have no economic pressure for financial returns, but focus on being of service to the scientific community in the university. Regional business incubators serve a local community and their goal is to create jobs and support local entrepreneurship and wealth. Independent commercial incubators are profit-oriented, and often focus on a particular technology or industry in order to succeed. Virtual incubators are also for-profit but they are oriented towards the special needs of the business community rather than a particular industry. Company-internal incubators are harder to classify, partly because their mother companies have strong corporate goals: the internal incubator serves (internally and externally) political interests as well as corporate growth objectives. Obviously, these different goals and sources of competitive advantage have specific consequences on incubator business models. (Carayannis and von Zedwitz 2005; Carayannis et al. 2006).

6.5.2 Determination of the Five Incubator Services

Entrepreneurs need business facilitation services such as financing, office space, Information Technology (IT) infrastructure, leadership, etc., provided by consulting firms, real estate companies and other service provider agencies. The following are identified as five core incubator services:

1. **Access to physical resources—**Incubators offer office space, furniture, sports facilities, a computer network, twenty-four hour security, and other amenities

relative to physical infrastructure and real estate. Low performance Incubators focus too much on their role as owners, neglecting other services described further. In this area, incubators compete with science and technology parks and sometimes real estate companies.

2. **Office Support—**In addition to infrastructure, incubators also offer office support such as secretarial and reception services, computer network support and accounting support. These services surely do not qualify as complex or technologically advanced, but they ensure the existence of basic organizational resources and save time and effort for entrepreneurs, who are willing to move too far too fast. While these services can be taken for granted when functioning well, the lack of Technological Information may constitute an obstacle.
3. **Access to financial resources—**Incubators also provides access to venture capital that is usually a combination of private equity and external capital invested by business angels, venture capitalists or local institutions and companies. Generally, incubators target early stage and start-up. Natural competitors are angel investors as well as early stage venture capitalists and investment companies.
4. **Entrepreneurial startup support—**Entrepreneurs may be strong in technology and business vision but they usually have poor organizational, administrative and legal skills. Incubator mentors provide mentees with all the business basics in order to guide them through the steps a startup needs to take. New tenants are given all the necessary support in the business plan process through professional services such as accounting, and legal advice on integration and taxation issues. Incubatees are also assisted while formulating the structure of employee ownership and selection plans. Highly valued administrative support is also provided to help entrepreneurs develop management and leadership skills, and learn how to use them. Many incubator managers, however, are not in a position to offer real added value to the initial guidance, resulting thus in competition with accounting and consulting firms during this launching or initial phase.
5. **Network access—**Successful incubators exert positive influence on new entrepreneurs trying to build and grow a successful startup. As a matter of fact, entrepreneurs are unlikely to have in their possession an incubator's networking system that takes years of effort to be created. Incubators can bring significant people in the startup: a prospective customer, a brilliant programmer of cutting edge software, a new General Company Director, a venture capitalist interested in investing. Access to these networks is also sometimes granted to companies by human resource, consulting firms, business angels or networking organizations.

"What" or the actual service mix depends on the focus of the BI as well as the needs and preferences of the incubatees". An agreement developed between the entrepreneur and the incubator would definitely describe this actual mix of services. Some incubators offering all five services described above are called incubators in the strong sense of the word; some others offering only four of them are called incubators in the weak sense of the word. The organizations offering even fewer than four of these services would consequently miss too many hatching elements to be called incubators. It is at this point that startup accelerators, technology transfer offices, entrepreneur mentoring programs or accounting firms are employed.

References

Albert P, Marion S (1997) Ouvrir l'enseignement à l'ésprit d'entreprendre

Brandenburger AM, Nalebuff BJ, Nalebuff BJ, Brandenburger A, Maulana A, Nalebuff B, Brandenburger AM (1996) Campus-Verlag, 1996. 201

Carayannis E (1993) Incrementalisme Strategique, Le Progrès Technique, no. 2, Paris, France

Carayannis E (1994a) A multi-national, resource-based view of training and development and the strategic management of technological learning: keys for social and corporate survival and success. In: 39th International council for small business annual world conference, Strasbourg, France, June 27–29

Carayannis E (1994b) The strategic management of technological learning from a dynamically adaptive high tech marketing perspective: sustainable competitive advantage through effective supplier-customer interfacing, University of Illinois, Chicago/American Management Association Research Symposium on Marketing and Entrepreneurship, Paris, France, June 29–30

Carayannis E (1994c) Gestion Strategique de l'Acquisition des Savoir-Faire, Le Progrès Technique, no. 1, Paris, France

Carayannis E (1998a) The strategic management of technological learning in project/program management: the role of extranets, intranets and intelligent agents in knowledge generation, diffusion, and leveraging. Technovation 18(11):697–703

Carayannis E (1998b) Higher order technological learning as determinant of market success in the multimedia arena; a success story, a failure, and a question mark: Agfa/Bayer AG, enable software, and sun microsystems. Technovation 18(10):639–653

Carayannis E (1999) Fostering synergies between information technology and managerial and organizational cognition: the role of knowledge management. Technovation 19(4):219–231

Carayannis E (2000–2009) GWU Lectures

Carayannis E (2001) Learning more, better, and faster: a multi-industry, longitudinal, empirical validation of technological learning as the key source of sustainable competitive advantage in high-technology firms. Int J Technovation

Carayannis E (2002) Is higher order technological learning a firm core competence, how, why, and when: a longitudinal, multi-industry study of firm technological learning and market performance. Int J Technovation 22:625–643

Carayannis E (2008) Knowledge-driven creative destruction or leveraging knowledge for competitive advantage: Strategic Knowledge Arbitrage and Serendipity (SKARSE) as Real Options Drivers (RODs) triggered by co-opetition, co-evolution and co-specialization (C3). J Ind Higher Edu 22(6):343–353

Carayannis EG (2009) Firm evolution dynamics: toward sustainable entrepreneurship and robust competitiveness in the knowledge economy and society. Int J Innov Regional Dev (1)3: 235–254

Carayannis EG, Alexander J (1999a) To intellectual capital in co-opetitive research and technology management settings. Int J Technol Manage 18(3/4):326–352

Carayannis E, Alexander J (1999b) Winning by co-opeting in strategic Government-University-Industry (GUI) partnerships: the power of complex, dynamic knowledge networks. J Technol Transfer 24(2/3):197–210, August. Note: Awarded 1999 Lang-Rosen Award for Best Paper by the Technology Transfer Society

Carayannis EG, Campbell DFJ (2006) A "'Mode 3' Systems Approach for Knowledge Creation, Diffusion and Use: Towards a 21dt Century Fractal Innovation Ecosystem", re-discovering schumpeter: creative destruction evolving into 'Mode 3'. In: Carayannis EG, Ziemnowicz C (Co-Editors) Chapter 7, Palgrave Macmillan

Carayannis EG, Ziemnowicz C (2007) Co-editors, re-discovering Schumpeter: creative destruction evolving into 'Mode 3'. Macmillan, Palgrave

Carayannis E, Campbell D (2009) "Mode 3" and "Quadruple Helix": towards a 21st century fractal innovation ecosystem. Int J Technol Manage 46(3/4):201–234

Carayannis E, Gonzalez E (2003) Creativity and innovation = competitiveness? When, how, and why. In: Shavinina LV (ed) The international handbook on innovation, Part VIII, Chapter 3. Elsevier Press, Oxford

Carayannis E, Maximilian von Zedwitz (2005) Architecting GloCal (Global – Local), Real-Virtual Incubator Networks (G-RVINs) as catalysts and accelerators of entrepreneurship in transitioning and developing economies: lessons learned and best practices from current development and business incubation practice. Int J Technovation 25(2)

Carayannis E, Rogers E et al (1998) High-technology spin-offs from government RandD Laboratories and Research Universities. Technovation 18(1):1–11, January. NOTE: 1998 Recipient of two Emerald Management Reviews Citations - Citation of Excellence for Practical Implications and Citation of Excellence for Originality

Carayannis E, Kassicieh S, Radosevich R (2000) Strategic alliances as a source of early-stage seed capital in technology-based firms. Technovation 20(11):603–615

Carayannis E, Alexander GJ, Geraghty J (2001) Service sector productivity: B2B electronic commerce as a strategic driver. J Technol Transfer 26(4):337–350

Carayannis EGD, Popescu CS, Stewart M (2006) Technological Learning for Entrepreneurial Development (TL4ED) in the Knowledge Economy (KE): case studies and lessons learned. Technovation 26(4):419–443

Carayannis EG, Assimakopoulos D, Kondo M (Co-editors) (2008) Innovation networks and knowledge clusters: findings and insights from the US, EU and Japan. Palgrave Macmillan

Drucker PF (1998) The discipline of innovation, Harv Bus Rev 63(3):3–8 Drucker PF, 1998

OECD (1996) The Knowledge based economy, OECD, Paris

Porter ME (ed) (1986) Competition in global industries. Harvard Business School Press, Boston

Schumpeter JA (1934) Theorie der wirtschaftlichen Entwicklung. Duncker and Humblot, Berlin (reproduced 1997)

Smith, A. 1776 [1977]. An inquiry into the nature and causes of the wealth of nations. Chicago, University Of Chicago Press

Chapter 7
Entrepreneurship and Innovation Practices

7.1 Technology Management and Transfer

7.1.1 General

Technology and Technology Transfer are concepts that have a high degree of complexity surrounding them, so it would be quite difficult to establish a precise definition for these terms. Technology Generation and Diffusion are processes deeply dependent on the socio-economic structure. In fact, technology may take various forms, ranging from non-embodied technology (patents, licenses, ideas, know-how, etc.) to technologies embedded into mechanical systems, machines, or even into the human body. Technology Transfer Mechanisms vary even more, since different forms of technology can be transferred through different channels. Consequently, the variety of technology types along with the complexity of their transfer processes creates serious problems concerning the quantification and study of the results and effects of technology, on society in general or on the industry sector, in particular.

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7.1.2 Technology

In a context where conceptual confusion prevails, as to what technology really is, it would be interesting to refer to some previously established definitions of the term, later in this subsection. The attempted definitions of technology, however, will simply highlight how inconsistent and largely unsuccessful the results of these efforts were.

It should be made clear that technology is the accumulated specific knowledge that gives a manufacturer the ability to produce a product, in other words it is the know-how: technology is a body of knowledge. The process of manufacturing a product is considered to be the proven technique. As pointed out by Emmanuel (1980), techniques substitute each other, while technologies are constantly growing and expanding.

By definition, technology presents certain peculiarities, either of its perception or of its synthetic components. Therefore, technology can be:

1. Specific and distinct for each firm: as each company has its own way of acquisition and accumulation of technological knowledge, firm characteristics have significant effects on the technology that is developed.
2. Often involved in problem solving: the knowledge gained by addressing issues and problems that occur often leads to an improvement of the existing technology.
3. Possessing a systemic dimension: technology depends on all the individual elements it is composed of and their change affects the overall performance of the technological system.
4. Affecting procedures deeply entrenched in the social process: technological change is an ideal agent of social change.
5. Exhibiting cumulativeness: the technological knowledge gained at any time is added to the existing and this process is repeated again and again.
6. Allowing interchange of continuity and discontinuity: a technology (e.g. product manufacturing) builds on previous, improved technologies (continuity), but the emergence of another different technology may completely eliminate the former (discontinuity).
7. Possessing Corporate Memory and exhibiting Historicity: related to the above-mentioned continuity/discontinuity. The growth path that has been followed by a company largely determines the company's future.
8. Creating new business opportunities and venues, but also inverting familiar norms: the development of a technology can create new sectors of economic exploitation that did not exist before, but also make others shrink or disappear.
9. Involving risk and uncertainty: both have to do with risks occurring during the development of a technology. For example, the product of a technology may not be successful, thus causing regrets over wasted resources, missed opportunities, or undesirable results.

Multiple definitions have emerged describing "technology", overtime:

The **National Curriculum Council of United Kingdom (1993)** defines technology as the creative application of knowledge, understanding, and skill in designing and making quality products.

In a report of **EIRMA (European Industrial Research Management Association)** technology is defined as the means by which knowledge, science, and discoveries are applied to produce goods and services.

Pitono believes that technology is a combination of the four key elements below that interact with each other:

- **Techno-ware:** machinery, apparatuses, tools, means of production, etc**.**
- **Human-ware:** abilities, skills, industriousness, resourcefulness, etc.
- **Info-ware:** facts, data, observations, theories, plans, etc.
- **Infra-ware:** administration, organization and production systems, structures etc.

As mentioned above, technology is the knowledge, experience, skill, and dexterity required to produce beneficial products or services. Technological advances can be considered a necessary precondition for economic development, improvement of living and working conditions and satisfying human needs.

Rogers (1983) defined the technology concisely as follows**:**

'… technology is a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome'.

We adopt the following working definition for Technology:

'Technology is a word with Greek roots that in free translation means the logic or method of an art. Technology is the art of science and the science of art in its etymological origins, namely the words "art" and "reason", and recommends a systematic, structured and creative solution with predictable and controllable behavior [Carayannis 1994–2009, RPI/UNM/GWU Lectures; Carayannis et al. 1998; Carayannis 2001; Carayannis and Gonzales 2003]'

Solow and Hogan (1957) estimated that 90 % of the increase of the Gross National Product (GNP) per man-hour can be attributed to imported technology.

In the history of global industrialization, the development of technology has been the main factor of economic growth for developing countries, while technology transfer has been of great importance both for developed and developing countries. Technology transfer has always played an important part in establishing new industries all over the world, by creating new economic activity in both local and international markets. As a result, trade relations as well as transport and communication between countries have grown stronger, and technology transfer can be seen as a 'bridge' trying to narrow the big wealth gap between developed and developing countries.

7.1.3 Technology Transfer

The term Technology Transfer (TT) also called Transfer of Technology (TOT) is defined in the following ways:

According to the United Nations Conference on Trade and Development **(UNCTAD),** 1976:

'Transfer of technology means introducing certain technological factors from developed to developing countries allowing the latter to set up and run new production facilities and expand the existing.'

Brooks (1981), states that:

Technology transfer may be described as the process by which science and technology are diffused throughout human activity. In cases when systematic, rational knowledge developed by one group or institution is embodied in a way of doing things by other institutions or groups, technology transfer may be said to have taken place. Gruber and Marquis (1969) have defined technology transfer as:

…the utilization of our existing technique in an instance where it has not previously been used.

According to Cooper and Sercovitch (1971):

'Technology transfer covers the transfer, from developed to developing countries, of know-how data that are usually necessary for the organization and operation of new production facilities and are rarely used (if ever) in developed economies.'

In Rubenstein (1976):

'Technology transfer generally involves the transfer of a capability to not only use, but also to adapt and modify and, in many cases, to innovate with respect to a product, process, piece of equipment, or field of technology (broad and narrow).'

According to **Islam** and **Kaya** (1985):

'Technology transfer is a process through which technical information and development that emerge from an institutional environment are adapted to operate in another. It implies the adaptation of a new technology to a different environment through creative transformation and practical application.'

Hoffmann (1985) defines it as:

'…the country's technological capacity as the object of the transfer process, given that the transfer of knowledge improves a country's technological capacity.'

In Kaynak (1985) are:

'…the transmission of know-how to suit local conditions, with effective absorption and diffusion both within and from one country to another.'

Finally **Appleton** (1991) defines it as:

'The exchange of an ability, along with the thinking behind this ability, in order to enrich existing capacity and to support organizations in developing countries using their own projects and development efforts.'

The overall conclusion is that technology transfer occurs when an established technology moves from one operational environment to another, where it comes into effect. This transfer involves the movement of technology from one area to another and vice versa.

Prominent among the various dimensions of transfer is the functional definition given by Enos (1988). In the case study of Enos and Park (1988), the technology transfer process is conducted in six stages, according to the function of the activities carried out by the recipient firms at each stage: determining the needs; surveying the alternative technologies and the alternative supplies; choosing a particular combination of technology and supplier; absorbing the techniques in their first application in the importing country; disseminating the techniques throughout the economy; improving upon them; and developing new and superior techniques through research and development in the importing country itself.

Numerous definitions have been reported related to the transfer of technology. This book elaborates on the bilateral trade between two countries for technology purchasing. Reference is made to technology embodied in capital goods such as machinery or facilities, and to new labor-saving technology embodied in industrial sectors transferring tasks from humans to machines, including skilled workers, engineers, managers or even administration bodies. In this piece of work we are not interested in the technology used for military purposes. However, if this technology is adjusted for political purposes and for research in strategic implementations, it may generate peaceful uses of technology, drawing our attention to the growing importance of Dual-Use Technologies (Carayannis 2001).

Thus the term technology transfer may generally be defined as know-how transfer suited to local needs, with simultaneous absorption and diffusion within the limits of a country or company. However, the definition of a concept such as technology transfer presents no interest whatsoever, since any potential definition will always be far from reality. Technology transfer should be approached based on substantive criteria, rather than on any definition given. The benefits of successful technology transfer are so many that its definition takes second place. Below, we will try to explain what the actual essence of technology transfer is, its relationship with technology (as a general concept) and the forms of technology transfer today.

Initially, before proceeding further, it is necessary to make a distinction. Technology transfer is not an automatic process in which the positive results come by themselves. The technology recipient, whether it is a country or company, should make an endogenously determined effort, so that the transferred technology can achieve the desired results. That is, the transfer of any technology is rendered useless, if the recipient is not able to use it properly and efficiently. A detailed analysis of the capabilities of the technology recipient is beyond the scope of this essay. But it is important to say that technology transfer should be treated as an integrated process that requires the attention and contribution from all the transacting parties (the owner/supplier of the technology, the recipient, the state, society, etc.)

The firm specific and cumulative nature of the concept technology, analyzes in 7.1.2 is perhaps the most important source of problems during technology transfer. This very nature of technology mentioned above makes it necessary for the sake of analysis to discuss some components of technology transfer further below.

In this book the working definition for Technology Transfer is as follows:

> *'Technology transfer is the transfer of applied knowledge from one application area – thematic, geographic, technological, functional, and corporate or institutional – to another, in order to achieve better performance and results. Examples are spin-offs, strategic alliances and Public-Private Partnerships (PPPs) in Research and Technology (Carayannis 1994a, b, c; Carayannis et al. 1998; Carayannis 2001; Carayannis and Gonzales 2003).'*

7.1.3.1 Technology Transfer as an Investment

The firm specific nature of technology causes significant difficulties in understanding technology transfer. This difficulty is manifested due to implicit (tacit) knowledge that is embedded in technology, whether technology is mature or not. Therefore, a high maturity level of a manufacturing process will not facilitate technology transfer. This is mainly due to the tacit knowledge embedded in all the standard operating procedures (SOPs) of any company. Successful technology transfer requires additional investment in learning in order to acquire the necessary tacit knowledge. The local (corporate) character of technology and technological change turns any new application into a new investment, regardless of its innovation.

Technology transfer is not only the process of transferring appropriate information and usage rights from one company to another, or simply the transfer of machinery from one place to another. Experience has shown that additional services (technical, administrative, R & D, etc.) are required for successful technology transfer. All the above mentioned presuppose significant costs, unavoidable though for the transfer and absorption of the necessary embedded knowledge.

7.1.3.2 Technology Transfer as Skills Transfer

An important part of technology is tacit and embedded in people's minds and in organizational routines. Consequently, successful technology transfer should include, in addition to technological information, the skills necessary for "in-depth" monitoring and understanding of technology. In other words, a simple technology-based business transaction would transfer only elements of a technology and not the skills necessary to develop these elements.

