Enterprise Knowledge Capital

To J.-C. L.

Smart Innovation Set

coordinated by
Dimitri Uzunidis

Volume 13

Enterprise Knowledge Capital

Blandine Laperche

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Contents

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Foreword

In a film that is already 20 years old, *New Rose Hotel*, Abel Ferrara described a society in which large corporations dominate the world. They have money, power and, above all, competences to do it. The key element for their success is knowledge and they fiercely compete among each other to generate innovation-based new products. New knowledge is still generated by humans rather than by machines, and therefore bright scientists and engineers are the strategic resources for companies' prosperity. Corporations rightly assume that very creative individuals are likely to generate several good ideas in their life – the very gooses that lay golden eggs. The film describes the attempt of one corporation to "steal" the most creative scientist, the genius of the time, for the competing company. The scientist is already very well paid, and is unlikely to be attracted by a greater salary. Here starts the thrill: will the gangsters hired by the company manage to persuade a spectacularly successful scientist to abandon his corporation and to join the competitor? Will they manage to get his brain by conquering his heart?

The film addresses several issues that are essential in the knowledge economy. First, is it true that top scientists and engineers are the core strategic asset of modern corporations? So far, this is far from being the case. Those who work in the R&D departments are unlikely to be the better-paid employees of a company. Most of the chief executive officers of large corporations originated from the financial sector or marketing, under the assumption that being good at managing money and selling products is more important than generating exciting new products and processes. But in the future this is less likely to occur and the progress of the knowledge economy will give more weight to those who are scientifically and technically competent rather than to those who command the tricks of the stock markets or of advertising.

Second, are some individuals so creative that they generate several fundamental discoveries and inventions in their working lifespan? This is already the case and we know that a few creative people are able to generate a wealth of great ideas. Bach, Mozart and Beethoven have composed dozens of masterpieces and this is not an exception. The statistics on the authorship of scientific articles and patents do show that a very few scientists and engineers are responsible for delivering the large majority of high-impact results. It is therefore understandable that corporations try to secure the best minds and head-hunting is already a common practice of oligopolistic competition. It is very likely that we see head-hunters more often around the areas where creativity is a must such as R&D, software development and design. It might appear that the film underestimates the importance of teams and gives too much credit to individual geniuses, but a surprise hidden in the finale shows that networks of good inventors can be economically more important than a single top scientist.

Third, the film challenges the traditional view that the most important incentive to stimulate very creative people is financial. Of course, we know that incentives are crucial to secure the talent of the most gifted. In football, the transfer of top players from one team to another is dominated by the salaries paid, but perhaps those who have their talent in their heads, rather than in their feet, are likely to be more sophisticated and to praise other aspects of life as well as money. Not only scientists working in universities and public research centers, but also their colleagues employed in the business sector give high importance to the intellectual environment in which they operate, the freedom they enjoy in pursuing their agendas, the possibility to discuss ideas with colleagues as well as real or potential competitors.

Twenty years ago, a few spectators were persuaded that knowledge would become the crucial competitive asset for companies. Today, only a few will dispute it. But for those who still have some doubts, this book, elegantly written by Blandine Laperche, will provide definitively convincing arguments. This book clearly explains how the knowledge capital of companies is constructed and how it provides benefits to companies as well as to society at large. Three issues are crucial to Blandine Laperche's enquiry.

The first is the definition of innovation. For several decades, the Schumpeterian tradition has argued that innovating firms bring dynamism to the economy and are able to generate profits, efficiency and employment through the introduction of new products and processes. Innovating firms have unanimously been considered the frontrunners of progress and prosperity. But the specific understanding of innovation has too often been too narrow. Implicitly more than explicitly, we have assumed that innovation should be understood as something "technological" that is introduced in the "manufacturing" industries. True, for many decades the manufacturing industry provided a wealth of new products and processes that were used and diffused in agriculture as well as in the services. Still, it is too limited to presume that the production of innovation is confined to manufacturing and that the other industries are just users. In a world where the largest share of employment and value added comes from services, this traditional approach needs to be radically revised. We need to understand that innovation occurs in a much broader context; otherwise, we will not be able to understand why some that do not belong to the manufacturing industry are among the more prolific generators of fresh ideas and patents. Take the case of IBM, a company with more than a century on its shoulders, or the much younger Google: both are world leading innovators outside the realm of the manufacturing industry. Are we ready to take the challenge on board and to revise our toolkit? This book faithfully reports the state of the art: we can be happy for the progress achieved in the last decades producing broader and more comprehensive concepts and measures of innovation, but it clearly emerges that much still needs to be done to have instruments able to guide public policies and business strategies.

The second issue is the strong belief that the successful creation of knowledge capital by firms is rooted in a much wider economic and social space. Blandine Laperche builds upon the literature on national innovation systems to give a proper role to the relations between public and business players in augmenting the stock of knowledge. She shows that knowledge-based corporations do not work in a vacuum but rather in a heavily populated space where they interact with governments, universities, research centers, users and competitors. Her insights derive from an older and glorious academic tradition, the French historical *École des Annales*, which long before the economics of innovation became a popular subject, already understood the crucial role played by complex interactions between social institutions and techniques. In describing the boundaries of the firm, Blandine also takes into account how they have been transformed by the Internet revolution. The open innovation model, one of the most popular developments in the field, has penetrated large and small firms differently and this has relevant consequences for business strategies. The implication is that all companies could potentially take advantage of the existing opportunities, but if they fail to do it, it is likely that they will be marginalized.

The third issue is the way in which corporations are opening to the global society. The knowledge capital developed by companies is not sufficient by itself to sustain economic performance. It should also be properly protected against real and potential competitors in internal and, above all, global markets. But the boundaries of intellectual property right are highly uncertain: as with any property rights, intellectual property is guaranteed, protected and enforced by national governments. In spite of the harmonization that has taken place over the years and, most notably, since the foundation of the World Trade Organization in 1995, each nation still has its own rules and practices. Companies' strategies are therefore forced to operate in uncharted waters and the attempt made in this book to map them is precious. The potential of companies to defend their own knowledge in isolation is more and more blurred. Blandine suggests that a really successful innovative company should not be obsessed with the protection of its knowledge, but rather it should be willing to share it because they know that this is the best way to move up in the learning curve. To put its own knowledge into a common pool is often the best way for a corporation to provide the standard to everybody. This is a lesson that perhaps several governments, obsessed with the protection of the intellectual property belonging to their own nations, have not yet properly assimilated.

The main lesson to be drawn from this dense, well-written and well-informed volume is that knowledge-based firms are not just profit-maximizing machines but rather institutions embedded into a much wider social fabric. In spite of the several attempts made to create fences around its fruits, knowledge will continue to provide benefits to a larger community of users. Marc Bloch already taught this in the 1930s with his seminal investigation of the Medieval watermills and Bertrand Gille in the 1970s with his comprehensive *Histoire des techniques*. We should be grateful to Blandine Laperche and her colleagues at the Research Network on Innovation for developing these ancient insights to better understand the knowledge-based company of the 21st Century.

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Introduction

> "Every civilization" writes Braudel "imports and exports aspects of its culture. These may include the lost-wax process for casting, the compass, gunpowder, the technique for tempering steel, a complete or fragmentary philosophical system, a cult, a religion or the song about Marlborough that went the rounds of Europe in the eighteenth century: Goethe heard it in the streets of Verona in 1786…" (p. 14). He continues on to say that "civilizations continually borrow from their neighbors, even if they 'reinterpret' and assimilate what they have adopted. At first sight, indeed, every civilization looks rather like a railway goods yard, constantly receiving and dispatching miscellaneous deliveries" (p. 29) (Braudel [BRA 93]).

Innovation today is at the heart of business strategy: it is associated with adaptation, change, rebirth, recovery, competitiveness and growth. It is embellished with qualifying adjectives intended to make it even more original: innovation today is disruptive (Christensen [CHR 97]), open (Chesbrough [CHE 03]), frugal (Radjou *et al.* [RAD 12]), reversed (Govindarajan and Trimble [GOV 12]), fractal (Midler *et al.* [MID 17]), etc. Technological, organizational and commercial innovation is thus an inevitable trajectory, which can even be considered, for both small and large companies alike, as an injunction carrying with it the penalty of going under in the face of the continuous and globalized tide of competition. But how does a company innovate? What activities become intertwined once the black box of innovation has been opened? How does a company decide what the necessary collaboration with other actors should be in order to succeed in its innovation process and, equally fundamental, what protection it needs to implement in order to secure these achievements and cement their dominant position within their networks?

The purpose of this book is to study the strategies and processes of innovation through the prism of *knowledge capital*. Here, we define knowledge capital as *the set of scientific and technical information and knowledge produced, acquired, combined and systematized by one or more companies within a particular productive objective, and more broadly, within a process of value creation*. Knowledge capital therefore refers to the knowledge accumulated by a company, which often maintains collaborations with other companies or institutions for this purpose. It is integrated into the individuals, machines, technologies and routines of a company. It is constantly enriched by the flow of information. It is used to create or improve upon existing products and services, but it can also become an intangible product to be transferred to other economic actors. Knowledge capital is therefore a dynamic concept, a process that describes accumulated knowledge, its enrichment, its combinations and the various forms of its use. This associated objective of value creation is the main condition for transforming *knowledge* into *capital*.

Understanding the meaning of knowledge capital requires a return to the key terms and central concepts that structure it. Therefore, Chapter 1 shall revisit the definition of innovation, its evolution over time, but also the processes, that is the organization of activities, that give rise to it. It will also recall the difficulties in assessing innovation. We shall set out to dissect the words *knowledge* and *information*, showing how they differ and how they complement each other in order to organize our approach to knowledge capital. We shall also detail its roles, both productive and organizational, within the broader process of value creation. Our definition of knowledge capital is based on the theoretical developments of three key concepts: *firm*, *knowledge* and *capital*. A brief review of contemporary theories of the firm allows us to grasp the advancements being made in the analysis of knowledge production activities within organizations. However, the re-reading of a few founding authors is also essential for a better understanding of the dynamics for the production, use and appropriation of knowledge capital.

Chapter 2 positions knowledge capital in terms of its historical context: industrial capitalism. The rapprochement between *science* and *technology*, which is essential to the formation of knowledge capital, is an old one, but has been advanced largely through the impulse of industrial needs, all the way from the manufacturer to the large-scale industry (Gille [GIL 78]).

Teams or worker collectives are formed, combine skills and facilitate their appropriation in order to accelerate value production (Marx [MAR 67]). We trace this history and expound upon the reasons and forms of this rapprochement that culminated at the end of the 19th Century in the systematic relationship between science and technology (Habermas [HAB 68]), orchestrated by the States and the gradual creation of national innovation systems (Freeman [FRE 87]), (Lundvall [LUN 92]). This chapter presents the organizational changes in large enterprises in the 20th Century and the emergence of the various forms of organizational networks. The modern network firm model allows for multiple collaborations that are implemented (through open innovation) in order to collectively build knowledge capital (Laperche and Uzunidis [LAP 18]). In this chapter, we study the ways in which large companies create their knowledge capital by drawing on internal resources (accumulated skills, research and development expenditures) and external resources developed together with other companies, both large and small, as competitors or as partners, with institutions of academic research but also directly with consumers. The case of small companies is also analyzed, emphasizing their greatest difficulties, particularly in France, to independently capitalize on their knowledge capital, that is to say without integrating into existing networks formed and dominated by larger firms. This chapter therefore points to the increasing socialization of knowledge capital, which means that an increasing number of all kinds of companies and institutions contribute to the enrichment of the knowledge capital of each firm. At the forefront of these institutions are universities and public research centers. The third mission, which has been assigned to these institutions since the end of the 20th Century, that of the commercialization of research, is part of this desire/need to support the enrichment of the knowledge capital of firms.

Furthermore, this enrichment of knowledge capital is also reflected in the constant expansion of scientific and technical networks at the global scale (Archibugi and Filippetti [ARC 15]). This topic is the subject of Chapter 3. The multinational corporations of yesteryear have since become global and today weave their webs at the scale of the whole planet. Certainly, as Fernand Braudel emphasized in the words quoted above, cultural, scientific and technical goods have always had the peculiarity of being mobile. Yet, up until the end of the 20th Century, business research and development (R&D) activities were most often locked safely within the borders of the multinational companies' home country. However, R&D has gradually become more internationalized as value chains have become more globalized. R&D laboratories were first established in other Triad countries and today are also based in the ultra-sophisticated clusters of emerging countries. Strategic alliances connect the scientific and technological centers of the planet (Narula, Martinez-Noya [NAR 15]). Reasons for this phenomenon of R&D globalization are to be found in the liberalization of markets (goods and services, labor, financial), which makes this globalization of R&D not only possible but flexible. The reasons are also related to the climate of trust that ensues from the globalization of intellectual property rights (IPRs), which ideally ensures the protection of the scientific and technological resources being propagated worldwide. Above all, the globalization of R&D is mainly driven by the profitability imperative that induces enterprises to reduce production costs, and absorb any new creative source or any new commercial opportunity, wherever it emerges in the world. This need for profitability stems from the weighting of finance in the strategy of companies, with shareholders demanding substantial returns on their investment (*shareholder value*). Financial globalization, an advanced feature of commercial and productive globalization, plays a key role in business strategies and the structuring of our knowledge-based societies (Chesnais [CHE 96], Laperche and Uzunidis [LAP 08]). It also plays a role in the strategies for the appropriation of knowledge capital, which are becoming increasingly aggressive the more that knowledge capital becomes socialized.

Indeed, this chapter also devotes focus to the important strategic developments of the appropriation of knowledge capital as it is deployed by companies. IPRs are controversial, as they are coupled with traditional roles of protection and incentives to innovate, as well as with barriers to entry (Boldrin and Levine [BOL 08]). We look at these contradictory roles from two angles, that of the multi-partner relationship and that of the extension of IPRs at the international scale, and into new fields. In the context of multi-partner innovation strategies, IPRs acquire a central coordination role, helping to legitimize their existence and even their profusion within knowledge markets. Nevertheless, opportunistic strategies are present at all stages of cooperation, thereby highlighting the role of IPRs in the creation and structuring of networks. They make it possible to draw a hierarchy between, on the one hand, those who appropriate rents in order to strengthen their dominant position and, on the other hand, other actors, resource suppliers, or prospective participants, who are blocked or in a situation of dependency. Geographical expansion through the agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS, 1994) has the concurrent aim of accelerating the transfer of technology to countries with less scientific and technological resources with the view to stimulating their ability to innovate. Similarly, expansion into new areas (ICT, living organisms, etc.) aims to stimulate innovation in auspicious sectors. Again there are many contradictions. These are revealed, for example, in the costs associated with newly protected technologies, which slow down their dissemination in emerging countries, and the multiple patent wars that, in the field of ICTs in particular, fill the pages of our newspapers. More generally, these contradictions reveal the poor knowledge on the mechanisms by which innovation emerges and spreads.

This book therefore deals with a series of themes, themselves the subject of very detailed, but also relatively fragmented study, within the fields of economics and the management of innovation. Some authors devote their entire careers to the analysis of, for example, open innovation strategies, research commercialization policies, international strategic alliances and/or the use of IPRs. Their work is fundamental because such expertise makes it possible to identify new strategic enhancements, such as how to exploit a particular tool, etc. Nevertheless, it should be noted that there are inherent risks to a fragmented analysis, in the event that it overlooks any links with other similar phenomena, or in terms of their scopes or implications at a broader level. Adopting a systemic approach, and following the thought of Blaise Pascal, who affirmed that "I hold that it is impossible to know the parts without knowing the whole as it is to know the whole without detailed knowledge of the parts", our goal was to assemble the pieces of the puzzle to reveal a general framework for analysis. It seems to us that this is essential to reach a deeper understanding of the role and meaning for each piece of the puzzle. It reveals two strong and contradictory tendencies: on the one hand, a growing socialization in terms of the production of knowledge capital, and on the other hand, the offensive strategies of appropriation of the value it produces. The understanding of these two parallel and contradictory phenomena is, to our view, really useful in any reflection on innovation. What is the ultimate goal of innovation? Is it contributing more and more to the profit creation of a few dominant companies, or is it responding to the major challenges facing our societies? We believe that these two objectives rarely intersect.

To conclude, this book naturally has its limits. The literature on these themes is so abundant that other developments certainly could have been included. That being said, it should be noted that rather than seeking to provide definitive answers to the questions posed above, this work is part of a desire to stimulate reflection and debate, while at the same time providing key understandings of the issues surrounding the topic that is innovation.

1

The Firm, Knowledge and Capital: Toward the Definition of Knowledge Capital

In this chapter, we investigate the meaning of words. The term *innovation* is plural and its sense has evolved over time. Here, we examine the current typologies, the modalities of organization of activities that intertwine to give rise to innovation and the indicators used for its measurement (section 1.1). In order to grasp the knowledge capital of an enterprise, it is also useful to review the relationship between information and knowledge. The productive use of a set of information and knowledge produced, acquired and mobilized by a company makes it possible to understand the transformation of knowledge into capital and thus the formation of knowledge capital (section 1.2). The analysis of knowledge capital is based upon the contemporary theoretical developments of the firm and knowledge, which are associated with the contributions of some pioneer authors. We refer to them in section 1.3 of this chapter.

1.1. Innovation: definition, organization and measurement

1.1.1. *"From vice to virtue": the evolution of the definition for innovation*

While the concept of innovation is everywhere today, and symbolizes the very latest in modernity, it is nonetheless very old and has not always been associated with progress and growth. According to Godin [GOD 14], the concept of innovation goes back to antiquity and was then used by Greek philosophers in their political theories. This political sense would remain dominant until the 19th Century, up until when innovation meant a "change in the established order" with regard to politics and religion. Innovation was thus banned (e.g. by Edward VI of England in 1548) and religious or political innovators (such as the French revolutionaries of the 18th Century and the reformers of the 19th Century) were indicted, imprisoned, or even worse.

It is only in the 20th Century that the meaning of innovation began to transform and came to be associated with positive notions of progress, creativity and economic growth. From this century onwards, "there is no longer any doubt that the vice that was once characterized innovation, has become a virtue" (Godin [GOD 14, p. 33, our translation]). As such, innovation quickly became associated with technology.

Schumpeter (1883–1950) is often considered as the first economist to use and construct an economic theory based on innovation. However, before him, classical economists were largely preoccupied by the changes brought about through "technical progress", or "mechanization", key terms found in the writings of Adam Smith, David Ricardo, Jean-Baptiste Say and Karl Marx to name only a few. In addition, as noted by Godin [GOD 14], the sociologist Gabriel Tarde (1843–1904) is often mentioned as the first person to have devoted theoretical writings to innovation, toward the end of the 19th Century. According to Djellal and Gallouj [DJE 17], although the latter never cited him, he would have been an important inspiration for Schumpeter, at least in his work devoted to the theory of innovation. Despite this, Schumpeter is still widely considered as the father of modern innovation theories.

In Schumpeter's *Theory of Economic Development* [SCH 11], he considers that "To produce means to combine materials and forces within our reach (...). To produce other things, or the same things by a different method, means to combine these materials and forces differently" [SCH 05, p. 65]. Evolution results from the execution of "new combinations amongst the means of production", which include the following cases (Box 1.1).

1) The introduction of a new good – that is, one with which consumers are not yet familiar – or of a new quality of a good.

2) The introduction of a new method of production, that is, one not yet tested by experience in the branch of manufacture concerned, which need by no means

to be founded on a new scientific discovery, and which can also exist in a new way of handling a commodity commercially.

3) The opening of a new market, that is, a market into which the particular branch of manufacture of the country in question has not previously entered, whether or not this market has existed before.

4) The conquest of a new source of raw materials or half-manufactured goods; again, irrespective of whether this source already exists or whether it has to be created first.

5) The realisation of a new organization of any industry, such as the creation of a monopoly position (for example through trustification) or the breaking up of a monopoly position.

Box 1.1. *Forms of new combinations, according to Schumpeter [SCH 05, p. 66]*

The importance of this definition and Schumpeterian analysis in the theory of innovation in general can be explained via several arguments, which are presented below.

In the first place, this definition is important inasmuch as for the first time it distinguishes the various forms that innovation can take, without reducing it to technology. These various forms of innovation are central to the contemporary definition proposed by the OECD, and which we will discuss in greater depth later. Meanwhile, in the analysis of long waves by Kondratieff, technology occupies a central position. In *Business Cycles* [SCH 39], Schumpeter links the three Kondratieff movements, from the period 1750 to 1940, to the three waves of fundamental innovations, which mainly concern technology, namely the textile, steel and steam industries of the late 18th Century; the railroad empires of the middle 19th Century; and the electricity, automotive, chemistry-based industries at the turn of the 20th Century. "Consequently, the role of innovation… is essential to the explanation of economic cycles" (Uzunidis [UZU 96, p. 122, our translation]). These innovations lead to an increase in supply-side capacities (increased demand for production goods, lower production costs and an increase in the quantities of new products on offer) that is accompanied by an increase in demand (new consumption needs and recourse to credit). We also find this primacy of technology in the analysis of the technoeconomic paradigm proposed by Freeman and Perez [FRE 88, FRE 08, PER 10]. It is defined as the set of the most successful, cost-effective practices in terms of input choices, methods and technologies, as well as in terms of organizational structures, economic models and strategies. The paradigm forms a kind of common sense that facilitates the diffusion of technologies that shape a technological revolution, defined as a constellation of technical systems with a common dynamic that can integrate a set of generic technologies, which can be widely applied (Boutillier and Laperche [BOU 16]).

In Schumpeter's analysis, innovation is therefore associated with evolution and change. This is the second essential point. "Capitalism, then, is by nature a form or method of economic change and it not only never is, but never can be stationary" [SCH 75, p. 82]; in fact, "The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forms of industrial organization, all the elements created by the capitalist initiative" [SCH 75, p. 83]. These new combinations cause the hurricane of *Creative Destruction*, continuously destroying older elements and continuously creating new ones. Thus, changes induced by innovation also have negative consequences. If we return to the analysis of long waves, excess investment in the growth phase is in fact penalized by losses, redundancies and bankruptcies that will carry out a "vacuum clean-up" at the same time creating anew the spirit of enterprise.

This central role of technology and as such the potential for change, as made possible through technology, is still a subject of debate today. For Gordon [GOR 16], for example, information and communication technologies (ICT) affect a smaller number of activities as compared with the key technologies of the second industrial revolution (electricity and aviation), which is hampering the resumption of activity. On the contrary, other authors (Achibugi [ARC 16], Archibugi *et al.* [ARC 17]) consider that current technologies offer many opportunities, in terms of job creation and new growth. However, they believe that the economic and social system do not sufficiently promote their exploitation or dissemination. According to these authors, massive public investment into not only science and technology but also infrastructure should be made to help companies develop marketable products and services. The current high financialization of the economy, which makes equity investments more profitable and productive investments more risky, also plays a key role in the absence of a long-awaited recovery and the emergence of a new period of growth (Uzunidis [UZU 03]). Another connected argument is for the focus of science and technical progress to be toward short-term profitability targets, which do not sufficiently take into account large-scale challenges (e.g. climate change, aging populations), which could offer many new business opportunities.

Of course, and this is the third argument justifying the importance of Schumpeter's analysis, not all innovations have the same effects on the economic structure. New combinations can result from continuous, small-scale transformations – now called minor or incremental innovation – and their effect on the economic structure will therefore be limited. "Insofar as the 'new combination' may in time grow out of the old by continuous adjustment in small steps, there is certainly change, possibly growth, but neither a new phenomenon that would be out of the bounds of an equilibrium interpretation nor development in our sense" [SCH 05, pp. 65–66]. On the other hand, Schumpeter goes on to refer to what is today called radical or major innovation: "Insofar as this is not the case, and the new combinations appear discontinuously, then the phenomenon characterizing development emerges. For reasons of expository convenience, henceforth we shall only mean the latter case when we speak of new combinations of productive means" [SCH 05, p. 66].

A radical innovation can be defined as an innovation with a significant impact on the market and on the economic activity of firms. This impact may include changing the market structure, creating new markets or making existing products obsolete. In fact, in the analysis of cycles the new combinations appear in clusters, thereby combining both major and minor innovations. Radical innovations launched by entrepreneurs trigger the beginning of the cycle. The creation of profit opportunities attracts imitating entrepreneurs who offer incremental innovations and thus prolong the growth trend at a slower pace until the eventual turning point of that cycle. Researchers in economics and management now refer to a third category of innovation with respect to these effects: breakthrough, or disruptive innovation (Christensen [CHR 97, CHR 03]). Its trait is to introduce new performance criteria by targeting different users. It opposes continuous innovation and favors new entrants, who adopt a different business model. Consequently, the notions of disruptive innovation and radical innovation are close; however, radical innovation is more closely associated with new technologies that originate from advancements made in science and technology, whereas disruptive innovation can be ascribed to non-technological changes. Products can simply be more basic and not necessarily rely on technological change, or they should introduce new features and functions aimed at appealing to new consumers.

The fourth argument that illustrates Schumpeter's contribution to the theory of innovation is that innovation is embodied by individuals, or more precisely within "economic functions" as carried out by specific individuals. In this sense, an entrepreneur according to Schumpeter is an individual whose function is to carry out new combinations [SCH 05, p. 74]. By doing so, Schumpeter prolonged the analysis of the French economist J.-B. Say (1767–1832), who considered the entrepreneur as a producer, alongside the scientist and the worker (Boutillier and Tiran [BOU 16]). The entrepreneur's primary competence lies in the "art of application", which rests not only on science and knowledge but also on their application in terms of the needs of people (Tiran [TIR 17]). The entrepreneur implements new combinations. By highlighting this function of "placing on the market" or "introducing into production", Schumpeter highlights the essential difference between novelty or invention (in the technical sense) and innovation. If the invention is defined as a technical solution to a technical problem, innovation consists of its productive and commercial exploitation with the objective of making a profit. The characteristic that distinguishes a novelty from an innovation is that the latter involves "implementation", whether that is in the form of a market launch of a product or service or a productive use for innovation in commercial or organization processes. The aims of innovation are always linked to economic objectives: increasing the company's turnover, opening up new markets, reducing production costs, internalizing organizational costs, internalizing and externalizing transaction costs, increasing labor productivity.

However, the creative power of the entrepreneurial spirit and the advent of entrepreneurs as a "group" at the heart of this analysis on the theory of economic development depersonalizes itself in the course of its work, showing an awareness by Schumpeter as to the nature and scope of the transformations which had taken place in the structure of capitalism since the beginning of the 20th Century. The discovery of the existence of what he calls "trustified capitalism" in *Business Cycles*, will be the object of increasing attention, to the point of becoming the essential cause behind the historically determined character of "capitalism" as it features in *Capitalism, Socialism and Democracy*. The planning of technological progress by large companies, the development of private research laboratories whose aim is to reinforce the innovation potential of the company are the signs of the "bureaucratization" of technical progress: "Technological progress", writes

Schumpeter, "is increasingly becoming the business of teams of trained specialists who turn out what is required and make it work in predictable ways. The romance of earlier commercial adventure is rapidly wearing away, because so many more things can be strictly calculated that had of old to be visualized in a flash of genius" [SCH 75, p. 132]. This bureaucratization, necessary in the face of competition, is a sign of the strengthening of monopolistic structures. Economists, especially neo-Schumpeterians, raise this evolution by referring to *Schumpeter Mark I* for small companies that innovate, and to *Schumpeter Mark II* for the larger corporations that take on this role (Nelson and Winter [NEL 82], Malerba and Orsenigo [MAL 95]). This distinction, as Munier [MUN 13] explains, should be nuanced, since the decisive role of the entrepreneur – and the small business – is a constant theme in all of Schumpeter's work; it is indeed the disappearance of the entrepreneur that will sound the death knell of capitalism.

The Schumpeterian legacy is thus omnipresent in the themes that animate researchers who specialize in the subject of innovation. Indeed, the contemporary definition of innovation is part of this legacy.

1.1.2. *Typology of innovation: the contemporary definition*

The contemporary definition of innovation is that as outlined in the third edition of the Oslo manual, published by the OECD in 2005. It is part of a series of OECD-edited textbooks on measuring and interpreting data as it pertains to science, technology and innovation. For example, it complements the Frascati Manual from 2015 [OEC 15a], which focuses on R&D, and the Canberra report from 1995 [OEC 95], which deals with the measurement of human resources that are devoted to science and technology.

The definition of innovation incorporates for the first time forms of technological and non-technological innovation. Indeed, previous versions of the Oslo manual restricted innovation to its technological form (products and processes). Innovation is defined as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" [OEC 05, p. 46].

1.1.2.1. *The four categories of the Oslo manual*

Four categories of innovation are thus distinguished: product, process, marketing and organizational innovations.

Product innovations relate to "the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics" [OEC 05, p. 48]. New products can be based on original knowledge and technologies (such as the first microprocessors or digital cameras) or a combination of existing technologies (e.g. the first portable MP3 players). They may also relate to a new type of use, for example an existing chemical composition that is used to produce a new type of detergent when its previous use was quite different. Significantly improved products relate to changes in materials, components or other characteristics that make these products more efficient. Examples not only include "stop and go" systems that cut car engines at traffic lights, GPS navigation systems or automatic parking, but also the increase in the computing or storage power of our electronic devices. The term *product innovations* also apply to services, whether they are completely new (e.g. a new apartment rental service) or simply improved (e.g. Internet banking).

Process innovations are defined as "the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software" [OEC 05, p. 49]. The introduction of collaborative robots in industry (cobots) is an example of a new production method. New distribution methods, for example, barcode tracking systems or active radio frequency identification goods-tracking systems. Process innovations also apply to services, for example, a new online product reservation system in the case of local food systems (for example *La Ruche qui dit Oui!*: a Website where consumers can select artisanal products online, whereupon once a critical mass is reached, a pick-up location and time is issued), or the geolocation of available urban rental bikes (or parking spaces).

Marketing innovations concern "the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing" [OEC 05, p. 49]. Changes in product design refer to changes in its shape and appearance, without altering the functional characteristics of the product. Marketing innovation constitutes a change in the wrapping or packaging of foods, beverages, or moisturizers, which does not change the composition of the product itself. Marketing methods for product placement refer to new distribution systems (such as the introduction of a franchising network) or new ways of displaying products, such as furniture, for example, giving the customer the impression of visiting their future home. In the domain of the promotion and pricing of products and services, these new marketing methods denote branding or the first use of a method to adjust the price according to demand.

Organizational innovations refer to “the implementation of a new organizational method in the firm’s business practices, workplace organization or external relations” (OECD, 2005, p.51). Practices relate to new methods for organizing the routines of a company or enterprise (this may be to facilitate learning and disseminate knowledge through the creation and use of new shared databases, or through the introduction of further education and/or training systems) and work procedures (production management systems, for example waste assessment and management systems such as product Life Cycle Analysis (LCA)). The organization of the workplace can be modified through a new structuring of services and activities, giving greater autonomy to employees (project teams for example) or by contributing to a greater centralization of decision making. The company's external relations can be organized in a new way. The introduction of forms of collaborative innovation (open innovation) or outsourcing through the use of subcontracting for the first time are additional examples.

Novelty is accounted for in the definition of innovation and the Oslo manual distinguishes three forms of novelty: novelty to the firm, to the market and to the world. Novelty to the company is the implementation of an existing innovation by a company; it may already have been implemented by other companies, but is new to that particular firm. The notion of novelty within a market refers to an innovation which a company is the first to implement within said market. For a new global innovation, the innovation needs to be implemented worldwide.

1.1.2.2. *The combination of the forms of innovation*

For statistical or pedagogical purposes, the forms of innovation are well distinguished from one another, but in reality they are often linked or associated. Hence, in the communication of companies, it is common to hear or to read that they propose “solutions”, which essentially seek to combine different forms of innovation, in particular products, services and organizations. These solutions are often implemented to reduce the environmental impact of the activity (known as “product–service systems” [PSS]); nonetheless, they are also found in areas relating to caring activities, for example in innovations targeted at dependent persons. In the latter case, there is no correlation in terms of a reduction in the environmental footprint of the activity, but rather these solutions are developed to offer a complete and diverse package of products and services, adapted to the needs of each consumer. These two cases are examined in further detail below.

In addition to the desire to respond to the environmental impact of the offer, solutions combining products and services have resulted in the development of a concept referred to as the “product–service system”. Firms, such as Arcelor Mittal, STMicroelectronics, Saint-Gobain and Schneider Electric for example, provide solutions or systems by mixing products, components and services in order to adapt to the customers’ needs that relate to environmental constraints. For example, Arcelor Mittal develops lightweight steel solutions for the automobile industry; Saint-Gobain develops exterior thermal insulation and many other insulation solutions to meet all types of insulation requirements in new and existing buildings; Schneider Electric develops intelligent energy management systems to help companies measure and manage their energy use; Air Liquide, in its health division, provides new services to patients (for more details, see Laperche and Picard [LAP 13]). The term “product–service system” (or PSS) was defined by Goedkoop *et al.* [GOE 99] as “A system of products, services, networks of ‘players’ and supporting infrastructure that continuously strives to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models”. According to Baines *et al.* [BAI 07] literature review, most contributors on this topic have since broadly adopted this definition. The link with the environment lies in the fact that the focus is shifted from the sale of a product to a function capable of fulfilling consumers’ needs while lowering environmental impact (Mont [MON 02]). The main point is that the means by which the environmental impact of an economic activity is decreased can be found in the dematerialization and growth of services within the supply. This approach matches the notion of a functional economy that aims to “optimize the use (or function) of goods and services and thus the management of existing wealth (goods, knowledge and nature). The economic objective of the functional economy is, as explained by Stahel, to create the highest possible use value for the longest possible time while consuming as few material resources and energy as possible” [STA 97]. PSSs have some specific characteristics, well summarized by Geum and Park [GEU 11]: PSS integrate products and services, combine value creation and environmental performance (measured by a decrease in the environmental impact) and they also induce a change toward functional economy (the ownership is not transferred to the customer, but rather retained by the producer).

According to the product service ratio that forms the PSS, different types of PSS can be characterized with various sustainability potentials. The following typology (Table 1.1) is usually retained (Geum & Park [GEU 10], Tukker *et al*. [TUK 04, TUK 06]) and links the type of PSS with functional economy.

Product-oriented services	Services are just added to an existing product system to guarantee the functionality and durability of the product owned by a customer
Use-oriented services	Services intensify the use of the products. The use or the availability of the product is sold but the product is not owned by the customer (product renting, sharing, pooling)
Result-oriented services	The only true "need-oriented" PSS. A result or a capability is sold instead of a product. One actor becomes responsible for all costs of delivering a result and hence has a great incentive to use materials and energy optimally

Table 1.1. *The typology of product–service systems (Source: [GEU 10, TUK 04, TUK 06])*

In addition to the characteristics and typology of PSS, this literature provides methodologies for their design and strategic planning (Aurich *et al*. [AUR 10], Geum and Park [GEU 10, GEU 11], Morelly [MOR 06]). The definition of design methodologies aims to provide management tools for planning, forecasting and administrating the step-by-step development of PSS. The systemic characteristics of PSS (integration of products and services, involvement of various actors, lifecycle approach) need to be taken into account; in other words, "the effective design of PSS is a key to success" [GEU 11]. The presentation of these design methods and tools goes beyond the scope of this chapter, but nevertheless two important aspects are emphasized. The first is the interaction among the stakeholders of a company induced by PSS development: "a PSS is a social construction" [MOR 06, p. 1496]. The definition of a service itself, apart from its current characteristics (intangibility, immateriality), implies an interaction with the user (Gallouj and Weinstein [GAL 97]). The integration of products and services within PSS and the supply of solutions thus call for partnerships between different stakeholders, namely customers and providers of parts of the PSS, or of necessary complementary knowledge. Many of the above mentioned scholars stress this point. Some of them propose methods to map the actors involved in a PSS [MOR 06]. The second aspect is the link between PSS and ecodesign, which is also worth noticing. The supply of services is part of an ecodesign strategy: "The environmental impact can be minimized by providing the appropriate service activities during the product lifecycle or delivering the desired function itself, rather than providing the tangible products" [GEU 10, p. 411]. Moreover, Aurich *et al.* [AUR 10] propose to develop PSS lifecycle management (LCM) methods. They explain that with PSS development, "companies have to shift their focus from designing and selling products only, to supporting and accompanying their usage and end-of-life. So, they have to take care about lifecycle phases that are usually outside the traditional buyer–seller relationship, such as take-back, recovery of products and materials, reuse and refurbishment as well as remanufacturing. Contrary to other business models, the LCM of PSS focuses on the design and the realization of required user functionalities over the whole product life cycle".

The development of solutions that combine different forms of innovation can also be independent of environmental considerations and a result of the willingness of companies to be closer to the individual needs of consumers. A current example is innovation for the elderly dependent. Several terms coexist to name technologies dedicated to the frail and dependent elderly. The most popular is "gerontechnology" invented by Graafmans in 1989. Gerontechnology, as a scientific discipline, is "the study of technology and aging for the improving the daily lives of the elderly" (Bouma and Graafmans [BOU 92]). But the term also refers to technological products based on ICT, robotics and home automation, and NBIC (nanotechnologies, biotechnologies, artificial intelligence, cognitive sciences). Other terms are also found in the literature such as "gerontechological innovation" (Neven [NEV 15]), "silver innovation" (Kohlbacher *et al.* [KOH 15]) and "welfare technology" (Ostlund *et al.* [OST 15]). They all put forward the technological dimension of innovations.

Within the ICT, the "Internet of Things" corresponds to a progressive transformation of the Internet into an extensive network linking several billion human beings and tens of billions of objects. These connected objects are found in applications across many fields, ranging from of security (connected pendants, fall detectors in the home), mobility (connected wheelchairs) or health and care services (connected pillboxes). Robotics offers a whole range of robot prototypes (dedicated to security and home protection, rehabilitation). Social service robots can interact with the user and encourage participation in certain activities (travel, domestic tasks, surveillance and entertainment). In the field of health, technologies act on reduced capabilities, notably through cataract surgery, hip and knee arthroplasty, cochlear implants, as well as in the application of genetics, biomaterials and biological engineering (artificial retinas, artificial pancreas, artificial hearts, artificial bladders, etc.). NBIC propose to integrate nanotechnologies with human functions. Cerebral implants are already able to command technical assistants (such as wheelchairs), stimulate the muscles of the disabled or govern technical extensions of the body (via exoskeletons). They thus open up considerable prospects in terms of prolonging life expectancy in terms of good health. Nanotechnologies make it possible to envisage the manipulation of matter for human beings at the molecular level by manipulating atom by atom. Biotechnology has made significant progress in the field of genetic engineering. The increase in computing speeds and the emergence of artificial intelligence make it possible to create automata whose intelligence could ultimately exceed that of man. As such the cross-fertilization of these areas is promising. However, the innovations developed in the Silver Economy are not just technological in nature.

A French study carried out by the Research Network on Innovation (Laperche (ed.), [LAP 16]) – included a survey on the Silver Valley[1] stakeholders in France and a literature review on several technologies (robotics, home automation) and fields of application (food, mobility, care services). It highlighted various forms of innovation, not limited to technology. In particular, 70.6% of respondents said they were proposing "solutions" that combine products, services, new business and new organizational methods (see Figure 1.1). This is the case for home automation solutions: objects connected to the house and associated

1 Silver Valley is a cluster of private and public players of the Silver Economy, with the objective of creating favorable conditions for the development of a market dedicated to senior citizens, see http://www.silvervalley.fr. The survey of Silver Valley stakeholders from December 15, 2014 to February 10, 2015 (51 respondents), concerned the company profile, the type of activities developed, the resources and innovation strategies implemented, and the constraints facing the dissemination of innovation management.

with support services. This is also the case for elderly care services that may rely on robotics.

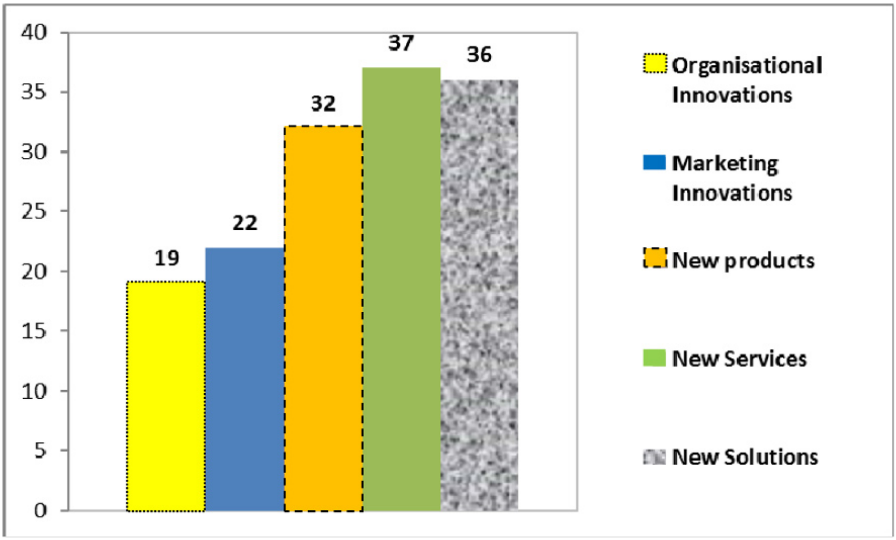

Figure 1.1. *Forms of innovation in the silver economy in France (51 respondents). Source: [LAP 16]. For a color version of the figure, see www.iste.co.uk/laperche/knowledgecapital.zip*

This result led us to propose a new term to describe innovations dedicated to the elderly: that of "geront'innovations". By adapting the OECD definition of innovation (Oslo manual), geront'innovation is defined as "the implementation of a new product (good or service or a combination thereof) or a new or significantly improved process, a new marketing method or a new organizational method that benefits frail, elderly, and/or dependent people" [LAP 16, p. 27–28].

Figure 1.2 represents an "innovation tree", the scientific fields, the key technologies and the areas covered by the geront'innovations. This representation makes it possible to better understand the process that leads to their development, but also to visualize the domains/sectors in which the geront'innovations, which combine the various forms of innovation, are "flourishing".

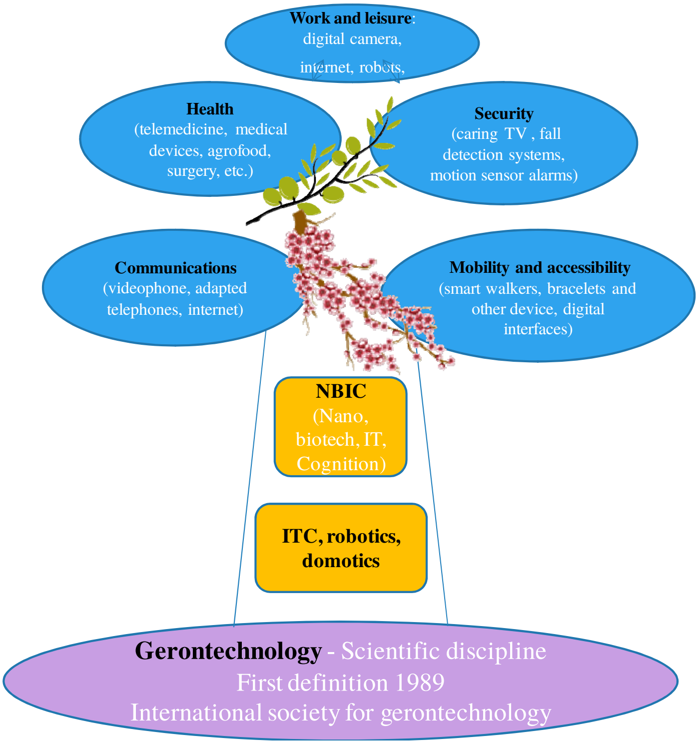

Figure 1.2. *Geront'innovations. Source: [LAP 16]*

Innovation is therefore increasingly multifaceted and it profits from technical possibilities as offered by interoperability, making it possible to approach as closely as possible the individual needs and demands of each consumer, while seeking to meet new objectives (e.g. taking into account environmental constraints).

1.1.3. *How are innovation activities organized? The innovation models*

The organization of the many activities that are part of the innovation process (research of scientists and scholars, engineering applications, launching activities by marketing and commercialization services) was first conceived as a linear model in which each of the phases of R&D (basic research, applied research and development) come after one another (see Figure 1.3).

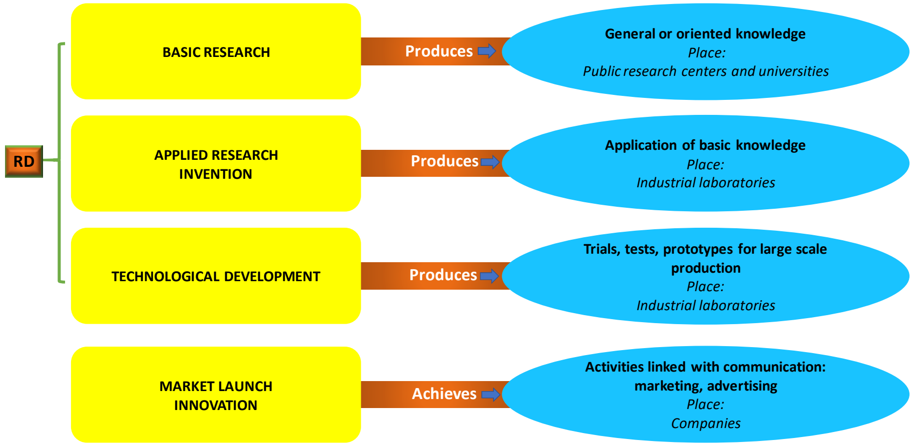

Figure 1.3. *The linear model of innovation. Source: Author*

In this figure, each phase pursues a goal and is carried out in a different place (basic research at the university or the public research laboratories, applied research and technological development at the industrial laboratory). The three phases mark the progress of scientific and technical discoveries, from the idea of a product or service to its conception and exploitation. This is the transition from a stock of knowledge produced by basic research through to invention, resulting from applied research, and then in terms of innovation. To quote Kline and Rosenberg [KLI 86, pp. 285–286]: “These events are implicitly visualized as flowing smoothly down a one-way street, much as if they were the ‘begats’ of the Bible”.

The origin of this linear model is often attributed to a report by the Director of the US Office for Scientific Research and Development, Bush’s *Science: The Endless Frontier* [BUS 45). Yet, as Godin [GOD 06] points out, Bush has emphasized the relationship between science and socioeconomic progress but the report does not give a detailed description of this model. In his article, Godin retraces the history of this model and defines three essential steps. The first began at the beginning of the 20th Century and continued up until 1945, marked by the ideal of pure research and the definition of links between pure and applied research. A secondary stage takes its beginnings in the 1930s up until the early 1960s, when a third term – development – emerged, giving rise to this three-stage model of innovation: basic research–applied research–development. The third period that began in the 1950s extended the model to include production and dissemination activities. Ultimately, according to Godin, the model owes less to the report of Bush than to the work of the industrialists, consultants, business schools and finally economists who have lately taken up this question. Similarly, the author emphasizes the role played by the production of statistical tools, first by the National Science Foundation (NSF) in the United States and then by the OECD (first publication of the Frascati Manual in 1963) in the stabilization, diffusion and longevity of this model: "Statistics solidified a model in progress into one taken for granted – a social fact" [GOD 06, p. 647]).

However, this model was strongly criticized because it avoided the phenomena of feedback between each phase, or because the role of demand was neglected, coming into play only at the end of the process. It seemed to correspond to the neoclassical theoretical representation of growth in which technical progress and *a fortiori* scientific and technical discoveries are considered as being outside the sphere of the economy. From the 1980s, technical progress and innovation began to be understood as endogenous phenomena within the sphere of the economy. Indeed, interactions (via contracts and the mobility of scientific and technical work) between all types of public and private institutions devoted to scientific and technical activity have been more fully included in the analysis of innovation processes.

These are designed according to interactive and systemic models that emphasize the interactions between the R&D phases and market integration (see consumer tastes, quality requirements) throughout the process leading to innovation (Kline and Rosenberg [KLI 86], Rothwell [ROT 94]); the latter who emphasized five models of innovation since the 1950s). Therefore, in these models, technology evolves throughout its diffusion. The marketing of an invention generally leads to multiple improvements that are essential to its success. Similarly, if scientific developments can lead to innovation, then innovation can also take place without an established scientific theory having preceded it. Kline and Rosenberg [KLI 86, p. 288] cite the example of the bicycle that was an essential innovation, despite the absence of a theory explaining the stability of the man/bicycle couple. We must attribute to Kline and Rosenberg [KLI 86] the best known representation of the interactive model of innovation (see Figure 1.4).

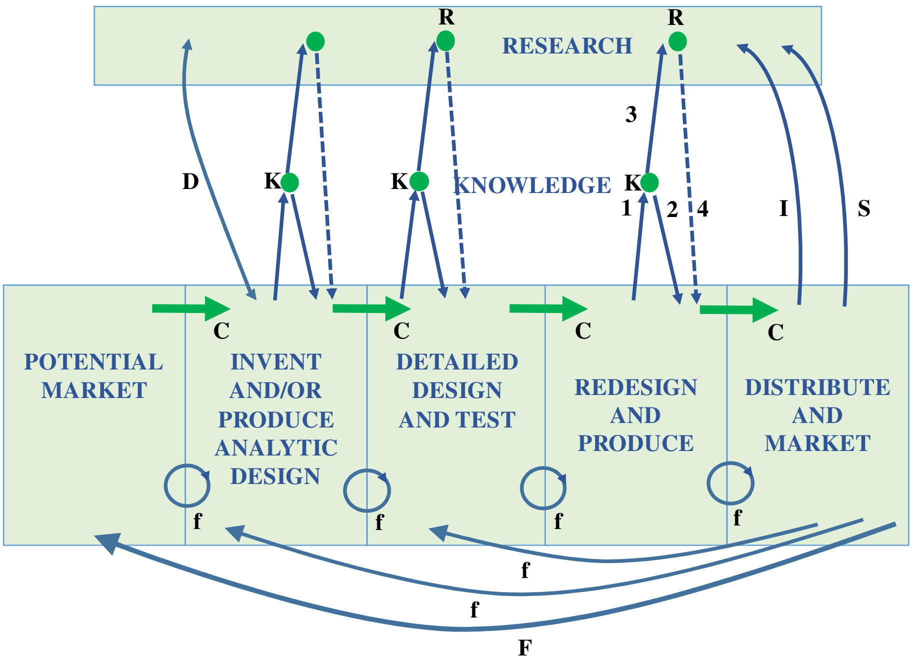

Figure 1.4. *The chain-linked innovation model. Source: [KLI 86]*

In this model, there is no longer a single path between each of the phases of the innovation process, but rather five paths. The first is the central, linear link between design, production and the market (the central chain of innovation). Nevertheless, the potential market is taken into account upstream of the process; this main path is characterized by the arrows denoted here as *C*. The second path is juxtaposed to the first by feedbacks *f* and *F*, which emphasize the links and the activity back and forth between each stage of the innovation process. Scientific development in the form of knowledge already available (link *K*) does not appear upstream but irrigates the whole of the central chain. If this knowledge is not sufficient to solve the problems posed in the central chain, then research is mobilized to develop new knowledge (*K* and *R* Links); the third path. Of course, science can be at the origin of new technological developments, which will most often be radical in nature (arrow *D*); this is the fourth path of innovation. The last path, symbolized by arrows *I* and *S*, highlights the fields that technological innovations can open for research.

In this model, the different phases of research are intertwined, to the point that the terms basic research, applied research and development have disappeared in favor of "research" or "R&D". This is due to the growing rapprochement between the academic world and the business world. On the one hand, universities and public research centers have as their new mission (the "third mission") the commercialization of research (we will return to this in Chapter 2), which should strengthen their contribution to economic growth and enable them to build up autonomous budgets. This impels them to not only carry out fundamental research but also applied research more likely to appeal to investor companies. The pivotal period of the 1970s was marked by the exhaustion of Fordist modes of production, based in particular on the mass production of standardized goods. This model, dominant in the postwar years of growth, justified price competition. It was well suited to a linear model of innovation, where the major programs of basic and applied research, especially in the military sector, provided techniques that could be developed on a large scale in the form of new products and processes. The crisis of the Fordist model (which in particular reflects the saturation of the demand of national markets for standardized capital goods) has gradually led companies to differentiate their offering. Innovation has thus become a key element of their strategy. In the 1980s, the openness and liberalization of markets (goods and services, finance, labor) made innovation the driving force behind the competition between firms on the world market stage. Hence, the willingness of companies to cooperate more closely with public research, on the one hand by increasing their internal research staff and on the other hand by financing public research in order to access as soon as possible, and possibly exclusively, its results. To the extent that, it is becoming increasingly difficult to define the exact border where basic research ends and applied research begins. Finally, the market no longer appears at the end of the chain but tends to be taken into account upstream of any innovation project. *Market research* has become the key element of any business venture. Advertising helps to shape consumer needs and choices, as well explained by Galbraith in the late 1960s [GAL 74].

The nature of technological change is another factor that explains the increasingly fuzzy boundary between the various phases of R&D and justifies the existence of an interactive model of innovation. In biotechnology or in genomics, for example, the boundary between the R&D phases is increasingly tenuous. Research carried out in universities and public research centers therefore almost naturally combines the theoretical and practical aspects and makes the results potentially exploitable; hence, the emergence of numerous university spin-offs (Droganova [DRO 12]). These fields of research that combine theory and practice are now increasing in number. For example, linguistics is traditionally regarded as basic research; nowadays, however, it is closely associated with software advancements being made in the computer industry. The researchers' awareness as to the possibility of linking the two activities together, in view of the financial resources generated by the commercialization of their research results (which will be able to finance their future research), has accelerated the association between basic research and applied research.