7.1.3.3 Technology Transfer and 'Technology Gap'

The local character of technology is connected to what we call 'Technological Distance' or 'Technology Gap', partly because technology exhibits 'sensitivity' to differences in economic, physical and social conditions. Therefore, understanding the concept of technological distance helps to explain the difficulty encountered in technology transfer to developing countries. Companies in developing countries need a broader range of technologies, especially of production know-how. The technological distance between suppliers and buyers not only determines the amount of cost and payment, but also makes technology acquisition a local process, deeply dependent on the learning path even when the technology in question is widely known and mature.

7.1.4 Technology Transfer Mechanisms

Most definitions of technology transfer do not include technology transfer mechanisms. International technology transfer is defined as a process in which knowledge associated with the conversion of revenue to expenses is accrued by an organization in a country (e.g. firms, research centers, etc.) from overseas sources. (Radosevic 1999).

There are many criteria that can be used to categorize technology transfer, but none encompasses all dimensions of technology transfer. Also, the distinction of technology transfer can be based on conventional and unconventional transfer mechanisms:

A. Conventional mechanisms	B. Unconventional mechanisms
• Foreign direct investments • Technology licensing • Joint ventures • Franchising • Marketing agreements • Technical assistance agreements • Turnkey contracts, and • International outsourcing • Personal contacts • International literature	• Reverse engineering • Brain-drain

The above distinction reveals some dimensions of technology transfer, having to do with the sources and direction of technology transfer. It would be appropriate to mention here that the distinction between the terms 'channels' and 'mechanisms' of technology transfer, as defined by Laamanen and Autio (1995) ceases to exist with the constant interaction between the two companies. See also (Carayannis et al. 1998; Rogers et al. 1998; Carayannis et al. 1997; Carayannis and Alexander 1998, 1999a, b).

Undoubtedly there are diverse classifications of technology transfer, each highlighting the different aspects of technology transfer. Our attention is focused on the official **technology transfer mechanisms**, such as **foreign direct investment**, licensing and **joint ventures**.

7.1.4.1 Foreign Direct Investment

Foreign Direct Investment (FDI) is an investment conducted outside the borders of the investor's home country but within the borders of the company making the investment. In the National Income Accounts, foreign direct investments include all cash flows, whether direct or from subsidiaries, as well as reinvested profits, fixed debt funding and mainstream equity funds. The foreign investor has full control over the technology transfer resources, and the subsidiary usually follows the firm-specific strategy of the parent company. The investment includes a 'package' of assets and intermediary goods such as capital, technology, managerial skills, market access, and business skills.

A long time ago, Multinational Companies or Corporations (MNCs) conducted their business exclusively through direct investment. In the seventies, small proprietary companies and new forms of investment made their first appearance, thereby leading to the creation of complicated types of technology transfer. Today, MNCs make different types of relationships and contracts, often referred to as agreements, of which foreign direct investment is only one part. A range of cooperation agreements including joint ventures, outsourcing, franchising, and marketing are complementary to foreign direct investment. The multinationals should act as transaction cost minimizers, by conducting separate added-value management processes, and as a driving force behind technology: whoever organizes technology is not necessarily an innovator. It should be noted at this point that the connecting link between foreign direct investment and technology transfer has become loose, due to various new types of investments that have occurred. Nevertheless, it has not ceased to exist because of the widening technology gap and the existence of extensive FDI from previous periods, in the newly industrialized economies.

The investment trend analysis of MNCs in the late twentieth century, according to (1) UNCTAD *in* 'Transnational Corporations in World Development: Trends and Prospects' New York, United Nations, 1988 and (2) the United Nations Economic and Social Council *(*UN ECOSOC1989) in 'Role of Transnational Corporations in Services, including Trans-border Data Flows' showed that:

1. There was a concentration (higher than before) of international investments in the three industry poles, United States of America (USA), European Union (EU)—European Free Trade Association (EFTA) and less in Japan, whereas in less developed countries investments were limited.
2. The well-known types of International Direct Investment (IDI), in both industrialized and non-industrialized countries, had given way to new types of investment. Those new types (subcontracting, joint ventures, etc.) did not necessarily involve funds transfer to the country of establishment but they, additionally, further reduced both investment risks and the extent of the investment commitment of international bodies.
3. In terms of sector specific guidance there was a notable shift from raw materials (as well as other sectors such as manufacturing) to services and especially in banking, insurance, advertising, consultancy, tourism businesses, etc.
4. Since the late mid-eighties a strong tendency for mergers and acquisitions was observed, either between firms in the same country or between companies of different nationalities, devising a strategy for business expansion without a need for fixed capital formation to be used for investment purposes.

Since 2007 though, there can be no doubt that the fallouts of the global financial crisis have irked investors, foreign or domestic, thus suppressing their appetite for new ventures. The dramatic changes in the global economic structure have made earlier expectations seem like impossible missions.

It has also been noted that technology transfer activities are often reduced concerning know-how, in particular, the selling of individual pieces of technical knowledge and skills to lesser developed countries. This can be explained by the fact that technology has become more sophisticated and seems to constitute an element of a general knowledge grid. This knowledge is **firm-specific** and cannot be successfully transferred if separated into pieces. In other words, the technology which is transferred has limited utility for the buyer, if it is separated from the dense set of the other nodal points of the knowledge grid that make it usable. Consequently, successful technology transfer would not constitute an integrated process (Rogers 1995) by simply moving a technology to a new environment; it also requires the transfer of the necessary knowledge, which enables recipients not only to understand the ‘function’ of the new technology, but also to use it, in order to build their company’s capabilities and eventually create a tangible benefit.

As mentioned previously, foreign direct investments are made primarily in the parent-subsidiary context, the parent/holding companies usually being multinationals. In developed and developing countries, multinational corporations are the main channels of technology transfer and diffusion (Rugman 1983). While multinationals seek profitable returns on their efforts, they also try to improve the functional profitability of their investments or to produce certain technical products. At the same time, parent companies have a leading role in the investment decision making process, primarily examining the probabilities of repatriation of capital (Kazis and Perrakis 1984). In any case, multinational corporations transfer technology through their global production networks.

The positive impacts of MNCs in technology transfer are enumerated by Raj Aggarwal (1982):

1. MNCs have the ability to replenish the local capital required in economically weak countries.
2. Technology transfer from MNCs to a hosting country may result in the development of secondary industries and the creation of new jobs, thus creating additional national income.
3. The MNC activity will most possibly create additional income, thus raising additional state revenue.
4. Technology transfer from a MNC can improve the country’s export capacity: the adoption of high technology will expand the country’s export market.
5. The external transaction shortfall may be reduced or foreign exchange reserves may be increased.
6. MNCs sell technology with a marginal cost that does not include most of the fixed cost that would be spent in case of endogenous development of technology.

However, MNCs may equally create negative impacts (Aggarwal 1982):

1. The outflow of dividends and profits, salaries of foreign managers, royalties, loan interests and other remittances could cost a country dearly.
2. Technology transfer on a massive scale will possibly destroy the domestic “embryonic” industry.
3. MNCs will probably use the scarce economic resources of the country; as a result local industries will have difficulty in raising capital.
4. Similarly, other insufficient resources such as qualified personnel, raw materials, etc., that may be committed by MNCs at the expense of domestic industries.
5. Technology transfer by MNCs poses the risk of restricting or even crowding out domestic firms.
6. Domestic industries will often see MNCs as models and may adopt inappropriate technologies, in their attempt to catch up with the multinational giants.

In addition to all the above negative effects of technology transfer by MNCs, there is one more depressing effect to discuss: the state of mono-oligopoly, which has to do with the way in which multinationals operate. MNC activities create the ideal breeding grounds for two of the least competitive market structures, namely, oligopoly and monopoly. We chose to elaborate on this specific negative impact among all others, in the light of the Greek economy. As P. Roumeliotis and Kalogirou (1976) have observed, it can be safely deduced that the existence of oligopoly and monopoly, as market structures or economic systems in today's society in Greece, is directly due to MNCs. In major cities all over Greece, multinational titans have spread their tentacles through their subsidiaries, penetrating current target markets. Similar conclusions about the structure of the Greek economy are drawn by Benas (1978), Kapetanakis (1985) and Georgopoulos (1994).

Concerning MNCs and subsidiaries, both favorable and unfavorable views would lead us to the conclusion that the gigantic parents and their dispersed foreign daughters should above all operate in a well-defined and controlled environment. Wrong moves on the part of the technology-recipient country may exacerbate the gap between the upper economic level (capital-intensive technology or industries and the lower economic level (local, labor-intensive industries Aggarwal (1982). Moreover, in the case of MNC activity in an economically weak country, some sectors are likely to grow only at the expense of others that are equally important.

7.1.4.2 License Agreements

Non-embodied technology flows, reflected in licensing fees and franchise royalty payments, occur mostly as intra-company transfer between parent companies and their subsidiaries. In 1995, about four fifths of franchise royalty payments (royalties) and license issue fees for license agreements (licensing), in the US and Germany, took place between parent companies and their subsidiaries. US companies transferred 75 % of the value of the licenses they granted via FDI, the British companies about 50 % and the German approximately 90 %. Over 80 % of the official fees from technology sales in the US came from the subsidiaries of American companies. In Japan, more than 60 % of the payments came from Japanese subsidiaries in foreign countries. In recent years, payments for non-integrated technology have increased significantly worldwide. This is indirectly justified by the simultaneous increase in technology alliances where the exchange of non-integrated technology is an important element.

7.1.4.3 Technology Alliance/Business Alliances

The alliances between companies can take many different forms which do not include arm's length relationships or mergers and acquisitions. The creation of these alliances peaked in the 80s, originally comprising affiliated companies, that is, firms that had entered into secret agreements between them to promote their interests.

While the definition of FDI is relatively easy to create, the concept and content of alliances between companies are generally difficult to identify. The difficulty lies in the controversy that exists about the specific content of these legal agreements. Numerous researchers have noted that an alliance between two firms allows the occurrence of bidirectional technology transfer. Other scientists believe that these alliances also include production and marketing cooperations, in addition to technology flow and Research and Development (R&D). However, irrespective of the content of technology alliances between companies, these collaborative relationships or partnerships linking independent business entities are an inevitable reality in the business environment. It should also be noted that as domestic firms start to go global, FDI is usually complemented by technological alliances during the technological catch-up process, in order to facilitate technology transfer.

7.1.4.4 Technical Assistance and Cooperation

This type of technology transfer presents many similarities with technology transfer through people. However, this mechanism of technology transfer has specific characteristics (e.g. financial, organizational), which differentiate it from others. Although this mechanism does not bring the expected results and often leads to waste of financial resources, in terms of the value of the transaction currency it is still important.

7.1.4.5 Outsourcing–Offshoring

Outsourcing is a mechanism for technology transfer which was developed simultaneously with the global search for yield. Outsourcing takes place when a domestic company or organization (Outsourcer or client) enters into a contractual agreement with another domestic company (Outsourcee or supplier) for the production of intermediate goods and services. These goods or services are used in turn by the client as inputs or components in the production of the final goods or services, which will be offered for sale in the market as finished products. When a company or organization (client) enters into a contractual agreement to have goods produced or services performed, but hires a company or trains employees (suppliers) from another country to accomplish these tasks, the mechanism is called Offshoring, the client Offshorer and the supplier Offshoree.

Outsourcing as a technology transfer mechanism is unevenly diffused across countries: it usually takes place in Eastern Asia, to a lesser extent in Latin America and, in the last few years, a higher percentage of outsourcing is undertaken by Former Eastern Bloc countries.

The term outsourcing includes many different types of relationships between different types of companies. However, it should be separated from the concept of the Original Equipment Manufacturer (OEM). In an outsourcing agreement the client has to buy the goods he has assigned for production to the supplier.

In OEM agreements on the other hand, the producer manufactures products—in close technological collaboration with the client's company-eventually retailed under another company's brand name. Although outsourcing is very important for technology transfer, the analysts had initially underestimated it because of the implicit nature of the technology transferred through this mechanism.

Notwithstanding the issues arising both for clients and suppliers, global outsourcing contracts appear to be an effective way for accelerating industrial development. Complying with strict technical specifications, outsourcing suppliers develop specific complementary sets of capabilities on the production line, thus creating a specialization offering comparative advantage. Furthermore, outsourcing contractual agreements facilitate the transfer and allow better use of a country's human resource. Moreover, apart from workforce mobilization, the evolution of global outsourcing contributes to the dissemination of technological knowledge in less industrialized countries, as it is the case in outsourcing companies. The latter was strongly observed in outsourcing companies of East Asia.

International outsourcing could also induce foreign capital inflows and act as a catalyst in attracting other investments. The two abovementioned would result to an increase of local value-added and a promotion of diversification of production. Outsourcing agreements could be the first step in creating joint ventures. This is justified by the view that the supplier customizes the production processes as per clients' requirements and affordability, eventually gains his confidence and prepares the ground for future cooperation. In this case, technology transfer is accelerated and outsourcing becomes a viable and affordable option.

7.1.4.6 Exporting

Foreign markets are a source of demand and knowledge, if the buyer works closely with the vendor. However, the recognition of purchasers as a knowledge source does not constitute a widely accepted mechanism of technology transfer: their role, in internal or external markets, is underrated in aiding product improvement. The East Asian experience shows that the transfer of information, knowledge and requirements from the product purchaser to the product supplier, through the commercial activity of the latter, is an important source of knowledge for the product seller. The information that comes from buyers is a kind of 'free advice' for improving production capacity. The close long-term cooperation between seller and buyer provides the former with information on the international market, product specifications and the appropriate production techniques.

This 'circular' relationship between the seller and the buyer is beneficial for both parties: the information from the buyer is embodied in the products making them more competitive (benefit of the seller) and improved products are put in the market (benefit of the buyer). Thus, the knowledge provided by buyers returns to them in the form of an improved product.

The quantity and quality of knowledge transferred is closely connected to the form of communication between the buyer and the seller. Close and effective communication would mean better flows of knowledge from the market. Measurement of the technological knowledge transferred in this manner may be impossible, but is possible to measure the impacts of this knowledge transfer as the results are evident in the products. Another indicator of knowledge transfer, in the above manner, is the organizational context and scope of buyer-seller relationship. The extent, to which the seller will convert the information received from the market into real technological knowledge and embed it in his products and production processes, depends on his ability to assimilate knowledge.

7.1.4.7 Capital Goods

Technology could be considered as an unknown percentage of the total value of an imported product. Among other products, capital goods are with high technological content. In the early eighties, the value of capital goods imported in developing countries was four times the average annual flow of foreign direct investment and 14 times greater than the total technical cooperation expenditure.

The importance of capital goods in the economic development of a country is great, because they are a basis for the development and assistance of other disciplines that are either new in the industrial sector of the country or restricted by capital inflows. The existence of even a limited industrial base for capital goods production is a major advantage when operating in new areas (e.g. in the field of electronics). Although domestic production of capital goods can be seen as an important advantage for overall development, the importance of correct use and proper management of imported capital equipment should not be ignored. In Greece, where this industry sector has not achieved a broad-based growth, its restructuring and further development becomes second priority. In Greece, where capital equipment is almost exclusively imported, the proper fitting, use, management, and improvement of the foreign origin equipment may be a better strategy than the attempt for its domestic production.

Over the years, the technological content of capital goods has become largely intangible and abstruse. As a result, countries with a generally limited technological background and possibilities are not in a position to take advantage of the technology embedded in capital goods. Thus, the import of capital goods as an autonomous mechanism for technology transfer is of little significance or value. However, in cases when it complements other mechanisms suitable for the transfer of intangible assets, such as outsourcing, personnel transfer etc., it acts as an effective mechanism for technology transfer.

7.1.4.8 Through People, Print Media and Reports

The importance of transferring people as a mechanism for technology transfer has been recognized ever since the industrialization of the US and Europe. However, there is limited potential for a systematic analysis of the role of this technology transfer mechanism in modern-day developing countries. Over the last decades, the blossoming of the highly dynamic Asian economies has made the advantages of large scale emigration of educated individuals or talented professionals (Brain Drain) obvious. On the other hand, though, brain-drain had until recently been accused of having only negative impacts on the economies experiencing this massive outflow of human capital. Nevertheless, considering the reverse phenomenon of brain drain, that is, the return migration of scientific manpower called Brain Gain, we realize that the aforementioned negative trend is actually reversing. Brain gain may partly or totally counterbalance the unfavorable effects of brain drain: in most of the cases skilled professionals return home with more knowledge, skills and experience. Consequently, turning brain drain to brain gain as well as developing and improving communication with returning migrants (also called agents of development) underline the importance of technology transfer through people. This phenomenon has taken such an extent in the electronics industry in East Asia (e.g. in India), that it is difficult to classify it as an ordinary technology transfer mechanism. The above industry sector has developed to such an extent mainly due to the return migration of technological potential and to 'reverse engineering', that is, the viable method to create 3D manufacturing models from existing parts and system components.

The options offered through the technology transfer mechanism of print-media are countless. The plethora of publishing options available, from technical magazines to scientific essays, provide valuable insight into areas of interest that otherwise would be difficult to detect. Today's engineer has the ability to monitor new developments in a particular subject area, by reading technical journals or books, or by visiting exhibitions and attending lectures.

Tacit innovations related to the production process (and other processes) are transferred through the mechanism of reports. Many organizational changes (e.g. the Japanese management techniques) are now available to the general public through the international literature. However, their transfer is more efficient when combined with industrial visits.

7.1.5 Technology Transfer Models

The term 'model' for technology transfer is largely arbitrary, since this process cannot take place in a vacuum. There are many different factors influencing technology transfer, therefore the definition of a general model comprising all possible cases would be a difficult task. Thus, models that have been occasionally designed focus on some individual elements and do not cover the full range of technology transfer activities. Certain models from the existing technology transfer literature and their basic components are briefly presented below.

The term **'general model'** (Samli 1985) is unfair, since in reality there is no such model. The general model describes a process of technology transfer that is, however, not applicable in all cases. This model has five main components: the sender of technology, the technology, the receiver of technology, the aftermath, and the assessment (Fig. 7.1). Each one of the components of this model affects technology

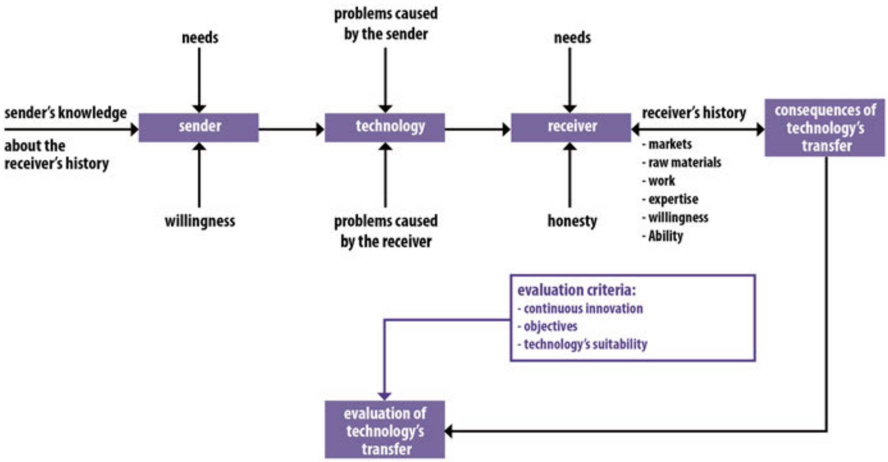

Fig. 7.1 General standard technology transfer (Doinakis 2005)

transfer and will determine the success or failure of goal setting, in its own way. The components mentioned above consist in turn of individual factors that also influence technology transfer.

The **culture-based technology transfer model** is unique due to the absence of the usual components present in other models, such as buyer–seller of technology, sender–receiver, etc.; it focuses on the values and culture of a country instead.