However, according to Godin, models that are alternative to the linear model, such as the interactive model, are more like "modern art" than a true analytical framework [GOD 06, p. 660]. This is due to the fact that innovation indicators still correspond to the linear model of innovation; indicators that seek to measure knowledge flows and the interactions between actors in the innovation process are still under construction. The longevity of the linear model is also, as Joly [JOL 17] explains, in the definition of public policies of innovation. An example of such is set by the Lisbon strategy, whose objective was to reach 3% of European GDP. The implicit or explicit assertion of that policy is that "Science is the solution, society the problem": science will develop because of more R&D investment and innovation will be successful if the society becomes more entrepreneurial and more enthusiastic about new technologies [JOL 17, p. 84]. In addition, it is in the interest of innovation stakeholders to remain committed to this linear model. Since the linear model values basic research, some researchers seek to maintain it as it is. This is also true of firms who are the main beneficiaries of public innovation policies, which allocate a high share of support (through tax credit for example) to R&D performers. One of the reasons for the longevity of the linear model also lies in its simplicity of comprehension and use, as the two authors we have cited emphasize. In the same reasoning, we can refer to the fact that in the management of their innovation projects, companies (mostly large ones) very often use a "linear" scale developed by NASA in the 1970s (and extended since) (Mankins [MAN 09]). This Technological Readiness Level (TRL) scale was originally intended to be a tool for evaluating technological programs, showing the different stages of their maturation, and has been adopted by many organizations, both public institutions and firms. It consists of nine stages, from the most basic research (TRL1) to the application of technology in real-world conditions (TRL9).

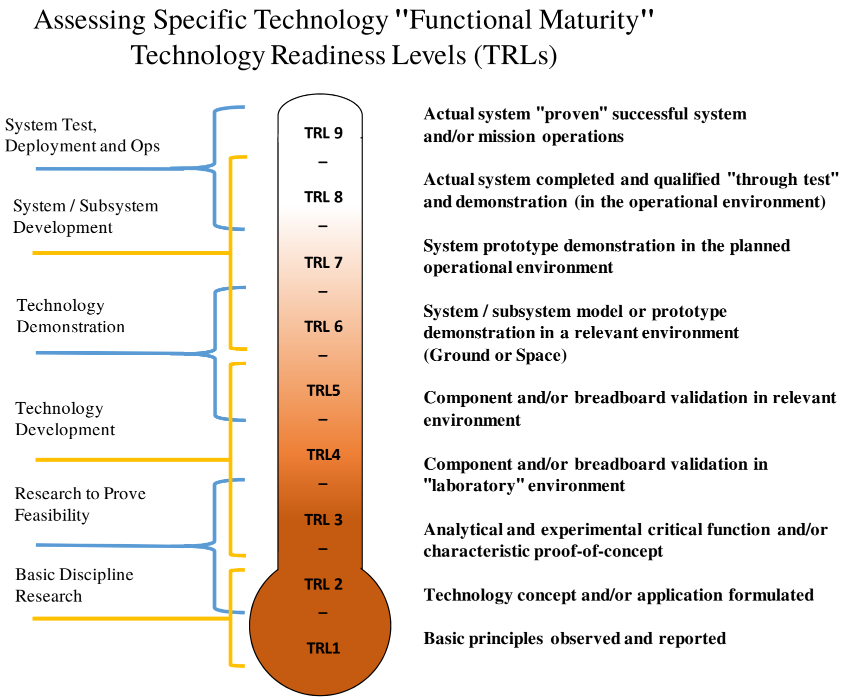

Figure 1.5. *Scale: technology readiness levels. Source: [MAN 09]*

While the practical application of the interactive model of innovation is not widely observable, it has however become an analytical and conceptual norm. It paved the way for the analysis of the interaction networks inherent to the innovation processes.

1.1.4. *Measuring innovation*

Innovation is a multifaceted phenomenon and cannot easily be confined to a standard indicator, as is the case for example, in measuring economic growth which despite the limitations of this indicator is demonstrated by the gross domestic product. R&D and patents have long been regarded as key indicators of innovation, the former measuring the means allocated to innovation and the second measuring the results of the activity.

The measurement of R&D is based on data collected from companies and research organizations according to the codification carried out by the seventh edition of the Frascati Manual, published in 2015 [OEC 15a]. A distinction is made between gross domestic expenditure on R&D (GERD), which refers to total expenditure (current and fixed capital) on R&D performed by all enterprises, the State, higher education and the private non-profit sector of the economy. These expenditures include R&D financed from funds abroad, but exclude the financing of R&D activities performed abroad. This indicator is expressed in millions of U.S. dollars and as a percentage of GDP [OEC 15, Chapter 4]. It can also be broken down by measuring the Business Enterprise Expenditure on R&D (BERD) or Higher Education Expenditure on R&D (HERD), the State sector and private non-profit institutions expenditures in R&D. The intensity of R&D is measured by the ratio of R&D expenditure to GDP for a country or the ratio of R&D expenditure to turnover for companies.

The global R&D capacity, as measured by public and private investment, doubled during the period from 1990 to 2014 (Figure 1.6(a)). This increase in global R&D capacity can be explained in particular by growth in business spending, which has expanded faster than public expenditure in R&D (Figure 1.6(b)). The financial crises that marked the period (the crisis of the emerging countries in the early 1990s, the start-up crisis of the new economy in 2001 and the financial crisis of 2008) have led to cyclical reductions in companies' R&D investments. However, the behavior of companies is rather counter-cyclical, in that they rely on innovation to restart the growth of their activities. This was confirmed following the 2008 crisis by several quantitative and qualitative studies (Archibugi *et al.* [ARC 13], Laperche *et al.* [LAP 11]). The strong growth in overall R&D investment over the period from 1990 to 2014 is also explained by the sharp increase in spending in emerging countries such as China, which can be compared to the decline in the triad countries: the United States, Europe and Japan.

One of the major limitations of this indicator is that R&D is mainly focused on science and technology and it has difficulty capturing spending so as to bring about other forms of innovation, such as organizational or marketing innovations. Services that make up an important part of the new solutions offered by firms are better measured by the marketing expenses, which do not even come into the measurement of R&D. Also, expenditures by small firms (which rarely employ researchers) for organizational or commercial innovation are not recorded and as such are not considered as innovative. This is true, for example, in the agri-food sector, which is traditionally considered to not be very innovative, while finer indicators show that innovations are numerous (Tanguy [TAN 16]).

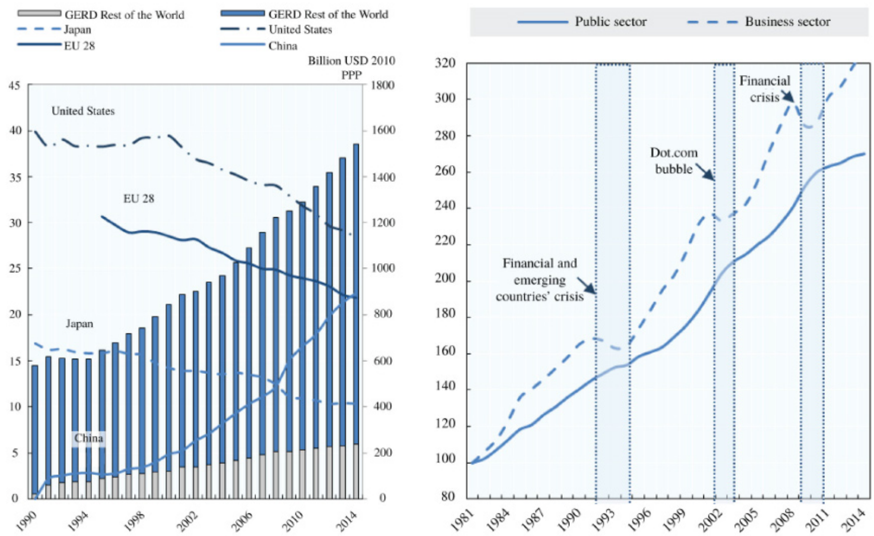

Figure 1.6. *R&D investment over the period from 1990 to 2014. Source: OECD [OEC 16a]. For a color version of the figure, see www.iste.co.uk/laperche/knowledgecapital.zip*

Patent is an industrial property right granted to an inventor for a period of 20 years, often used as a result indicator for innovation performance. It has the advantage of being an indicator that is both available and reliable and whose databases are public since it is managed by national intellectual property institutes. Worldwide patent filing statistics show strong growth in patent filings from the 1970s (Figure 1.7). Patent filings tripled between 1985 and 2014. While the Triad countries for a long time used to attract the most patent filings, China has since surpassed them, by quite a lot since the early 2010s, showing at once the attractiveness of this country for the exploitation of inventions but also the strengthening of its capacities for innovation.

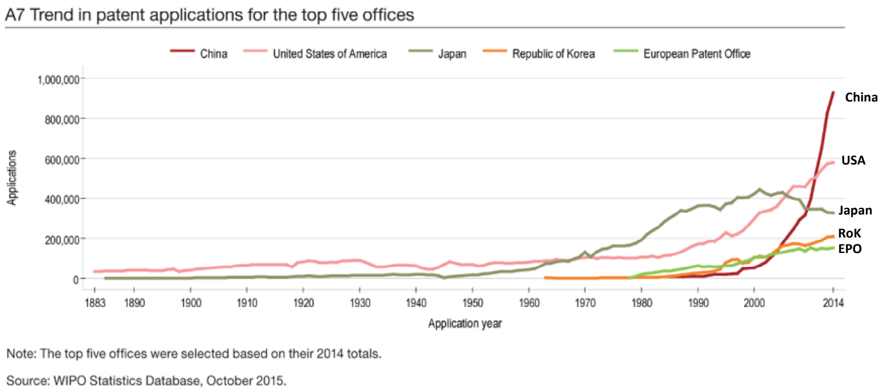

Figure 1.7. *Patent filings in the top 5 patent offices from 1883 to 2014. For a color version of the figure, see www.iste.co.uk/laperche/knowledgecapital.zip*

However, as an indicator of innovation, the patent also suffers from many limitations. First, it only measures the "inventions" that are subject to patent filing, leaving aside all other possible forms of innovation. Many inventions are also not patented, especially if they do not meet the novelty, inventive step and industrial application criteria. A useful but not new invention (already incorporated into the state of the art, that is, all that has been made public at the time of filing) will normally not pass the report stage of research carried out by the industrial property institute. Moreover, a registered patent does not always result in an innovation, that is, a new product launched on the market, or a new process integrated into the production process. Many patented inventions remain unexploited, often for strategic reasons. Patents are used as "lures" intended, for example, to deceive competitors on the technological trajectories being pursued. Dormant or submarine patents are also very common. In this case, patents are not exploited because the outlook for profits is lower than the costs incurred by placing the product on the market. The company holding the patent may also lack the resources necessary to exploit the invention. It may prefer to wait for the complete profitability of the preceding invention before launching a new one (in such instances we can speak of technological Malthusianism) (Walsh *et al.* [WAL 16]). Criticism was also expressed about the quality of patents, particularly those issued in the United States in the years 1990–2000, given the favorable attitude of the country to inventors. In fact, the criteria for patentability have in many instances been poorly respected, leading to the proliferation of low-quality patents and numerous disputes and trials. In any case, the statistics would thus be distorted by the multiplication of these "rotten" patents. Another difficulty related to the measurement of patents lies in the fact that patents are only effective tools of protection in the countries where the protection has been claimed (apart from the unitary patent in Europe, the use of which is still dependent on the ratification of certain agreements among signatory countries). To avoid counting them several times, statisticians have therefore defined an indicator called a patent family, which refers to a set of patents filed in several countries (i.e. patent offices) that protect the same invention. For example, the "triadic patent families" are a set of patents filed with three of the main offices, namely the European Patent Office (EPO), the Japanese Patent Office (JPO) and the United States Patent and Trademark Office (USPTO) (OECD [OEC 05]).

On this basis, World Intellectual Property Organization (WIPO) conducted a study of the 100 largest patent filers in the world based on the number of patent families between 2003 and 2012 [WIP 15]. These are from Japan (55), the Republic of Korea (15) China (10), the United States (9), Germany (5), Taiwan-China (1) and France (1). The list is made up mainly of multinational firms but includes four Chinese universities among the top 100. The main sectors are ICT, electrical machinery and the transport sector. Japanese companies dominate the top 10 (see Table 1.2) and the company Panasonic is ranked as the top patent filer in the 2000s, as was already the case in the 1990s and 1980s. The only French company in the top 100 is Peugeot-Citroen, ranked 75th with 8,679 patent families over the period of 2003–2012.

Of course, indicators of innovation are not limited to these two indicators. The number of researchers, the number of scientific publications and the sums of venture capital invested in the financing of innovative enterprises, other types of intellectual property rights (trademarks, designs and models), the turnover from innovation, the dissemination of key technologies, etc., are also counted. This better understanding of the innovation process results, not with a reduction in the study of traditional indicators, but with a refinement of the evaluations used to measure the efforts and performances of innovation by using other indicators. For example, at the level of the company, statisticians seek to better measure non-R&D intangible investments (e.g. software and databases) or the interactions being developed with other companies or institutions (see [OEC 10]). At the country level, indicator tables and synthetic indicators are also used to measure innovation.

Applicant	Origin	Total number of patent families (2003–2012)
Panasonic Corporation	Japan	111,653
Samsung Electronics	Republic of Korea	95,852
Canon	Japan	74,193
Toyota Jidosha	Japan	73,220
Toshiba	Japan	65,151
LG Electronics	Republic of Korea	64,593
Seiko Epson	Japan	62,305
International Business Machines (IBM)	United States of America	45,473
Ricoh	Japan	45,306
Sony	Japan	44,261

Table 1.2. *Top 10 patent filer in the world (2003–2012). Source: [WIP 15] (extract from the top 100)*

The European Innovation Scoreboard (which has existed since 2001), for example, provides a synthetic indicator that allows countries to be ranked according to their innovation performance. Four categories of countries are defined: modest innovators, moderate innovators, notable innovators and champions of innovation. The results for 2016 are as follows.

Sweden, Denmark, Finland, Germany and the Netherlands appear to be the champions of innovation, positioning themselves at least 20% above the European average. Notable or strong innovators include Ireland, Belgium, the United Kingdom, Luxembourg, Austria, France and Slovenia. Their results are slightly higher or nearer to the European average. The performance of moderate innovators is between 50% and 90% the European average. This category includes many countries in Eastern and Southern Europe such as Cyprus, Estonia, Malta, Czech Republic, Italy, Portugal, Greece, Spain, Hungary, Slovakia, Poland, Lithuania, Latvia and Croatia. Finally, the modest innovators, Romania and Bulgaria, perform 50% below the European average.

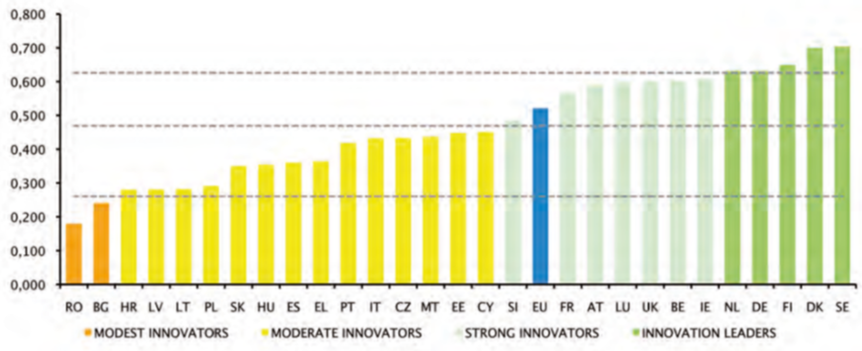

Figure 1.8. *Innovation performance in Europe. Source: [EUR 16]. For a color version of the figure, see www.iste.co.uk/laperche/knowledgecapital.zip*

This synthetic indicator – the Summary Innovation Index – is based on three main categories of indicators (enablers, firm activities, outputs), which have eight dimensions of innovation: human resources; open, excellent research systems; finance and support; firm investments; linkages and entrepreneurship; intellectual assets; innovators and economic effects. In total, the average results of the countries are measured on the basis of 25 indicators (see Figure 1.9).

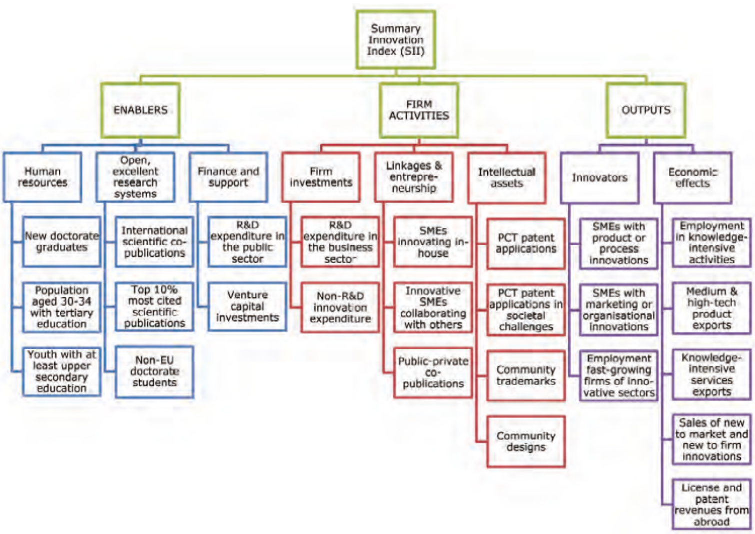

Figure 1.9. *The indicators included in the Summary Innovation Index. Source: [EUR 16]*

Such an indicator makes it possible to monitor the performance of the European Union according to each country over time, but also serves as a guide for the definition of public policies that can be adapted to address the specific problems encountered in each country. One notable outcome is that the innovation champions perform similarly in each of the eight dimensions of innovation measured. As such, this result reinforces the opinion that the overall strength of the national innovation system plays a key role in the performance of innovation.

The opening of innovation's black box thus reveals many activities, which are articulated and measured in several ways. In order to create new products, processes, marketing methods and types of organization, the company must constitute a "knowledge capital". The next step is to better understand its origins and the roles it plays in the activities of firms.

1.2. Knowledge capital: definition and roles

1.2.1. *From scientific and technical knowledge to knowledge capital*

Knowledge is traditionally linked to the individual and is acquired by a continuous mental activity. This first definition focuses on the production of knowledge. Within the firm, innovation must therefore be thought of as an endogenous process: it is the result of a motivated investment in human resources (researchers, engineers), material (scientific and technical instruments, machines) and intangible ones (R&D databases, software). This investment contributes to produce knowledge that will eventually be transformed into goods, services and processes. However, this definition hides all the economic intelligence activities, which are nevertheless essential.

Indeed, the composition of what we call *Knowledge Capital* requires the research and acquisition of scientific, technical and commercial information that can not only enrich, but also *shape* or *systematize* the knowledge being produced within the company. We can therefore define the scientific and technical knowledge of the company as a set of acquired knowledge combined with the scientific, technical and commercial information gained through productive activities and continuous economic intelligence.

To understand this, it is useful to recall the difference between *information* and *knowledge*. This can be studied as a difference in terms of content of knowledge, information and data. It can also be based off of the way of measuring each of them. In the first instance (see Figure 1.10), knowledge appears as a nested "Russian doll". It is defined as a set of formatted information. Information corresponds to a set of data and the data corresponds to a set of facts.

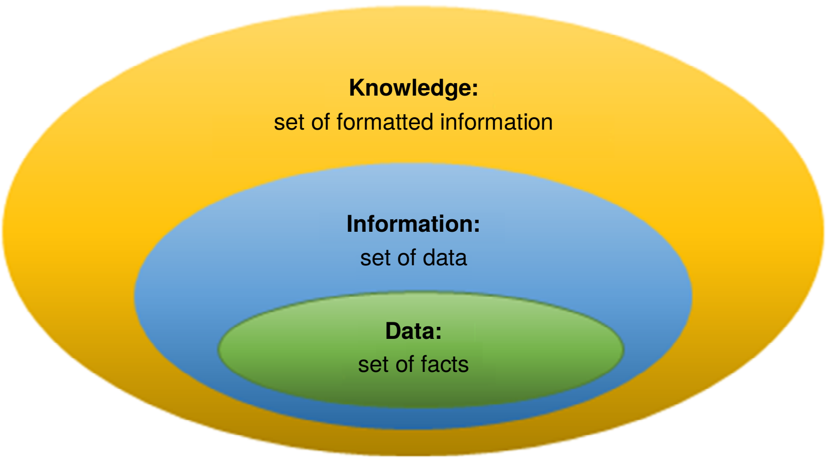

Figure 1.10. *Knowledge: a Russian doll. Source: Author*

While this approach is interesting, it may itself be restrictive in the application of terms. Economists have highlighted the common characteristics of information and knowledge and have often treated them in a synonymous way. According to Machlup [MAC 84], knowledge (the same applies to information) is characterized by a high fixed production cost and a zero or near-zero reproduction cost. This is explained by the characteristics attributed to these specific goods, in particular their non-exclusiveness (i.e. the impossibility of excluding users even if they do not contribute to the financing of the good) and non-rivalry (which means that the consumption by one individual does not diminish the amount available to others). Hence, as scrutinized by Arrow, the problems of incentivizing firms to invest in knowledge production [ARR 62a]. However, these properties of knowledge and information are somewhat altered when strategies of appropriation are implemented by companies and supported by public authorities. We will come back to this point further on.

Others have sought to highlight the differences between information and knowledge and thus to dissociate them by relying precisely on the meaning given to information by cybernetics, that is to say, a set of data. For example, Foray states that "knowledge is fundamentally a matter of cognitive capability. Information, on the other hand, takes the shape of structured and formatted data that remain passive and inert until used by those with the knowledge needed to interpret and process them" [FOR 04, p. 4].

A second perspective on how to differentiate the two terms – which is not incompatible with the previous view – is by looking at how knowledge and information can be accounted for: knowledge can be viewed as a stock and information as a flow. This recognition makes it possible to distinguish the internal production of knowledge (knowledge as a stock) and the activity of economic intelligence that feeds the process of knowledge production. Knowledge (stock) and information (flows) thus appear to be complementary.

Knowledge is associated with the individual. It is the fruit of the intellectual processes of understanding, learning and behavior. Therefore, knowledge is first and foremost embodied in individuals and in the collective memory of the social whole. In the case of the firm, scientific and technical knowledge is incorporated into the individuals (knowledge and expertise of researchers, engineers, workers) and in the collective memory of the company ("routines" if we adopt evolutionary vocabulary, translated for example into specific production procedures). It is also incorporated into the machines, objects and products created by the members of the company and used in its scientific and technical activities.

Knowledge, but also information, can be codified, that is, written and indexed, and made explicitly available in a "directory" or it can be tacit. According to Polanyi, tacit knowledge expresses the idea that "we can know more than we can tell" [POL 66]. It is contained in the know-how of individuals and transmitted through learning by doing (Arrow [ARR 62b]), using (especially advanced technologies) (Rosenberg [ROS 82]) or interacting (Lundvall [LUN 92]). The role of tacit knowledge is fundamental as it makes it possible for the company to appropriate the knowledge capital that it holds; however, this makes it more difficult, for example more time-consuming to diffuse knowledge to competitors.

The example of the chocolate mousse recipe makes it possible to differentiate between the codified and tacit character of the knowledge.

On the website www.marmiton.org, the recipe for chocolate mousse is as follows:

– "separate the whites from the yolks";

– "soften the chocolate in a saucepan in a bain-marie";

– "remove from heat, then add yolks and sugar";

– "beat the whites into a firm white peak and gently fold into the mixture with a spatula";

– "pour into a bowl or dessert glasses and cool for 1 or 2 hours minimum".

This recipe is, presented like this and for the novice in the kitchen, codified information. If the novice tries to reproduce it, s/he will implement a learning process and this recipe will become knowledge for him. Nonetheless, will it lead to the desired result, which in this case is the creation of aerated chocolate foam and not a chocolate cream? Indeed, "tacit" elements are hidden in this recipe. In particular, the phrase "beat the whites into a firm white peak and gently fold into the mixture with a spatula" is essential. It is sufficiently explicit for those who have already practiced chocolate mousse (they already have the know-how, obtained through learning by doing) or for those who have watched the gestures made by someone else (learning by interaction). For the novice, gently folding the mixture with a spatula can lead to "breaking the white peaks" if the gait of the spatula, which must "roll" around the white peaks, is not respected... This key element is tacit knowledge, which is difficult to explain and is held as know-how by the one who has gone through the learning process. If this know-how is not acquired, the result will not be a mousse, but a chocolate cream!

The same reasoning can be applied to freely circulate patent documents. The invention that a patent document contains must be reproducible by a person skilled in the art in question. Here again the reproduction cannot be instantaneous because of the tacit knowledge that must be acquired through learning, a process which is often long.

Box 1.2. *Codified knowledge, tacit knowledge and chocolate mousse*

The company's scientific and technical knowledge thus forms a stock that can be used by the company. This stock is constantly evolving in a changing economy and this trend tends to call into question the existence of a zero marginal cost, which would go hand in hand with the identical reproduction of the stock of knowledge.

Scientific and technical information, as a flow, thus appears as both an input and an output of knowledge (see Figure 1.11). Information and knowledge are therefore neither synonymous, nor dissociable: they are complementary. Information is a written, visual or audible description of knowledge, codified or tacit. It consists of images, published and disseminated, of events, behaviors and facts of the physical, biological, natural and human world. The word 'information' comes from the Latin *informare* (date of apparition: 1190). It essentially means to give a form, a meaning[2]. Information is thus endowed with a structuring power.

Knowledge and information are thus intrinsically linked: the flow of information entering the company has a structuring power over the accumulated knowledge. This information flow allows for the organization of accumulated knowledge for a specific purpose: to create a new product, for example. However, knowledge, like information, is the fruit of work. Knowledge implies work that is theoretical but also practical, aimed at improving the understanding of natural and social facts. Information describes and disseminates this knowledge produced by work and involves additional work in selecting the most relevant knowledge elements. This means that information is the disseminated result of knowledge.

Not all knowledge will become information. Either because it has not reached a sufficient degree of formalization to be able to achieve a better understanding of natural and social facts (knowledge is still only a series of hypothesis), or because it is of no immediate use for the purpose of commercial transformation of individual or collective knowledge.

2 This meaning is first granted to the verb "to inform" in the dictionary of Furetiere "To give the form". It is found in Littré (19th Century) for the word "information": "Philosophical term. Action to inform, to give form". The verb "to inform", in the proper sense, is a "Philosophical term. To give form", and figuratively, "Gives form to the mind and consequently warns, instructs".

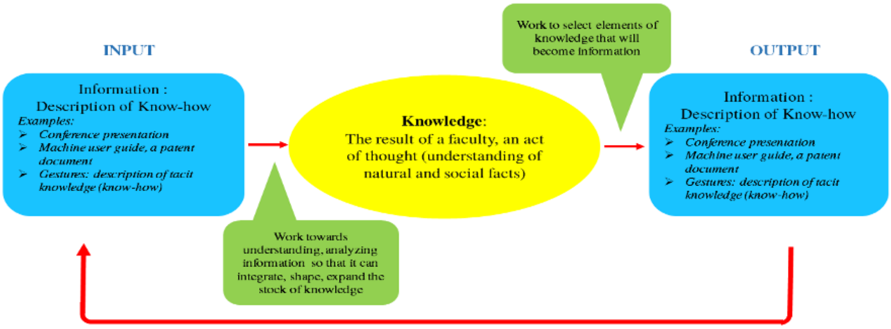

Figure 1.11. *Information, input and output of knowledge. Source: Author*

In order to arrive at the notion of knowledge capital, attention must be paid to the specific use of knowledge by the firm. In what case can a resource be classified as capital? When it is used in a production process. This is the case, for example, with science, which, when integrated into production, becomes a productive force of capital (Marx [MAR 67], Uzunidis [UZU 03]).

We can define the knowledge capital as the set of scientific and technical information and knowledge produced, acquired, combined and systematized by one or several firms within a particular productive objective and, more broadly, within a process of value creation. Knowledge capital (see Figure 1.12) refers to the accumulated knowledge of one or several linked firms. It is embedded in the individuals (know-how), the machines, the technologies and the routines of the enterprise. It is continuously enriched by the information flows and is used in the production process or, more globally, in the value creation process. The knowledge capital is more than the sum of its parts: a process of cross fertilization between all the sources of information and knowledge makes it so that the return from the use of this combined set of information and knowledge is higher than the return from the use of these pieces of information and knowledge taken separately. Thus, knowledge capital is a dynamic concept – a process – that defines the knowledge accumulated by one or several firms and which is continuously enriched and combined in different ways. This productive aim – the creation of value – is the main characteristic which turns knowledge into “capital”.

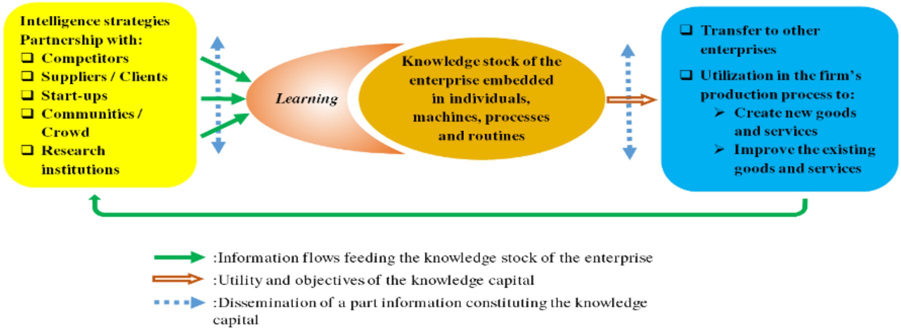

Figure 1.12. *Enterprise knowledge capital. Source: Author. For a color version of this figure, see www.iste.co.uk/laperche/knowledgecapital.zip*

Studying the knowledge capital of firms makes it possible to understand how they generate new knowledge and how they transform this knowledge into (technological, organizational and commercial) innovation. The information is collected on markets through intelligence strategies, through access to patent information, through the purchase of technology, and the signing of licenses and other cooperation contracts. It is integrated into the knowledge stock through learning processes, which are the basic elements in the transformation of information (flow) into knowledge (stock). The use of the knowledge stock depends on the market and production opportunities, and on the degree of maturity of the developed technologies.

The concept of knowledge capital is mainly analytical and aims to go deeper in its understanding of the content of the black box that is the firms' innovation process. It thus complements but also differs from the "knowledge-based capital" (KBC) recently developed by the OECD [OEC 13a]. The aim of the KBC concept is to list and better measure the intangible assets invested in by firms, such as data, software, patents, designs, new organizational processes and firm-specific skills. They are divided into three groups: computerized information, innovative property and economic competency (see also Corrado *et al.* [COR 05]). Another division is often kept in mind when dealing with "intellectual capital" (IC), broadly defined as a sum of useful knowledge that can be converted into value (Edvinsson and Malone [EDV 97]): human capital (knowledge, know-how, life skills), relational capital (external relations with clients and suppliers) and structural capital (databases, organizational routines, culture) (Mignon and Walliser [MIG 15]).

The ultimate goal of the KBC or IC concepts is to provide evidence for the economic value of intangible assets; that is to say, to study their impact on growth, productivity, competitiveness and innovation of firms in order to promote policy measures adapted to a broad vision of innovation. However, according to Zambon and Monciardini [ZAM 15], most studies on this subject are focused on the measurement and reporting of intangible assets and neglect the analysis of their specific role in the value creation process.

They are, nonetheless, useful concepts since they allow for the quantitative assessment of the contribution of intangible assets. In this sense, they complement our approach to the firm's knowledge capital, and the need to be more accurate in the listing of intangible assets that contribute to innovation. However, these certainly need to be linked to other managerial concepts if they are to lead to a dynamic vision of the innovation process, as also suggested by Užiené [UŽI 15]. Moreover, although intangible assets are crucial to the firm's innovation strategy, tangible ones also contain knowledge as a form of dead labor, included in tools, machines and production processes. These tangible assets are, according to us, essential to the innovation process, as much as the intangible ones. Our concept of knowledge capital in this regard therefore has a larger scope.

The use of knowledge capital in the process of creating value in the enterprise can take two forms:

– the sale of this knowledge capital to another company (for example the sale of software). In this case, the knowledge capital is transferred to another company (and others) that will use it in its production process;

– the use of this knowledge capital in the company's own production process. In the second case, knowledge capital can be considered as both a means of producing goods, as a tool for cohesion of worker collectives (or teams) and as a tool capable of reducing the time that the production process usually requires. It is these forms of productive use that we are interested in for the rest of this section.

1.2.2. *The productive use of knowledge capital*

Our approach to knowledge capital can be described as dynamic. Knowledge capital is constantly changing and it is this constant transformation that justifies the importance that it bestows on companies. At the origin of this dynamic process is scientific and technical information in particular, but there is also commercial information. It is through the structuring power of information that knowledge capital becomes a means of producing new commodities. It is also because of information that it acts as a means of cohesion within groups or "work collectives". The acquisition, processing and dissemination of some of the information contained within the knowledge capital finally makes it possible to reduce the process time of production as well as the placing of goods on the market.

1.2.2.1. *Knowledge capital and the production of new goods and services*

The scientific and technical information and knowledge that make up knowledge capital have been, since the beginning of industrial capitalism, essential inputs in the production of new commodities. This is the first aspect of its role in the production process. Information has an organizing role: integrated into a stock of knowledge, it allows one to orient it for a different application, or as a means to strengthen the existing one.

The constitution of knowledge capital requires the gathering of various inputs; that is to say, human resources (researchers, engineers), materials (machines, tools) and information (patents, software and free information databases). The company seeks to integrate new scientific and technical information and knowledge that will in turn enrich the knowledge already accumulated through the use of various means: the salary of the personnel, the activity of economic intelligence, the cooperation with other firms and external institutions, and the intramural and extramural execution of research development. We shall return to these in Chapter 2, which will explore the evolution of knowledge capital formation strategies over time.

The combination of new scientific and technical information to the knowledge already accumulated by the company makes it possible to use it productively, by developing new products and services or by improving them. Therefore, the protection of this knowledge capital is fundamental. The performance of firms depends on their capacity to appropriate this knowledge capital and generate income from it. The appropriation of knowledge by the firm begins with the sphere of production and signifies the formation, the productive use and the protection of this knowledge as capital. The protection of knowledge capital is the subject of rigorous strategies (use of intellectual property, secrecy, lead time over competitors). For more on this topic, see Chapter 3.

1.2.2.2. *Knowledge capital and the cohesion of work collectives*

Knowledge capital also plays a key role in the cohesion of working groups. Durkheim at the end of the 19th Century coined the concept of "organic solidarity" that results from the learning processes, which gives the working group its truly collective character. The work collective, or "collective worker" in Marxist terminology, is at the origin of the processing of scientific information acquired outside of the company, and therefore of the enrichment and (re)production of knowledge capital. It is also this working group that ensures the productive use of knowledge capital.

The work collective is a result of the interweaving of the fragmented scientific and technical know-how of the paid employees. The circulation of scientific and technical know-how and information within the working group in turn conditions the existence, functioning and cohesion of the work collective. The latter, once well defined within the boundaries of the firm, is at the time of the network firm and open innovation, extended beyond its borders (see Chapter 2). Therefore, the diffusion of knowledge capital to beyond the boundaries of the company is fundamental to ensure the cohesion of its teams. Scientific and technical information can then be studied, taking into account the terms developed by information theory and cybernetics, as a means of controlling, commanding and directing work collectives toward clearly defined goals in the same way that information typically plays this role within the machine or within society in general (Wiener [WIE 48]).

Knowledge production is increasingly taking place within *knowledge communities* (Amin and Cohendet [AMI 04]), a unifying term that helps understand the different forms of communities (e.g. communities of practice, epistemic communities). At the origin of the concept, communities of practice (Brown and Duguid [BRO 91], Lave and Wenger [LAV 91]) present themselves as informal groups of individuals making exchanges in terms of practices within the framework interactive norms built via learning, without hierarchy and production of knowledge in specific areas. The typical example is that of open-source communities. As explained by Barbaroux *et al.* [BAR 16], companies are increasingly aware of the importance of these knowledge communities as a vehicle for innovation. The example developed in the literature is that of IBM, which gave birth to the notion of communities of practices, where the company "looks for the alignment between the activity of a community and its strategic orientations, while preserving the self-organized and spontaneous character of the community" [BAR 16, p. 77]. In other words, we could say that the goal is to take advantage of the creativity that is a result of this type of organizational flexibility, in the form of a community, in order to strengthen the firm's knowledge capital.

These multiple roles of knowledge capital justify corporate investment in its constitution and protection. Then again, in modern times there is an increase in the dissemination of scientific and technical information being integrated into advertising, and via sophisticated and rapid tools (e.g. the Internet). In other words, modern communication accelerates the dissemination of information. The quest for information, but also its increased diffusion, is explained by the fact that knowledge capital is not only used, even if it is its primary role, as a means of creating value during the productive process. It is also used to reduce the duration of the entire production process, whether at the investment stage, the production stage or the marketing of the goods.

1.2.2.3. *Information processing and decision-making in the era of big data*

The work of acquiring and collecting new information available on the market and integrating it into the knowledge capital takes the form of economic and technological intelligence activities (consultation of patent databases, trade fairs, specialized press, data processing). These activities give to companies the possibility increasing the speed of their technological, productive and commercial choices as well as avoiding errors and redundancies.

This activity of research and information processing has always existed in the world of business. As early as the 17th Century, then big commercial companies were already sending out informants on horseback across Europe to find out the economic evolution and consumer tastes. However, it has taken on new dimensions along history and in this era of Big Data (see Box 1.3).

This activity of processing data and scientific and technical information, which is already organized as a system (for example patent documents), or which is not, such as intermediate results of scientific works, etc., also accelerates the choice of the means of production that the company must acquire in order to implement the production. The greater speed of information (due to advancements in the means of communication) also limits the delivery time of the means of production, in particular those which take an immaterial form (software, databases, etc.). Furthermore, the globalized organization of firms (see Chapter 2) makes it possible to monitor internationalized technology and recruit skilled personnel, rich in "human capital" and therefore in scientific and technical knowledge, wherever they may be found. The selection of future employees is facilitated by collection and processing of information in various locations.

To define Big Data, it is usual to refer to the four Vs: volume, variety, velocity, value. A fifth V can also be considered: veracity. With information technologies (Internet-related), new media (tablets, mobile phones, connected devices) and the multiple sources and forms of information, the amount of data a firm has to manage has reached a very large size and requires new approaches and tools (such as data- and text-mining, profiling techniques, visual analysis) to store, process and utilize them. The term Big Data refers to "a set of methods and tools used to process and interpret large quantities of data that are generated by the increasing digitization of content, the monitoring of human activities and disseminating the Internet of Things" [OEC 15b]. These are processes and techniques that enable organizations to create, manipulate and manage data on a large scale (Hopkins and Evelson [HOP 11]), as well as to extract new know-how in order to create new economic value (Monino and Sedkaoui [MON 16, p. 10]). It also gives rise to new professions, such as the Data Scientist, whose mission it is to sort data and transform it into information that can feed into the company's stock of knowledge.

These Big Data technologies, according to the OECD [OEC 16a], are among the ten most important technologies in the economy and society. They offer opportunities for companies to both manage their activities and improve their decision-making, but also to adapt the offer to the needs of consumers. Companies' interest in these techniques can be found in patent filings (linked to Big Data technologies, the Internet of Things, quantum computing and telecommunications), which, according to the OECD, has seen double-digit growth rates in recent years.

Box 1.3. *Processing information in the era of big data*

During the production process, delays are also reduced through the use of sophisticated technical methods (the Internet, intranet, databases), which multiply the flows of codified scientific and technical information. The internal dissemination of scientific and technical information thus consolidates the work collectives and increases labor productivity.

1.2.2.4. *The regulated dissemination of knowledge capital*

Finally, the external dissemination of some of the information that constitutes knowledge capital makes it possible to reduce the time needed to market the goods and services produced by the company. In order to sell the goods, the company of today distributes scientific and technical information (not exclusively, but these are a decisive part of the disseminated information, which also concerns price, form, etc.). This information lends credibility to the product, to educate consumers (or to define and make fundamental the use of the goods) and to retain them (in a period of great uncertainty, the risk involved will be reduced). Advertising that conveys scientific and technical information was used early on by industrialists to accelerate the sale of goods and to consolidate their power in the market, and still, the current technical means of communication strengthens this power. The large-scale processing of collected data also makes it possible to adapt an offer to the needs of the consumer. For example (Monino and Sedkaoui [MON 16, p. 27]), by collecting and processing the histories made by consumers on its website (purchase and search history), Amazon in turn can offer them a range of targeted literature. Nike on the other hand offers its customers a complete ecosystem in order to manage their physical activity, which also gives them the possibility of suggesting specific products to them.

This dissemination of scientific and technical information is also followed by the job of collecting and analyzing the impact on the consumer. Opinion surveys, questionnaires, etc. serve as a basis that will guide the next cycle of productive capital development. These direct the productive work (design, production) but also the choice of the means of production upstream and the employees best able to develop them. The innovation process, which is now interactive and no longer linear, explains the increasing intertwinement of the stages of the production process and of all the activities being carried out (scientific work, productive work, marketing work). The collection and dissemination of information, usually considered as characteristic of the commercialization stage now serves as a basis for the new production process, and takes place at the investment stage, even before the actual production of goods. The aim is to shorten further still this difficult stage of the transformation of commodities into cash.

The time required to complete the production process will depend, of course, on market prospects: supply and demand. But it can be technically reduced by the voluntary dissemination of scientific and technical information, which encourages a more rapid resumption of the production process.

1.3. The theoretical origins of knowledge capital

The concept of knowledge capital is based on the definition and evolution of three key concepts in economics and management science: *Knowledge*, *The Firm* and *Capital*. The contributions of contemporary theories of the firm and of innovation are decisive for the better understanding of knowledge capital. Nevertheless, the contributions of pioneering economists must also be highlighted.

1.3.1. *Contemporary theories of the firm and of innovation*

It is possible to backdate contemporary economic analyses of the firm to the 1930s, when the first published works began challenging the validity of the assumptions of pure and perfect competition. The neoclassical approach, dominant since the end of the 19th Century, reduces all production activity to simply a technical production function linking input (raw materials, services) to output (finished products) and a company to an individual, at the same time its owner and its manager. Similarly, neoclassical economists first considered technical progress as outside the sphere of the economy (this is called "exogenous technical progress", that is to say technical progress acting as a *deus ex machina*). In neoclassical growth models (Solow [SOL 56, SOL 57]) technical progress is a residue of the production function whereby the fundamental factors of production are capital and labor. Knowledge has long been regarded as a non-appropriable, public good.

Berle and Means [BER 32] broke from the neoclassical identification between the owner and the manager of the firm, in the context of the concentration phenomenon in the United States, which led to the domination of large firms in the markets. The works of Robinson [ROB 33] and Chamberlin [CHA 33] also questioned the existence of pure and perfect competition, thus permitting a better understanding on the variety of firms (in terms of size and economic strength). It was also in the 1930s that Coase published the article *The Nature of the Firm* (1937), which addressed the simple question "why does the firm exist?". Considering that the market is imperfect, he defined the firm as a form of administrative coordination, alternative to market coordination. Market coordination, which is achieved through the price mechanism, is a source of costs: search and information costs (finding adequate prices); bargaining and decision-making costs (costs of negotiating separate contracts); policing and enforcement costs (costs related to supervising other parties' actions). These costs – to be later termed as "transaction costs" – are eliminated by the firm, which for Coase therefore justifies its existence. Although it had little influence at the time, this article was resumed by Williamson in the 1970s and marks the birth of transactional approaches.

Multiple approaches on the enterprise, along numerous lines of diverse interrogations, were developed during the 20th Century. But to what extent do these theories allow us to understand and analyze the contemporary realities facing the firm, and which can be summarized in a few key words: innovation, networks, globalization and finance? To what extent do they enable us to better understand the needs and modalities for the composition and use of knowledge capital by firms?

Different theoretical approaches developed during the 20th Century sought to overcome or enrich the neoclassical approach, which reduces the firm to an individual, imbued with perfect rationality (that implies a complete knowledge and understanding with which to choose among all the available alternatives, and the ability to evaluate and compare both the current and future consequences for each of these alternatives) and capable of logically pursuing the objective that best maximizes profits. This objective stems from an ideal vision of the functioning of markets, in which the pursuit of self-interest serves the general interest. The absence of a theory of the firm (that is to say, the firm considered as a "black box") is explained by the major questions raised by this school of thought – market efficiency and price mechanism – which occur in the sphere of the market, as opposed to the sphere of production.

We can consider that the theories of the firm during the 20th Century have in essence taken two paths (even if some of these approaches have a somewhat hybrid status): some of them, those relying on the questioning of perfect rationality, consider firms to be complex organizations whose decision-making processes, power structures, factors of differentiation and evolution, must be explained. These contributions are essential for understanding the role and methods of building the knowledge capital. The other group seek to enrich the neoclassical approach, based on perfect rationality, by analyzing the firm not as an agent but rather as a set of agents associated through contracts (a nexus of contracts), the coordination of which must be understood (see also Coriat and Weinstein [COR 95]).

1.3.1.1. *The firm as a complex organization*

The analysis of the firm as an organization is based on a new approach of rationality, "bounded rationality", as proposed by Simon [SIM 59]. According to this approach, agent behavior results from a search for the best possible decision for a given situation, wherein it is impossible to know all the alternatives, let alone all the possible outcomes. The objective of maximization is therefore replaced by that of satisfaction: an agent does not seek the action that gives the best result under given conditions, but an action leading to a result that can be deemed satisfactory.

The behavioral theory of the firm is interested in the decision-making processes within the company and builds on the foundational work of Simon on bounded rationality. The firm, for Cyert and March, is composed of a coalition of groups with different interests (traders, financiers, industrialists) [CYE 63], and seeks a compromise through a process of learning and the development of routines. The firm seeks to *satisfy* (attain a given level of profit, a certain market share, a particular sales target) rather than *maximize*.

At the same time, the managerial approach (Chandler [CHA 77], Galbraith [GAL 74]) was developed alongside the increase, in the United States and Europe, of market domination by large enterprises and the development of mass production and mass consumption. The firm is defined, in line with that of Penrose [PEN 59], as a set of productive resources organized within an administrative framework. The main question of the authors concerns the power structure within the company, with that acquired by managers and organized into a "technostructure", that is to say, according to Galbraith, "the association of men of diverse technical knowledge, experiences or other talent which modern industrial technology and planning require" [GAL 74, p. 74]. As a consequence, for Chandler, "The visible hand of management replaced the invisible hand of market forces" [CHA 77, p. 12]. The power of management and the technostructure, characteristic of modern large-scale enterprises, are justified by the uncertainty inherent to the functioning of imperfect markets, the need for modern technology and the intensification of consumer demand.

Penrose's analysis of the firm as a collection of resources to be managed is at the heart of the theoretical approach called the *resource-based view* (RBV), in which researchers – especially those in strategic management –

are interested in the skills, dynamics and absorptive capacities which enable firms to enhance their performance, particularly in the area of innovation (Wernefelt [WER 84]).

Evolutionary theory also takes ground in these preceding approaches (behavioral and managerial approaches of the firm), but has also been enriched by the work of industrial economists seeking to enter ‘inside the black box’ that is technology (Rosenberg [ROS 82]). Here, the main line of questionings concerns the coherence of the firm (that is the degree of proximity between the activities of a large modern firm) and the question of its evolution (any changes in the portfolio of activities or even its main activity) (Coriat and Weinstein [COR 95], Dosi *et al*. [DOS 90]).

The evolutionary school of thought, as well as the RBV, have been particularly interested in the subject of change. Evolutionary theory, which originated with Nelson and Winter [NEL 82], focuses on the behavior of economic agents and in particular on the behavior of organizations, considered as economic systems themselves. Their evolutions and objectives are defined through the processes of learning and coordination, according to search procedures which in turn must lead to satisfactory results. The adoption of the hypothesis of bounded rationality is explained by the importance of the uncertainty by which organizations act and interact. Among the questions posed on the evolutionary theory of the firm ([DOS 90], see also [COR 95]), one encounters:

– the question regarding the coherence of the firm (that is, the degree of proximity between the activities of a large modern firm);

– the question of the evolution of the firm (that is a change in the portfolio of activities or the principle activity itself).

At this point, it is this second question that is of particular interest. The evolution of the firm, according to evolutionary theory, follows the process described in Figure 1.13.

The learning process is a process whereby experimentation and repetition make tasks faster and less time-consuming, wherein new opportunities created by various modes of operation are constantly being tested. This cumulative process engenders the production of knowledge, which becomes manifest in organizational routines, defined as interaction models, and which become effective solutions to specific problems. They form an *organizational memory*, integrated into the skills of the employees themselves, as well as into documents, archives and artifacts [NEL 82].

These tacit routines are constituted as "specific assets"[3] for the firm and are difficult to transfer. The firm evolves along a path determined by the skills accumulated through learning. These specific assets therefore determine the evolutionary path or trajectory of the firm. The secondary assets or complementary assets (to the main asset), along the value chain will allow the firm to change direction. The evolutionary theory of the firm thus makes it possible to understand the endogenous transformation of the firm over time [DOS 90].

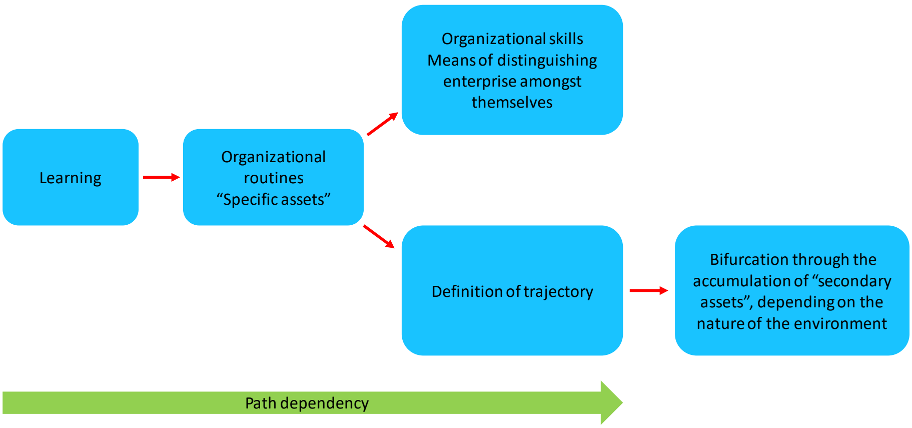

Figure 1.13. *The evolution of the firm. Source: Author*

If accumulated skills make it possible to differentiate firms and strengthen their competitive advantage, they can also constitute a sort of competency trap (Levitt and March [LEV 88]. Dependency on a given path expresses precisely this "forced" evolution of the firm, constrained as it were by past investments. Embroiled in their routines, companies can neglect new technological opportunities or changes within the economic environment. In the context of technological change, lock-in situations can be explained through the increasing returns of adoption and by the phenomena of institutional and strategic inertia. This same reasoning can be applied to the firm.

In the wake of evolutionary theories that have had the merit of underlining the dual nature of knowledge, both codified and tacit, the

3 In the economy of transaction costs, whose chief representative is O.E. Williamson, a specific asset refers to an investment that cannot be redeployed to alternative uses without losing its productive value.

question of the non-appropriability of knowledge (its characteristics as a public good) has been investigated further. Indeed, the tacit nature of knowledge at least makes its appropriation possible in part (Dosi *et al.* [DOS 00], Nelson & Winter [NEL 82]). This makes it possible to distance oneself from a particular vision according to which knowledge is assimilated into information and is associated with a public good. This vision was based on the fact that knowledge, being not excludable, is difficult to control and generates positive externalities. The fact that it does not destroy itself confers on it the property of non-rivalry, which has important implications in terms of cost and price. Moreover, knowledge is cumulative, which means that it can be used infinitely and accumulates through every successive use. As a result, the dilemma facing knowledge and information lies in the fact that private return (the return on investment for the firm) is lower than the social return (the return for the whole society assessed by knowledge externalities). However, the tacit nature of knowledge diminishes its uncontrollable character. Similarly, the use of knowledge often requires specific skills and tools (complementary assets) that increase its cost of use and reproduction and thus limit its transmission (Foray [FOR 04]). This work has contributed to a vision where appropriation is possible, in part. Moreover, to increase private returns without reducing social returns, incentives and appropriate public policy must be developed. The typical example is the patent which, by conferring a monopoly on the inventor, makes it possible to increase the private return, while at the same time fostering the diffusion of knowledge; the monopoly conferred is only temporary and after 20 years, the invention falls into the public domain. The new growth theories have engaged with these arguments and combine, with public intervention, the market as a place for the allocation and appropriation (through intellectual property rights, routines) of the fundamental elements of growth (Romer [ROM 90]).

The importance of tacit knowledge and its interactions with explicit knowledge is also at the heart of management studies concerned with the genesis of knowledge within organizations. This is the case, for example, with the work of Nonaka and his co-authors, on the genesis and circulation of knowledge in the organization. This makes use of the SECI model (Socialization Externalization Combination Internalization) (Nonaka and Takeuchi [NON 95]), whereupon organizational innovation emerges from the interaction between explicit and tacit knowledge, coupled with a circulation of knowledge at the individual and interorganizational levels (for a detailed presentation, see Barbaroux *et al.* [BAR 16], Lièvre *et al.* [LIÈ 16]). We can consider that this process for the genesis of knowledge makes it possible to detail the activities at work within the stock of central knowledge in terms of our structure of knowledge capital. Likewise, the Concept and Knowledge (C-K) approach is focused on the issues of creativity and design, and brings further elements on the generation of knowledge within organizations (Hatchuel and Weil [HAT 09], Le Masson and Mcmahon [LEM 16]).