This model is based on the theory of social systems of Parsons and Shils (1962). This theory uses the structure of personality to explain the functional dynamics of the social system. According to Parsons (IBID) the social system is determined by 'social preferences', which characterize the people who make up the social structure. This theory will be no further analyzed here; we will rather concentrate on the relevant model. This model supports that the transferred technology will eventually lead to the production of a product. As this transferred technology did not previously exist in the country, this will be an innovative product and eventually, it will be made available in the market. This market should be evaluated in terms of its ability to absorb the new product. In such cases, market size does not play an essential role, our interest lies in the synthesis of "social preferences" in the market. In other words, what are the product selection criteria in a market? For example, a social group prefers cheap products and another selects products with attractive appearance. Moreover, another group may choose a product following a lead user, that is, a leading buyer serving as a role model, who is an early adopter of new products, methods, and technologies. Parsons (IBID) distinguished four different types of social preferences regarding the criteria for the selection of a product, for the satisfaction of the needs of a social group:

1. Affectivity Orientation—Preferences are based on criteria of comfort, social status and prestige that the social group expects to gain from the product.
2. Particularistic Orientation—Preferences are purely subjective based on external product characteristics (e.g. color, style, shape).

3. Universalistic Orientation—Preferences are based on external stimuli, for example a magazine review praising the quality of the product.
4. Collectivity Orientation—Preferences are considered to promote the group's common interest.

At this point, one could justifiably wonder how the aforementioned are connected with successful technology transfer. The answer is simple: successful technology transfer is intrinsically linked with the concept of innovation. Any transferred technology leading to products that do not satisfy the buyers' social preferences is doomed to failure. Consequently, a product will succeed in the market, if the used technology meets the expectations and needs of a certain society. Therefore, conducting a market survey to gather information about the social preferences of a certain society will give us insight into the composition of the consumers' preferences. Subsequently, technology and, hence, the products should be suitably adapted to meet society's needs.

7.1.6 The Vicious Circle of Underdevelopment Versus Technology Transfer

In this section we examine the so called 'vicious circle of underdevelopment' and its relation to technology transfer. According to Ragnar Nurkse (1953), the essence of the vicious circle is that economically underdeveloped or developing countries cannot overcome the unfortunate situation of their country. In his attempt to offer an economic explanation for underdevelopment, he observes that the inadequacy of saving out of regular incomes dooms poor developing countries to a vicious circle of poverty. The latter make serious efforts for development, using different development methods, only to end at the same point from where they had started. This idea is illustrated in Fig. 7.2.

The initial stage, that is, economic underdevelopment is the reason why these countries have low incomes. Therefore, they have low per capita income and low Gross Domestic Product (GDP). By definition, low income leads to a higher propensity for consumption and lower propensity for saving, thus causing low levels of bank savings accounts. The latter, in turn, leads to low investment, which is, by definition, the cause of lack or insufficiency of funds. Eventually, lack of funds can easily be associated with low productivity. Although in many underdeveloped countries, there is abundant labor force, a minimum capital/labor ratio is required in order to achieve a satisfactory level of productivity. So, as we can see, these countries move around a circular path only to reach the point where they had started.

Therefore, in order for a country to achieve a certain degree of economic growth, it is necessary to break out of this vicious circle. Among the many strategies to achieve this objective are the alternatives by Cassen et al. (1982):

i. Increase in National Savings
ii. International trade
iii. External financial assistance, and
iv. Technology transfer.

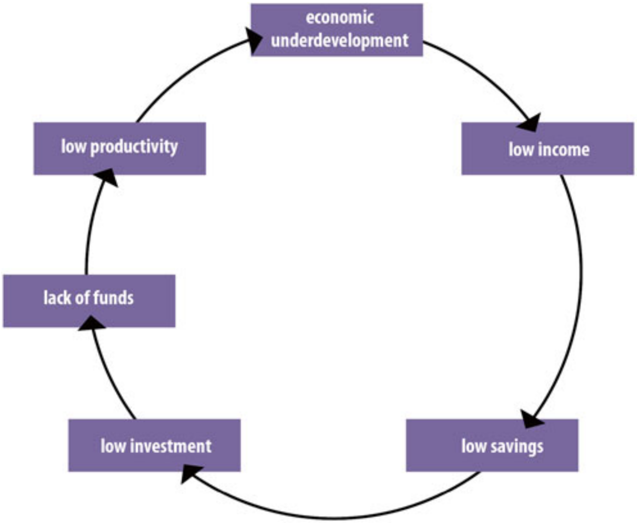

Fig. 7.2 Vicious circle of underdevelopment

The presentation and analysis of the above alternative strategies is beyond the context of this book so, even though each of these strategies is of grave importance, emphasis will be given on technology transfer. It should also be mentioned that they tend to be highly incompatible if they work together, as each one erases the others' advantages.

Regardless of whether technology is high or low, the successful transfer of appropriate technology has the ability to 'break' the vicious circle of economic underdevelopment. In this context, has there are three different approaches to technology transfer (Samli 1985): improving export performance, import substitution, and "neutral" approach.

Improving competitiveness and extroversion means that the country will import a technology which will help increase exports. This way the country will escape the vicious circle of underdevelopment. This tactic has been followed quite successfully by Korea, Singapore and Taiwan. These countries imported technology which was export oriented, in order to grow stronger and become competitive in the global market. Their national economies experienced a large boom in the seventies.

Import substitution is considered to be an option of developing countries with a large internal market and heavy dependence on imports. The imported technology in this case will be used in the production of goods and services to replace imports in this sector, for example, exploitation of domestic energy resources instead of importing fuel from abroad.

The 'neutral approach' covers cases that are not covered by the other two approaches. Under this approach, the imported technologies are often implemented in some industry sectors that did not exist before or they are used to ensure balanced development throughout the country, by providing opportunities to increase overall profitability. As a result the host country will benefit from the proper use of its resources, thus increasing economic efficiency.

7.1.7 Technology Transfer Obstacles

The factors that prevent, restrain or delay the performance of transferred technology are classified in two categories:

- Legal hurdles, such as government regulations and contract restrictions, and
- Sociotechnical barriers, such as infrastructure, cultural, communication or language barriers.

The concept of culture includes all stereotypes and values developed within a country. The language barrier is significant, as contact between people is essential for technology transfer. Such a failure in communication can be caused either by the language itself or by the fragmentary thinking and communication.

The infrastructure obstacle is most important in technology transfer, as its existence causes the occurrence of other obstacles. Researchers have at times argued that the technological/scientific infrastructure often presents the most serious obstacle. The technological infrastructure concerns the educational policy required in order for the recipient company or country to increase its absorptive capacity and use the transferred technology. This capability should be available to all levels of technological process (Carayannis and Alexander 1998).

7.1.8 Success Factors for Technology Transfer

The lack of skilled personnel is considered to be one of the main problems faced by developing countries, in the acquisition and utilization of the appropriate technology. In 1969, the United Nations Advisory Committee on Science and Technology for Development reported that the real obstacle for the above countries was neither the lack of available technology nor its cost, but the lack of a country's capacity to absorb technology efficiently. This absorptive capacity of the transferred technology depends on the levels of technological literacy, education and technical training. In general, ensuring high quality of comprehensive technology education would definitely be the leading success factor in technology transfer.

Porter (1983) and **Andrews-Miller** (1985) recommend education and training of the local workforce. **Vaizey** (1969) noted that education should take place simultaneously with practice and stop being limited to conventional teaching methods. A study in manufacturing industries in Zaire showed that the most important component of technology transfer was the know-how transfer through employee training, in conjunction with practical experience.

Crawford (1987), **Singh** (1983) and **Rodrigues** (1985) pointed out another factor for successful technology transfer: undertaking and reinforcing Research and Development (R&D) activities which will facilitate the introduction of high technology. In the past, lack of R&D has several times hindered the transfer of technology to developing countries. Companies allocating 2 % of their sales on R&D

activities are called technology-intensive, while those who spend more than three percent are high-tech companies.

Gee (1981) observed that in order for imported technology to produce positive results existing managers should be innovative at each given time. **Wallender** (1979) reached the same conclusion, adding that managers should develop the ability to anticipate, diagnose, and solve problems. The ability to predict the probability of future behaviors and decisions, through the extra-sensory perception called **clairvoyance** (clear vision), supports the safe and efficient handling of coming changes and facilitates crisis management and avoidance. Normally, ambitious senior managers and executives, adhering to the corporate mission statements, use methods to control their companies, in an attempt to energize and engage the workforce. However, managers are in need of business executive coaching and cultivation of their intuition, in order to navigate potential obstacles and lead a successful change management process, when it is necessary. See also the concepts **Strategic Knowledge Serendipity and Arbitrage** (Carayannis 2008) referring to **'happy accidents'** of knowledge discovery and utilization.

7.1.8.1 Selecting the Appropriate Technology

The concept of appropriate technology is not always fully understood. The question whether the transferred technology is inappropriate has been posed many times, by many writers. In order to choose the best alternative it would be necessary to calculate the highest net profit, by evaluating expected benefits and estimated cost.

According to Samli, raw material requirements are the criterion for the selection of appropriate technology. The three questions he poses concerning the candidate technologies are the following:

- Can the technology make efficient use of the raw materials found in the recipient country? If not, then it could be a national economic burden for ever.
- Does the manufacturing of the product require importing large quantities of raw materials? If yes, then the candidate technology is of doubtful appropriateness.
- Does the product require using rare earth elements or draining scarce resources? Even if these elements are available domestic materials in the recipient country, depriving other more important sectors of these resources, makes this technology unwelcome and unwanted.

The **United Nations Industrial Development Organization (UNIDO)** identified three factors to consider when selecting the appropriate technology:

I. Development goals:
   - Increase work force employment and production through optimal utilization of local resources
   - Promote skills development
   - Narrow the income gap of employees
   - Satisfy the basic needs of poor people
   - Improve the overall quality of life.

II. Resource Supply:
   - Examine the extent to which available resources are exploited by the new technology

III. Implementation Conditions:
   - Infrastructure status
   - Climate and natural environment
   - Social conditions in the host country
   - Traditional cultural values
   - Education standards
   - Domestic and foreign market

Consequently, in order to avoid the choice of an inappropriate technology in developing countries, the recipient company or country should, initially, pay special attention both to the type of agreement entered into by the parties involved and to the type of imported technology: technologies that are outdated or have been unused for a long time should be rejected. Moreover, technology recipients should be cautious towards supplying companies, as the latter usually transfer technologies that are available but not necessarily suited to the needs and special circumstances of a developing country, in order to avoid wasting money and time to customize these technologies. Finally, recipients should never engage in technology transfer through poor communication channels, internationally or locally, or if there is shortage of properly trained local workforce.

Considering all the factors mentioned in this subsection, we can safely assume that the choice of the most appropriate technology is an important factor for successful technology transfer. Our top candidate should definitely exhibit adaptability to particular conditions (social, cultural, economic, etc.) of the host country. However, the technology qualifying for transfer should above all meet the needs and achieve the targets of the recipient company: in the manufacturing process, the eligible candidate should facilitate the optimal management and utilization of available resources (raw materials, human capital, assets, etc.), while in the marketing process, being embedded in products and services that circulate in domestic and foreign markets, it should satisfy consumers' preferences.

7.1.9 Cooperative Research and Development Agreements (CRADAs)

Cooperative Research and Development Agreements (CRADAs) function as a mechanism that transfers technologies developed at Federal R&D laboratories to private companies (Carayannis et al. 1997; Rogers and Carayannis 1998; Carayannis and Rogers 1998; Carayannis and Alexander 1999; Carayannis 2001).

CRADAs constitute lengthy legal agreements establishing procedures for sharing research personnel, equipment, and intellectual property in conducting joint research. They are based on a model of cooperation and partnership with industry, in which each partner will have to pay their share. The government contributes by paying researchers' salaries and certain research expenses, associated with the activities of its researchers. It is prohibited for the government to make payments to firms.

A thorough investigation by Rogers and Carayannis (1998) demonstrates the importance of the dissemination of information to private companies about CRADA opportunities, the need to facilitate exchange of technical information between CRADA partners, as well as goal achievement and task attainment of both partners. In this project we realize that the main obstacle in this agreement process was complicated procedures. CRADAs are considered as an impetus for commercialization and technology transfer as they often prevent the cancellation of the R&D in private companies and Federal laboratories. The CRADAs can also serve to maintain the smooth functioning of the R&D mechanisms. Consequently,

> *'…such collaboration between two organizations with quite different organizational cultures may be valuable to each of the partners because each has certain resources that the other needs. However, successful collaboration depends on the Federal R&D laboratory and the private company finding enough common ground to be able to communicate effectively about their mutual interests. Because of their differences, such effective communication is often problematic. (Rogers and Carayannis 2008)'*

7.1.10 Spin Offs

A Spin Off is a mechanism preparing technologies to be transferred from lab to market, after they have originated in a parent organization, such as a university, a Federal R&D laboratory, or a private company:

> *'A spin-off is the commercial application of a product or technology originally developed for a particular government mission. It can refer to commercial products stemming from government R&D – vertical transfers of technology – and also to horizontal transfers in which military devices, tools, or technology are adopted in new civil applications. (Carayannis and Rogers 1998)'.*

The term spin off usually refers to a new company created by a corporate parent. In this scenario, an employee leaves a private enterprise, often taking—directly or indirectly—trade secrets, business technology, or intellectual property intending to compete with the parent company. The assiduous research of **Carayannis and Rogers (1998)** defined spin off as: a new company formed by an individual or individuals who used to be or still are employees of a Federal R&D laboratory, around technologies originating from a Federal R&D laboratory (see also: Carayannis et al. 1997; Carayannis and Alexander 1998, 1999; Carayannis 2001).

Radosevich et al. (1993), based on experience in national laboratories, describe high-tech spin-offs as a form of technology transfer: "the laboratory context within which the decision to become a technical entrepreneur is made, varies significantly from laboratory to laboratory, and very few analyses have been made to improve understanding of the spin-off phenomenon". According to a thorough research by Carayannis and Rogers (1998) concerning high tech spin-offs, technological knowledge acquisition and unforeseen institutional consequences (e.g. various mechanisms for financing high risk ventures and organizational culture problems) can either be a success factor or a potential cause for failure, in growing and managing these new technology-based ventures.

Stankiewicz (1994) observes that spin-offs, especially those coming from universities, are considered to be a particularly significant mechanism for technology commercialization. This view stems from the broader belief that these new technology-based firms (NTBFs) apparently introduce a disproportionately large number of commercially oriented innovations to the market. Stankiewicz (1994) also makes comments on academic spin-offs that also hold true for spin-offs from public laboratories: "Formation of a spin-off can be interpreted as an attempt to create an institutional space for activities which do not quite fit into the established structures of academia and business; a space which would allow the scientists and engineers to preserve their professional identities while acquiring new roles in the process of commercializing technology".

7.1.11 Strategic Alliances

Yoshino and Rangan (1995) give their definition of the term strategic alliance as a trading partnership possessing three necessary and sufficient features:

- "The two or more forms that unite to pursue a set of agreed upon goals remain independent subsequent to the formation of the alliance.
- The partner firms share the benefits of the alliance and control over the performance of assigned tasks—perhaps the most distinctive characteristic of alliances and the one that makes them so difficult to manage.
- The partner firms contribute on a continuing basis in one or more key strategic areas."

There are four kinds of benefits connected with forming an alliance:

a. Economies of scale (static and dynamic) and economies of scope
b. Quick and easy access to knowledge and markets
c. Reducing capital requirements and risks associated with new product and technology development, and
d. Possible influence on the structure of competition in the relevant markets.

7.1.12 Technology Transfer and Commercialization Metrics

The measurement systems for technology transfer and commercialization performance present difficulties, from definition and all the way through implementation. The word 'metric' originated from the Greek verb 'μετρώ', meaning 'to measure', that is, to determine the dimensions or calculate the volume of an object, using standard units of measurement. This deliberate process encompasses a wide range of parameters, both qualitative and quantitative that can be used as benchmarks (Carayannis and Alexander 1998; Carayannis 2001; Carayannis and Gonzales 2003; Carayannis et al. 2003).

Hence, it can be safely assumed that metrics exhibit a great diversity of types, while trying to cover a wide scope of application:

'Since technology transfer involves numerous processes that occur across multiple disciplines and organizations, appropriate metrics and the methods for quantifying them vary considerably…Also, the choice of appropriate metrics depends on the availability of data and may change with time as new data emerge (Carayannis and Alexander 2009).'

Numerous studies conducted over the years, have identified metrics that can be categorized in three groups (Carayannis and Alexander 1999; Carayannis and Provance 2008):

1. Inputs/Expenditure/Resources
2. Intermediate Stages/Activities/Cultural Changes
3. Outcomes/Long-Term Goals/Economic Impacts

The case studies described below focus on a number of inputs, intermediate and short-term, as well as on long-term outcome-based performance metrics collected from numerous past studies on technology transfer.

Table 7.1 is a comprehensive list of major performance metrics having been adapted from the studies cited above.

It should be noted that most people experience difficulty in linking these performance metrics categories. Penaranda (1996) examines the distinction between 'process' and 'outcome' metrics and notes that 'process' metrics are less often used: "…expediency and pressures to satisfy the 'bosses' often lead to the establishment of purely 'outcome' metrics, even though these are the least quantifiable and least accurate to predict".

Table 7.1 Sample input, intermediate, and outcome metrics

Input metrics	Intermediate metrics	Short-term metrics	Long-term metrics
Technology transfer expenses	Invention disclosure	Patents issued	Return On Investment (ROI)
Time spent on technology transfer	Technical presentations	Licenses granted	Cost-reduction
Requests for technical assistance	Technical papers required	Licenses and options executed	Royalties
Number of on-site visits	Technical papers published	Technical problems solved	
Full-time professionals		Patent applications filed	Number of new product
Accounting and legal fees spent and reimbursed		Success stories published	New commercial sales Number of new customers User satisfaction degree New start-ups Job openings created/ positions lost

Furthermore, the focus given to each particular category depends on the role of the party involved (technology transferor vs. technology recipient, etc.):

> *'As is often the case in every realm of public policy there has been no commensurate effort to determine systematically the effectiveness of these new and accelerated technology transfer activities of government laboratories… Even the more skeptical views of the potential of government laboratories in the technology transfer arena are more often based on personal opinion or direct personal experience than on systematic data (Carayannis and Alexander 1999).'*

The evaluation of technology transfer activities started with examining input metrics, as they were definitely easier to identify, monitor, and measure:

> *'Persons responsible for technology transfer, and their superiors, sometimes count instances of technology transfer and assume those numbers are a useful surrogate indicator of success. If technology transfer is conceived as a probability distribution with success 'parameters', then increasing the instance of transfer increases, ceteris paribus, the likelihood of successes. Thus, the input to success becomes a surrogate for the output (Carayannis and Alexander 1999).'*

However, the recent trends in evaluations of technology transfer performance focus on **output metrics**, such as market share gains, new commercial sales, cost reduction, and jobs created. Two well-known methods are used to measure both 'out the door' technology transfer performance (e.g. number of technologies transferred) and 'market impact' performance (actual improvements experienced by the recipient company from the transfer). These methods correspond to the categories of short-term and long-term outcome metrics (Carayannis and Alexander 1999).

Nevertheless, this prevailing situation reflects a tendency for a choice of metrics that is purely observers-based, without any scientific theoretical background:

> *'In general, success suggests a performance outcome that satisfies an individual's or an organization's objectives. However, given the large number of organizations and individuals involved in a technology commercialization effort, it is virtually impossible to have a completely 'successful' commercialization (Carayannis and Alexander 1999)'.*

Finally, intermediate metrics such as technical problems solved, technical papers published, and success stories are necessary in order to support both assessments and evaluations of technology transfer:

> *'Assessments provide guidance for establishing what mix of activities would bring about technology transfer… Evaluations measure actual performance, thereby providing information for improving the overall technology process (Carayannis and Alexander 1999)'.*

Intermediate metrics are often qualitative measurements that actually provide in-depth descriptions of improvements in the technology transfer process and make actionable recommendations, simultaneously with their routine efforts to increase the rates of transfer (Carayannis and Alexander 1999).

7.1.12.1 Problems with Existing Institutional Frameworks for Technology Transfer Metrics

There is a widespread dissatisfaction with many of the current metric systems used to evaluate technology development. For instance, Return on Investment (or 'the ROI concept') is known in industrial research communities by the derisive name 'restraint on innovation'. The reason for this is that it measures only short-term benefits rather than the long-term advantages gained by research. Technology transfer gurus equally express their dissatisfaction when over-simplified metrics are applied on their attainments (Carayannis and Alexander 1999).

A permanent problem in evaluating technology transfer and providing actionable recommendations is that there are no established standards for metrics to be used in evaluation. Consequently, there is no consistent performance level to be used as a basis for the measurement of a particular technology transfer effort.

As it is observed by Radosevich and Kassicieh (1993), a comparison of outcomes to established standards or baseline performance would require sufficient understanding of the process, in order to establish realistic expectations. Given the fact that the possibilities for federal technology transfer processes have not been well understood, only a few programs have actually been developed by agencies. In a study of technology transfer programs at Marshall Space Flight Center in Huntsville, Alabama, it has been pointed out by Spann et al. (1993) that:

> *'The success of government-to-private-sector transfers has generally been less than satisfactory…This low rate of transfer may be the result of inabilities to reach consensus on how to define, track, or measure transfer progress and success. Organizational, financial, behavioral, and other barriers in federal-to-private technology-transfer processes may also effectively limit if not nullify the spirit behind…federal technology-transfer mandates.'*

Technology transfer metrics vary not only across cases, but even within the same case among the various parties involved. Span et al. (1993) also found:

> *'…while [technology transfer] sponsors appear to be more aware of the need for measurement, their apparent willingness to substitute input and intermediate outcome measures for adopter-favored long-term outcome measures means the measurement approaches of the two roles may be in conflict.'*

In the case of CRADA agreements, Ham and Mowery (1995) state that the evaluation of CRADAs cannot rely exclusively or primarily on short-term economic measures. The qualitative assessments of CRADA results may change drastically within a 6-month period. Moreover, the legislative context in which technology transfer takes place has undergone relatively frequent changes. Consequently, even an all-inclusive historical survey would, upon completion, measure the outcomes of multiple processes with a high degree of variance due to the absence of a single process model which is being consistently implemented (Rogers and Carayannis 1998).

Given the volatility of the situation, the adoption of a new approach is required, in order to achieve an effective development of technology transfer metrics, for evaluative purposes. The **case study** approach is a research strategy excellent at facilitating the understanding of complex real-world issues and can serve as a promising alternative to address the continued shortcomings of current technology transfer studies (Carayannis and Alexander 1999). More specifically, in the present paper we focus on case studies not only to demonstrate the long term market success achieved by some firms, but mainly to emphasize the intrinsic value of the qualitative factors that are critical for success or failure.

The aforementioned factors may lead to a better understanding both of the inherent nature of technology transfer and commercialization, and of the challenges that emerge during the execution of the respective processes. Thus, the use of the case study as a research strategy adopts a global perspective in understanding both the processes involved in the leap of technology concepts from lab to market, and their potential short-and long-term value added. These are subsequently evaluated not only in terms of strictly financial benchmarks but also in terms of quality of life and other social benefits.

7.1.13 The Case Study as an Evaluation Tool

Case studies often receive negative criticism by the research community for being an inappropriate tool for empirical research. According to Yin (1991), the cause for this negative attitude is a great concern over:

- The lack of rigor in case study research, as there is absence of validity and reliability
- The inability to use a case study as a basis for scientific generalization, and
- Their extensive descriptions, often resulting in 'massive, unreadable documents'.

See also Carayannis and Alexander (1999)

Nevertheless, the case study approach, if used consistently and rigorously, would alleviate understandable concerns and add new dimensions to the evaluation of technology transfer. Yin (1991) stresses that the case study constitutes a serious research strategy rather than a methodology, as it can actually integrate diverse methodologies into a single study. Therefore, he defines the case study as an empirical study (i.e. a way of gaining insight based on observation or experience rather than quoting experts) that examines and analyses a current real-life situation in its general operational framework. Note, however, that the boundaries are not clearly evident between the situation and its context, in which multiple sources of evidence are used.

Moreover, case studies can be a useful tool for evaluations, which constitute a special type of research. Technology transfer evaluations often involve complicated and difficult conditions regarding the conduct of research, mainly due to the changeability of processes and components involved. Technology transfer would therefore be the ideal candidate for analysis using the case study strategy. As it has been discussed by researchers though, the term transfer becomes misleading when it refers to technology: in theory, technology transfer may appear as a discrete act, presenting the recipient as a passive receiver of a technology, which is developed somewhere else and works like a plug and play device. However, in reality, technology transfer is an extended process through which "application relevant knowledge is usually what is transferred, not a device". Case study methodologies offer a suitable means of exploring such processes (Carayannis and Alexander 1999), being superior to surveys or other quantitative approaches, by providing rich descriptive and prescriptive detail towards a better understanding of causal processes.

Yin summarizes that the case study possesses a distinctive ability to:

- Attend to project orientation and general framework
- Adapt its size to accommodate from single projects (cases) to situations with numbers of cases or, even, to all projects within a country

- Capture process and outcomes in a project matrix, assessing causal relationships between project elements and providing useful and intermittent feedback to managers and project evaluators
- Adapt to the availability of various types of evidence
- Assess outcomes and test both causal and conflicting theories, and
- Offer generalizable lessons on major substantive topics in a field.

All the aforementioned conditions, often encountered in studies on technology transfer, make the case study a perfect choice as a strategic plan in the development of metrics.

7.1.13.1 Case Studies as Examples of Technology Transfer and Commercialization Performance Metrics

Existing metric systems rely on quantitative measures, which either miss major key factors in the success or failure of technology transfer processes or measure initial inputs and total number of outcomes as opposed to process improvements.

A case study approach should capture both prescriptive and descriptive information of technology transfer and make it available for re-engineering technology transfer processes. This kind of approach would also provide significant qualifiers, which put the available quantifying factors in their appropriate context, as it can be seen in the case studies described below. More specifically, they focus on input, output and intermediate technology transfer performance metrics that have been identified and traced in each one of the cases presented. Based on the available information, this study attempts a comparative evaluation of the role and intensity of influence of each technology transfer performance metric, in each profiled case study.

Cases drawn from previous research (Carayannis and Bush 1997) are presented in this essay through a new data analysis. Using the framework of input, intermediate, and short-and-long term outcome metrics, it is illustrated how a case study approach can provide a richer understanding of the dynamics of technology transfer and the elements of successful technology transfer.

Ending this analysis, case studies become '**cash cows', 'dogs', 'question marks'** or **'stars'**, according to the **Boston Consulting Group (BCG) matrix**: this model ranks case studies on the basis of their current and anticipated potential market success, as a rough way of future case evaluation (Carayannis and Alexander 1999).

7.1.14 NASA Case Studies

The lengthy history of NASA's technology transfer has often been controversial, especially in the case of spin-offs. Government agencies, such as the National Space and Aeronautics Administration, which are always under pressure to submit cost-justification of their activities, boost the value of spin-off investments making extravagant claims. Spin-offs, however, have always been regarded with skepticism.

In the late fifties, Dr Ralph Lapp, annoyed by the Atomic Energy Commission's exaggerated claims for research spin-off benefits, created a simile comparing a spin-off with a drip off. Insinuating the meager momentum, the lack in spirit, and the hindered progress accompanying the transfer of defense technology from national lab to market, he derisively equated this transfer process with a liquid moving from one position to another drop by drop. Providing an explanation, Samuel Doctors (Carayannis and Alexander 1999) concluded that NASA's Technology Utilization Program "was founded primarily in response to political pressures and has continued to be used as a device for partial justification of NASA R&D funding".

This discussion will continue with the description of three cases of successful technology transfer from **NASA Langley** to the private sector. These cases have been identified for closer examination and will be presented in chronological order, starting from the oldest: **MacNeal-Schwendler Corporation** (1960s), **Pressure Systems Incorporated (**late seventies to eighties), and **Tecnico** (1993–1996) (Carayannis and Alexander 1999).

7.1.14.1 MacNeal-Schwendler Corporation

MacNeal-Schwendler Corporation ('MS Corporation' or MSC) was formed in 1963, specializing in Computer Consulting Services. Almost simultaneously, NASA decided to fund the development of a finite element analysis (FEA) software program, as a means to upgrade the analytical capability of the entire aerospace industry. MSC was selected, together with a larger partner, in order to further develop this software program and create the public domain NASTRAN code. In 1971, MSC decided to offer its version of the NASA software code to the public on a leased basis, incorporating original MSC code with the package developed for NASA. In the following years the income from the leasing of this code reached an annual rate of 50 %.

Grumman and General Motors were two of the first large companies to use this commercial package. NASA's reaction was to sue MSC over the intellectual property rights to the code, but MSC won the case and continued marketing the product. The commercial success of the product was so overwhelming that on May 5, 1983, MSC went public with an initial offering of stock at $23.00 per share, only to close at the same day at $36.75! The company's commercial sales skyrocketed reaching US$79 million in 1994 and $100 million in 1995, making MSC the world leader in mechanical computer-aided engineering software capturing over 30% of the global market, as measured by annual sales.

MSC Case Analysis

MSC's astonishing success can be attributed to the following critical success factors, identified by those involved in this case:

- Perfect timing—key elements such as funding, technology, science, and timing came together seamlessly

Table 7.2 Key metrics reflecting facilitating and impeding factors in MSC

Input metrics	Intermediate metrics	Short-term metrics	Long-term metrics
NASA funding	Key champions inside NASA	Software development	Growth of MSC sales
Technology readiness level	Champions' commitment to commercialization	MSC success in following on NASA contracts	MSC customer base
State of theory and science of software	MSC's founders' persistence despite NASA's absence of continuous support	New feature development for commercial market	Market share growth

- Government funding—NASA's capital investment to develop the NASTRAN code was approximately three million dollars, of which one million from government contracts
- A large pool of highly qualified human capital acting as internal and external champions of MSC and its product
- The dedication and devotion of the main participants in the commercialization process.

Information concerning metric systems of the MSC case is given in Table 7.2

7.1.14.2 Pressure Systems Incorporated

Since 1977, Pressure Systems Incorporated (PSI) has been developing, manufacturing, marketing, and servicing pressure measurement instruments for aerospace and industrial measurement applications. In the seventies, NASA had commenced designing a National Transonic Facility (NTF) wind tunnel, where it would be possible to observe a speed range above or below the speed of sound. The Instrument Research Division (IRD) at NASA's Langley Research Center was planning to develop a pressure scanning electron microscope, which would be a hundred to a thousand times more rapid than conventional measuring techniques would allow that time. During sensor development, NASA realized that the pressure sensor had to be assigned to a manufacturer. Grasping the opportunity, a member of the IRD left NASA and formed PSI in order to produce the sensors.

NASA agreed to license the technology to the newly formed company, on a non-exclusive basis. PSI has become a very successful commercial entity supplying pressure sensors worldwide. PSI's annual sales reach approximately ten million dollars, with a client list including some of the largest manufacturing companies worldwide reigning high in aerospace, automobiles, and heavy machinery: Pratt & Whitney (United Technologies), Asea Brown Boveri, Honda Motor Corporation, Caterpillar and General Electric.

Table 7.3 Key metrics reflecting facilitating and impeding factors in PSI

Input metrics	Intermediate metrics	Short-term metrics	Long-term metrics
NASA development of technology and application	Work of champions inside and outside NASA	Creation of a working prototype	PSI sales growth
Research funding from NASA	Development funding from NASA	License technology from NASA to PSI	PSI customer base growth
	Collaboration for initial development between NASA and PSI		Export sales success for PSI product

PSI Case Analysis

According to the former NASA official and founder of the company, the 'combination of a technology and a champion' was the key to PSI's success story. Being interviewed about PSI's booming sales and skyrocketing shares, he stated that the company's story is a case of successful technology transfer, in which the founder himself had acted as both internal and external champion, and as his own company's technology transfer agent. Initially, he played a key role in sensor technology development at NASA Langley and then in the creation of PSI in order to bring that technology to market.

NASA Langley's instrumental role in this case was threefold: this leading edge national research centre recognised a 'real world' need, funded the necessary research and extended its research funding beyond the critical 'go/no-go' decisions made after feasibility studies, all for the creation of a working prototype at PSI. Acting bona fide, NASA Langley selected a start-up as the manufacturer of the sensor technology it needed, taking the extra effort to work closely with that manufacturer in order to see the product reach commercialization.

Table 7.3 displays some of the factors impending or facilitating technology transfer in the PSI case, on the basis of case study-driven metrics.

7.1.14.3 Tecnico

Tecnico is a privately owned industrial and marine manufacturing firm, specializing in turnkey ship repair items, located in Chesapeake, Virginia. Founded in 1999, Tecnico is activated in the field of structural welding, piping, electrical, painting, rigging, blasting, and dry-dock work. Furthermore, the company offers shipboard furniture fabrication, sheet metal fabrications and extensive welding capabilities. The US Department of Defense has been the firm's primary customer.

In 1993, however, a wave of pending Navy budget cuts pushed Tecnico towards new target markets. The invitation came from Loral Vought, a company located in Texas interested in the investigation of the possibility to produce the mid-body section for a missile system. For Tecnico, this would require the production of composite material parts, for which the startup cost was prohibitively high. As the situation was calling for a market scan, a Tecnico manager visited a technology exposition at NASA Langley, in 1993. During the presentations, the attendee observed a technique for composite material manufacturing called rubber expansion molding. This technique was expected to reduce investment costs from two million to 2,000 dollars.

On August 8, 1994, Tecnico signed a Memorandum of Agreement (MOA) with NASA Langley, to jointly explore the transfer of the aforementioned technology from the laboratory situation into a production facility. Taking for granted the positive outcome of that cooperative venture, Tecnico signed an exclusive licensing agreement. The new commercial activity, created by the adoption of the rubber expansion molding, lead to the creation of a new group within Tecnico called Advanced Materials Group. So, by May 1995, Tecnico had hired eight skilled engineers and technicians to work in this group, which generated over 800 dollars in revenues.

Tecnico Case Analysis

According to one of the two NASA Langley technology transfer agents, the key to the Tecnico project's success lay on the critical activities of the 'champions'. Keeping track of the transfer process of the rubber expansion molding technique, this lead NASA researcher was convinced that Tecnico's commercial success would not have been achieved without the effort of its key manager. In his opinion, there were two critical success factors for the development of the rubber expansion molding technique: (a) the technology included information that was easily reproducible and transferable into a commercial product, and (b) the NASA Langley Expo that provided the ideal setting for the encounter between a lab researcher and a company manager, who was on the lookout for a new technology.

According to the technology hunting manager from Tecnico, the critical success factors in the commercialization of this technology transfer were three: (a) Tecnico's faithful commitment to the commercialization of the new technology (b) NASA Langley researchers' critical support, and (c) the emotional support stemming from Langley's valuable technical support. This psychological support, along with NASA's positive belief in this venture, reached out to Tecnico's human heart and soul like an innovation opportunity coming with the rustling of the breeze, making the Tecnico staff members committed believers and, consequently, turning its clients into a powerful and sustainable marketing force. Credit was also given by the manager to the lead NASA researcher, for his enthusiasm and his catalytic role in the technology transfer process.

In Table 7.4 we can see some of the metrics emerging from this case:

Table 7.4 Key metrics reflecting facilitating and impeding factors in Tecnico

Input metrics	Intermediate metrics	Short-term metrics	Long-term metrics
NASA technology development	Tecnico's commitment to technology	Technology patent by NASA Langley	Fresh revenue generated by Tecnico
NASA Expo	NASA's technical and emotional support	Exclusive license granted to Tecnico	New positions created for new division
Two tech transfer agents cooperation	Legal preparations by NASA transfer agents	Investment cost savings	Tecnico's customer base growth
NASA lead researcher's commitment	MOA for joint R&D between Tecnico and NASA	Tecnico signs new technology use agreement	

7.1.15 New Mexico Federal Laboratories Originating Case Studies

7.1.15.1 Amtech Corporation

The Animal Management Technology Corporation (Amtech) was founded by a veterinarian, who served at Los Alamos National Laboratory (LANL) as a liaison officer from the U.S. Department of Agriculture. He was assigned to explore the ways in which the LANL technology, used in its Electronic Identity (ID) Project, could be applied to problems in agriculture and the dairy industry. In 1983, at exactly the right time, the liaison official founded Amtech in order to commercialize this technology. In the spring of 1984 LANL allowed him to borrow a reader, an antenna and half a dozen html tags to use as demonstration equipment, in order to attract investments for Amtech. Amtech eventually became one of the first spin-offs to purchase patents from the U.S. Government.

Amtech initially had great difficulty in raising capital for the commercialization of its products, until the moment when one of its key investors told the founder that the problem lay in direction of the company's marketing efforts; in other words, Amtech had the right product for the wrong market. Following the investor's recommendation, the vet ex-liaison turned the company's focus from the dairy industry to the commercial transportation industry and saw the fortunes of his company turn around. Amtech was far more successful in this field, as the company was able to attract start-up capital through informal networks, by demonstrating the technology in its new application.

Table 7.5 Key metrics reflecting facilitating and impeding factors in Amtech

Input metrics	Intermediate metrics	Short-term metrics	Long-term metrics
LANL development of technology	LANL's continued support	Sale of patents to Amtech	Acquisition of startup Capital to launch Amtech
LANL transfer of prototypes to Amtech Founder	Use of informal networks to raise investment capital	Investor interest prompted by demonstration	
Amtech team's decision to leave LANL and found a new company	Streamline processes governing technology transfer		

Amtech Case Analysis

According to Amtech's founder, a prevalent reason for the initial success of the company was the entrepreneurial spirit exhibited by the founding partners of Amtech. The original founders had worked together at Los Alamo, on the electronic ID project for a period of 10 years, having a good personal rapport with each other and sharing the same dream of developing and commercializing the electronic ID technology. In general, LANL offered extensive support and assistance throughout the formation and growth of Amtech.

As it was observed by Amtech's founder, the existing bureaucracy in technology transfer has increased in direct proportion with the rising emphasis on technology transfer. As a result, this highly appreciated practice of moving new technologies from the creator or researcher to a user is inhibited and usually becomes a bureaucratic headache: the numerous technology transfer mechanisms get caught in the slow grinding gears of bureaucracy, while trying to obtain an approval or clearance in order to finalize technology transfer agreements, and are often immobilized, wrapped up in the bureaucratic red tape.

Table 7.5 illustrates the key metrics developed from the case study on Amtech.

7.1.15.2 Permacharge Corporation

Permacharge Corporation (PC), founded in 1987 by two women entrepreneurs, was built around the Electret technology. The Electret technology is based on the electret (*electr*icity and magn*et),* a dielectric material that can retain a near-permanent electric charge embedded at the time of its manufacture, thus being the electrical equivalent of a magnet that has a near-permanent magnetic field instead. It is mainly used as a microphone element in multimedia computers, telephones, camcorders, hearing aids, etc. In 1990, PC was granted exploitation rights over a patent on microporous foam technology, from Sandia National Laboratories (SNL), aiming to combine it with the dielectric material Electret, in order to develop a filtration system. PC made modest sales of its proprietary technology product to cleanroom, construction, and asbestos removal industries. However, the increasing costs and difficulties of selling to the cyclical semiconductor industry lead PC to the development of a new core product called WallWrite.