The literature on the production and dissemination of knowledge within organizations is integrated into the resource-based theory, which has been based from its beginnings on the work Penrose. The authors put particular emphasis on the role of competences (including key competences (Prahalad and Hamel [PRA 90])) and capabilities in explaining the competitive advantage of firms. Capabilities, able to develop new specific assets and reassemble them into organizational routines, are called "dynamic capabilities" by Teece *et al*. [TEE 97]. They refer to "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" [TEE 97]. The study of how dynamic capabilities are developed is the focus of the cognitive theory of the firm, according to which "Knowledge constitutes the most crucial asset and hence, the ability to develop and employ knowledge is the most crucial organization capability" [NOO 09, p. 11]. Among these dynamic capabilities, absorptive capacity is central to the analysis of the formation of enterprise knowledge capital. Absorptive capacity was first defined by Cohen and Levinthal [COH 90] as the firm's ability to recognize the value of new information, transform it into knowledge, assimilate it and apply it to for commercial purposes. Four dimensions of absorptive capacity are usually identified: acquisition, assimilation, transformation and exploitation [ZAH 02]. "Acquisition refers to a firm's capability to identify and acquire externally generated knowledge that is critical to its operations" [ZAH 02, p. 189]; "assimilation refers to the firm's routines and processes that allow it to analyze, process, interpret, and understand the information obtained from external sources" [ZAH 02, p. 189]; "transformation denotes a firm's capability to develop and refine the routines that facilitate combining existing knowledge and the newly acquired and assimilated knowledge" [ZAH 02, p. 190]; "exploitation reflects a firm's ability to harvest and incorporate knowledge into its operation" [ZAH 02, p. 190]. These four dimensions of absorptive capacity are considered as essential in order to build and sustain a competitive advantage over competitors, especially in a context of growing open innovation.

According to us, the absorptive capacity refers to the central part of the knowledge capital in our scheme, as follows.

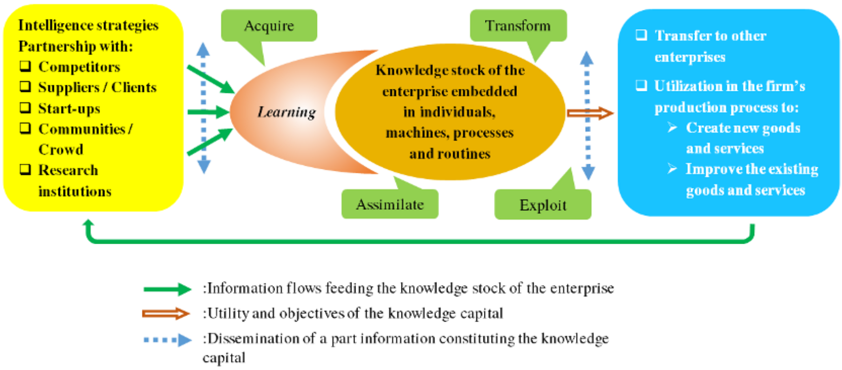

Figure 1.14. *Absorptive capacity and Knowledge capital Source: Author. For a color version of the figure, see www.iste.co.uk/laperche/knowledgecapital.zip*

The learning process is a way to integrate (assimilation) the information flows coming from outside the enterprise (acquisition). They are transformed (transformation) into knowledge and integrated in the knowledge stock of the enterprise. This knowledge is then exploited through the various forms of innovation or integrated as such in another production process (exploitation).

A second set of theories consider the firm as a set of agents linked through contracts. Notwithstanding the fact that we rely on the approaches of the firm as complex organizations, this second set of theories makes it possible to insist on the contractual dimension, fundamental in the current modalities for the constitution of knowledge capital.

1.3.1.2. *The firm as a nexus of contracts*

The work of Williamson [WIL 75, WIL 85], which extends the analysis of Coase, has a somewhat hybrid status in the theories of the firm. On the one hand, Williamson adheres to the theory of bounded rationality, but considers the firm as a system of contracts between individual agents. Due to imperfect information, signed contracts are incomplete (it is impossible to predict any contingencies). In particular, if the investments are specific (not reusable outside of the transaction), opportunistic behavior on the part of certain agents seeking to take hold of the transaction remains possible, and therefore justifies the existence of a governance structure (a hierarchy) to make decisions in unforeseen situations.

Another branch, which arises from Coase's work, also defines the firm as a nexus of contracts, retaining the hypothesis of perfect rationality and thus remaining in line with the neo-classical analytical foundations (Coriat and Wienstein [COR 10]). In agency theories (Jensen and Meckling [JEN 76]), as with the theory of property rights (Alchian and Demsetz [ALC 72]), the company "nexus of contract" no longer exists on its own: it is a "legal fiction". It cannot have an objective since it cannot be reduced to an individual. There is also no relationship in terms of authority and therefore no opposition between the firm and the market, as was the case in Coase's analysis. Individuals with inputs (capital, labor) enter freely into contractual relationships and seek to maximize their own utility. On this common basis, the questions of these theories differ and yet they are complementary. The object of the theory of property rights is to study the impact of property rights on behaviors and on the economy as a whole. The agency's theory is concerned with the coordination of interindividual relations (principal–agent) and serves as a basis for analyzing the question of corporate governance. Who runs the business? The owners (the shareholders, the principal) or the managers (the agents)? Under this approach, shareholders, the owners of capital, delegate to managers the right to control this. Nevertheless, it is necessary to ensure that the managers act in the interests of the shareholders. This theme became predominant in the 1980s in the real economy, both by the liberalization of financial markets and by repeated management scandals. Shareholders (who play the role of principal) seek the highest possible value creation, while managers (the agents) may have other objectives. Problems of "moral hazard" (e.g. insufficient effort) and "adverse selection" (taking advantage of the information at hand) can create agency problems that need to be addressed by a set of incentives (financial incentives for managers, role and composition of boards, codes of governance, competition in the manager labor market, capital structure, use of external finance, implicit contracts, etc.). While finance dominates and firms' productive investments (their innovation strategy) are constrained by the possibility of rapid gains made in the financial markets through the multiplication and sophistication of financial products, the firm appears to result in a shareholder/manager showdown driven by a single goal, maximizing value for the shareholder.

The theory of incomplete contracts (Grossman and Hart [GRO 86], Hart and Moore [HAR 90]) also has a somewhat hybrid status in that it recognizes the opposition of firm and market (like Williamson) and the existence of a relationship of authority, while maintaining the hypothesis of perfect rationality. Authority is the result of the distribution of property rights. The theory of incomplete contracts thus links the theory of transaction costs and that of property rights. Integration results from the incompleteness of the contracts; however, this is not the result of a limited cognitive capacity on the part of the agents, but rather of the impossibility of verifying the commitments included in the contracts. In such a case, it is the owner of the assets who will decide on their use. Asset ownership is thus a source of power.

<table>
<tr><td>Theoretical approach and lead authors</td><td>Definition of the firm</td><td>The central issues</td><td>Objective(s) of the company</td></tr>
<tr><td>Neo-classical approach</td><td>Production function “black box”</td><td>Efficiency of the market, price mechanism</td><td>Profit maximization</td></tr>
<tr><td>Behavioral approach
(Cyert and March)</td><td rowspan="4">Complex organization
↓
Place of innovation and of resource production</td><td>Study of the decision-making processes</td><td>Principle of satisfaction</td></tr>
<tr><td>Managerial theory
(Penrose, Chandler and Galbraith)</td><td>Power structure</td><td>Various objectives of the “technostructure”: autonomy, growth, technical virtuosity (profit remains the basis)</td></tr>
<tr><td>Resource-based view
(Penrose Wernefelt, Teece, Hamel and Prahalad; Nooteboom, Cohen and Levinthal)</td><td>Skills, competences, dynamic capabilities, absorption capacity</td><td rowspan="2">Various objectives of the groups constituting the organization (profit remains the basis)
Response to routines</td></tr>
<tr><td>Evolutionary theory
(Nelson and Winter; Dosi; Teece)</td><td>Coherence and evolution of the firm</td></tr>
<tr><td>Transaction costs theories
(Coase; Williamson)</td><td>Governance structure
“hierarchy”</td><td>Reason for the existence of the firm and study of its transactions (transaction cost theory)</td><td>Possibility of opportunism given the fact of incomplete contracts: various objectives</td></tr>
</table>

Agency theory (Jensen; Meckling)	Nexus of contracts "legal fiction"	Problem of coordination and incentives	Absence of goal since the firm is a "legal fiction" Maximizing the utility
Theory of contracts, ownership rights (Alchian and Demsetz)		Distribution of property rights	
Theory of incomplete contracts (Hart, Moore, Grossman)	All assets subject to a unified property	Distribution of property rights and the relationship between ownership and control	Maximizing the utility Research for the optimum

Table 1.3. *Definitions, questions and objectives of the firm in the contemporary theories of the firm*

Several observations can be made from this brief overview of the contemporary theories of the firm.

First, they create a toolkit with which to study the many contemporary themes, such as the question of the evolution of firms and the role that knowledge plays in this dynamic, the conflicts of interest between the stakeholders, the impact of "shareholder values" on resource allocation decisions and so on. However, this toolbox is divided into two large compartments, characterized by very different working hypotheses: on the one hand is the hypothesis of perfect rationality and maximizing behaviors (which for some work together), and on the other hand is the bounded rationality that opens the way to a variety of objectives for others. As a result, the issues dealt with are also compartmentalized. While competence-based approaches and evolutionary theory make it possible to study knowledge production and innovation, contractual approaches focus more on issues of coordination, control and incentives. This divergence in the analysis frameworks makes it difficult to combine the different tools for the study of the same phenomenon (such as a growth in the size of the company, its capacity to innovate, etc.).

Second, the tools themselves, whatever they are, are the subject of many criticisms. These relate, for example, to the lack of realism in the theories. In the agency theory, why is the manager considered as an agent of the shareholder when they, following the logic of this theoretical approach, bring in the capital and yet do not own the firm? If he is considered to be an agent, why would he be the sole agent of the shareholders and not of all the other stakeholders (consumers, suppliers) of the company (Coriat and Weinstein [COR 10])? Above all, the agency theory, as well the contractual approaches, does not recognize the firm as an entity in its own right, whereas in reality the firm holds assets and is itself the object of commercial transactions (Weinstein [WEI 12]). Finally, agency theory suggests that the financial compensation granted to managers has the effect of aligning the interests of managers and shareholders but also increases the company's performance. However, in real-world situations, market performance does not necessarily go hand-in-hand with innovation, but more often results from a reduction in investment and from the development of speculation (Lazonic [LAZ 12]). Criticisms can also be attributed to the "tools" developed by resource-based approaches and evolutionary theories. Resource-based approaches have grown stronger in recent years with multiple definitions that often reflect a closer reflection of reality. Nevertheless, there is also a split between these approaches, between those authors who remain close to the traditional assumptions (perfect rationality) and the others who do not. While the former are criticized for lack of realism, the latter are criticized for having a weak methodological basis (Foss and Stieglitz [FOS 12]). In all cases, including those approaches closer to reality, empirical verification remains insufficient, as they are essentially centered on the study of large enterprises. Evolutionary theory is often criticized for being an endogenous explanation of the change it proposes and for poorly taking into consideration the economic, social and political environment when analyzing the changes taking place within a firm and/or its activities.

1.3.2. *The contribution of pioneer economists in the definition of knowledge capital*

The notion of knowledge capital is built on the main evolutions of theories on the firm and on knowledge. Nevertheless, the contribution of pioneer authors, especially of classical economists, must not be overlooked. We emphasize, on the one hand, the contributions of Adam Smith and Jean-Baptiste Say in the analysis of the origins of the advancements being made in scientific and technical knowledge. On the other hand, we also return to the essential writings of Karl Marx concerning the establishment of the collective worker and, alternatively, the analysis of the use of knowledge as a productive force of capital.

1.3.2.1. *Technical progress as an endogenous process*

Smith was interested in the institutional framework necessary for the production and exploitation of production techniques. In this way, he highlighted the complexity of the relationship between science and technology in the production process and offered an explanation for the role of labor organization (the division of labor) in increasing the stock of knowledge and the number of inventions. The analysis of Say acknowledges the fundamental role of the entrepreneur in the production process and as a fundamental agent for technical improvement.

The organization of labor, that is to say the technical and social division of labor, is, in Smith's analysis, at the origin of technical developments: "labour is facilitated and abridged by the application of proper machinery. It is unnecessary to give any example. I shall only observe, therefore, that the invention of all those machines by which labour is so much facilitated and abridged seems to have been originally owing to the division of labour" [SMI 76, p. 20]. In the manufacture of pins, the technical division of labor increases the skill of the workers and encourages them to improve their work tools, to invent a large number of machines thereby reducing and shortening working time. "A great part of the machinery made use of in those manufactures in which labour is most subdivided, was originally the invention of common workmen, who, being each of them employed in some very simple operation, naturally turned their thoughts toward finding out easier and readier methods of performing it" [SMI 76, p. 20]. To these pragmatic technical developments – independent from scientific theories – ensuing from the technical division of labor and implemented by the workers themselves, are added those resulting from the social division of labor. "Many improvements have been made by the ingenuity of the makers of the machines, when to make them became the business of peculiar trade; and some by that of those who are called philosophers or men of speculation, whose trade it is, not to do anything, but to observe everything; and who, upon that account, are often capable of combining together the powers of the most distant and dissimilar objects" [SMI 76, p. 21]. The second source of technical progress is therefore the productive application of formal scientific knowledge. The subdivision of "speculative" intellectual activities into different branches in which scholars specialize, has the same advantages as the technical division of labor (skill, time gains), and "more work is done upon the whole, and the quantity of science is considerably increased by it" [SMI, 76, p. 22].

In the analysis of Say, the recognition of a specific activity implemented by a particular economic agent also highlights the endogenous nature of technical progress and the creation of knowledge production. The entrepreneur has an essential role in the economic activity because he is a creator of wealth, and because, thanks to his charisma and his capacity for judgment, he stimulates all forms of economic activity. The work of the "implementation by the entrepreneur", which lies between the work of the "research by the scientist" and the "execution by the worker", is at the origin of technical developments. It is in this that the entrepreneur of Say relates to Schumpeter: according to Say, the entrepreneur takes advantage of the highest and humblest faculties of humanity, receiving them from the scholar and transmitting them to the worker. In addition to the work of the entrepreneur – which consists of the acquisition of the knowledge which is at the basis of the art he wishes to implement, the gathering of the tools of implementation necessary to the creation of a product, followed by the presidency of its implementation – the role of the scientist occupies an equally fundamental place. S/he conveys to the entrepreneur the knowledge of "natural laws" and "the nature of the things on which he must act, or which he must employ as instruments". His or her work, which consists of collecting, arranging, preserving and increasing knowledge daily, makes it possible to escape the illusion of "chance" and thus undoubtedly takes part in the production of wealth since the truths the scientists teach are, for Say, the basis for all the arts [SAY 96, pp. 321–322].

1.3.2.2. *Knowledge: productive factor or social relation?*

For some classical economists, knowledge is regarded as a productive input at the service of the individual to abridge and facilitate their work (Smith), and it is an inalterable property of the individual (Say). Marx considers this to be on the contrary, and advocates that knowledge arises from, nourishes and crystallizes the antagonistic mode of production and therefore the social relation between capital and labor. The tools of work (knowledge) become external to the individual, in opposition to him, transforming him into a superfluous appendage of the machine.

The know-how of individuals appears in Say as the unalterable property of the individual. In his *Catechism of Political Economy*, he treats the "industrial faculties" (education, the acquired talents which are "the fruit of our cares and our sorrows") in the chapter "*De la propriété*" ("*On Property*"). These faculties are a "capital property" of the individual, which cannot be "alienated" and have "no exchangeable value" [SAY 96, p. 365]. The knowledge embodied in machines (fixed capital) or in the know-how of individuals (human capital) is thus, in the analyses of the classics, not the fundamental contradiction between labor and capital in the capitalist mode of production. For Smith, the tools of work remain the possession of the individual, not in opposition to him, and the worker consciously uses these to facilitate and abridge his work. The pursuit of individual interests brings about the general interest: that of increasing the productivity of labor and the volume of production.

The instrument or the means of work (the machine) and the potential of work (the knowledge embodied in the machines or in the know-how of the individual) appears as the product of social organization and as the property of those who use them. For Smith, the technical and social division of labor favors technical developments and thereby increases the "productive power of work" through learning by practice. The resulting increase in the output of all arts and crafts leads, if society is "well governed", to a universal opulence that spreads even to the lowest classes of the people [SMI 76]. Knowledge, the source of wealth and the result of the division of labor, thus appears as being at the service of labor: it is the raw material for the work of the scientist who uses it for the "selfish" aim of his intellectual enrichment (the profession of "philosopher", according to Smith "does nothing, but observe everything"), the worker's means of working, which he uses to abridge and facilitate his work by improving his tools of production and, according to Say, the capital of the entrepreneur that creates value.

For Marx, on the other hand, in the capitalist mode of production, science, as appropriated by capital, is opposed to the worker: "it is not the means of the worker but the means par excellence of his exploitation and his alienation" [FAL 66, p. 62].

In Marx's analysis, it is technology that creates the antagonism between capital and labor. In the third edition (1821) of *On the Principles of Political Economy and Taxation*, D. Ricardo, who came before Marx, pointed out the struggle between workers and machines: "machines and labor are in perpetual competition", wrote Ricardo [RIC 17], in opposition to his first conception that machines improve the fate of the working classes. According to Marx, if this struggle initially takes place between the employee and the instrument of labor (the machine), the antagonism between labor and capital in the capitalist mode of production is itself more fundamental. At first, the employee "revolts against the particular form of the means of production, as being the material basis of the capitalist mode of production..." [MAR 67, vol. 1, p. 287] and "[...] it took both time and experience before the workpeople learnt to distinguish between machinery and its employment by capital, and to direct their attacks, not against the material instruments of production, but against the mode in which they are used" [MAR 67, p. 288]. This antagonism between labor and capital, embodied by technology, is revealed from the moment when the general knowledge of natural laws becomes the "productive forces of capital".

The "general work of the human mind", for Marx, corresponds to all human knowledge pertaining to Nature. It includes "all discoveries and all inventions. In part due to the collaboration amongst the living, and in part on the works of our predecessors" (Marx, Capital, vol. 2, quoted by [FAL 66], p. 113). This scientific knowledge possesses the attributes of free and inexpensive goods: "Science", writes Marx, "generally speaking, costs the capitalist nothing, a fact that by no means hinders him from exploiting it. The science of others is as much annexed by capital as the labour of others" [MAR 67, p. 333].

Knowledge is not then, at this moment, the expression of a social relation, it is the result of the work done by the scientist, a result which belongs to him. But once captured and "pressed into the service of capital" [MAR 57, p. 635] by the mediation of industry, "Invention then becomes a business, and the application of science to direct production itself becomes a prospect which determines and solicits it" [MAR 57]. Knowledge thus loses its passivity, the scientist is separated from his means of work and the technological applications of science become productive forces essential to an increase in the productivity of labor and the development of productive forces.

Marx highlighted the link between science and technology in the capitalist mode of production. From the moment when the scientist is himself integrated into the production process, his work is appropriated by capital and he is himself separated from his means of work. What the capitalist entrepreneur appropriates is no longer the result of research: free and inexpensive knowledge, but the process of work itself which is at the origin of the production of scientific and technical information and knowledge. He is thus able to direct it according to his own objectives. Knowledge therefore becomes a means of production, the property of the capitalist entrepreneur and applicable to the production processes.

Marx considers that it is through the mediation of industry that the natural sciences cease to be abstract knowledge and become essential forces of production. Indeed, it is the activity of the collective worker, the foundation of large-scale industry, which has an effect on science: "it is only the experience of the collective worker that shows where and how to save, how to implement in the simplest way possible the discoveries already made, what practical difficulties must be overcome when implementing theory – as it is used in the process of production, etc." (K. Marx, Capital Vol. II, cited by Fallot [FAL *op. cit.*, p. 113]).

Knowledge is incorporated into the know-how of individuals or as fixed capital (machines). In both cases, it cannot be regarded as an individual's means of labor, but as a means of capital for the exploitation of labor. On the one hand, in the capitalist mode of production based on private property and the private appropriation of the means of production, the know-how of the worker, an integral part of his labor power, is reduced to the rank of a particular commodity: to be sold to and appropriated by the owner of the means of production. On the other hand, "as machinery develops with the accumulation of society's science, of productive force generally, general social labor presents itself not in labor but in capital". Therefore, "the productive force of society is measured in fixed capital, exists there in its objective form; and, inversely, the productive force of capital grows with this general progress, which capital appropriates free of charge" [MAR 57, p. 623].

It is therefore the incorporation of scientific information and knowledge into fixed capital, which realizes the transformation of the passive labor of the human mind into a means of production that is essential to the process of production. Scientific and technical information and knowledge are means of production which are essential to the capitalist production process because, on the one hand, it makes it possible to perpetuate and accentuate the relationship between capital and labor: "insofar as the *means of labour*, as a physical thing, loses its direct form, becomes *fixed capital*, and confronts the worker physically as *capital*. In machinery, knowledge appears as alien, external to him; and living labour [appears as] subsumed under self-activating objectified labour. The worker appears as superfluous to the extent that his action is not determined by [capital's] requirements" [MAR 57, p. 623]. On the other hand, the private ownership of the means of production allows the capitalist to increase labor productivity, to save constant capital and to increase the profitability in relation to the competition. It is indeed at the moment when fixed capital enters the scene as a machine in the production process, and in which the process of production is no longer conditioned by the skill of the worker but by the technological application of science, that the full development of capital may take place. This is why "the tendency of capital is to give production a scientific character; direct labour [is] reduced to a mere moment of this process" [MAR 57, p. 631]. What was the activity of living labor becomes the activity of the machine, "Thus the appropriation of labour by capital confronts the worker in a coarsely sensuous form; capital absorbs labour into itself – 'as though its body were by love possessed'" [MAR 57, p. 636].

1.3.2.3. *The collective worker and the appropriation of knowledge*

The development of manufacturing and the introduction of the division of labor give rise to collective know-how, of which the "collective worker" is the sole repository. Learning, the product of the collective nature of work, is accumulated and transmitted through the *organic solidarity* produced by the division of labor. According to Durkheim, the social division of labor and its specialization produces an organic solidarity, derived from the individual personality acquired through the specialization of the work and which enables society to become "more capable of collective movement, at the same time that each of its elements has more freedom of movement" [DUR 47, paragraph 3]. The capitalist organization of labor, by dividing and subdividing labor, by reducing the individual to a piece of himself, thereby gives birth to the collective worker and engenders solidarity between individuals. More precisely, as K. Marx has long explained, in the capitalist organization of labor, the know-how of the individual is monopolized by the owner of the means of production, so as to identify them as collective workers. "In manufacture, as well as in simple co-operation, the collective working organism is a form of existence of capital. The mechanism that is made up of numerous individual detail labourers belongs to the capitalist", writes Marx in *Capital* [MAR 67, p. 248], continuing on to say that "In manufacture, in order to make the collective labourer, and through him capital, rich in social productive power, each labourer must be made poor in individual productive powers" [MAR 67, p. 249].

With regard to the latter, Durkheim writes that with the division and specialization of work "on the one hand, each one depends as much more strictly on society as labor is more divided; and, on the other, the activity of each is as much more personal as it is more specialized"; he continues on to say that, "Doubtless, as circumscribed as it is, it is never completely original. Even in the exercise of our occupation, we conform to usages, to practices which are common to our whole professional brotherhood" [DUR 47, para.

3]. It is through this organic solidarity that learning abilities ensuing from interactions between the work of individuals develops. Through organic solidarity, the technical information contained in this collective know-how is transmitted between individuals, or over time (intergenerational transmission), as well as the customs and practices particular to enterprise: "The workman's continued repetition of the same simple act, and the concentration of his attention on it, teach him by experience how to attain the desired effect with the minimum of exertion. But since there are always several generations of labourers living at one time, and working together at the manufacture of a given article, the technical skill, the tricks of the trade thus acquired, become established and are accumulated and handed down" [MAR 67, p. 239].

Scientific and technical information and knowledge is the subject of a sophisticated protection strategy. According to Smith, "particular accidents, sometimes natural causes and sometimes particular regulations of police, may, in many commodities, keep up the market price, for a long time together, a good deal above the natural price" ([SMI 76, p. 60]) and therefore generate great profit. Evoking the notion of trade secrets, Smith highlights the imperfection of information. The latter may, in his view, come about from the distance separating the market from its suppliers. However the "extraordinary profits" engendered by this type of secret are supposed to be ephemeral: "Secrets of this kind, however, it must be acknowledged, can seldom be long kept; and the extraordinary profit can last very little longer than they are kept". Secrets of manufacturing, derived from learning through practice and allowed by the technical division of labor, on the other hand "are capable of being longer kept than secrets in a trade. A dyer who has found the means of producing a particular color with materials which cost only half the price of those commonly made use of, may, with good management, enjoy the advantage of his discovery as long as he lives, and even leave it as a legacy to his posterity. His extraordinary gains arise from the high price which is paid for his private labour" which consist of the high wages of that labour… they are commonly considered as extraordinary capital profits [SMI 76, p. 60]. While Ricardo's view on the longevity of trade secrets is more limited, he recognized the advantages that a monopoly of a new discovery or a new machine, can provide: "He, indeed, who made the discovery of the machine, or who first usefully applied it, would enjoy an additional advantage, by making great profits for a time" [RIC 17, p. 263]. However, as has been previously pointed out, the longevity that characterizes the trade secret takes into account collective character of the work that this division produces. In order to increase its longevity, as Marx emphasizes, manufacturers “preferred, for certain operations that were trade secrets, to employ half-idiotic persons” [MAR 67, p. 249].

1.3.2.4. *A dynamic conception of capital*

The concept of *knowledge capital* also borrows from the classics the dynamic conception of the notion of capital, which is well appreciated in the process of accumulating capital in the analysis of Marx. In it a sum of money M is invested in a productive process in which a commodity C is transformed by capital and labor (K and L) into a commodity with a higher value C’ that will be attained by its sale on the market in a greater sum of money M’, which in turn is projected to be reinvested.

In this approach, capital is not only a stock of resources available for productive activities. It is a process that indicates the constant renewal and productive use of this stock. Knowledge capital is therefore not an inert stock but rather integrates value creation as a key component of its definition. This perspective on value creation determines the integration of new information, the combination of information and knowledge, and the dual process of dissemination/protection. By focusing on the objective – value creation – we also reintegrate into the analysis tensions linked to the power relations existing between firms of different sizes and strengths, which, as we shall study in Chapter 2, are taken into account in the current context for the constitution and protection of knowledge capital.

2

The Building of the Knowledge Capital

This chapter analyzes the building of firms' knowledge capital in its historical context, that of industrial capitalism. It begins with a history of the integration between science and technology, showing how companies, manufactures and large industry have gradually developed strategies for the appropriation of scientific and technical information and knowledge. The formation of enterprise knowledge capital has been largely supported by the governments and the progressive structuring of National Innovation Systems (section 2.1). The second part of this chapter deals more specifically with the modern era and details the strategies deployed by companies to establish, enrich and exploit their knowledge capital. The largest companies, organized in networks, rely on their internal investments but increasingly on their external collaborations (open innovation) as well. These partnerships of the network firm also involve smaller companies, which benefit from the strength of these networks and, in fact, often become dependent on them. They also involve academic research, which has become a major source of new knowledge, through the third mission of universities, namely "research commercialization" (section 2.2).