The WallWrite electrostatically charged sheets are made of a microporous, high quality polypropylene material and can be used repeatedly as a writing surface. These easy-to-transport sheets, also called ClingZ, come in roll form and once they are placed on any wall surface, they cling and stay there without sellotape or pins. For the development of this product there was a need to repurpose the previously approved foam technology, licensed from SNL. As a result, WallWrite's annual sales reached two hundred thousand dollars, between 1990 and 1993, mostly through the company's own marketing efforts at training conferences. This was the time for PC to seek a strategic partner to embark on the next higher growth stage. Following the consummation of fervent negotiations in 1994, the strategic partner provided PC with access to major distribution chains such as Wal-Mart, gaining in return a proprietary technology for product line filling. The WallWrite success translated into a total of eight to ten hundred thousand dollars from PC's sales in 1995.

PC Case Analysis

The PC case highlights the important role of serendipity, entrepreneurial initiative, and continuing support from The Federal Laboratory that helped in turning an apparent transfer failure into a success story. The initial support coming from SNL was decisive: apart from gaining access to the basic technology, the co-founder made use of her laboratory contacts in order to meet with potential customers in the semiconductor industry. Thus, it is fairly obvious that the founders placed their emphasis on the market-pull orientation of PC, rather than the adoption of a technology push attitude. Nevertheless, the original application was not a viable product, and this was apparent from the initial development and marketing process. Recognizing the limits of the market, PC took the daring step to reformulate its business plan and focus on an entirely new application, also supported by SNL technologies. In this case, the Federal Laboratory support definitely played a key role in this transformation; however, the entrepreneurial initiative exhibited by the founders of Permacharge was the crucial factor in the company's success.

Table 7.6 presents these and other metrics of the process of technology transfer in the PC case.

7.1.15.3 Radiant Technologies Incorporated

Radiant Technologies Incorporated is a premier test equipment company focusing its activities on the measurement and testing of ferroelectric materials, and the application of thin ferroelectric films to products found almost everywhere: cameras, cell phones, automobiles, electronic equipment, etc. (Ferroelectric materials have the property of a spontaneous electric polarization which can be reversed by

Table 7.6 Key metrics reflecting facilitating and impeding factors in PC

Input metrics	Intermediate metrics	Short-term metrics	Long-term metrics
Existence of established electret technology with no existing applications	Contact with customers and prototype through SNL connections	Initial technology license from SNL	Modest success of clean room technology and similar applications
Market scan to determine best target applications	Lack of interest from strategic partners to fund development for contaminant removal	Further technology development and initial sales to high-tech industry	Sales growth for WallWrite
	Decision by PC to refocus on consumer application (WallWrite)	Securing of strategic alliance for WallWrite and distribution agreement	

the application of an external field. The prefix *ferro,* meaning iron, is used to describe this very property in analogy to the ferromagnet, as most ferroelectric materials do not contain iron).

Radiant is a unique spin off, as its core technology did not come from a Federal Laboratory. Being U.S. Air Force officers at the time, its founders had been exposed to the electronic modulator technology while working at the Phillips Air Force Laboratory, formerly called Air Force Weapons Laboratory. Fully aware of the implications for making integrated circuits (IC) using that basic technology, the two ex-officers and others created Chrysalis Corporation in 1984, a company that declared bankruptcy in 1987. After that, the two of them founded Radiant Technologies, and initiated two CRADAs with Sandia National Laboratories and one CRADA with Los Alamos National Laboratory, in 1992. Since Radiant technologies had previously established contacts with labs, it took only 6 weeks to formulate the CRADAs. The company tested its technology at the Sandia laboratory for IC manufacturing technology, located just across the street from Radiant Technologies, and technical information was formally and informally exchanged between Radiant employees and the neighboring Sandia R&D personnel.

The company had 14 in 1996 and had reached ten million dollars in sales by 1994. Furthermore, it was able to enter the Japanese market through the formation of a strategic alliance with BDM corporation and Rio Grande Corporation. Radiant Technology sells about a third of its testers in Japan, through an agreement with a Japanese company that handles their distribution.

Radiant Technologies Case Analysis

The experiences of Radiant Technologies clearly illustrate the challenges spin-off companies face and the special requirements placed on technology transfer and commercialization purposes. Lessons gleaned from the failure of Chrysalis steered the founders towards sustaining their company through internal growth, rather than

Table 7.7 Key metrics reflecting facilitating and impeding factors in radiant

Input metrics	Intermediate metrics	Short-term metrics	Long-term metrics
Availability of technology from Phillips laboratory	Assistance of SNL contacts in establishing CRADA	Initial CRADAs with SNL and LANL	Growth in sales to domestic market
Founders' decision to create radiant after the failure of Chrysalis	Proximity to SNL researchers and facilities	Continuing contracts and CRADAs with DOE, Labs, and defiance advanced research projects agency (DARPA)	Expansion into international market
Work of former SNL employees on core technology for radiant	Development of alliances with BDM and Rio Grande Corporation	Initial product development for semiconductor industry	Development of new related product and technology capabilities
	Experience of founders from previous failure	Growth of company through internal efforts	

exposing the firm to the unpredictability of the venture capital market. It can also be observed that support from Federal Laboratories, in technology transfer and commercialization processes, comes both through informal mechanisms (e.g. contacts within the labs and exchanges with lab researchers) and by formal methods, such as granting access to user facilities. So ultimately, we can say that Radiant's commercial success would not have been possible without the help of private sector partners (BDM and Rio Grande Corporation) as well as the Federal facilities involved.

Table 7.7 summarizes the Radiant case analysis using key metrics of the transfer process.

7.1.15.4 Yamada Science & Art Corporation

Yamada Science and Art Corporation (YSA) is located in Santa Fe, New Mexico. Before establishing YSA, its founder had worked in the Environmental Sciences Division of LANL, where he studied air pollution simulations, numerical weather predictions, atmospheric sciences, and meteorology. As a natural consequence, YSA specializes in atmospheric modeling solutions predicting the patterns and effects of airflows, as well as the dispersion of airborne materials over urban areas, coastal regions, and complex terrain. This spin-off was established in 1988, when the founder merged his scientific interests and computer modeling technologies with his wife's fine art business.

Yamada was one of the first spin-offs from LANL to receive an exclusive technology license for a three-dimensional numerical model, developed by the founder himself while he worked at LANL. As the process of acquiring a technology license was at that time unprecedented, the three parties involved, namely, the U.S. Department of Energy (DOE), LANL, and YSA, had to overcome emerging issues over the 6 or 7 month period required for the acquisition of an exclusive technology license.

YSA's client list now includes weather bureaus, utility companies, U.S. Army and Air Force research laboratories, national research laboratories, Japanese universities, and construction companies.

Yamada Science and Art Corporation Case Analysis

Resembling the MSC case described above, the YSA case reflects the success of a technology transfer against the obstacles posed Federal laboratories. The Department of Energy has since then streamlined the processes for spinning off technologies and signing CRADAs, thus making the environment for spin-offs more favorable than it was in the YSA case.

Table 7.8 provides the key metrics used to analyze the Yamada case.

In the diverse cases described above, we can be observe the existence of a repeating pattern involving the presence of internal and external champions, appropriate technology, and long term, patient risk capital: it is exactly this recurrent pattern that distinguishes an attempt and makes the winning difference in a competitive environment. Part of the same pattern, however, is the absence of any identifiable 'success recipes' as critical factors appear to be situation-specific.

General Findings from Case Studies

Using the discussion framework constructed above, we are in a position to draw some preliminary conclusions concerning the degree of significance of metrics, in measuring success in technology transfer.

In the NASA cases, the common denominator of success was the presence of internal and external champions in all three cases, additionally to government funding, appropriate technology, and a license grant, existing in two of the three. All the above elements were also critical success factors for technology transfer, as revealed by a closer analysis of these case studies.

In the case of New Mexico projects, it is clearly observed that the idiosyncratic nature of spin-off creation would not fit into any cut and dried clichés. Nevertheless,

Table 7.8 Key metrics reflecting facilitating and impeding factors in Yamada

Input metrics	Intermediate metrics	Short-term metrics	Long-term metrics
Technical ability of the founder	Difficulties in licensing technology	Exclusive license to key YSA technology from LANL	Growth in applications for YSA technology
Modeling technology developed at LANL	Problems with CRADA negotiations	Lack of a continuing relationship between YSA and federal laboratories	Growth of YSA customer base
	Absence of related resources in area near YSA	Successful launch of YSA	Continued relations between YSA and customers

despite variety and uniqueness of each case, there seem to be three recurring critical success factors: **(i) the technical entrepreneurs, (ii) the risk-capital supporting technology-based ventures, and (iii) the underlying technology behind these ventures**.

Despite the abundance in technological knowhow and assets with considerable commercial promise in New Mexico, the roadmap for successful technology transfer and the commercialization paths to be followed were fraught with difficulties (Carayannis and Alexander 1999).

As it can be observed, the profiles of the four spin-offs and their founders' personalities definitely seem to confirm Radosevich's views: in the cases analyzed above, we notice that the founders are either inventor- entrepreneurs, that is, ex laboratory employees seeking to commercialize their own inventions or surrogate entrepreneurs, that is, not inventors but license holders of federally sponsored technologies, willing to launch a new venture. Between the aspiration phase and the launching of the new venture, in both models, there is a complicated preparation phase (Carayannis and Alexander 1999).

Overemphasizing short-term metrics in the 'out-the-door' concept often leads government laboratories to end their involvement with a technology after the transfer process. In many cases though, continued laboratory involvement is considered to be necessary until the transformation of the technology into a product is achieved. Ham and Mowery (1995) discovered that the CRADA process followed in laboratories often dictated the disengagement of the personnel as soon as a prototype was demonstrated, even though their expertise would still be necessary to incorporate technology into production. This finding is consistent with other authors' conclusions, such as those drawn by Eldred and McGrath (1997) who note: "The transition team is central to the technology transfer process. It has evolving membership… The transition team may ultimately evolve into the product development core team after the initial phase of product development".

7.2 Conclusions and Recommendations

In the light of the findings from the seven case studies presented above, a **hybrid portfolio approach** will be used in assessing the success of technology transfer and commercialization efforts. Incorporating both quantitative and qualitative measures, this approach is flexible in its implementation. It definitely should be based on raw data and facts, rather than having underpinnings on economic models that introduce levels of uncertainty and are more open to criticism. This approach would require an attitude without any preconceptions or prejudices and openness to learning by doing (Carayannis and Alexander 1999).

The hybrid portfolio approach consists of input, intermediate, and short and long term output, qualitative and quantitative metrics. The platform for identifying and synthesizing major facilitating and impeding factors that can determine market success or failure is provided through systematic case study development and analysis, as it is outlined in this paper (Carayannis and Alexander). Consequently, based on these factors, we can link key drivers of the technology transfer and commercialization processes to market success or failure and gain the ability to reengineer the above process, according to the situation.

More specifically, in the case studies outlined above, the facilitating or impeding factors focus on the collaboration both between government and industry, and between marketing and technology. These factors fall under the following broad categories:

- Financial
- Technology lifecycle/maturity
- Market lifecycle/maturity
- Cultural (trust issues, openness/sharing issues)
- Systemic (bureaucratic issues, intellectual property rights issues)
- Strategic orientation (competitive vs co-operative or collaborative/competitive issues)
- International vs. domestic market and technological orientation, and
- Timing and selection of all the above factors (synchronization issues).

Table 7.9 provides a typology of technology transfer and commercialization outcome factors, outlining and grouping both facilitating and impeding factors from all seven cases discussed in this chapter. The factors are then labeled as common or differentiating, based either on whether they were common and in how many of the cases or on their being unique in only one case.

As we can see from the findings in the table below, a common facilitating factor is the presence and role of internal and external champions, whereas a common impeding factor, being systemic in nature, is the conflict over the transfer of ownership of

Table 7.9 Categorization of key metrics derived from cases

Key metric	Common, facilitating	Common, impeding	Differentiating, facilitating	Differentiating, impeding
Emergence of internal and external champions	**y**			
Cultural barriers separating laboratory and industry		**y**		
Financial support of laboratory	**y**			
Continuing support from laboratory researchers	**y**			
Experiences of entrepreneurs			**Y**	
Outside advice from investors/ sponsors				**Y**
Difficulty of negotiating IPR ownership		**y**		
Lack of available investment capital		**y**		

Legend: *Common Factors* are those found in three or more of the case studies
Differentiating Factors are those found in only one of the case studies

Table 7.10 Analysis of case portfolio using Business Consulting Group (BCG) framework

Potential or actual market share, profitability, customer base, etc.	
Cash cows MSC	**Stars** Yamada PSI
Dogs Permacharge (Particle Filtration)	**Question marks** Radiant Amtech Permacharge (WallWrite)
Potential or actual rate of growth in market share, profits, etc.	

Not applicable: Tecnico

intellectual property rights, in a collaborative rather than in a competitive context. A differentiating or unique factor was the laboratory connections held by the founders of Radiant Technologies, while a differentiating impeding factor was the usage of the lawsuit filed by NASA against MacNeal-Schwendler Corporation in order for the company to stop using NASA's intellectual property in their software.

In Table 7.10, a grouping of the case studies is attempted into the four categories defined under the Boston Consulting Group (BCG) model: the terms '**cash cows, dogs, question marks, and stars'** are used to indicate the relative current and expected technological and market prowess of the companies, profiled as case studies. The classification of these companies, according to the market success measures identified earlier, is performed by guesstimating the private companies' individual levels and rates of growth, as field data are limited in these cases. Consequently, the following table provides only a framework to be used along with more robust empirical data samples.

Linking tangible inputs with tangible outputs, namely, technology as input and money as output has always been fruitful. However, the situation becomes unmanageable when linking intangibles, namely, the transfer of processes, knowledge, and skills with tangibles, such as money or other measurable return on investment (ROI). Thus, the most effective way for examining and understanding a process dealing with both tangible and intangible inputs and outputs, seems to be the case study approach capturing at the same time the value added in the case of intangibles,. However, in a case study there may not be sufficient information accessible to researchers, in order to create a comprehensive 'picture' that would allow proper evaluation of technology transfer (Carayannis and Alexander 1999). It should be noted that the choice of who will conduct the case study research is as important as the research itself, in determining whether a true evaluation is achieved.

According to Penaranda (1996):

> *'If credible, substantiated cause-effect statistics are to be gathered so appropriate benefits may be attributed to the technology transfer and commercialization processes, every technology transfer event or 'hit' must be tracked and documented to its ultimate conclusion… but the sources of the most critical information are often uncooperative. These are the commercial partners themselves… Sometimes the information is impossible to extract from the overall corporate records… Very often, however, there is a general reluctance to share this information with the 'feds' for fear of 'revenues' knocking at their doors, literally or figuratively.'*

Therefore, one may consider a case study as a **'performance metric'** in a broad sense: unlike econometric statistical models, it provides a context or frame of reference, common enough to make meaningful comparisons, rather than focusing on the identification of **ambiguity and uncertainty**, anyway inherent in the intangibles of technology transfer and commercialization.

Consequently, **a case study as a 'performance metric'** could be a source of insight and information both in depth, as a 'well' of knowledge, and in breadth, as a check-pattern 'fabric' across which case studies emerge as distinctive, recurrent patterns (Carayannis and Alexander 1999).

The case study method can serve as the conceptual 'bridge' between tangible outputs and intangible processes and critical success factors. Undoubtedly, a combination of qualitative and quantitative measures provides a more comprehensive assessment not only of the degree of success but also of the reasons for success.

Furthermore, just raw data can be very enlightening in the evaluation of the value added of intangibles, such as technical assistance, for instance, through the correlation of technical assistance to jobs created. This kind of data should include quantitative measures of value added such as survey data, numbers of cooperative agreements, number of patents and licenses, streams of future royalty payments, as well as qualitative measures of value added such as quality of life, etc. (Carayannis and Alexander 1999). These quantitative data, rather than absolute numbers, can be very informative in distinguishing trends and predicting their evolution over time, and can prove very useful as benchmarks.

Finally, such a hybrid approach can help leverage technology and gain special advantage from its knowledge content in order to increase the potential return of an investment. It provides the grounds for building and sustaining competitive advantage for both the transferor and the transferee of technology: both financial and strategic imperatives, short and long term criteria are allowed to come into play in evaluating the outcomes and reengineering the process of technology transfer and commercialization.

References

Aggarwal R (1982) The role of foreign direct investment and technology transfer in India. In: Proceedings of AIB conference, University of Hawaii

Carayannis E (1994a) A multi-national, resource-based view of training and development and the strategic management of technological learning: keys for social and corporate survival and success. In: 39th International council for small business annual world conference, Strasbourg, France, June 27–29

Carayannis E (1994b) The strategic management of technological learning from a dynamically adaptive high tech marketing perspective: sustainable competitive advantage through effective supplier-customer interfacing, University of Illinois, Chicago/American Management Association Research Symposium on Marketing and Entrepreneurship, Paris, France, June 29–30

Carayannis E (1994c) Gestion Strategique de l'Acquisition des Savoir-Faire, Le Progrès Technique, no. 1, Paris, France

Carayannis E (2001) Learning more, better, and faster: a multi-industry, longitudinal, empirical validation of technological learning as the key source of sustainable competitive advantage in high-technology firms. Int J Technovation

Carayannis E (2008) Knowledge-driven creative destruction or leveraging knowledge for competitive advantage: Strategic Knowledge Arbitrage and Serendipity (SKARSE) as Real Options Drivers (RODs) triggered by co-opetition, co-evolution and co-specialization (C3). J Ind Higher Edu 22(6):343–353

Carayannis E, Alexander J (1998) Secrets of success and failure in commercializing US Government RandD Laboratories Technologies: a structured case study approach. Int J Technol Manage 18(3/4):246–269

Carayannis E, Bush L (1997) The case study as a "Performance Metric". In: Evaluating and reengineering technology transfer and commercialization: dealing with the challenge of quantifying intangibles, successes, failures and lessons learned, technology transfer society 1997 annual meeting: leveraging technology for competitive advantage, Denver, Colorado, July 19–23

Carayannis EE, Rogers et al (1998) High-Technology Spin-offs from Government RandD Laboratories and Research Universities, Technovation, 18(1):1–11, January. NOTE: 1998 Recipient of two Emerald Management Reviews Citations - Citation of Excellence for Practical Implications and Citation of Excellence for Originality

Carayannis EG, Provance M (2008) Measuring firm innovativeness. Int J Innov Regional Dev 1(1):90–107

Carayannis E, Alexander J (1999) Winning by co-opeting in strategic Government-University-Industry (GUI) partnerships: the power of complex, dynamic knowledge networks. J Technol Transf 24(2/3):197–210 (Note: Awarded 1999 Lang-Rosen Award for Best Paper by the Technology Transfer Society)

Carayannis E, Kassicieh S, Radosevich R (1997) Financing technological entrerpeneurship: the role of strategic alliances in procuring early stage seed capital. In: Portland international conference on management of engineering and technology, Portland, Oregon, July 27–31

Carayannis E, Rogers E et al (1998) High-technology spin-offs from government RandD Laboratories and Research Universities. Technovation 18(1):1–11 (Note: 1998 Recipient of two Emerald Management Reviews Citations - Citation of Excellence for Practical Implications and Citation of Excellence for Originality)

Cassen PM, Peale SJ, Reynolds RT (1982) Structure and thermal evolution of the Galilean satellites. In: Morrison D (ed) Satellites of Jupiter. The University of Arizona Press, Tucson, pp 93–128