2.1. The first forms of knowledge capital and the formation of national innovation systems

2.1.1. *The science–technology relationship: from opposition to integration*

Historians of science and/or technology, economists, and sociologists for a long time placed science and technology in opposition to one another. This

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distinction or opposition is based on the social division of labor, with philosophers, scholars and researchers on the one hand, and artisans and technicians on the other hand. Science, "critical knowledge of the real", is originally the domain of free men and women, philosophers, and citizens of the ancient Mediterranean world. *A priori* science, considered as disinterested knowledge, is by definition quite removed from technique, which naturally orientates itself toward expertise, the perfection of technique with the goal of productive action. The contemplative purposes behind science are fundamentally opposed to the pragmatic objectives of technique, as is the nature of work it classically entails: intellectual work for science, manual work for technique.

However, this formal opposition has not always been true. In Greco-Roman antiquity, if the philosopher felt contempt for the practical application, reserved for artisans and slaves, "necessity" would compel the scientist to use his knowledge, for instance, to ensure the defense of the city (Klemm [KLE 66]): did not the learned Archimedes use his intellect, as his contemporaries have credited, to defend Syracuse (in 214 BC) by burning the Roman galleys with the aid of ardent mirrors? (Thuillier [THU 88, pp. 31–55]). From this period, political powers intervened so as to initiate the "rapprochement" between science and technology in order to perfect weapons. The evidence for scientific intervention in the realm of technical achievements, above all in the military sector, without being systematic is, when the need arises, nevertheless very visible.

At the very least, the history of science and technology shows numerous examples of "exchanges" between these two seemingly irreconcilable social practices (Russo [RUS 78]). According to this approach, until the middle ages, science and technology were developed in relatively compartmentalized ways. The birth of the "engineer" in the 15th Century, whose aim is to advance the techniques of scientific research, thanks to the involvement of mathematics marked the first stages of integration. From the 16th to the 18th Century, the instrumentalization of science, the development of learned societies and the first stages of technical education helped accelerate the development of industrial societies, characterized by the "scientificization of technology" and the "technicization of science" (Harbermas [HAB 68]).

It is generally accepted that this close rapprochement between science and technology dates from the last quarter of the 19th Century. According to

Madeuf, at the end of the 19th Century, the transition from the inductive process ("the use of science and the production of theoretical knowledge to solve technical problems"), to a process of deduction ("new scientific results that may give rise to a technical application") creates a situation where "it becomes difficult, as of this moment to deal with science and industry separately" [MAD 81, p. 16].

However, even before this period, there were of course many interconnections between science and technology. Indeed, if one considers the different modalities of scientific intervention in terms of technical conception, as Maunoury has shown, it appears that science has not only a "function of creation" (as the direct and primary source of technical objects and the new processes), but also the "function of enriching existing technical objects and processes" [MAU 68, p. 42], examples of which can be found in Ancient Egypt. The construction of the pyramids and the temples was then the work of master craftsmen, who were specialized in specific techniques, and who were supported by the priests (scholars dedicated to contemplation), who in turn were in charge of the global conception of the construction, ensuring that the theological and mythological imperatives were respected. Their scientific knowledge (architecture, astronomy, etc.) defined the orientation of the temple so as to ensure its harmonious integration "into the cosmos" (Grenier [GRE 96]). In this case, the technical process is dependent on scientific knowledge. The instrumentalization of science in the 16th Century, which we have already mentioned, on the other hand also shows that technical intervention in scientific research predates the 19th Century.

If the processes of deduction and induction intensify – instead of replacing the other – as of the 19th Century, an explanation must be sought for the accompanying adjustment of the economic and social contexts. The large-scale development of industrial capitalism involved the systematic use of science in the production process. This systematic use is brought about by the mobilization of financial and human resources by private enterprises to develop what Marx called "the technical application of science". Therefore, to paraphrase Marx: science, through the mediation of industry, bypasses its passivity in order to become a productive force of capital, and the scientist becomes separated from his means of work.

Nevertheless, the stock of knowledge, before this conscious usage, was closely intertwined with technology. The only difference lies in the fact that apparently it had no capital cost: “the law of the deviation of the magnetic needle in the field of an electric current, or the law of the magnetisation of iron, around which an electric current circulates, cost never a penny” writes Marx [MAR 67, p. 268]. The non-systematic and non-conscious relationship between science and technology does not, however, lend itself to the conclusion of an autonomous development between science and technology prior to the development of industry. The impetus given by the latter to the systematic use of science in the production process, and the mobilization of resources necessary for its development, only demonstrates their cumulative integration.

2.1.2. *The role of the State in the appropriation of scientific and technical information and knowledge*

The acquisition of scientific and technical information and knowledge was initially and for a very long time the domain of States, pursuing economic, political and military objectives. For example, the attraction and even the “taking hostage” of craftsmen during territorial conquests was, as Needham notes, a common occurrence in feudal China: “China’s technical skill was spreading everywhere; there were Chinese metallurgists and well drillers in Parthia (the cradle of the Parthian Empire, between the Caspian and the Indus) and in the Ferghana (Syr-Daria Basin) of the second Century AD, as well as eighth Century Samarkand, Chinese technicians were in demand everywhere, for example, in 1126 AD, when the Tartars of the Jin era besieged the Song capital of Kaifeng, every artisan was taken hostage, and in 1675, a far later date, a Russian diplomatic mission officially requested that Chinese bridge builders be sent to Russia” [NEE 73, p. 18].

In light of all this evidence, the establishment of institutions promoting scientific and technical information can no longer be dated as originating in the 19th Century. Over the course of history, the creation of such institutions appears to be linked to the objective engaging in the concentration of knowledge, which is necessary to consolidate the power of States and the influence of official religions. The concentration of knowledge made it possible to orient research according to its objectives. In medieval China, both pure and applied science has an official overtone and the most advanced techniques are often State-controlled. The scientist (for example the astronomer) was himself an “official”, often housed in the imperial palace.

Engineers and craftsmen were also a part of the bureaucracy, and throughout the dynasties, they were organized into the imperial framework within workshops and arsenals, in every capital of each successive dynasty as well as in the most important provincial cities. They functioned as the outlying nodes of a vast administrative network (Needham [NEE 73, p. 17]). The forced labor of the people, as imposed by the State, was the means for China, as it was for Egypt and/or India, to create the "collective worker" fundamental to the development of a productive labor force and to extract "the surplus existing only in and through their united, combined labor", essential for erecting colossal constructions, producing weapons en masse as well as the myriad of general public work projects. "Capital" as we shall see "effects the same concentration in another way, through the manner of its exchange with free labor" (Marx [MAR 57, p. 463]).

The link between the assertion of power and the concentration of knowledge is also perceptible in the creation of the first European universities of the 18th Century. As they developed, they emancipated themselves from local political and religious powers, largely because of the support of the Papacy, which saw this as a means of increasing its own influence. Terminating the erroneous and "heretical" intellectuals of the 17th Century, the development of universities meant that "intellectuals in the West were becoming, to a certain degree, but nevertheless, pontifical agents" (Le Goff [LEG 85, pp. 79–80]).

These few historical, disparate and non-systematic examples emphasize the existence of political strategies behind the mobilization of resources necessary to the production and protection of scientific and technical information and knowledge. More strongly, the measures developed by the French mercantilists of the 17th Century are generally cited to highlight the State's interventionist policy in industrial concerns.

The great discoveries at the end of the 15th Century (in 1487, Diaz circumvents the Cape of Good Hope, in 1492, Columbus discovers America, in 1498 Vasco da Gama reaches India) and the plundering of these new countries elicits a massive influx of precious metals that flooded Europe at the beginning of the 16th Century rapidly led to a tremendous price growth that plunged a large portion of the population into destitution. From the beginning of the 16th Century, a broad debate on currencies and prices developed, in which a "monetarist" explanation of inflation was interpreted, according to which "the principle cause of a rise in prices is always an abundance of that with which the price of goods is measured" (Bodin, quoted by Beaud [BEA 01, p. 16], with regard to criticisms of other sources of inflation (the luxury of kings, the costs of war, the burdens of debt, etc.). The commonly shared idea was also that the abundance of precious metals made the wealth of a kingdom, and its corollary that "in well-organized republics, the State should be rich and the citizens poor" as stated by Nicolas Machiavelli in *The Prince*.

In the early 16th Century, the static response to the question "what to do with gold?' was simple: hoard it and prevent it from exiting the kingdom. However the failure of this policy led to the emergence of Mercantile ideas promoting the development of Trade and Industry. The foundations for the further development of capitalism were established: "banking and merchant bourgeoisies having at their disposal immense fortunes and banking and financial networks; national States having available the means for conquest and domination; and a conception of the world which valued wealth and enrichment" (Beaud [BEA 01, p. 21]). In Holland, England and France, commercial and manufacturing capitalism, supported by colonial conquests and the establishment of outlets across the newly discovered worlds, developed the commercial, industrial and political dynamism of the bourgeoisie that would at a later point overthrow the absolutist powers and the offensive of mercantilist policies. "The core of mercantilism" resides, according to Mark Blaug, "in the doctrine that a favorable trade balance is desirable because it is somehow productive of national prosperity" [BLA 85, p. 10].

However, to this commercial argument, dominant in England, can be added an industrial argument that was particularly popular in France. In his *Treatise on Political Economy*, published in 1615, A. de Montchrestien maintains that the development of industry is an essential source of enrichment. He thus recommended the development of national trade, the creation of manufacturing, thereby preventing gold from exiting and promoting conquest through colonization. These ideas were applied by Richelieu (Chief of Council from 1624 to 1642), and especially by Colbert (Louis XIV' minister). The latter considerably boosted the development of French production by opting for protective tariffs. According to Colbert: "trading companies are the armies of the king and the industries of France are his reserves" (Colbert, quoted by Beaud [BEA 01]). The development of industry thus makes it possible to strengthen the power of the State through the impetus they give to commercial trade.

Mercantilist policies paved the way for greater control of information and knowledge, which had the effect of increasing the productive power of national economies. This is reflected in the development of national trade which required the development of communication infrastructures. In France, Vauban and Colbert sought to develop a fluid and coherent communication system in order to economically unify the national sphere. This period was also marked by a rapprochement between science and technology, which had already begun at the time of the Renaissance. It was notably the case in 15th Century Italy, when attempts were made by "artist engineers", the best known of which is Leonardo de Vinci, to establish a still modest link between practical life and scientific experience. The great spread of scientific knowledge in the 16th Century, marked by the printing of mathematical or technical works of antiquity, will continue into the Baroque period (17th Century) up until the first signs of the "technicization of science" and the "scientificization of technique".

This link between technology and science is marked by (1) the development of mathematics as a tool "par excellence" to describe the knowledge of the world, as used in physics, astronomy and of course mathematics (Galileo, Kepler, Huygens, Newton), as in philosophy (Descartes, Spinoza, Leibniz); (2) the creation of important experimental equipment, often made by the scientist himself (microscope, bezel, barometer, calculating machine, air pump, pendulum clock, etc.); (3) the appearance of the first important scientific societies, such as the Royal Society of London or the Academy of Sciences in Paris, and the first academic journals substantiated by Calvinist utilitarianism and thus resolutely directed toward technology.

Technique thus assumes an important place in science, ensuring for the technical efficiency which must make man, in the words of R. Descartes, "like masters and possessors of nature"; an idea already found in 1620 in the *Novum Organum* of Bacon: "Human knowledge and human power meet in one; for where the cause is not known the effect cannot be produced... the empire of man over things depends wholly on the arts and sciences" [BAC 66, p. 4 and p. 55]. The acquisition of human resources through the attraction of foreign artisans is one of the salient features of the policies pursued by Colbert: "For production, would be imported from abroad: machines, in particular those not yet used in France, for example one which made stockings 'ten times more quickly than with a needle'; and technical workers: German and Swedes for iron working, Dutch for cloth, Venetians for embroidery and glass, and Milanese for silk – all of them recruited by the

French consuls" (Grousset, EG Leon, *Universal History*, Library of the Pleiades, III, p. 142, Quoted by Beaud [BEA 01, p. 39]).

The acquisition of external expertise (know-how) is coupled with a policy of promoting emerging industries (regulations for production, direct financial support from the State to royal factories or specialized factories, and support for the establishment of new industries with foreign know-how). A policy for the protection of scientific and technical information and knowledge either produced or acquired, through the regulation of foreign trade and the protection of industrial property rights was for the first time ever recognized legally. Foreign trade, highly regulated, aimed to promote the import of capital-intensive products and the export of the finished products being manufactured by intensive labor. The importation of capital products makes it possible to acquire the technical information and knowledge incorporated into these products, and to copy and imitate them in order to use them in domestic production. On the other hand, the export of labor-intensive finished products protects the domestic industry as well as the scientific and technical knowledge embodied in more capital-intensive domestic products.

The earliest legislation concerning industrial property also appeared at this time. If, in the Middle Ages, the privileges of inventions, intended to protect inventors from imitation, were granted on an isolated basis, the mercantilist policies of the 16th and 17th Centuries offered a formidable boost to the development of patent legislation. It took the dual form of the protection of intellectual property (inventor) and the exclusivity of the use of an already known technique (imported patents in particular) (Gille [GIL 78, p. 1320]). According to Klemm, the development of patent law shows the predominance of a conception of "natural law" that corresponds in political terms, to "the need for general legal rules, excluding individual exceptions". It also allows for the broader and unrestricted dissemination of scientific and technical information [KLE 66, p. 108]. However, this legislation also provided an additional mechanism for the protectionism of mercantilists, whose fundamental objective of building and consolidating the State was recognized as only being achievable through the weakening of its neighbors' economic power and by strengthening its own.

In this context, the development of patent legislation appears to be the means used by the States to acquire scientific and technical know-how, which in turn will help strengthen the technical and economic domination of their own economy. Indeed, one of the oldest patents granted in France (in 1551) was an import patent, intended to reappropriate the Italian know-how in the field of glassworks. This privilege was granted to Thesto Muthio, a “gentilhomme de Bologna”, bestowing on him the exclusive right to make “all Venetian glass for ten years” (Gille [GIL 78, p. 1320]). Similarly, the patents for inventions granted in the 16th Century in the Netherlands and Germany were aimed at supporting the mining industry. In England, the *Bill on Monopolies* voted for in 1624 under James I responded to the resolve of the House of Commons to fight against abuses by the Crown, which arbitrarily granted privileges, including trade for a variety of goods (Boldrin and Levine [BOL 08]). However, on the one hand, for reasons of State, this law did not prevent the granting of a patent as a prerogative of the crown until the end of the 18th Century. On the other hand, the introduction for the first time of the novelty clause extended to the importation of techniques hitherto unknown in the country, and which could be very old techniques, greatly favored the technical development of England; as Goethe bitterly comments (the development of German patent law was slowed down by the 30-year war): “The Englishman is master of the art of making profitable right away those discoveries that lead to new inventions and applications; is there still any need to wonder why they are ahead of us?” (Klemm [KLE 66, p. 113]).

The periods of the 16th and especially of the 17th Century are strongly marked by the protectionist policies that flourished in Europe, which allowed for the pragmatic use of information and scientific knowledge in production; even if their aim was only to take advantage of the full development of commerce. The decline of mercantilist policies and the liberal era that began in the 18th Century did not, however, lead to a decline in the State’s interest in industrial development. Nevertheless, gradually the intervention of the State became more indirect: the first diplomatic missions, the progenitors of industrial espionage, sponsored by liberal ministers such as Trudaine in France, demonstrate that the liberal era simply transformed State intervention without questioning it. Indeed, during the English industrial revolution of the 18th and 19th Century, European governments, fearful of English technical superiority, gave many technicians “official missions’ to inform themselves more or less clandestinely about British production. These missions continued well into the 19th Century. One such example took place in 1814 when Dupont de Nemours and Talleyrand entrusted Jean-Baptiste Say (at his request) to inquire about the economic forces of England (Tiran [TIR 14]). Of interest, this mission took place 25 years after the interruption in regular contact between France and England due to the Revolution and Napoleonic wars. Jean Baptiste Say, author of the Traité d’Ecoomie politique (*A Treatise on Political Economy*) published in 1803, enjoyed, as A. Tiran explains, a certain reputation for his entrepreneurial experience (he created a factory in Auchy-les-Hesdin, North of France in 1805), and his participation in the creation of the "*Société d'encouragement pour l'industrie nationale" (Society for the encouragement of national industries)* at the initiative of Chaptal in 1801. During his stay, he visited numerous factories and "his journal reveals how very impressed he was by the level of industrial activities, in particular those to do with coal, iron and steel" (Tiran [TIR 14, p. 90]). He also encountered intellectuals (such as Ricardo, Malthus, Bentham, etc.), and wrote a very detailed report on the industrial situation of England at the time.

The indirect intervention of the State is also marked by a conscious effort toward technical education: many technical colleges and officer military schools, born during the second half of the 18th Century, were the first to form the national State technical framework, but also opened it up to future entrepreneurs in the private sector (for example in France: France : Ponts et chaussée, École des mines, Génie maritime, École polytechnique; and, later in Europe: the Polytechnical Institute in Vienna (1819), the Academic School of Kielce in Poland (1816), the Polytechnic Institute of Warsaw (1825)) (Gille [GIL 78, pp. 1373–1374]).

However, this formation and mobilization of scientific and technical resources was not systematic, nor was it always a co-venture of State and private entrepreneurial interests. B. Gille even notes the almost identical, complete indifference by European and French entrepreneurs of the 18th Century to cross the sea to England and study the technical transformations taking place [GIL 78, p. 1372]. This demonstrates the absence of comprehensive policies supporting technological innovation, but stresses that the acquisition of scientific and technical information and knowledge, which is the source of technical advances (such as the aforementioned mining techniques of the 18th Century), has always been one of the main issues of political power.

In fact, scientific and technical information and knowledge has for a long time been a means for increasing the productivity of labor, and thus the productive power of economies. However, a large number of economic and social transformations are still necessary before science becomes the "productive force" that is essential to the realization of profit. The use of scientific and technical information and knowledge as a systematic means of production, resulting from constant and sustained investments by enterprises and the State, goes hand in hand with the consolidation of capitalist production structures.

2.1.2.1. *Knowledge capital, manufactures and modern industry*

The consolidation of capitalist production structures goes hand in hand with the development of large-scale industry. It is not a linear process, starting from primitive accumulation, passing through the establishment of manufactures, and naturally leading to the development of modern industries. This long historical process is marked by political and social upheavals, periods of varying length of economic prosperity and crisis. Without going into historical details, having established this caveat, we wish to show here the process by which scientific and technical information and knowledge, which, as we have seen, have always been considered first as stakes in political and military power, and also in economic power, have become a means of production essential to profit making.

The development of manufactures can be considered as "primitive appropriation" by the capital of the scientific and technical information and knowledge originally contained in a labor force of individuals. This appropriation was made possible by the combination of previously independent professions, the fragmentation of labor, and finally the formation of the collective worker. "The mode in which manufacture arises, its growth out of handicrafts, is therefore twofold. On the one hand, it arises from the union of various independent handicrafts, which become stripped of their independence and specialized to such an extent as to be reduced to mere supplementary partial processes in the production of one particular commodity. On the other hand, it arises from the cooperation of artificers of one handicraft; it splits up that particular handicraft into its various detail operations, isolating and making these operations independent of one another up to the point where each becomes the exclusive function of a particular laborer. On the one hand, therefore, manufacture either introduces division of labor into a process of production, or further develops that division; on the other hand, it unites together handicrafts that were formerly separate. But whatever may have been its particular starting point, its final form is invariably the same – a productive mechanism whose parts are human beings" (Marx [MAR 67, p. 238]).

The use of the term "primitive appropriation" refers to the fact that it is the Capital that gives the orders, to the individual who possesses knowledge, the knowledge of a craft or skill corresponding to the technical basis of the industry and which, if integrated with the collective worker, multiplies the productive force of labor. If, at the time of the manufacture, this appropriation is only partial, it is because the knowledge of the individual is not opposed to him by the crystallization of knowledge within fixed capital.

The manufacture however lays down its essential bases, but will only be truly effective with the development of large-scale industry and its corollary, mechanization. Therefore, the mobility of craftsmen, which is common during the period of the manufacture, and which we have mentioned with a few examples above, cannot be interpreted as a real appropriation of scientific and technical information, but rather as resulting from the mere dissemination of "cultural goods" [BRA 93], driven by voluntary or involuntary population migrations.

Nonetheless, the generalization of manufactures brings about a fundamental change in the usage of scientific and technical information and knowledge through the socialization of their use. The manufacturer puts an end to the secrecy surrounding the methods of production, which are peculiar to caste or corporatist systems, which elicits an important dissemination of scientific and technical information. Debates regarding trade corporations were numerous during the 16th and 17th Centuries [BOU 12], Kaplan [KAP 01] but continued to exist in France, even after the abolition of corporations during the French Revolution. This is the case, for example, in the work of J. B. Say, who makes the criticism of corporations as justification for the superiority of following the natural course of the market compared to public interventionism (see Box 2.1). A century later, Lafargue again emphasizes the longstanding atmosphere of secrecy, since antiquity, with regard to artisanal crafts: "Until the age of great industrial engineering, the trades were mysterious, jealously concealed from the profane and revealed only to the initiated, to whom this knowledge enabled him to carry out works which would otherwise have been impossible for him to execute" [LAF 97].

In the aftermath of the French Revolution, the corporations in France were suppressed (the D'Allarde decree adopted by the Constituent Assembly of March 2–17, 1791). In spite of their abolition, in his *Traité d'économie politique* (first published in 1803) and in *Cours complet d'économie politique* (first published in 1828) Jean-Baptiste Say states long critical developments, which seem to serve as justification for his liberal theory [SAY 06, SAY 07]. His arguments on corporations and more generally, on regulations concerning the mode of production (or the processes used in the production of goods) can be presented in four points:

1) Regulations hinder freedom of enterprise and any advancement in the arts

According to Say, regulations restrict the free movement of the factors of production (labor and capital). This applies not only to France but to the whole of Europe, where, he writes, a man cannot dispose of his industry and capital as he wants. Regulations arising from the existence of communities or corporations engender discouragement and vexations. He refers to the case of several individual inventors, such as Argand, inventor of dual-air lamps, or Lenoir, a manufacturer of physics and mathematical instruments, attacked by the communities for being too dangerous as competitors. For Say, corporations are a brake on the progress of the arts, and in modern terms, obstacles to innovation.

2) Regulations are a means of policing

On several occasions, Say explains that regulations reinforce the authority of those who have power. They create an authority–complacency relationship that serves as a means of policing. If the role of the State embraces this function of policing, the role played by the distribution of privileges, he argues, serves only to strengthen the power of bad governments. According to Say, the State must limit itself to enforcing property, punishing fraud, and ensuring the maintenance of infrastructure. On the other hand, industry must be driven by self-interest and exist in the midst of free competition in order to bring forth new ideas. It is through this free competition and this search for distinct interests that will make it possible to increase national wealth.

3) Illusory expected benefits and effects which are in fact harmful

The expected benefits of regulations, in terms of perfect execution, product quality and prosperity are illusory, according to Jean-Baptiste Say. On the contrary, he gives numerous examples explaining why the suppression of corporations in France, for example in the textile industry, has favored the diversification and quality of products. He cites several examples in other countries to show that the cities with the most prosperous industries are those with no trade associations, such as Manchester, Birmingham, Liverpool, and Glasgow. Say refers to Smith to make the argument for the free trade as the source of prosperity, to which he adds the respect for property, the accumulation of capital, and education. Finally, the illusory nature of regulations stems from the fact that it is possible to evade them with money, giving rise to injustices and favoritism.

In reality, regulations are, for Say, harmful to consumers, since they contribute to the increase in prices thereby impoverishing them. They are also detrimental to monopolists since they also suffer from the rise in prices of others. They are harmful to society as a whole because they reduce competition, inhibit the spread of ideas and practices, and are also responsible for the burial of trade secrets, thus precipitating the ruin of industries and empires (citing for example, the case of purple tincture privileged by the royal family of the Eastern Empire).

Useful regulations or a "necessary evil"

On the other hand, there are useful regulations such as those which make it possible to establish a professional capacity (for example, that of doctors) and protect oneself against "charlatans". In the chapter on useful regulations, in the *Treaty*, Say develops a few paragraphs on patents for inventions, and for which he has a mixed opinion. The privilege granted to manufacture a specific product or to use a particular process (Say cites the case of Arkwright, inventor of the cotton spinning machines) is considered positive, as it does not hinder an existing industry and the price is paid by a consenting individual. Moreover, the inherent advantage arises from the fact that the patent (or privileged secrecy) is limited in time, and then falls into the public domain, thereby allowing everyone to use it and as a consequence the price falls. On the other hand, according to Say, this should not be the consignment of the State, but rather for the market to define the utility or novelty of the invention. What Say rejects are the import patents, at the time being enforced in France. These allow for a privilege to be obtained on the manufacture of an imported good thereby preventing other producers from using processes that are only being imitated from abroad. According to him, these patents should be abolished, since they attribute advantages to importers of techniques and not to actual inventors.

Say's argument against industrial regulations is part of his method of building his version of political economy. This is both a theoretical construct and an analysis that is "close to reality". The liberation of the forces of production, which Say recommends, passes through the criticism of industrial regulations. It implies a "political" action aimed at constructing a framework favorable for the freedom of enterprise and a flourishing of the forces of production that gained ground during the first industrial revolution observed by the author.

Box 2.1. *Say and the criticism of corporations and industrial regulations. Source: Diemer and Laperche [DIE 14], Laperche [LAP 15]*

The greater socialization of scientific and technical information and knowledge and the organization of work within the factory between the members of the collective worker lead to the differentiation and specialization of tools and prepare the mechanization of production, both in terms of material as well as social conditions. The specialization of tools goes hand in hand with the fragmentation and specialization of the professions, which make the worker dependent. His skills "can be exercised only in an environment that exists in the workshop of the capitalist" [MAR 67, p. 249]. This dependence is expressed by the fact that the factory worker, when separated from his colleagues, no longer has either professional capacity longer or independence.

This domination of capital over labor, created by the industrial division of labor, makes the mobilization and concentration of human resources necessary for the production of scientific and technical information and knowledge to become systematic and quasi-natural, since an individual laborer can no longer value its know-how independently. The systematic mobilization and concentration of other resources (financial, institutional and informational) result from this, since, confronted with the law of competition, and in order to benefit from the advantages of a subsequent division of labor, the manufacture must at the same time increase the variable components (e.g. the number of workers) but also its constant components (e.g. tools, instruments, buildings, etc.). The concentration of capital (the means of production which assumes a capital form), necessary for the development of manufactures, thus becomes its principal means of existence.

While creating the material basis for the mechanization of work, the manufacture also prepares the social aspect to it. Indeed, as long as a craft or skill remains the foundation of the industrial organization, the domination of capital is not yet total, in view of the potential resistance by workers who are not yet separated from their knowledge and know-how. "Intelligence in production expands in one direction, because it vanishes in many others. What is lost by the detail laborers is concentrated in the capital that employs them. It is a result of the division of labor in manufactures, that the laborer is brought face to face with the intellectual potencies of the material process of production, as the property of another, and as a ruling power. This separation begins in simple co-operation, where the capitalist represents to the single workman, the oneness and the will of the associated labor. It is developed in manufacture that cuts down the laborer into a detail laborer. It is completed in modern industry, which makes science a productive force distinct from labor and presses it into the service of capital" (Marx [MAR 67, p. 249]). Without machines, which complete the separation of the worker from his means of work (his know-how) and make it the primordial means of production, capital develops strategies, which are only partial, for the appropriation of scientific and technical information and knowledge.

The scientific and technical information and knowledge used by Capital in the era of the merchant capitalism and still at the time of manufactures have not yet taken the form of an organized system: this means that their use in production and the processes of transformation, should these stem from strategies developed by both the State and corporations, are not the result of systematic investments by companies. They make use of, practically for free, the knowledge brought about by the work of the laborer and the scientist.

Major transformation arises from the invention of a machine, which, by appropriating the intellectual content that it needs from specific individuals, will impose a new order among the existing large industries. The transition from manufactures to modern industry has not been smooth, and strikes and refusals to work multiplied throughout the 18th Century. The machine created order in two ways: on the one hand, it is representative of past work (from the employees who built it) and stands against living labor as a force that dominates them; and on the other hand, by making work-life potentially superfluous, ready to "give the axe" to any revolutionary forces. For example, as Marx [MAR 47] explains, "In England, strikes have regularly given rise to the invention and application of new machines. Machines were, it may be said, the weapon employed by the capitalist to quell the revolt of specialised labour." He goes on to cite "The self-acting mule, [as] the greatest invention of modern industry, put out of action the spinners who were in revolt" (p. 77). The transformation of the instrument once handled by man into a machine-tool driven by a mechanical principle and integrated into a combined mechanism, replaces the subjective technical basis of manufacture, the skill of the trade, with an objective principle, emancipated from the individual faculties of individuals, so that "the cooperation by division of labour (…) characterises Manufacture; only now [in modern industry, added by us], it is a combination of detail machines" [MAR 67, p. 264].

Unorganized scientific and technical information and knowledge still present in manufactures here becomes a system, organized and financed by the company. Indeed, at first glance, the functioning of the mechanical automaton, which requires linking the partial processes that constitute it, requires a deeper knowledge of the laws (mechanical and chemical) which will ensure the transmission of the information required to regulate and modify the movement, and for which the known driving forces (man, water, animal) become insufficient. It follows that the disruption of production methods, brought about through the use of the machine in the industrial sector, diffuses into other industrial sectors, and requires the construction of new machines, the creation of which is conditioned by the deepening of knowledge.

Moreover, it is through the analysis of the nature of competition that one can understand the constitution of organized knowledge systems and the constitution of knowledge capital. The formation of an organized system of scientific and technical information and knowledge goes hand in hand with the move toward the concentration and centralization of capital, and the transformation of free competition into competition between large enterprises, in which the technological advantage becomes the most decisive means with which to outpace contenders. Marx and Schumpeter have made the move toward the concentration and centralization of capital a fundamental characteristic of their respective analyses. For Marx, this is the result of competition, which encourages individual capital to affect branches of industry where free competition still prevails. It follows that a competitive struggle, which takes place through prices, ends up ruining the weakest companies. "The smaller capitals, therefore, crowd into spheres of production which Modern Industry has only sporadically or incompletely got hold of. Here competition rages in direct proportion to the number, and in inverse proportion to the magnitudes, of the antagonistic capitals. It always ends in the ruin of many small capitalists, whose capitals partly pass into the hands of their conquerors, partly vanish" [MAR 67, p. 441]. The "march" imposed by competition results in the unprecedented development of technical labor-saving inventions.

For Marx and Schumpeter, through the financial blessing it brings to accumulation, credit contributes to the formation of capital: "The additional capitals formed in the normal course of accumulation serve particularly as vehicles for the exploitation of new inventions and discoveries, and industrial improvements in general. But in time the old capital also reaches the moment of renewal from top to toe, when it sheds its skin and is reborn like the others in a perfected technical form, in which a smaller quantity of labour will suffice to set in motion a larger quantity of machinery and raw materials" [MAR 67, p. 442]. Similarly, for Schumpeter, credit serves economic development, being a source on which the entrepreneur can draw to finance the execution of new combinations ([SCH 05], chap. III, Credit and Capital).

Competition encourages the capitalist to increase labor productivity and therefore leads to a relatively greater use of constant capital in relation to variable capital, and causes a downward trend in the rate of profit. Competition between large companies under these conditions takes a special turn: since it takes place between equals, the battle of lowering the price becomes futile; each is of a sufficient enough size to support it; it is in such instances that technical performance becomes crucial in order to get ahead. The different forms of innovation "that capitalist enterprise creates" [SCH 75, p. 83] require the mobilization and combination of organized systems of scientific and technical information and knowledge. The development of capitalist production structures, and competition, instilled the concentration of production structures, thereby facilitating the constitution of knowledge capital.

Thus, both a public and private process of production of scientific and technical information and knowledge and a sector for the production of goods are put in place, in turn ensuring the dissemination of scientific and technical information within the various branches of industry. The modification of the production process within an industry, brought about by the introduction of machines – based on the transmission of information between the various partial elements which constitute the global mechanism – also required a greater dissemination of information at the macroeconomic level. In order to profit from fixed capital investment, an increase in the mobility of inputs (capital and labor) between the various industrial sectors and their direction toward lead markets is required. This necessitates the development of communication facilities (steamboats, railways, telegraphs) and of the range of institutions necessary for the collection and dissemination of information. Many institutions for collecting, processing and disseminating information were created in the second half of the 19th Century, as detailed by Mattelard: "The Central Commission of Statistics in Belgium, founded by Quételet, became an institutional model for other countries. In 1832, Quételet proposed to the British the creation of the future Royal Statistical Society. Its statutes would be approved two years later. The Statistical Society of Paris came into being in 1860. […] In 1885, ten years after the creation of the International Bureau of Weights and Measures, statistics would have its own transnational body: the International Institute of Statistics. [...] In 1880, the American statistician Hermann Hollerith (1860–1929), inspired by the weaving loom of Joseph-Marie Jacquart (1752–1834), invented the perforated card machine. Its first wide-scale application was for the exploitation of data from the United States census in 1890. Six years later, the statistician would found his own society to produce and market his invention (in 1924, Hollerith Tabulating Machines would become International Business Machines, the future giant of computing" [MAT 96, p. 46].

The national innovation systems cemented the alliance between science, technology, enterprise and the State. It is indeed possible to connect the formation of national systems of innovation, linked to the consolidation of capitalist production structures, with the advent of modern science in the West. By "modern science" we mean a science whose applications are more practical in nature, rather than directed toward the objective of knowing the laws of nature. Whether modern or not, science has always been linked to the assertion of power, however the nature and objectives of this power conditions the directions of the science.

The relations between the sciences, enterprises and States will become systematized with the advent of modern industry. The second industrial revolution of the 19th Century illuminates the willingness of companies and States in terms of the production, collection and control of scientific and technical information and knowledge. While the production of highly capitalized commodities becomes the engine driving the competition between businesses, the mass production of weapons becomes the foundation of national defense. Scientific information and knowledge thus become means of production essential to the competitiveness of enterprises and the defense of national economies. The enormous sums needed to mobilize the resources for the production of scientific and technological information and knowledge, and the increasing industrialization of the defense sector will make States the main mobilizing and regulating center of national innovation systems. Even in eras strongly marked by liberalism, the intervention of the State to stimulate scientific and technical development cannot be ignored.

More generally, in the last 30 years of the 19th Century, the most successful companies carried out strategies for the "internalization of research" in various sectors of their activity. It was also during this period that industrial States developed coherent industrial property systems (Hilaire Perez [HIL 00]) to provide firms with incentives to invest in the production of knowledge. The creation of large laboratories was at the time mostly established by German and American companies, such as the Bayer laboratory, founded in the 1880s to carry out research in the field of chemistry, or those created by General Electrics in 1901. At the end of the 19th Century, capital from the bankers and financiers who supported Edison, helped to create companies that were from the outset giants. They put together large teams of scientists tasked with completing shortfalls in Edison's knowledge on chemistry, physics and mechanical electricity, over which he had absolute authority.

"Most of them," Daumas writes, "remained faithful to him for a long time, and allowed themselves to be won over by his creative fever. Later some of them would question Edison's paternity for certain inventions, [...] all agreed that when it came to the question of recognition, their name would never join that of their great patron at the release of a sensational novelty. Edison was the be all and end all, he shared none of the glory of the inventor." Moreover, he continues on to say, "he had the means to buy out the other affair, or to establish an alliance with it, as he did, for example, with the company that supported Swan in England" [DAU 96, pp. 406–407]. Research was above all a means for creating and strengthening a dominant position, based on the mastery of know-how: "From that time onwards, the various industrial sectors evolved rapidly toward the creation of global oligopolies based on a negotiated balance in the distribution of forces, and which made the entry for new contenders increasingly difficult" (Caron [CAR 97, p. 236]). In France, on the other hand, entrepreneurs relied heavily on State support and the internalization of research did not really take off until the start of the First World War.

The appropriation of scientific and technical information and knowledge is inseparable from the dynamics of capital accumulation. Driven by competition, the latter promotes and necessitates the strengthening of links between firms and States for the creation of national systems of innovation, from which companies obtain and appropriate the scientific and technological information and knowledge that will fuel their production process. The operational complexity of national innovation systems and the crucial role of scientific and technical information and knowledge in competition contribute to explaining their concentration in industrialized countries.

2.1.2.2. *National innovation systems and the building of firms' knowledge capital*

A "national innovation system" is defined as all public and private institutions (companies, public and private scientific research and technological development centers – R&D, financial companies, regulatory and policy, etc.), involved in the realization of innovation processes and linked together by financial and information flows and by the movements of people (scientists, engineers, workers of all qualifications and competences). This system, formed by market and non-market transactions (formal and informal), is fully mobilized so as to enable companies to realize new productive combinations, thereby renewing production, activity and the markets.

The concept of a national innovation system emerged in the late 1980s from the work by Freeman [FRE 87] and Lundvall [LUN 92]. However its study is far older; it was initially expressed in terms of the R&D system and scientific education. Originally, through the prism of enterprise: science becomes the very foundation of industry; and since the Second World War, through public intervention: applied research and experimental development for new means of production and consumer products ensue from the experience and research of military industries.

In the aftermath of the Second World War, the State in all industrialized countries played a very important role in the promotion of national innovation systems. The massive intervention of the State in the scientific and technical fields is of an economic (support to the firms) and nationalist nature: excellence in scientific research is a signifier of cultural influence, economic and strategic independence (the ability to communicate, ensure its supply of energy, and secure key raw materials); these were significant issues for post-World War II industrialized economies.

Scientific policies were initially directed toward major military research programs. The aim of science policies is to (1) define the objectives for the development of national science and technology activities by establishing priorities, (2) to mobilize the potential for public and private research and (3) to promote technological innovation and to arbitrate the allocation of resources (jobs, facilities). These policies gave rise to major national programs of basic and targeted research, especially in sectors that represent economic, social or strategic issues. Such programs illustrate the role of the State in the direction of knowledge. They reflect political choices given that they combine defense and objectives for national independence (for example ensuring energy independence by building nuclear power plants), prestige considerations (being present in space) and participate in technological logic. The construction of a new nuclear weapon or telecommunication network requires research and development across a wide range of disciplines and techniques (from nuclear physics to applied mathematics). Through these major programs, the State thus establishes the objectives to be achieved within a given timeframe, determines the means, directs finance and oversees management in all areas of research. This massive intervention by the State in industrialized countries, with regard to the financing and direction of research, has greatly influenced technological development ever since the Second World War.

Major programs, massive subsidies for research and development, especially military, and public procurement have enabled a large number of technologies to be developed within protected markets, after which they are then transferred to the civilian sector where they are implemented at a larger scale. The birth of the computer industry reveals the close relationship between the State, the military and the merchant for the commercial exploitation of new technology. The computer, "machine born of war" (Manhattan project) benefited greatly from State intervention. On the one hand, this promoted the development of learning processes within firms, and on the other hand, helped to propagate innovation to the entire industrial framework. Government support, in terms of both supply and demand, has largely contributed to the emergence of the American computer industry.

The history of the Internet is based on the same logic. In 1969, the US Defense Advanced Research Projects Agency (DARPA) set up a network for the exchange of information between agencies working for the Ministry of Defense and was quickly expanded to include universities. In the late 1970s, large firms (Compuserve, American On Line, and Prodigy) were added to provide commercial services (e-mail, access to databases) for professionals and individuals. The opening of the network to the general public in the 1990s saw a sharp increase in the expansion of the latter.

From the mid-1980s, major programs in the industrialized countries were increasingly directed toward the promotion of that which R. Nelson has termed "strategic industries" [NEL 84], selected as key sectors for the further development of scientific and technical information and knowledge (in the domains of electronics, computer, aeronautics, chemistry, materials, etc.). These are therefore all sectors where technological change has been rapid and in which technical progress has conferred a position of strength in an increasingly competitive technological world. Their significance is at the same time economic since these sectors give rise to technologies that are broadcast across the whole of industry, but also within the military, given the fact that a number of techniques being developed will have a corresponding military application. Technological transfers from the military to the civil sector explain the establishment (even in the most liberal economies such as the United States), of policies supporting mainstream research as well as extensive research programs directed at defense. The "Star Wars" program launched by R. Reagan in 1983, later renewed and redefined in 1991 as "National Critical Technologies", was intended to identify the investment priorities critical to the maintenance or restoration of American competitiveness. They reveal the intervention of the State in the field of research in spite of the absence of any clear willingness to establish a real industrial policy. The Department of Defense and the department for Research and Technology in France, the MITI in Japan, or the Federal Ministry of Education and Research in Germany, all took the same course of action.

Indeed, the uninhibited race to generic technologies reveals the need for firms concentrated on the search for new investment "spaces" in highly capitalized markets. As with the liberalization of capital, State stimulus policies in the domain of science and technology (notably through major national programs) are part of the devaluation of capital. By strengthening the innovation capacities of companies, the State facilitates the devaluation of previous technologies that have exhausted their capacities to make a profit and creates new protected areas for the valorization of capital and the realization of profits (Uzunidis [UZU 03]).

Thus, mentioning the role of the State in the control of technical progress cannot be reduced to either the modes of finance for basic and industrial research, nor to the explicit strategies it formulates in terms of scientific and technical research. Study of the multiple interventions of the State (law, currency, finance) reveals that it is the essential regulating agent for national innovation systems. It finances, motivates and directs research, taking care to ensure the consistency and effectiveness of the links between the elements in the national innovation system, with the aim of ensuring the accumulation of capital from one period to the next. This State, "entrusted" with the direction of knowledge and in the diffusion of technologies, contributes to an increase in the technological level of the national economy and therefore the strength of it (concentration) within the competitive sphere that has since become globalized. As part of its regulatory policies, it establishes extremely close relations with companies located within its own borders.

A new stage was reached in the 1990s, with the recognition of the multiple forms of learning available through the circulation of knowledge, between firms, between firms and research institutions, and between producers and users of technologies (Edquist [EDQ 97], Lundvall [LUN 92]). The theory of innovation systems closely follows developments in international economic relations. Since the 1980s, the reduction of trade barriers (intra- and international) and access to savings sources (development and integration of financial markets) have been profitable to large companies, which thus became global. In these conditions of intense competition, public R&D and innovation policies were the main levers for the support of their offering. The public research sector, education, major technological programs, etc., are shaped to better create "reservoirs of scientific value" from which companies can draw upon resources to renew their offering.

State intervention is always paramount in the management of national innovation systems, nevertheless it has become more indirect: this is reflected in the financing of activities that generate resources that can be appropriated individually or collectively by companies; through the creation of mechanisms for re-appropriating the return on R&D investment (intellectual property); through the implementation of cooperation schemes between public and private entities in order to ensure the profitability of a private investment project likely to have a large scale economic impact. The development of a reservoir of productive abilities, at any moment accessible and appropriable by firms, is considered by economists (e.g. Branscomb & Keller [BRA 98], Uzunidis [UZU 08]) as the essential component for innovation public policy. Indeed, noting that the creation and dissemination of knowledge increases the performance of a nation's economy (and the large companies that constitute it), the idea that traditional policies for science and technology (that focus on financing major public research and development programs, mainly in the fields of defense, energy, space or medicine) must be replaced by policies encouraging private research and innovation. The State must guarantee the effectiveness of privatization procedures ("valorization") through regulation (the protection of industrial property rights, anti-trust laws, etc.), taxation, budgets, etc., in order to promote the accumulation of firm's knowledge capital. All these functions are grouped together within the notion of the "legal framework of accumulation" (Uzunidis [UZU 03]). It includes forms, modalities, means of competition and cooperation between economic agents that enable the production process to be carried out, that is, the bringing into conformity the social relations of production with productive forces.

For industrial countries, national legal frameworks of accumulation are directed toward the creation and maintenance of conditions for endogenous growth in the long term: transport and communication infrastructures; effective education, successful research and engineering structures; an innovation-oriented financial system, etc. And above all, since the early 2000s according to the OECD, emphasis has been placed on programs supporting the creation of networks. Research and innovation policies therefore focus on (1) R&D programming in areas that are beneficial to the international corporations of the country; (2) the networking of research, industry, engineering, trade and prospective players for the realization of investments that increase added value in the federative domains and strategic niches as defined by the regulatory authorities. It is indeed the creation of a public pool of innovation resources which is at the very foundation of the clusters of innovation. Hence the rise of transversal policies for: coordination, support to partnerships and networks (companies, companies/institutions).

These policies have undergone significant regional variations as the cluster policy has become disseminated on the global scale. Indeed, industrial policies have been directed toward the creation of systemic links between knowledge and the market. In France, this is reflected through the policy of clusters, or "Pôle de compéttivité" (regulatory), which seeks to create, at a regional scale and within certain scientific and technical fields, innovation ecosystems, a source of positive externalities. These, as well as other opportunities potentially brought about through the creation of new businesses and new jobs, will lead to new innovative products and services (Laperche *et al.* [LAP 10]).

In France, the competitiveness clusters policy launched in 2005 can be considered as a step toward collective capacity building by clearly targeting collaborative research projects carried out by firms of different sizes. Although "technopoles" promoting R&D networking between firms and public research institutions existed before 2005 [LIU 13b], the competitiveness clusters policy was the first instrument to focus on collaboration between firms. This policy has had a significant impact on the networking and innovation collaborations among firms [DOR 13]. As members of clusters, French SMEs receive more public support (grants and fiscal measures notably the research tax credit) than those who are not members of clusters, even though they might not participate in collaborative R&D projects, although big firms who opt to participate in a collaborative R&D projects with SMEs can bring extra public funding to the table. All large firms, as well as the small- and medium-sized companies that spent more than 16 million euros in R&D before 2005, joined the clusters [DOR 13]. To the end of 2009, almost 40% of clusters have participated in at least one collaborative project, while the average participation rate was 1.9 per firm [WEM 11].

Box 2.2. *"Pôle de compétitivité", the French clusters*

Figure 2.1 reproduces in a simplified way the elements defining the national innovation system presented above:

– the national innovation system describes the main sectors (institutions) that are at the origin of the development and diffusion of new productive combinations: scientific and technical training, finance, research and development, the sphere of production;

– the national innovation system is a system of relations between these institutions. These relationships are characterized by information and financial flows;

– the national innovation system is an open system that allows for its survival and constrains its development. This means that it is also fed by information and financial flows from other innovation systems or other parts of it: governments, associations, multinational firms, etc.;

– the national innovation system is governed by a set of rules that guarantee the organization, consistency, operation and evolution of the system. It is the legal framework of accumulation, itself consisting of a set of laws and policies: competition rules, market structures, intellectual property rights, industrial and innovation policies.

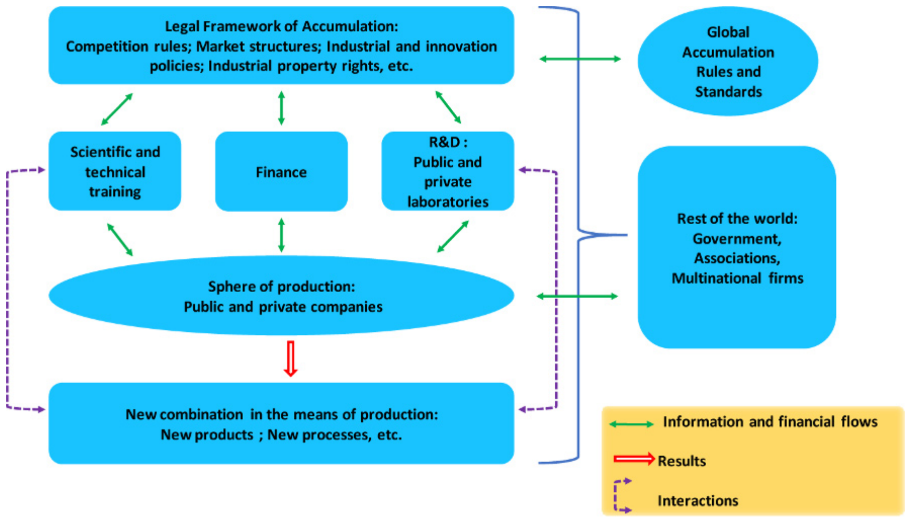

Figure 2.1. *The national system of innovation. Source: Laperche and Uzunidis [LAP 07]. For a color version of the figure, see www.iste.co.uk/laperche/knowledgecapital.zip*

According to the OECD [OEC 16a], following the 2008–2009 financial crisis and in the current context of weak growth and subsequent restrictive fiscal conditions, governments have focused more on accelerating business innovation and entrepreneurship than policies covering scientific research. States are particularly interested in improving the innovation capacities of companies by reorganizing their science, technology and innovation (STI) policies. Particular emphasis was placed on:

– the financing of business innovation and entrepreneurship and the increase in funding of SMEs, severely affected by the crisis and with a view to support their internationalization;

– rationalization of public research expenditure, increasing links between public and private research;

– the availability of talent and skills and the creation of a culture conducive to innovation;

– improving the governance of STI policies, enhancing policy evaluation and promoting responsible policy development.

The next point deals with the consequences of these innovation policies on current strategies for building the knowledge capital of firms, whose organizational logic is that of a network.

2.2. Multi-partner innovation and formation of knowledge capital

2.2.1. *Network firm and multi-partner innovation*

The changes in the organizational structure of the firm in the United States and in Europe since the 1980s have been the result of the transformation of economic structures (Uzunidis and Boutillier [UZU 97]). It is first a response to the limits of Fordism exposed at the end of the 1960s with the collapse of technological clusters – mechanics, electricity and automobile – with the growing denial of salaried working conditions, and the increase in internal organizational costs within large multidivisional firms. The transition from the unitary hierarchical structure to the multidivisional form had already helped limit the organizational costs stemming from the increase in the flows of information to be processed, and generated by an increasingly varied and extensive demand (Chandler [CHA 77]). Nevertheless, this organizational transformation of the firm proved to be inadequate in the context of change in the nature of competition. In the Fordist production model, competition was mainly based on prices and justified integration strategies that were based on internal and external growth. The saturation of the demand for standardized goods required, on the one hand, the introduction of flexibility in order to be able to generate variety in production and, on the other hand, the expansion of markets so as to re-establish profit opportunities for these large centralized entities.

The liberalization of the markets for goods, services and capital beginning in the 1980s represents the second significant development. These policies favored the globalization of markets and the globalization of firms' strategy. By the "globalization" of firms' strategy, we mean the freedom by which companies can manage their assets at the global level. The strategies for internal and external growth have proved to be too risky to deal with competition based on differentiation and reaction times at the global level, given the immobilization of capital that they involve. This explains why firms have reviewed their organization by focusing on areas of strategic activities and by outsourcing those that were not strategic. They pursued their expansion by either increasing or decreasing their long-term contracts (depending on the specificity of the assets concerned), and focusing less on direct investment (whether or not these were located abroad). Flexible methods of production (Toyotism, Onism), associated with the organizational model of the Japanese "Kereitsu", strongly influenced the new organizational structures of network firms. Firm J (Japanese) confronts firm A (American) by reconciling the advantages of integration and the market (Aoki [AOK 86, AOK 88]). Its advantages are based on an efficient system of information, organized horizontally, and by ensuring the coordination of activities. It is clear that the diffusion of information and communication technologies is an essential tool for establishing network firms and global innovation networks (conception, production and diffusion of new goods, services, organizational or commercial methods).

The network firm has been defined as the merging, through contract, of "a group of firms that are (1) legally independent, (2) vertically linked, (3) within which one main firm, described as a pivot firm, a core firm or a central agency (…) regularly coordinates operations of supply, production, distribution" (Beaudry [BEA 04, p. 250]). It combines classic integration (subsidiaries established through internal and external growth) with the decentralization of activities, through outsourcing and contractual relations (Uzunidis and Boutillier [UZU 97]). This allows the global organization of functions: most often these are commercial and engineering activities that are the most decentralized and located in different countries around the world. The essential functions of the firm (R&D, productive, commercial and financial management) are very centralized (even if they can also be globalized), and are made up of functional units charged with the management of international flows of productive inputs. Therefore, the planning of activities and decision-making power remains centralized, as it is in the integrated, centralized firm, while the management of activities (production, assembly, distribution) is outsourced to all or some of them. In this way, the parent company or pivot firm is the architect of a global network. The firm conducts a strategy of "internalizing outsourcing" (Uzunidis [UZU 96]), which, on the one hand, enables economies of scale to be extracted, largely due to the refocusing of key activities, and by strengthening its particular advantages and, on the other hand, by making the most of external economies linked to network organization, and the realization of economies of scope, all the while moving closer to the end customer.

The network firm is based on flexible financial relations that unify its organization, and informational flows, which allow the coordination of various decentralized activities (Antonelli [ANT 88]). The horizontal and vertical integration required by this dual necessity to reduce transaction costs linked to the imperfection of markets, and increase barriers to entry, forced firms to bear the costs of mergers, takeovers and majority ownership. In contrast, the network firm offers a more flexible range in terms of the contractual relations between firms, who are members of the network (joint venture, partnerships, subcontracting, franchises, license agreement, etc.). Nonetheless, these relations are similar to quasi-vertical integration, given that the contracting units (often cascading) are in a situation of dependence as compared with the pivot firm (Beaudry [BEA 13], Chassagnon [CHA 14]), thereby allowing the production of a "relational quasi-rent" (Aoki [AOK 86, AOK 88]).

Miles and Snow [MIL 95] postulate that the network firm adopts a spherical structure "that can rotate competent, self-managing teams and other resources around a common knowledge base" [MIL 95, p. 6]. However, in our view, the spherical structure gathers – around the pivot firm – dependent units acting as quasi-firms (QF) and independent units (IU) that are linked through contracts. In this framework, the main orders are given by the pivot firms, allowing for the QF to also benefit from an autonomy in decision making, and therefore endowed with the ability to give orders to other dependent or independent units, which can change/rotate according to the project and the competencies required. Control of the whole network firm is thus achieved through ownership and contractual relations (see Figure 2.2). Furthermore, this project-based management implies that the firms' boundaries are not strictly defined – they are fuzzy – and as such can be adapted according to the needs of the project.