Cooper C, Sercovitch F (1971) The channels and mechanisms for the transfer of technology from developed to developing countries. Geneva: UNCTAD

Crawford MH (1987) Technology transfer and computerization of South Korea and Taiwan – part I/II: development in the private sector. Inf Age (UK) (9(1):10–16/9(2):67–73)

Eldred, E.W, McGrath, M.E, 1997. Commercializing new technology– I. Research Technology Management, 40(1):41–47

Emmanuel A (1980) Technologie appropriée, mirage on réalité? (χειρόγραφο)

Enos JL, Park WH (eds) (1988) The adoption and diffusion of imported technology: the case of Korea. Croon Helm, Beckham, pp 176–261

Gee S (1981) Technology transfer, innovation and international competitiveness. Wiley, New York

Gruber W, Marquis D (1969) Research on the human factor in the transfer of technology. In: Gruber W, Marquis D (eds) Factors in the transfer of technology. The MIT Press, Cambridge

Ham R, Mowery D (1995) Enduring dilemmas in U.S. technology policy. Calif Manage Rev 37(4):89–107

Hoffmann L (1985) The transfer of technology to developing countries. Intereconomics 20(3):263–272

Islam N, Kaya Y (1985) Technology assimilation in the less developed countries of Asia: lessons from Japan. Int J Develop Technol 3:261–278

Kaynak E (1985) Global spread of supermarkets: some experiences from Turkey. In: Kaynak E (ed) Global perspectives in marketing. Praeger, New York

Laamanen T, Autio E (1995) Measurement and evaluation of technology transfer: review of technology transfer mechanisms and indicators. Int J Technol Manage 10(7/8):643–664

Nurkse R (1953) Capital formation in under-developed countries. Oxford, London
Parsons T, Shils EA (1962) Toward a general theory of action. Harvard University Press, Cambridge, pp 47–275
Penaranda FE (1996) Meet your partners and your enemies: the Federal sector. In: Proc. of technology transfer metrics summit, Santa Fe, NM, April 28–May 2
Radosevic S (1999) International technology transfer and catch-up in economic development. Edward Elgar Publishing, Cheltenham
Radosevich R, Kassicieh S (1993) Strategic challenges and proposed responses to competitiveness through public-sector technology. Calif Manage Rev 35(4):33–50
Rodrigues CA (1985) A process for innovators pin developing countries to implement new technology. Columbia J World Bus 20(3):21–28
Rogers E (1983) Diffusion of innovations. Free Press, New York
Rogers EM (1995) Diffusion of innovations. The Free Press, New York
Rogers E, Carayannis E et al (1998) Cooperative Research and Development Agreements (CRADAS) as technology transfer mechanisms. Rand Manage 28(2):79–88
Rubenstein AH (1976) Technical information, technical assistance and technology transfer, the need for synthesis. In: Research Development Management, vol. 6
Rugman AM (1983) Multinationals and technology transfer. Praeger, New York
Samli AC (1985) Technology transfer: geographic, economic, cultural and technical dimensions. Quorum Books, London
Spann MS, Adams M, Souder WE (1993) Improving federal technology commercialization: some recommendations from a field study. J Technol Transf 18(2/3):63–64, Summer-Fall
Stankiewicz R (1994) University firms: spin-off companies from universities. Sci Public Policy 21:99–107
Wallender HW (1979) Technology transfer and management in the developing countries. Ballinger Pub. Co., Cambridge
Yin JZ (1991) Foreign technology acquisition and technological capability development. In: Proceedings of the eastern academy of management, pp 124–145
Yoshino MY, Rangan U (1995) Strategic alliances. Harvard Business School Press, Boston

Literature

Aggarwal R (1982) The role of foreign direct investment and technology transfer in India. In: Proceedings of AIB conference, University of Hawaii

Albert P, Marion S (1997) Ouvrir l'enseignement à l'ésprit d'entreprendre

Amabile T (1996) Creativity in context: update to the social psychology of creativity. Westview Press, Boulder

Andrews KE, Christensen LE et al (1965) Business policy. Text and Cases, Homewood, 111, Richard D Irwin

Archibugi D, Michie J (eds) (1997) Technology, globalisation, and economic performance. Cambridge University Press, Cambridge

Arieti S (1976) Creativity the magic synthesis. Basic Books, New York

Arthur WB (1991) Increasing returns and the new world of business. Harv Bus Rev 74:100–109

Arundel A, Geuna A (2001) Does proximity matter for knowledge transfer from public institutes and universities to firms? SPRU, Brighton, p 37

Arundel A, Hugo Hollanders (2005) Policy, indicators and targets: measuring the impacts of innovation policies, European Trend Chart on Innovation, Enterprises Directorate-General, Brussels, European Commission, December

Astley WG, Fombrun CJ (1983) Collective strategy: social ecology of organizational environments. Acad Manage Rev 8:576–587

Bakouros YL, Demetriadou V (1999) The innovation process as facilitator of strategic decision. In: Intl. conference, preparing the manager of the 21st century, University of Macedonia, Thessaloniki

Balachandra A (1996) International technology transfer in small business: a new paradigm. Int J Technol Manage 12(5/6):625–638

Barnard CI (1938) The functions of the executive, Thirtieth Anniversary Editionth edn. Harvard University Press, Cambridge

Barney JB (1991) Firm resources and sustained competitive advantage. J Manage 17:99–120

Bartunek J et al (1987) First-order, second-order, and third-order change and organization development interventions: a cognitive approach. J Appl Behav Sci 23(4):483–500

Baruk J (1997) Innovativeness of Polish enterprises in the initial period of system transformation. Technovation 17(9):477–489

Bateson G (1972) Steps to an ecology of mind. Ballantine, New York

Bateson G (1991) Ecology of mind: the sacred. In: Donaldson R (ed) A sacred unity: further steps to an ecology of mind. Harper Collins, New York

E.G. Carayannis et al., *Innovation and Entrepreneurship*, Innovation, Technology, and Knowledge Management, DOI 10.1007/978-3-319-11242-8

Beckman T (1997) A methodology for knowledge management. International Association of Science and Technology for Development (IASTED) AI and Soft Computing Conference. Banff, Canada

Beckman T (1998) Knowledge management: a technical review. GWU Working Paper

Bierly P, Chakrabarti A (1996) Generic knowledge strategies in the U.S. pharmaceutical industry. Strategic Manage J 17(Winter Special Issue):123–135

Blanchard BS, Fabrycky WJ (1990) Systems engineering and analysis, 2nd edn. Prentice-Hall, Inc., Englewood Cliffs

Bohn RE (1994) Measuring and managing technical knowledge, Sloan Manage Rev No. Fall: 61–72

Borrus M (1998) Foreign participation in US-funded R and D: the EUV project as a new model for a new reality. BRIE Working Paper 118, University of California, Berkeley

Bozeman B (2000) Technology transfer and public policy: a review of research and theory. Res Policy 29:627–655

Brandenburger A, Nalebuff J (1996) Co-opetition. Currency Doubleday, New York, p 39

Branscomb LM (1993) National laboratories: the search for new missions and new structures. In: Branscomb LM (ed) Empowering technology: implementing a U.S. strategy. MIT Press, Cambridge

Breschi S, Malerba F (1997) Sectoral systems of innovation: technological regimes, Schumpeterian dynamics and spatial boundaries. In: Edquist C (ed) Systems of innovation. F Pinter, London

Bridwell L, Richard M (1998) The Semiconductor industry in the 21st century: a global analysis using Michael Porter's Industry-Related Clusters. Competitiveness Rev 8(1):24–36

Brooking A (1996) Introduction to intellectual capital. The Knowledge Broker Ltd., Cambridge

Brooks H (1966) National science policy and technology transfer. In: Conference on technology transfer and innovation, National Science Foundation, NSF 67-5, Mimeo

Brusoni S, Geuna A (2001) The key characteristics of sectoral knowledge bases: an international comparison. SPRU Electronic Working Paper Series, Paper No. 69. Brighton: University of Sussex

Brusoni S, Prencipe A, Pavitt K (2001) Knowledge specialization, organizational coupling, and the boundaries of the firm: why do firms know more than they make. Admin Sci Q 46:597–621

Burns T, Stalker GM (1961) The management of innovation. Tavistock, London

Bush V (2001) To president Truman, with title Science: The Endless Frontier. Business-Higher-Education Forum. http://www.nsf.gov/od/lpa/nsf50/vbush1945.htm

Camagni R (1991) Local milieu, uncertainty and innovation networks: towards a dynamic theory of economic space. In: Camagni R (ed) Innovation networks: spatial perspectives. Belhaven-Pinter, London, pp 121–144

Carayannis E (1992) An integrative framework of strategic decision making paradigms and their empirical validity: the case for strategic or active incrementalism and the import of tacit technological learning, Working Paper #131, School of Management, Rensselaer Polytechnic Institute, October

Carayannis E (1993) Incrementalisme Strategique, Le Progrès Technique, no. 2, Paris, France

Carayannis E (1994a) A multi-national, resource-based view of training and development and the strategic management of technological learning: keys for social and corporate survival and success. In: 39th International council for small business annual world conference, Strasbourg, France, June 27–29

Carayannis E (1994b) The strategic management of technological learning from a dynamically adaptive high tech marketing perspective: sustainable competitive advantage through effective supplier-customer interfacing, University of Illinois, Chicago/American Management Association Research Symposium on Marketing and Entrepreneurship, Paris, France, June 29–30

Carayannis E (1994c) Gestion Strategique de l'Acquisition des Savoir-Faire, Le Progrès Technique, no. 1, Paris, France

Carayannis E (1995) AGFA/Miles EPS: a case of technological learning renaissance. In: Eastern case writers association conference, Providence, Rhode Island, March 12–13

Carayannis E (1996) Re-engineering high risk, high complexity industries through multiple level technological learning: a case study of the world nuclear power industry. J Eng Technol Manage 12(4):301–318

Carayannis E (1997) Data Warehousing, Electronic Commerce, and Technological Learning: Successes and Failures from Government and Private Industry and Lessons Learned for 21st Century Electronic Government, Online Journal of Internet Banking and Commerce, March

Carayannis E (1998a) The strategic management of technological learning in project/program management: the role of extranets, intranets and intelligent agents in knowledge generation, diffusion, and leveraging. Technovation 18(11):697–703

Carayannis E (1998b) Higher order technological learning as determinant of market success in the multimedia arena; a success story, a failure, and a question mark: Agfa/Bayer AG, enable software, and sun microsystems. Technovation 18(10):639–653

Carayannis E (1998–2002) George Washington University Lectures on Entrepreneurship. Carayannis, E. The Globalization of Knowledge and Information Creation and Diffusion Processes and Standards in an Emergent Trading Groups Context: EU, NAFTA, Mercosur, and APEC, Seminar on Globalization of Knowledge and Information Creation and Diffusion Processes and Standards in an Emergent Trading Groups Context: Laying the Foundations for Latin American Competitiveness in the 21st Century, University of Puerto Rico Rio Piedras, San Juan, Puerto Rico, March 14, 1997

Carayannis E (1999) Fostering synergies between information technology and managerial and organizational cognition: the role of knowledge management. Technovation 19(4):219–231

Carayannis E (2000–2009) GWU Lectures

Carayannis E (2001) Learning more, better, and faster: a multi-industry, longitudinal, empirical validation of technological learning as the key source of sustainable competitive advantage in high-technology firms. Int J Technovation

Carayannis E (2002) Is higher order technological learning a firm core competence, how, why, and when: a longitudinal, multi-industry study of firm technological learning and market performance. Int J Technovation 22:625–643

Carayannis E (2008) Knowledge-driven creative destruction or leveraging knowledge for competitive advantage: Strategic Knowledge Arbitrage and Serendipity (SKARSE) as Real Options Drivers (RODs) triggered by co-opetition, co-evolution and co-specialization (C3). J Ind Higher Edu 22(6):343–353

Carayannis EG (2009) Firm evolution dynamics: toward sustainable entrepreneurship and robust competitiveness in the knowledge economy and society. Int J Innov Regional Dev (1)3:235–254

Carayannis E, Alexander J (1997). The role of knowledge exchange in trust, co-opetition and post-capitalist economics. Paper presented at the European institute for the advanced study of management, Belgium

Carayannis E, Alexander J (1998) Secrets of success and failure in commercializing US Government RandD Laboratories Technologies: a structured case study approach. Int J Technol Manage 18(3/4):246–269

Carayannis EG, Alexander J (1999a) To intellectual capital in co-opetitive research and technology management settings. Int J Technol Manage 18(3/4):326–352

Carayannis E, Alexander J (1999b) Winning by co-opeting in strategic Government-University-Industry (GUI) partnerships: the power of complex, dynamic knowledge networks. J Technol Transfer 24(2/3):197–210, August. Note: Awarded 1999 Lang-Rosen Award for Best Paper by the Technology Transfer Society

Carayannis E, Alexander J (2001) Virtual, wireless mannah: a co-opetitive analysis of the broadband satellite industry. Technovation 21(12):759–766

Carayannis E, Alexander J (2002) Is technological learning a firm core competence; when, how, and why: a longitudinal, multi-industry study of firm technological learning and market performance. Technovation 22(10):625–643, October 2002. NOTE: Recipient of Emerald Management Reviews Citation of Excellence for Research Implications

Carayannis E, Alexander J (2004) Trans-Atlantic innovation infrastructure networks: public–private, EU–US RandD partnerships. Accepted for presentation: IAMOT, Washington DC, 4 April to 7 April

Carayannis EG, Alexander JM (2006) International Public/Private R and D Collaborations: Focus on EU/US Government–University–Industry Research and Technology Development Partnerships, Palgrave Macmillan

Carayannis EG, Aris Kaloudis (2008) Diversity in the knowledge economy and society: heterogeneity, innovation and entrepreneurship. Edward Elgar Publishing, Incorporated

Carayannis E, Bush L (1997) The case study as a "Performance Metric". In: Evaluating and reengineering technology transfer and commercialization: dealing with the challenge of quantifying intangibles, successes, failures and lessons learned, technology transfer society 1997 annual meeting: leveraging technology for competitive advantage, Denver, Colorado, July 19–23

Carayannis EG, Campbell DFJ (2005) Co-editors, knowledge creation, diffusion, and use in innovation networks and knowledge clusters: a comparative systems approach across the United States, Europe, and Asia. Praeger Books/Greenwood Press

Carayannis E, Gonzalez E (2003) Creativity and Innovation = Competitiveness? When, How, and Why, The International Handbook on Innovation, Larisa V. Shavinina (ed.), Part VIII, Chapter 3, Elsevier Press, October

Carayannis EG, Campbell DFJ (2006) A "'Mode 3' Systems Approach for Knowledge Creation, Diffusion and Use: Towards a 21dt Century Fractal Innovation Ecosystem", re-discovering schumpeter: creative destruction evolving into 'Mode 3'. In: Carayannis EG, Ziemnowicz C (Co-Editors) Chapter 7, Palgrave Macmillan

Carayannis E, Campbell D (2009) "Mode 3" and "Quadruple Helix": towards a 21st century fractal innovation ecosystem. Int J Technol Manage 46(3/4):201–234

Carayannis E, Chanaron J (2007) Leading and managing creators, inventors, and innovators: the art, science, and craft of fostering creativity, triggering invention, and catalyzing innovation. Praeger Publishers, Westport, Conn.

Carayannis EG, Coleman J (2005) Creative system design methodologies: the case of complex technical systems. Technovation 25(8):831

Carayannis EG, Formica P (2006) Intellectual venture capitalists: an emerging breed of knowledge entrepreneurs. Ind Higher Edu 20(3):151–156

Carayannis EG, Formica P (Co-editors) (2008) Knowledge matters: technology, innovation and entrepreneurship in innovation networks and knowledge clusters. Palgrave Macmillan

Carayannis E, Gonzalez E (2003) Creativity and innovation = competitiveness? When, how, and why. In: Shavinina LV (ed) The international handbook on innovation, Part VIII, Chapter 3. Elsevier Press, Oxford

Carayannis E, Gover J (1996) Co-opetition, strategic technology options and game theory in science and technology policy: the case of sematech. portland international conference on management of engineering and technology, Portland, Oregon

Carayannis E, Gover J (2002) The SEMATECH-sandia national laboratories partnership: a case study. Technovation 22(9):585–591

Carayannis E, Jorge J (1998) Bridging Government–University–Industry technological learning disconnects: a comparative study of training and development policies and practices in the US, Japan, Germany, and France. Technovation 18(6/7):383–407, Jun/Jul. NOTE: 1998 Recipient of two Emerald Management Reviews Citations – Citation of Excellence for Practical Implications and Citation of Excellence for Readability

Carayannis E, Kassicieh S (1996) The relationship between market performance and higher order technological learning in high technology industries. In: Fifth international conference on management of technology, Miami, FL, 27 February–1 March, pp 309–320

Carayannis E, Laget P (2004) Trans-Atlantic innovation infrastructure networks: public–private, EU–US RandD partnerships. J RandD Manage 34(1):17–32

Carayannis EG, Provance M (2008) Measuring firm innovativeness. Int J Innov Regional Dev 1(1):90–107

Carayannis E, Roy S (1999) Davids vs. Goliaths in the small satellite industry: the role of technological innovation dynamics in firm competitiveness. Int J Technovation 20(6):287–297

Carayannis EG, Sipp M (2006) e-Development Towards The Knowledge Economy: Leveraging Technology, Innovation and Entrepreneurship for "Smart" Development, Palgrave Macmillan

Carayannis E, Stokes R (1997) A historical analysis of management of technology at Badische Anilin und Soda Fabrik (BASF) AG, 1865 to 1993: a case study. J Eng Technol Manage 14(2):175–193

Carayannis E, Maximilian von Zedwitz (2005) Architecting GloCal (Global – Local), Real-Virtual Incubator Networks (G-RVINs) as catalysts and accelerators of entrepreneurship in transitioning and developing economies: lessons learned and best practices from current development and business incubation practice. Int J Technovation 25(2)

Carayannis EG, Ziemnowicz C (Co-Editors) (2007) Re-discovering Schumpeter: creative destruction evolving into 'Mode 3'. Palgrave Macmillan, Basingstoke

Carayannis E, Preston A, Awerbuch S (1996) Architectural innovation, technological learning, and the virtual utility concept. In: Proceedings of the international conference on engineering and technology management, IEEE Engineering Management Society, Vancouver, Canada, August 18 20

Carayannis E, Kassicieh S, Radosevich R (1997) Financing technological entrerpeneurship: the role of strategic alliances in procuring early stage seed capital. In: Portland international conference on management of engineering and technology, Portland, Oregon, July 27–31

Carayannis E, Rogers E et al (1998) High-technology spin-offs from government RandD Laboratories and Research Universities. Technovation 18(1):1–11, January. NOTE: 1998 Recipient of two Emerald Management Reviews Citations - Citation of Excellence for Practical Implications and Citation of Excellence for Originality

Carayannis E, Alexander J (1999) Winning by Co-opeting in Strategic Government-University-Industry (GUI) Partnerships: The Power of Complex, Dynamic Knowledge Networks, Journal of Technology Transfer, vol. 24, no. 2/3, pp. 197–210, August. Note: Awarded 1999 Lang-Rosen Award for Best Paper by the Technology Transfer Society

Carayannis E, Kassicieh S, Radosevich R (2000) Strategic alliances as a source of early-stage seed capital in technology-based firms. Technovation 20(11):603–615

Carayannis E, Alexander GJ, Geraghty J (2001) Service sector productivity: B2B electronic commerce as a strategic driver. J Technol Transfer 26(4):337–350

Carayannis E et al (2003a) A cross-cultural learning strategy for entrepreneurship education: outline of key concepts and lessons learned from a comparative study of entrepreneurship students in France and the US. Technovation 23(9):757–771, September 2003. NOTE: Recipient of Emerald Management Reviews Citation of Excellence for Research Implications

Carayannis E, Gonzalez E, Wetter J (2003b) Nature and dynamics of discontinuous and disruptive innovations from a learning and knowledge management perspective. In: Shavinina LV (ed) The international handbook on innovation, Part II, Chapter 7. Elsevier Press, Oxford

Carayannis EGD, Popescu CS, Stewart M (2006) Technological Learning for Entrepreneurial Development (TL4ED) in the Knowledge Economy (KE): case studies and lessons learned. Technovation 26(4):419–443

Carayannis EG, Assimakopoulos D, Kondo M (Co-editors) (2008) Innovation networks and knowledge clusters: findings and insights from the US, EU and Japan. Palgrave Macmillan

Carlsson B (ed) (1995) Technological systems and economic performance: the case of factory automation. Kluwer Academic Publishers, Boston

Carlsson B (ed) (2002) New technological systems in the bio industries – an international study. Kluwer Academic Publishers, Boston

Carlsson B, Stankiewicz R (1991a) On the nature, function, and composition of technological systems. J Evol Econ 1(2):93–118

Carlsson B, Stankiewicz R (1991b) On the nature, function and composition of technological systems. JEvol Econ 1:93–118

Carlsson B, E.son G, Tayzmaz E (1992) The macroeconomic effects of technological systems: micro–macro simulations. Paper presented at the 20th annual conference of the European association for research in industrial economics (EARIE), Sent 4–7, Israel
Checkland P (1981) Systems thinking, systems practice
Chesbrough H (2003) Open Innovation: the new imperative for creating and profiting from technology. Harvard Business School Press, Boston
Chompalov I, Shrum W (1999) Institutional collaboration in science: a typology of technological practice. Sci Technol Hum Values 24(3):338–372
Chompalov I, Genuth J, Shrum W (2002) The organization of scientific collaborations. Res Policy 31:749–767
Choo CW (1998) The knowing organization: how organizations use information to construct meaning, create knowledge and make decisions. Oxford University Press, New York
Christensen CM (1997) The innovator's dilemma: when disruptive technologies cause great firms to fail. Harvard Business School Press, Boston
Christoph-Friedrich von B (1997) The innovation war. Upper Saddle River, Prentice Hall
Ciborra CU, Schneider LS (1992) Transforming the routines and contexts of management, work and technology. In: Adler PS (ed) Technology and the future of work. MIT Press, Cambridge, pp 269–291
Cimoli M (1998) Methodologies for the studies of NIS: a cluster based approach for the Mexican case. Presented at the OECD workshop on cluster analysis and cluster-based policies, October, Amsterdam, proceedings, 1997
Cohen W, Levinthal D (1990) Absorptive capacity: a new perspective on learning and innovation. Adm Sci Q 35:128–152
Cohen G, Salomon I, Nijkamp P (2002) Information–communications technologies (ICT) and transport: does knowledge underpin policy? Telecommun Policy 26(1–2):31–52
Cole R (1989) Strategies for learning: small group activities in American, Japanese, and Swedish Industry. Berkeley University Press, Berkeley
Conference Board (1996) Knowledge management in organizations. NY
Cooke H-K, Braczyk P, Heidenreich M (eds) (1998) Regional innovation systems. UCL Press, London
Coombs R, Narandren P, Richards A (1996) A literature-based innovation output indicator. Res Policy 25(4):403–413
Cooper JR (1998) A multidimensional approach to the adoption of innovation. Manage Decis 36(8):493–502
Cooper C, Sercovitch F (1971) The channels and mechanisms for the transfer of technology from developed to developing countries. Geneva: UNCTAD
Cooper RG, Edgett SJ, Kleinschmidt EJ (2004) Benchmarking best NPD practices – II. Res Technol Manage 47(3):50–59
Coriat B, Weinstein O (2002) Organizations, firms and institutions in the generation of innovation. Res Policy 31(2):273–290
Coyle RG (1977) Management system dynamics. Wiley, New York
Coyle RG (1996) System dynamics modelling: a practical approach. Chapman & Hall, New York
Crawford MH (1987) Technology transfer and computerization of South Korea and Taiwan – part I/II: development in the private sector. Inf Age (UK) (9(1):10–16/9(2):67–73)
Cummings JL, Teng B (2003) Transferring RandD knowledge: the key factors affecting knowledge transfer success. J Eng Technol Manage 20(1–2):39–68
Cusmano L (2000) Technology policy and co-operative RandD: the role of relational research capacity. DRUID Working Paper No 00–3, Copenhagen Business School, Institute for Industrial Economics and Strategy
Cyert RM, March JG (1963/1992) A behavioral theory of the firm, 2nd edn. Prentice Hall, Englewood Cliffs
D'Aveni RD (1994) Hypercompetition: managing the dynamics of strategic. The Free Press, Manoeuvring

Dacey JS, Lennon KH (1998) Understanding creativity: the interplay of biological, psychological and social factors. Jossey-Bass, San Francisco
Damanpour F (1996) Organizational complexity and innovation: developing and testing multiple contingency models. Manage Sci 42(5):693–716, Organizational innovation: a meta-analysis of effects of determinants and moderators. Acad Manage J 34(3):555–590
Davenport T, Prusak L (1998) Working knowledge: how organizations manage what they know. Harvard Business School Press, Boston
Davies A (2003) Integrated solutions: the changing business of systems integration. In: Prencipe A, Davies A, Hobday M (eds) The business of systems integration. Oxford University Press, Oxford
Day K (1997) A reinvention of patent rules. The Washington Post, April 24, p E1
Diwan RK, Chakraborty C (1991) High technology and international competitiveness. Praeger, New York
Dodgson M (1993) Organizational learning: a review of some literatures. Org Stud 14(3):375–394
Dosi G (1988) Sources, procedures and microeconomic effects of innovation. J Econ Lit 26:1120–1171
Doz YL (1996) The evolution of cooperation in strategic alliances: initial conditions or learning processes? Strategic Manage J 17:55–83
Drazin R, Glynn MA, Kazanjian RK (1999) Multilevel theorizing about creativity in organizations: A sensemaking perspective. Acad Manage Rev 42(2):125–145
Drejer A (2002) Situations for innovation management: towards a contingency model. Eur J Innovation Manage 5(1):4–17
Drucker P (1985) The discipline of innovation. Harv Bus Rev 76(6):149–157
Drucker PF (1998) The discipline of innovation. Harv Bus Rev 63(3):3–8
Drucker PF (1999) Management challenges for the 21st century. Butterworth-Heinemann, Oxford
Edquist C (ed) (1997) Systems of innovation; technologies, institutions, and organizations. Pinter, London
Edquist C (2001) The systems of innovation approach and innovation policy: an account of the state of the art. Lead paper presented at the DRUID conference, Aalborg, June 12–15, 2001, under theme F: ‘National Systems of Innovation, Institutions and Public Policies’. Draft
Edquist C, Jonhson B (1997) Institutions and organisations in systems of innovation. In: Edquist C (ed) Systems of innovation: technologies, institutions and organizations. Pinter/Cassell Academic, London
Emmanuel A (1980) Technologie appropriée, mirage on réalité? (χειρόγραφο)
Enos JL, Park WH (eds) (1988) The adoption and diffusion of imported technology: the case of Korea. Croon Helm, Beckham, pp 176–261
Enright MJ (2000) Regional clusters and multinational enterprises. Int Stud Manage Org 30:114–138
Ergas H (1986) Does technology policy matter?
Etzkowitz H, Leydesdorff L (eds) (1997) Universities in the global knowledge economy: a co-evolution of university–industry–government relations. Cassell Academic, London
Etzkowitz H, Leydesdorff L (2000) The dynamics of innovation: from national systems and “Mode 2” to a Triple Helix of University–Industry–Government relations. Res Policy 29(22): 109–123
European Competitiveness Report (2007)
European Innovation Scoreboard (2003)
Evangelista R, Sandven T, Sirilli G, Smith K (1998) Measuring innovation in European industry. Int J Econ Bus 5(3):311–333
Evangelista R, Iammarino S, Mastrostefano V, Silvani A (2001) Measuring the regional dimension of innovation. Lessons from the Italian innovation survey. Technovation 21:733–745
Fagerberg J (2004) The oxford handbook of innovation. Oxford University Press, Oxford
Feeny S, Rogers M (2003) Innovation and performance: benchmarking Australian firms. Aust Econ Rev 36(3):253–264

Fleming L, Olav S (2000) Science as a map in technological search. Working paper, Social Science Research Network. www.ssrn.com

Fleming L, Sorenson O (2000) Science as a map in technological search. Working paper, Social Science Research Network. www.ssrn.com

Florida RL, Kenney M (1990) The breakthrough illusion: corporate America's failure to move from innovation to mass production. Basic Books, New York

Forrester J (1961) The impact of feedback control concepts on the management sciences. Wiley, NY

Freeman C (1979) The determinants of innovation. In: Futures, June pp 206–215

Freeman C (1987) Technology policy and economic performance: lessons from Japan. Pinter, London

Freeman CJ, Soete L (1982) Unemployment and technical innovation: a study of long waves in economic development. Frances Pinter, London

Freeman C, Soete L (2007) Developing science, technology and innovation indicators: what we can learn from the past. Working Paper 2007–001. UNU-MERIT, Maastricht

Frenken K (2000) Fitness landscapes, heuristics and technological paradigms: a critique on random search models in evolutionary economics. In: Dubois D (ed) Computing anticipatory systems. American Institute of Physics, Woodbury

Frischtak CR (1995) Harmonization versus differentiation in international property rights regimes. Int J Technol Manage 10(2/3):200–213

Fukuyama F (1995) Trust: the social virtues and the creation of prosperity. The Free Press, New York, p 26

Fusfeld HI, Haklisch CS (1985) Cooperative RandD for competitors. Harv Bus Rev 63(6):60–76

Galli R, Teubal M (1997) Paradigmatic shifts in national innovation systems. In: Edquist C (ed) Systems of innovation: technologies, institutions and organizations. Pinter Publishers, London, pp 342–370

Garud R, Rappa M (1994) A socio-cognitive model of technology evolution: the case of cochlear implants. Org Sci 5(3):344–362

Gee S (1981) Technology transfer, innovation and international competitiveness. Wiley, New York

Georghiou L (1998) Global cooperation in research. Res Policy 27(4):611–626

Giddens A (1976) New rules of sociological method. Basic Books, Hutchinson

Godin B, Gingras Y (2000) The place of universities in the system of knowledge production. Res Policy 29:273–278

Gregersen B, Johnson B (1997) Learning economies, innovation systems and European integration. Regional Stud 31(5):479–490

Gruber W, Marquis D (1969) Research on the human factor in the transfer of technology. In: Gruber W, Marquis D (eds) Factors in the transfer of technology. The MIT Press, Cambridge

Gundry LK, Prather CW, Kickul JR (1994) Building the creative organization. Org Dyn 22(4):22–37

Hagedoorn J, Cloodt M (2003) Measuring innovative performance: is there an advantage in using multiple indicators? Res Policy 32:1365–1379

Hagedoorn J, Schakenraad J (1990) Inter-firm partnerships and co-operative strategies in core technologies. In: Freeman C, Soete L (eds) New explorations in the economics of technical change. Pinter, London, pp 3–38

Hagedoorn J, Schakenraad J (1992) Leading companies and networks of strategic alliances in information technologies. Res Policy 21:163–190

Hagedoorn JA, Link A, Vonortas N (2000) Research partnerships. Res Policy 29:567–586

Hagedoorn JE, Alexander J, Carayannis and J. Alexander E (2001) Strange bedfellows in the personal computer industry: technology alliances between IBM and Apple. Res Policy 30:837–849

Halpern D (1989) Thought and knowledge: an introduction to critical thinking. Lawrence Erlbaum, Mahwah

Ham R, Mowery D (1995) Enduring dilemmas in U.S. technology policy. Calif Manage Rev 37(4):89–107

Hamel G, Prahalad CK (1989) Strategic intent. Harv Bus Rev 67(3):63–74

Hamel G, Prahalad CK (1994) Competing for the future. Harvard Business School Press, Boston

Harvey M, Lucas L (1996) Intellectual property rights protection: what MNC managers should know about GATT? Multinational Bus Rev 4(1):77–93

Hedberg B (1981) How organizations learn and unlearn. In: Nystrom PC, Starbuck WH (eds) Handbook of organizational design. Oxford University Press, London, pp 8–27, This article focuses on the need to unlearn, that is to remove old knowledge

Hicks DA, Nivin SR (2001) Beyond globalization: localized returns to IT infrastructure investments. Regional Stud 34(2):115–127

Hindle B, Lubar SD (1986) Engines of change: the American industrial revolution, 1790–1860. Smithsonian Institution Press, Washington

Hoffmann L (1985) The transfer of technology to developing countries. Intereconomics 20(3):263–272

Hofstede G (1980) Motivation, leadership and organization: do American theories apply abroad? Organ Dyn 9:42–63

Hollenstein H (1996) A composite indicator of a firm's innovativeness, an empirical analysis based on survey data for Swiss manufacturing. Res Policy 25:633–645

Howells J (1995) Tacit knowledge and technology transfer. ESRC working paper n16, University of Cambridge

Howells J (1995b) A socio-cognitive approach to innovation. Res Policy 24(6):883–894

Howells J (1999) Research and technology outsourcing. Technol Anal Strategic Manage 11(1):17–29

Huber GP (1991) Organizational learning: the contributing processes and the literatures. Org Sci 2:88–115

Hughes JR (1987) The evolution of large technological systems. In: Bijker WE, Hughes JR, Pinch TR (eds) The social construction of technological systems: new directions in the sociology and history of technology. MIT Press, Cambridge, pp 51–82

Inkpen AC (1996) Creating knowledge through collaboration. Calif Manage Rev 39(1):123–140

Irwin D, Klenow P (1996) High-tech RandD subsidies: estimating the effects of SEMATECH. J Int Econ 40:323–344

Islam N, Kaya Y (1985) Technology assimilation in the less developed countries of Asia: lessons from Japan. Int J Develop Technol 3:261–278

Jacobsson S, Johnson A (2000) The diffusion of renewable energy technology: an analytical framework and key issues for research. Energy Policy 28:625–640

Janszen FHA, Degenaars GH (1997) A dynamic analysis of the relations between the structure and the process of National Systems of Innovation using computer simulation; the case of the Dutch biotechnological sector. Res Policy 27:37–54

Jelinek M (1979) Institutionalizing innovation: a study of organizational learning. Praeger, New York

Johnson B (1997) Systems of innovation: overview and basic concepts – introduction. In: Edquist C (ed) Systems of innovation: technologies, institutions and organisations. Pinter Publishers, London, pp 36–40

Jonash RS, Sommerlatte T (1999) The innovation premium. Perseus Publishing, Boston

Jung C (1958) The undiscovered self. Princeton University Press, Princeton

Kahn KB (2002) An exploratory investigation of new product forecasting practices. J Product Innovation Manage 19(2):133–143

Kaku M (1997) Visions: how science will revolutionize the 21st century. Anchor Books, New York

Kao J (1996) Jamming: the art and discipline of business creativity. HarperCollins, New York

Kaplan S (1999) Discontinuous innovation and the growth paradox. Strategy Leadership 27(2):16–21

Katz JS, Martin BR (1997) What is research collaboration? Res Policy 26(1):1–18

Kaufmann A, Todtling F (2001) Science-industry interaction in the process of innovation: the importance of boundary-crossing between systems. Res Policy 30(5):791–804

Kay J (1996) Why firms succeed. Oxford University Press, Oxford

Kaynak E (1985) Global spread of supermarkets: some experiences from Turkey. In: Kaynak E (ed) Global perspectives in marketing. Praeger, New York

Khanna T (1998) The scope of alliances. Org Sci 9(3):340–355
Killman R (1985) Gaining control of the corporate culture. Jossey-Bass, San Francisco, pp 1–16
Kim L (2000) The dynamics of technological learning in industrialization. UNU/INTECH Discussion paper
Kline S, Rosenberg N (1987) An overview of innovation. In: Landau R, Rosenberg N (eds) National systems of innovation. Oxford University Press, New York
Kneller G (1965) The art and science of creativity. Holt, Rinehart and Winston, New York
Kodama F (1991) Emerging patterns of innovation. Harvard Business School Press, Boston
Koen P, Kohli P (1998) Idea generation: who has the most profitable ideas. Eng Manage J 10(4):35–40
Kogut B (1998) Joint ventures: theoretical and empirical perspectives. Strategic Manage J 9:319–332
Kogut B, Kulatilaka N (1994) Options thinking and platform investments: investing in opportunity. Calif Manage Rev 36(2):52–71
Komninos N, Tsamis A (2008) The system of innovation in Greece: structural asymmetries and policy failure. Int J Innovation Regional Develop 1(1):1–23
Kotabe MA, Sahay A, Aulakh P (1996) Emerging role of technology licensing in the development of global product strategy: conceptual framework and research propositions. J Marketing 60(1):73–88
Kuhn TS (1962) The structure of scientific revolutions. University of Chicago Press, Chicago
Laamanen T, Autio E (1995) Measurement and evaluation of technology transfer: review of technology transfer mechanisms and indicators. Int J Technol Manage 10(7/8):643–664
Lane PJ, Lubatkin M (1998) Relative absorptive capacity and interorganizational learning. Strategic Manage J 19:461–477
Lang J (1996) Strategic alliances between large and small high tech firms (the small firm licensing option). Int J Technol Manage 12(7/8):796–807
Lansiti M (1997) From technological potential to product performance: an empirical analysis. Res Policy 26(3):345–366
Lee TL, Tunzelmann N (2005) A dynamic analytic approach to national innovation systems: the IC industry in Taiwan. Res Policy 34:425–440
Leenders MAAM, Wierenga B (2002) The effectiveness of different mechanisms for integrating marketing and RandD. J Prod Innovat Manage 19(4):305–317
Leonard D, Sensiper S (1998) The role of tacit knowledge in group innovation. Calif Manage Rev 40(3):112–132
Leonard-Barton D (1988). Synergistic design for case studies: longitudinal single-site and replicated multiple-site. Paper presented at the national science foundation conference on longitudinal research methods in organizations, Austin, TX
Levinthal D, Myatt J (1994) Co-evolution of capabilities and industry: the evolution of mutual fund processing. J Strategic Manage 15:45–62
Levitt B, March JB (1988) Organizational Learning. Ann Rev Soc 14:319–340
Leydesdorff L (2000) A sociological theory of communication: the self-organization of the knowledge-based society. Universal Publishers, Parkland, http://www.upublish.com/books/leydesdorff.htm
Leydesdorff L (2001) Indicators of innovation in a knowledge-based economy. Sci Technol Dyn, Cybermetrics 5(1):Paper 2
Liebeskind JP (1996) Knowledge, strategy and the theory of the firm. Strategic Manage J 17(Winter Special Issue):93–107
Liu X, White S (2000) Comparing innovation systems: a framework and application to China's transitional context. Res Policy 30(7):1091–1114
Liyanage S, Mitchell H (1995) Management of intellectual property rights in Australian Cooperative Research Centres. Int J Technol Manage 10(2/3):343–364
Lundvall B-A (ed) (1992) Introduction. In: Lundvall B-A (ed) National systems of innovation – towards a theory of innovation and interactive learning. Pinter, London, pp 1–19

Lundvall B-A (ed) (1992b) National systems of innovation – towards a theory of innovation and interactive learning. Pinter, London
Lundvall B-Å, Maskell P (2000) Nation states and economic development-from national systems of production to national systems of knowledge creation and learning. In: Clark GL, Feldmann MP, Gertler MS (eds) Handbook of economic geography. Oxford University Press, London
Lynn LH, Reddy NM, Aram JD (1996) Linking technology and institutions: the innovation community framework. Res Policy 25(2):91–106
Macher JT, Mowery D, Hodges DA (1998) Reversal or fortune? The recovery of the US semiconductor industry. Calof Manage Rev 41(1):107–136
Malerba F (2002) Sectoral systems of innovation and production. Res Policy 31(2):247–264
Malerba F (2004) Sectoral systems of innovation: concepts, issues, and analysis of six major sectors in Europe. Cambridge University Press, Cambridge
Mansfield E (1991) Academic research and industrial innovation. Res Policy 20(1):1–12
Mansfield E, Rapport AR, Wagner S, Beardsley G (1977) Social and private rates of return from industrial innovations. Q J Econ 91(2):221–240
March J, Simon H (1965) Organizations. Wiley, New York
Metcalfe S (1995) The economic foundations of technology policy: equilibrium and evolutionary perspectives. In: Stoneman P (ed) Handbook of the economics of innovation and technological change. Blackwell, London, pp 409–512
Meyer-Krahmer F, Schmoch U (1998) Science-based technology: university-industry interactions in four fields. Res Policy 27:835–851
Michalisin M (2001) Validity of annual report assertions about innovativeness: an empirical investigation. J Bus Res 53:151–161
Microelectronics Advanced Research Corporation (MARCO) (1998a) About MARCO, assessed on 22 December 1998, at http://marco.fcrp.org
Microelectronics Advanced Research Corporation (MARCO) (1998b) Focus Center Research Program-Press Conference Briefing, 9 December 1998
Mintzberg H (1978) Patterns in strategy formation. Manage Sci 24(9):934–948
Mintzberg H (1989) Mintzberg on management. The Free Press, New York
Moore LF (1996) The death of competition. HarperCollins, New York
Mowery DC (1996) The international computer software industry. Oxford University Press, Oxford
Mowery DC, Oxley JE, Silverman BS (1996) Strategic alliances and interfirm knowledge transfer. Strategic Manage J 17:77–91
Mullin R (1996a) Knowledge management: a cultural evolution. J Bus Strategic 17(5):56–59
Mullin R (1996b) Intellectual assets: know-how management systems, Chemical Week, pp 26–32
Myers, P. ed. 1996. Knowledge management and Organizational Design. Butterworth – Heinemann
Myers MB, Rosenbloom RS (1996) Rethinking the role of research. Res Technol Manage 39(3):14–18
Nahapiet J, Ghoshal S (1997) Social capital, intellectual capital and the creation of value in firms. Best paper proceedings of the academy of management annual meeting, Boston, Massachusetts, pp 35–39
US National Science Foundation (2002)
Nelson RR (1977) In search of useful theory of innovation. New Holland Res Policy 6:37–76
Nelson R (1991) How do firms differ, and why does it matter? Strategic Manage J 12:61–74
Nelson RR (ed) (1993) National innovation systems: a comparative analysis. Oxford University Press, Oxford
Nelson RR (1995) Co-evolution of industry structure, technology and supporting institutions, and the making of comparative advantage. Int J Bus Econ 2:171–184
Nelson RR (2000) Technology, institutions, and evolutionary economic theory, mimeo
Nelson RR, Winter SG (1982) An evolutionary theory of economic change. Belknap Press of Harvard University Press, Cambridge
Neuman W (2000) Social research methods: qualitative and quantitative approaches. Allyn and Bacon, Needham Heights

Nielsen R (1993) Woolman's "I Am We" triple-loop action-learning: origin and application in organization ethics. J Appl Behav Sci 29(1):7–138
Niosi J (2002) National systems of innovations are "x-efficient" (and x-effective): why some are slow learners. Res Policy 31:291–302
Niosi J, Saviotti PP, Bellon B, Crow M (1993) National systems of innovation: in search of a workable concept. Technol Soc 15(2):207–227
Noll DC, Cohen JD, Meyer CH, Schneider W (1995) Spiral k-space MR imaging of cortical activation. J Magn Reson Imaging 45:49–56
Nonaka I (1988) Creating organizational order out of chaos: self-renewal in Japanese firms. Calif Manage Rev 30(2):57–73
Nonaka I (1994) The dynamic theory of organisational knowledge creation. Org Sci 5(1):14–37
Nonaka I, Takeuchi H (1995) The knowledge-creating company: how Japanese companies create the dynamic of innovation. Oxford University Press, New York
Nooteboom B (1999) Innovation, learning and industrial organization. Camb J Econ 23:127–150
Nurkse R (1953) Capital formation in under-developed countries. Oxford, London
Oates TH, Taylor WA (1996) Technology as knowledge: towards a new perspective on knowledge management in electronics. Int J Technol Manage 11(3/4):296–315
OECD (1999) Managing national innovation systems. OECD, Paris
Olazarán M, Gómez Uranga M (eds) (2000) Sistemas Regionales de Innovación. Servicio Editorial de la Universidad del País Vasco, Bilbao
Ordover JA, Willig RD (1985) Antitrust for high-technology industries: assessing research joint ventures and merges. J Law Econ 28:311–333
Parsons T, Shils EA (1962) Toward a general theory of action. Harvard University Press, Cambridge, pp 47–275
Parthasarthy R, Hammond J (2002) Product innovation input and outcome: moderating effects of the innovation process. J Eng Technol Manage 19(1):75–91
Patel P, Pavitt K (1991) Large firms in the production of the world's technology: an important case of 'non-globalisation'. J Int Bus Stud 22(1):1–21
Pavitt K (1984) Sectoral patterns of technological change: towards a taxonomy and a theory. Res Policy 13:343–373
Penaranda FE (1996) Meet your partners and your enemies: the Federal sector. In: Proc. of technology transfer metrics summit, Santa Fe, NM, April 28–May 2
Penrose ET (1959) The theory of the growth of the firm. Wiley, New York
Perel M (2002) Corporate courage: breaking the barrier to innovation. Res Technol Manage 45(3):9–17
Persaud A, Kumar U, Kumar V (2001) Harnessing scientific and technological knowledge for rapid deployment of global innovations'. Eng Manage J 13(1):12–18
Pidd M (1998) Computer simulation in management science, 4th edn. Wiley, Chichester
Polanyi M (1958) Personal knowledge. The University of Chicago Press, Chicago
Polanyi M (1962) Personal knowledge: towards a post critical philosophy. University of Chicago Press, Chicago
Polanyi M (1966) The tacit dimension. Routledge, London
Porter ME (1985) Competitive advantage: creating and sustaining superior performance. Free Press, New York
Porter M (1990) The competitive advantage of nations. Free Press, New York
Porter M (1991) Towards a dynamic theory of strategy. Strategic Manage J 12:95–117
Powell WW (1996) Inter-organizational collaboration in the biotechnology industry. J Inst Theor Econ 152:197–215
Powell WW (1998) Learning from collaboration: knowledge and networks in the biotechnology and pharmaceutical industries. Calif Manage Rev 40(3):228–240
Quinn JB (1992) The intelligent enterprise: a new paradigm. The Free Press, New York
Radosevic S (1999) International technology transfer and catch-up in economic development. Edward Elgar Publishing, Cheltenham

Radosevich R, Kassicieh S (1993) Strategic challenges and proposed responses to competitiveness through public-sector technology. Calif Manage Rev 35(4):33–50

Roberts N, David FA, Deal RM, Garet MS (1983) Introduction to computer simulation: the system dynamics approach. Addison-Wesley Publication Company, Reading Massachusetts

Rodrigues CA (1985) A process for innovators pin developing countries to implement new technology. Columbia J World Bus 20(3):21–28

Rogers E (1983) Diffusion of innovations. Free Press, New York

Rogers EM (1995) Diffusion of innovations. The Free Press, New York

Rogers DM (1996) Knowledge management gains momentum in industry. Res Technol Manage 39(3):5–7

Rogers EM, Shoemaker FF (1971) Communication of innovations: a cross-cultural approach. The Free Press, New York

Rogers E, Valente T (1991) Technology transfer in high-technology industries. In: Agmon T, von Glinow M (eds) Technology transfer in international business. Oxford University Press, Oxford

Rogers E, Carayannis E et al (1998) Cooperative Research and Development Agreements (CRADAS) as technology transfer mechanisms. Rand Manage 28(2):79–88

Romer P (1990) Endogenous technological change. J Polit Econ 98:S71–S102

Rosenberg N (1976) Perspectives on technology. Cambridge University Press, Cambridge

Rosenberg N (1982) Inside the black box: technology and economics. Cambridge University Press, Cambridge

Rosenberg N (1990) Why do firms do basic research (with their own money?). Res Policy 19(2):165–174

Rosenberg N, Nelson RR (1994) American universities and technical advance in industry. Res Policy 23(3):323–348

Rosenbloom R, Spencer W (eds) (1996) Engines of innovation. Harvard Business School Press, Boston

Rothwell R, Gardiner P (1985) Invention, innovation, re-innovation and the role of the user: a case study of the British hovercraft development. Technovation 3(4):167–186

Roussell PA, Saad KM, Erickson TJ (1991) Third generation rand. Harvard Business School Press, Cambridge

Rubenstein AH (1976) Technical information, technical assistance and technology transfer, the need for synthesis. In: Research Development Management, vol. 6

Rugman AM (1983) Multinationals and technology transfer. Praeger, New York

Rushing RW, Brown CG (1990) Intellectual property rights in science, technology and economic performance: international comparisons. Westview Press, Boulder

Rycroft RW (2003) Technology-based globalization incubators: the centrality of innovation network data. Technol Soc 25:299–317

Sachs J, Mellinger A, Gallup J (2001) The geography of poverty and wealth. Sci Am 284(3):70–75

Samli AC (1985) Technology transfer: geographic, economic, cultural and technical dimensions. Quorum Books, London

Santarelli E, Piergiovanni R (1996) Analyzing literature-based innovation output indicators: the Italian experience. Res Policy 25(5):698–712

Sawhney M, Prandelli E (2000) Communities of creation: managing distributed innovation in turbulent markets. Calif Manage Rev 42(4):24–25

Saxenian A (1991) The origins and dynamics of production: networks in Silicon Valley. Res Policy 20:423–437

Saxenian AL (1994) Regional advantage: culture and competition in silicon valley and route 128. Harvard University Press, Cambridge

Schibany A, Polt W (2001) Innovation and networks: an introduction to the theme. In: OECD (ed) Innovation networks, co-operation in national innovation systems. pp 7–14

Schon D (1983) The reflective practitioner: how professionals think in action. Basic Books, New York

Schumpeter JA (1934) Theorie der wirtschaftlichen Entwicklung. Duncker and Humblot, Berlin (reproduced 1997)
Schumpeter JA (1942) Capitalism, socialism and democracy. Harper Brothers, New York
Senge P (1990) The fifth discipline: the art and practice of learning organization. Doubleday, New York
Senge PM (1994) The fifth discipline fieldbook: strategies and tools for building a learning organization. Doubleday, New York
Shannon CE, Weaver W (1949) The mathematical theory of communication. University of Illinois Press, Urbana
Shapiro C, Varian H (1999) Information rules. Harvard Business School Press, Boston
Simon H (1969) The sciences of the artificial. MIT Press, Cambridge
Simonin BL (1997) The importance of collaborative know-how: an empirical test of the learning organization. Acad Manage J 40:1150–1174
Smith, A. 1776 [1977]. An inquiry into the nature and causes of the wealth of nations. Chicago, University Of Chicago Press
Smith, A. γνωστή σαν το "Αόρατο χέρι της οικονομίας" http://www.lucidcafe.com/library/96jun/smith.html
Soh P, Roberts E (2003) Networks of innovators: a longitudinal perspective. Res Policy 32(9):1569–1588
Sowa JF (1999) Relating templates to logic and language. In: Pazienza MT (ed) Information extraction: towards scalable, adaptable systems, Lecture notes in AI #1714, Springer, pp 76–94
Spann MS, Adams, Souder (1993) Improving federal technology commercialization: some recommendations from a field study. J Technol Transfer 18(2/3):63–64
Stankiewicz R (1994) University firms: spin-off companies from universities. Sci Public Policy 21:99–107
Stead G, Harrington TF (2000) A process perspective of international research collaboration. Career Dev Q 48:323–331
Sterman JD (1989) Modelling managerial behaviour: misperceptions of feedback in a dynamic decision making experiment. Manage Sci 35(3):321–339
Sternberg R, Frensch P (1991) Complex problem solving: principles and mechanisms. Lawrence Erlbaum, Hillsdale
Stokes D (1997) Pasteur's quadrant. Brooking in Press, Washington
Sullivan P, Edvinsson L (1996) Developing an intellectual capital management capability at Skandia. In: Parr RL, Sullivan P (eds) Technology licensing: corporate strategies for maximizing value. Wiley, New York, pp 261–266
Sveiby K (1998) What is knowledge management? http://www.sveiby.com.au
Teece DJ (1986) Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. Res Policy 15(6):285–305
Teece DJ, Pisano G, Shuen A (1997) Dynamic capabilities and strategic management. Strategic Manage J 18(7):509–533
Thurow LC (1997) Needed: a new system of intellectual property rights. Harv Bus Rev 75(5):94–103
Tidd J (2001) Innovation management in context: environment, organization and performance. Int J Manage Rev 3(3):169–183
Tornatzky LG, Fleischer M (1990) The process of technological innovation. Lexington Books, New York
Towill DR (1995) Time compression and supply chain management – a guided tour. Logist Inf Manage 9(6):41–53
Tsipouri L, Papadakou M (2005) Profiling and assessing innovation governance in Greece: do increased funding and the modernisation of governance co-evolve? In: OECD (ed) Governance of innovation systems: case studies in innovation policy, pp 13–42
Tsoukas H (1996) The firm as a distributed knowledge system: the constructionist approach. Strategic Manage J 17(Winter Special Issue):11–25

Turban E (1992) Expert systems and applied artificial intelligence. Macmillan, New York
Tushman ML, O'Reilly CA (1997) Winning Through Innovation. Harvard Business School Pr, Boston
Utterback J (1996) Mastering the dynamics of innovation. Harvard Business School Press, Boston
Utterback JM, Abernathy WJ (1975) A dynamic model of process and product innovation, omega. Int J Manage Sci 3(6):639–656
Utterback JM, Suarez FF (1994) Innovation, competition, and industry structure. Res Policy 22(1):1–21
van der Spek R, Spijkervet A (1997) Knowledge management: dealing intelligently with knowledge. In: Liebowitz J, Wilcox LC (eds) Knowledge management and its integrative elements. CRC Press, Boca Raton
von Hippel E (1988) The sources of innovation. Oxford University Press, New York
von Krogh G, Vicari S (1993) An autopoiesis approach to experimental strategic learning. In: Lorange P, Chakravarthy B, Roos JV, de Ven A (eds) Implementing strategic processes: change, learning and co-operation. Blackwell, London, pp 394–410
Wallender HW (1979) Technology transfer and management in the developing countries. Ballinger Pub. Co., Cambridge
Weick KE (1979) The social psychology of organizing, 2nd edn. Addison-Wesley, Reading
White LJ (1985) Clearing the legal path to cooperative research. Technol Rev 39–44
Whitley R (2003) Competition and pluralism in the public sciences: the impact of institutional frameworks on the organization of academic sciences. Res Policy 32(6):1015–1029
Wiig K (1993) Knowledge management foundation. Schema Press, Arlington
Wolstenholme EF (1983) The relevance of system dynamics in engineering system design. Eur J Oper Res. No. 14
Woodman RW, Schoenfeldt LF (1990) An interactionist model of creative Behaviour. J Creative Behav 24:10–20
Yin JZ (1991) Foreign technology acquisition and technological capability development. In: Proceedings of the eastern academy of management, pp 124–145
Yoshino MY, Rangan U (1995) Strategic alliances. Harvard Business School Press, Boston
Zaltman G, Duncan R, Holbek J (1973) Innovations and organizations. Wiley, New York
Zedtwitz V, Maximilian L, Tarek LK, Haour G (2002) Management of technology: growth through business innovation and entrepreneurship. Pergamon, Oxford
Ziman J (1994) Prometheus bound: science in a dynamic steady state. Cambridge University Press, Cambridge

Greek

Γεωργιάδης Π (2006) Θεωρία δυναμικής συστημάτων με εφαρμογές στη σχεδίαση και λειτουργία συστημάτων παραγωγής. Εκδόσεις Σοφία, Θεσσαλονίκη Georgiadis P
Γεωργόπουλος Α (1994) Διαδικασίες παγκόσμιας οικονομικής ολοκλήρωσης και διεθνοποίηση της παραγωγής στην Ελλάδα. Εκδόσεις Παπαζήση, Αθήνα Georgopoulos A
Εθνικό Στρατηγικό Πλαίσιο Αναφοράς (2007–2013)
Καπετανάκη Κ (1985) Η διεθνοποίηση του κεφαλαίου στην Ελλάδα: Η περίπτωση των διυλιστηρίων. Παπαζήσης, Αθήνα Kapetanaki K
Μπενάς Δ (1978) Η εισβολή του ξένου κεφαλαίου στην Ελλάδα. Παπαζήσης, Αθήνα Benas 1978
Ρουμελιώτης Π, Καλογήρου Γ (1976) Μονοπωλιακή ή όχι η δομή της ελληνικής οικονομίας και ποιος ο ρόλος των πολυεθνικών επιχειρήσεων, Οικονομικός Ταχυδρόμος, Α.Φ. 1167, Σεπτ Roumeliotis Kalogirou 1976
Σαμαρά ΕΤ (2009) Διδακτορική διατριβή : Μοντελοποίηση Εθνικών Συστημάτων Καινοτομίας. Προσέγγιση με τη θεωρία της Δυναμικής. Συστημάτων, Κοζάνη Samara

Websites

http://www.access-ecom.info/article.cfm?id=63andxid=MN
http://www.madrimasd.org/ingles/transference/services/audit/default.asp
http://www.oxin.co.uk/downloads/taudit.pdf
http://www.strategicinformation.com/audit.htm
http://www.newventuretools.net/technology_audit.html..\Example of TA.doc
http://www.adi.pt/docs/innoregio_techn_audits.pdf
http://www.bpa.arizona.edu/~dmeader/MIS341/341files/341.SWOTAnalysis.pdf
http://www.planonline.org/planning/strategic/swot.htm
http://www.amputee-coalition.org/communicator/vol2no4pg1.html
http://www.panasia.org.sg/iirr/ikmanual/swot.htm
http://cbae.nmsu.edu/~dboje/sbc/pages/page3.html
http://www.quickmba.com/strategy/swot/
http://www.marketingteacher.com/Lessons/lesson_swot.htm
http://www.erc.msh.org/quality/ittools/itswot.cfm
http://www.businessmajors.about.com/cs/casestudyhelp/a/SWOT.htm
http://fdtd.rice.edu/GA/
http://www.informatik.uni-bremen.de/uniform/gdpa_d/methods/m-bbtd.htm
http://www.hi.is/~joner/eaps/y3_16047.htm
http://www.oxtrust.org.uk/oi
http://www.netmba.com/marketing/mix/
http://c2kschoolbox.granada-learning.com/pdf/keystage3and4/marketing_worksheet4.pdf
http://www.tpo.de/onli/
http://www.ris-scotland.net/pages/innovationbenefits/modelinnnovativeco.shtml
http://www.innovation.gov.uk/
http://www.advantest.com/aac/Careers/culture.html
http://www.24-7innovation.com/culturepressrelease.pdf
http://www.entreworld.com/ManagingGrowth/PDFs/SCANCh03.pdf