The network firm is distinguishable from the network of firms, which "characterizes firms regularly linked to each other, but in a horizontal dimension of different activities" [BEA 04, p. 250]. However, the network firm and networks of firms have a close relationship, as is shown by the spread of multi-partner innovation strategies. In a network firm, as in networks of firms, trade relations cannot be assimilated with pure commercial transactions since they create specific assets (tangible and intangible), generating sunk costs in the event there is a breakdown in the relationship, and which in turn helps explain their durability [BEA 04, pp. 251–253]. Interfirm cooperation (especially in terms of innovation) is not a new theme (Richardson [RIC 72]). However, nowadays, it is the subject of a large number of publications. Multi-partner innovation is understood here as a generic model for the integration of all instances where the firm opens up to its environment with the aim of innovating (Laperche *et al.* [LAP 08]). This is currently widely popularized by the term "open-innovation" (Chesbrough [CHE 03, CHE 06]).

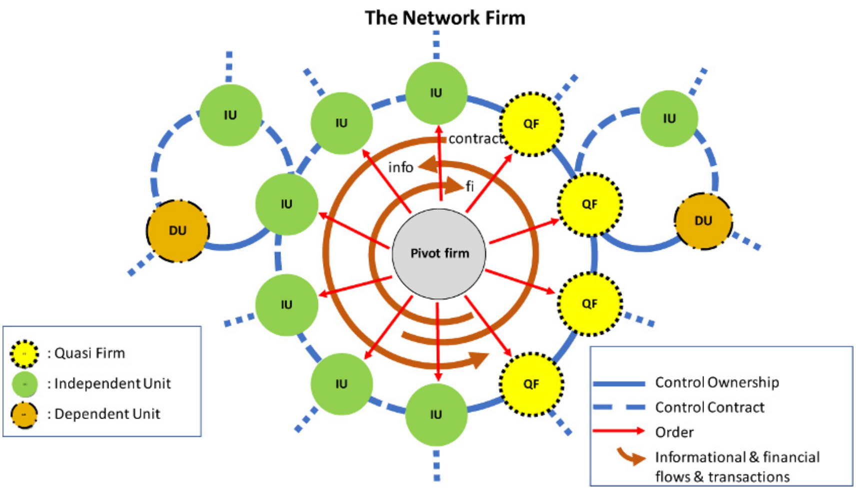

Figure 2.2. *The network firm. Source: Laperche and Uzunidis [LAP 18]*

Multi-partnership innovation gives rise to hybrid forms of organization, positioned between the market and the hierarchy: subcontracting, strategic alliances, partnerships, supplier networks, franchises, supply chain systems, joint ventures and consortiums; all of which are forms of hybrid organizations and deployed at each and every stage of the production process. Such hybrid organizations are defined as "arrangements in which two or more partners pool strategic decision rights as well as some property rights, while simultaneously keeping distinct ownership over key assets, so that they require specific devices to coordinate their joint activities and arbitrate the allocation of paysoffs" (Ménard [MÉN 12, p. 1066]). There are many reasons for the development of these forms of hybrid organization (which are positioned between the hierarchy and the market, such as cooperation agreements or strategic alliances), and can be attributed to different theoretical approaches

[MÉN 12]. The theory of transaction costs (Coase [COA 37], Williamson [WIL 85]) presents alternative forms to the market and the hierarchy, which are defined according to the specificity of assets, the degree of uncertainty and the frequency of transactions. Hybrid organizations, governed by contract law, offer advantages in terms of adaptability, incentivization and control. The approach of "relational contracts" (Malcomson [MAL 12]), adds the "relational" or "non-contractual" dimension to the analysis. The importance of non-contractual, tacit or relational elements (vis-à-vis prior experience or future projects), may explain this increase in hybrid forms. Similarly, these hybrid forms, through their adaptability, enable the tensions and conflicts linked to the tacit nature of non-contractual elements to be limited and managed. Agency theory, on the other hand, emphasizes the role of incentives and financial motivations as the major reason for the development of hybrid forms by focusing the analysis on the case of franchises. Resource-based theories (Nooteboom [NOO 99], Wernefelt [WER 84]) concentrate on the pooling of very specific resources and competencies, which in turn drive partnership relations. Evolutionary theory deepens this analysis by explaining learning processes and the construction of routines, notably at the global level. Science and technology are as a matter of fact generated through global strategies of multinational corporations organized as network firms.

2.2.2. *The formation of knowledge capital and multi-partner relations: open innovation*

Multi-partner innovation (or open innovation) is understood here as a generic model that integrates all the available forms of openness that a company can draw on from its environment in order to innovate. It suggests that the management of innovation activities by the firm has been changing over time, from a "closed" to an "open" process through which "valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well" (Chesbrough [CHE 03, p. 47]).

According to this author, the open innovation paradigm replaced the earlier paradigm of closed innovation as of the end of the 20th Century. The logic of the closed innovation paradigm was an internally focused logic wherein companies financed, generated, developed, built and marketed their inventions. We could say that it broadly corresponded to the linear model of innovation that prevailed after the Second World War, where innovation resulted from a succession of separated steps (in time but also institutionally), from scientific development to the diffusion of new products and services (see Chapter 1). This model started to be undermined at the end of the 20th Century due to a combination of factors, such as the growing mobility of high skilled workers, the growing presence of private venture companies, and new possibilities to market internal ideas and the increasing capabilities of external suppliers. The economic context where innovation performance is the engine of competition and where profitability imperatives constrain the investment policy of firms is also an important factor in explaining the rise in collaboration for the formation of the knowledge capital. Open innovation strategies promoted the growing importance of networks, considered as knowledge factories and boosters of knowledge (Laperche *et al.* [LAP 10]). This all takes place within the networks that these firms now use to build up their knowledge capital.

While Chesbrough emphasizes the novelty of the "open innovation model" by contrasting it with a "closed innovation model", a number of scholars argue that open innovation is essentially a continuum of innovation, collaborative innovation or networking. Callon [CAL 99] emphasized the role of the parent associations of sick children in the increase in scientific research activities; Von Hippel [VON 05] emphasized the integration of pilot users upstream of the innovation process and more globally the role of consumers [VON 16]. While this model of open innovation is now regarded as dominant, historical studies of innovation patterns highlight open innovation processes that were already visible in the United States at the start of the 20th Century (Mowery [MOW 09]). The rapprochement of science and technology presented above also substantiate this. However, the literature on scientific and technological co-operation clearly shows that the 1980s marked a turning point in the strengthening of interfirm cooperation (Chesnais [CHE 88], Colombo and Garone [COL 96]), but also the strengthening of other forms of cooperation (especially between companies and academic institutions).

According to the open innovation model, firms collaborate at all stages of the interactive innovation process (design, production and commercialization), and with multiple partners. The analysis of collaborative innovation with an "open" approach defines two main processes of open innovation (Chesbrough *et al.* [CHE 10]). The first is known as *inbound* or *outside-in* OI that refers to the exploration and integration of external resources for the development of internal knowledge. The second is known as *outbound* or *inside-out* IO that externally exploits the technological capacities through various paths of commercialization, intellectual property licensing, technology transfers or spinoffs. A third one is also mentioned as a coupled process, which mixes the “outside-in” and “inside-out” processes while dealing with different partners engaged in the same R&D project.

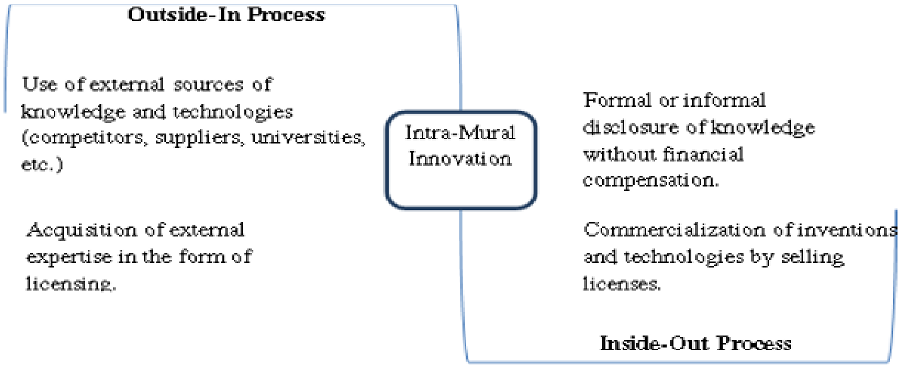

Figure 2.3. *The mechanisms at work in open innovation. Source: Picard [PIC 14]*

If we return to our knowledge capital scheme, we can thus consider that open innovation is concerned with two main poles of knowledge capital (see Figure 2.4).

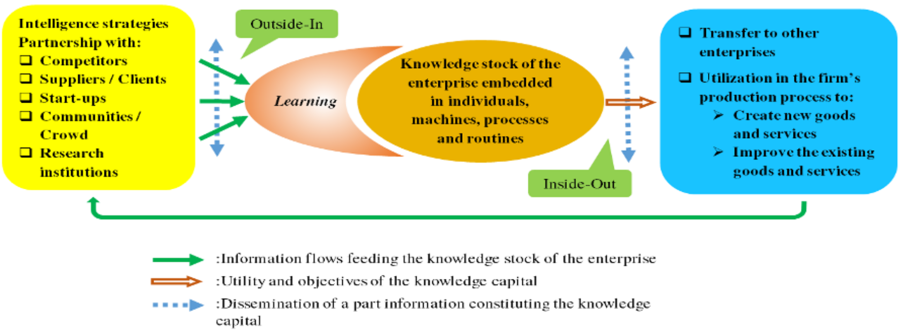

Figure 2.4. *Open innovation and knowledge capital. Source: Author*

Through intelligence strategies and partnerships with various actors (in the form of other competitors, suppliers, start-ups, clients, and research institutions), firms achieve the inbound process (outside–in), which will contribute to feeding the knowledge stock of the enterprise. At the right-hand side of the diagram, through the transfer to other companies via, for example, intellectual property licensing or spinoffs (inside-out), the firm commercializes and gives value to its knowledge stock.

2.2.2.1. *Large enterprises and open innovation*

Large firms are of course pivotal when dealing with the open innovation process. Studying the way they build their knowledge capital helps one understand the evolution of the firm's boundaries (from an integrated company to a networked one), and the innovation process (the role of open innovation and the building of innovation networks). As a matter of fact, the formation of a large enterprise's knowledge capital implies the gathering of different types of inputs, that is, human resources (competences of researchers and engineers), tangible resources (machines and tools) and intangible ones (patents, software, information, know-how, methodologies and protocols). The cross fertilization – through interactions – of all these sources of information and knowledge is at the origin of the firm's knowledge base, built and recombined throughout its history according to its innovation projects. The enterprise has to produce and appropriate scientific, technical and commercial knowledge and promote their interactions in order to expand the knowledge base it has already accumulated. Different means are used: internal (or in-house) means (investment and management of human resources, R&D and tangible and intangible resources) and external means (see Table 2.1). External knowledge is neither opposed nor supplementary to the internal knowledge base, but rather strictly complementary, as shown by Antonelli and Colombani [ANT 15] in their recombinant approach of technological knowledge generation: "The generation of new technological knowledge, at each point in time, by each agent, in fact, is strongly influenced not only by the internal accumulation of knowledge but also by the flows and stocks of knowledge made available by the other firms that belong to the system into which each firm is embedded" (p. 279).

Internal R&D corresponds to activities that occur very early in the development of new products (these are often carried out in cooperation with universities), but also in the development, testing, production and operation of existing products. They enable the development of new knowledge and know-how, but also the accumulation of freely circulating knowledge, by interpreting and evaluating it, transforming it into specific and partially tacit knowledge, which is therefore difficult to reproduce. The firm's internal research is thus essential to the monitoring and evaluation of research taking place elsewhere, that is, essential to increasing its capacity to absorb information being produced elsewhere by the firm (Pavitt [PAV 92]). Therefore, for N. Rosenberg [ROS 90], internal R&D expenditures are for firms "a ticket of admission to an information network" (p. 170).

In 2016, the top 1,000 firms who spent the most on R&D, spent USD $680 million on this activity, a sturdy amount when compared to the previous year, at the same time as their revenues decreased, which in turn increases the intensity of their R&D (ratio of R&D expenditure on revenue). Present in the top 10 are some very large companies (see Table 2.2) that operate globally and are predominantly active in the fields of computing, software and health.

Internal (in-house) means	External means
Investment in human resources. Investment in and management of R&D and the means of production (both tangible and intangible).	*Equity relations* Joint venture Acquisition of innovative enterprise Alliances *Non-equity relations* Contracts (including licensing) with other (industrial and service) firms. Contracts (including licensing and hiring of short-term researchers) with institutions: e.g. university research labs. Participation in common research programs (e.g. European research programs). More informal contacts.

Table 2.1. *Internal (in-house) and external means for the formation of a firms' knowledge capital*

External means can be divided into two categories: equity relations (for example joint ventures, the acquisition of start-ups) and non-equity relations (contracts with other firms and institutions, and more informal contacts) (see Table 2.1).

Partnerships (non-equity relations) may deal with precompetitive research, the design of new products and services, product development and product diffusion, each implying a different assembly of partners. In all cases however, the aim of reducing the risk, cost and length of the innovation process is apparent with the overarching aim of satisfying the profitability imperative.

Company	R&D spending ($M) (2016)	R&D intensity (%)	Headquarters	Industry
Volkswagen	13.2	5.6	Europe	Automobile
Samsung	12.7	7.2	South Korea	Computing and electronics
Amazon	12.5	11.7	North America	Software Internet year
Alphabet	12.3	16.4	North America	Software and Internet
Intel	12.1	21.9	North America	Computing and electronics
Microsoft	12	12.9	North America	Software and Internet
Roche Holding	10	19.9	Europe	Healthcare
Novartis	9.5	19.2	Europe	Healthcare
Johnson & Jonson	9	12.9	North America	Healthcare
Toyota	8.8	3.7	Japan	Automobile

Table 2.2. *Top 10 largest R&D spenders. Source: 2016 Global Innovation 1000 study, Strategy & PWC*

Table 2.3 and the following explanations present the different types of partners, the forms of collaboration and their objectives, as the result of several empirical studies carried out on this theme (Laperche and Lefebvre [LAP 11], Laperche *et al*. [LAP 13]). The objectives are the strategies of exploration and exploitation of the organizations presented by March [MAR 91]: "Exploration includes things captured by terms such as search, variation, risk taking, experimentation, play, flexibility, discovery, and innovation. Exploitation includes such things as refinement, choice, production, efficiency, selection, implementation, and execution" (p. 71). A company must strike the right balance between exploring new knowledge and the exploitation of existing knowledge: "[…] maintaining an appropriate balance between exploration and exploitation is a primary factor in system survival and prosperity" [MAR 91, p. 71].

Type of partners	Forms of collaboration	Objectives of the firm
Academic research	– Research programs – Research consortium – International and European tenders – Researchers' mobility and PhD funding – Licensing in	– Access to an anticipated vision of the technological evolution and to new knowledge – Reduction of the risk and cost of upstream research
Competitors	– Joint ventures – International and European research programs – Research consortium – Cross licensing – Pools	– Design of future technologies – Precompetitive research – Reduction of the risk and cost of precompetitive research
Communities/crowd	– Platforms (Website) – Games and prices	- Access to the creativity of anonymous individuals or groups of individuals – Disruptive ideas – Reduction of the cost of emerging of new ideas
Suppliers/clients	– Alliances and agreements (with or without capital participation) – Licenses – Games and prices	– Access to complementary resources and co-development of products and services – Reduction of the risk and cost of product development
Small innovative firms	– Venture capital, and acquisition of start-up, spin off – Cooperation agreements within clusters – European and national research programs	– Access to very specialized competencies – Technological watch; strategic intelligence. – Reduction of the risk and cost of development

Table 2.3. *The open innovation of large companies: partners, forms of collaboration and their objectives*

2.2.2.1.1. Relationship with academic research

When large companies and universities cooperate through bilateral contracts or research consortia, the objective is often exploratory with the intention of conceptualizing and designing future technologies. The aim of collaboration with universities is to gain access to new knowledge and the probable outcome of technological evolution. One example is Saint-Gobain's SUN program, a world leader in housing, and whose strategy is directed toward sustainable housing (see Box 2.3). Moreover, companies (both large and small) may also collaborate with universities by signing licenses to exploit scientific and technical knowledge and transforming it into innovation. The mobility of researchers (for example through thesis funding) is also part of the outside-in strategies (see section 2.2.3).

> "The SUN international scientific network enables the group to have access to high-level skills and benefit from the latest scientific advances taking place in the academic world. This approach also makes it possible to increase the pool of available researchers, already taking part in sponsored dissertation and postdoctorates theses, thus expediting the hiring of excellent trained staff in strategic countries".
>
> Examples of key partnerships include:
>
> – the National Centre for Scientific Research (CNRS) in France;
>
> – the Massachusetts Institute of Technology (MIT) and the Case Western Reserve University in the United States;
>
> – the Indian Institute of Technology in Madras, India;
>
> – the University of Aix La Chapelle and the Fraunhofer Institutes in Germany;
>
> – the Moscow State University in Russia;
>
> – the National Institute for Materials Science (NIMS) in Japan.
>
> Saint-Gobain has also created three mixed Units with CNRS.

Box 2.3. *Saint-Gobain University Network. Source: https://www.saint-gobain.com/fr/innovation/une-innovation-ouverte*

2.2.2.1.2. The relationship between competing large companies: coopetition

Competitors may be required to set up an innovation or R&D partnership and engage in a coopetition strategy (Le Roy and Yami [LER 10], Brandenburger and Nalebuff [BRA 96]). Several organizational arrangements support the development of these transactions between competing firms. Competition between firms does not disappear, but rather moves downstream of the value chain. For example, when car manufacturers pool resources and thus cooperate to develop a new, greener engine, at the same time they compete instead through automotive design and product services, downstream of the value chain. Joint ventures or consortia specializing in future technologies, strategic alliances and other collaboration agreements between competing companies, as well as participation in institutional research programs, clearly have an exploratory objective that reflects on future applications with the view to eventually develop some of these ideas. This is the case of the ULCOS consortium, coordinated by the ArcelorMittal group and which involves all the major European steel companies, as well as several universities. It is designed to reduce carbon dioxide emissions from steel production (see Box 2.4). Nevertheless, as this example shows, the development of new technologies is a long and costly process, and success is not necessarily guaranteed.

The ULCOS consortium was launched in 2004, bringing together 48 companies (including the main European Union steel companies, as well as energy and engineering partners) and organizations (research institutes and universities) from 15 European countries, as part of an R&D collaboration initiative aimed at reducing carbon dioxide emissions from steel production. The objective of the ULCOS program is to reduce CO_2 emissions by at least 50% in relation to the current most efficient production methods. Arcelor Mittal was the main coordinator of the program.

The work of this consortium has covered various fields: steel production, biomass production, geological storage of carbon dioxide (CO_2), process science, engineering, energy management and studies on prospective climate change.

The total budget over the period of 2004–2010 amounted to €75 million. The partners of the ULCOS consortium financed 60% of this programme, while the European Commission subsidized the remaining 40% through its 6th Framework Program and the FRCA (*Coal and Steel Research Fund*) project. These two programmes were designed to promote industrial research and technological development within Europe.

The second phase of the ULCOS program: ULCOS II (2010–2015) was aimed at the analysis of some technologies explored in ULCOS I in order to evaluate their potential and feasibility for industrial production on a larger scale. However, as a result of the closure of the ArcelorMittal site in Florange (France), which was to become an industrial demonstrator of the new technologies under development by the consortium, and the fact that the technologies developed were not yet ready to enter a test phase with the industrialization process requiring further research, the UCLOS programme was terminated.

More precisely, and at the level of ArcelorMittal, the ULCOS program was replaced in 2013 by the LIS program, for *Low Impact Steelmaking* where the main investors are Arcelor Mittal, ADEME (French environment and energy management agency), and local authorities. This program, which has the same objectives as UCOS (gave rise to a new generation of energy-efficient, low carbon-producing furnaces), although less ambitious, is nonetheless also carried out in partnership with several French research centers, including the University of Lorraine.

Box 2.4. *Collaborating with competitors: ULCOS Consortium: from "ultra-low carbon dioxide (CO2) steelmaking", to the low impact steelmaking (LIS) programme. Sources: Interviews in 2011 and 2017, http://www.ulcos.org/fr/ and http://corporate.arcelormittal.com/sustainability/whats-new/sd-updates/yr-2015/breakthrough-low-impact*

2.2.2.1.3. Relations between businesses, communities and the crowd

Multistakeholder innovations that involve communities connect the company to partners who are not identified as individuals (as in the case of free software community or crowdsourcing, see Box 2.5). One of the aims of this type of institutional arrangement is to involve potential users from the outset of the design process and to encourage the emergence of new types of implementation (see Barbaroux *et al.* [BAR 16]). This is clearly a process that uses the knowledge or skills of these users. This is part of the exploration strategy (search for new ideas by companies).

As Barbaroux *et al.* [BAR 16] explain, the concept of crowdsourcing was formalized by J. Howe in 2006, in the *Wired* journal, and is a contraction of the terms *crowd* and *outsourcing*. It is thus the outsourcing of an activity via a Website to a large number of individuals whose identity is not known. One of the reasons for this type of practice is to feed the knowledge capital of the company with external knowledge, derived from the creativity of individuals. An example presented in several publications is the Danish group Lego. While the well-known Lego company relied on its internal research for many years, due to difficulties encountered in the early 2000s, it had to change the organization of its innovation process by building on a crowdsourcing platform, first named Lego Cuusoo, then Lego Ideas since 2015. On the dedicated Website, anyone registered can propose a game box concept and vote on the submitted projects. From a database of 10,000 supporters, the project team then decides on which product to develop, and its creator receives a remuneration that amounts to 1% of the generated revenue. By the end of 2015, more than 5,000 models have been offered since the creation of this platform with 14 ideas having been the result of competitions.

Box 2.5. *Cooperating with the crowd: the Lego group case study. Source: Barbaroux et al. [BAR 16], Pénin et al. [PEN 13]; https://ideas.lego.com/*

2.2.2.1.4. Relations between partner companies: suppliers and customers

Companies also cooperate with their customers and suppliers, with a specific focus on exploitation, in the sense of March (see above). Partnerships with customers and suppliers focus on applied research and the development of joint products to reduce development costs. The creation of partnerships with non-competing suppliers or companies enables the development of new products: this strategy is based on the desire to combine complementary skills or assets (Teece [TEE 86]) in order to explore the boundaries of their core business (Laursen and Salter [LAU 06]). The most recent research focuses on the role of different categories of suppliers, including the role of remote suppliers, that is, from different sectors of the business (see Box 2.6). In some cases, suppliers may be at the origin of radical innovations, which may ensue as a result of exploration strategies.

In a recent article (Ben-Mahmoud Jouini and Charue-Duboc [BEN 18]), the authors investigate the role of suppliers in the emergence of discontinuous innovations (i.e. radical or disruptive innovations). They study the case of an automotive supplier, one of the top 10 in the automotive industry. This company has created an independent entity dedicated to the emergence of discontinuous innovations, in particular for the powertrain engineering in order to reduce consumption and emissions. Six years after the creation of this team, it appears that half of the discontinuous innovations identified and prototyped are the result of relations with distant suppliers (often small SMEs or start-ups). The authors study the methods of establishing relations with these remote suppliers.

Box 2.6. *The role of remote suppliers: the case study of automotive equipment*

Customers and more generally users are also recognized as having a growing role in product improvement and are increasingly seen as partners, as highlighted by the recent discussion on crowdsourcing. Depending on the sector, between 10 and 40% of customers (firms or individuals, often major clients) are involved in the development or codevelopment with producers, with the aim of modifying the final product (Von Hippel [VON 05]). By finding a solution that better meets their needs they get a head start regarding the major trends of the market.

2.2.2.1.5. Relations with small innovative companies: start-ups

Through venture capital, companies develop their business intelligence strategy and also stay in touch with new technologies proposed by start-ups. Start-ups may be bought at the end of the process. In this case, the development cost of the start-up is shared between several investors (Tidd *et al.* [TID 05]). They may also integrate the firm's network through collaboration agreements (licensing-in or licensing-out contracts).

NOVA External Venturing is the Saint-Gobain team dedicated to creating strategic partnerships between the Group and start-ups all over the world. The mission of this entity is to combine innovative start-up projects with the industrial and commercial resources of the group in order to increase the innovative capacities of young companies as well as of the group as a whole.

The cooperation can take a variety of forms: intellectual property licenses, joint technological developments, joint production ventures, commercialization agreements and more rarely, direct shareholding.

The priority areas of intervention are as follows:

– building materials and easy-to-install solutions that improve energy efficiency, safety, comfort (visual, acoustic, thermal) and air quality;

– clean technologies such as biomass, biopolymers, renewable energy, low CO_2 footprint materials and recycling;

– systems and solutions that integrate natural or artificial light into buildings and automobiles;

– construction services: software solutions, installation of renewable energies, value-added services for craftsmen, renovation and energy performance;

– innovative technologies for demanding industrial applications (abrasives, ceramics, crystals, glass and plastics).

As of 2015, the Nova External Venturing unit had examined more than 2,600 start-up companies and had signed 65 global partnerships.

Box 2.7. *Cooperation with start-ups: Saint-Gobain's Nova External Venturing. Source: Interview with the group, 2011, https://www.nova-saint-gobain.com/en/*

Work along this theme focuses on the contribution of small enterprises to groups in terms of technologies and know-how. Tidd *et al.* [TID 05] highlight the power of networks in terms of breakthroughs and radical innovation, and the key roles being played by innovative small enterprises. By using small specialized firms that perform well in their specific domain or sector, groups can access technologies outside their usual fields and can integrate complementary and innovative technologies and skills into their knowledge capital. Some groups, such as Saint-Gobain with its Nova External Venturing program, develop specific programs dedicated to the identification of start-ups with whom the company can collaborate. Collaboration with small companies also allows them to produce at a lower cost by shortening the development cycle. For small enterprises, collaboration contracts are a means of accessing better testing laboratories as well as access to the large enterprise market. Exploitation and exploration are thus mixed objectives when large firms collaborate with start-ups. It should be noted that small innovative companies also take part in the inside-out process, notably in the exploitation of patents owned by the group with which they cooperate.

Thus, today the process of knowledge creation is the result of a set of partnerships between the (more or less independent) units of a network firm, other network firms and other institutions (universities, research labs).

In this context, the question on the size and the power of the firms is no longer defined solely according to the ownership of assets, but also, and above all, to their capacity to absorb and appropriate assets, in particular intangible assets produced through contractual relations.

This is explained in detail by Rajan and Zingales [RAJ 00]. According to these authors, in an economy based on knowledge, where the critical resources of firms come about more from human capital than physical capital, the boundaries of the firm are no longer determined by the ownership of physical assets, but through the synergies created by the contractors. By conferring on some key subcontractors, the privilege of being able to access the firm's key resources (the authors give the example of subcontractors for Toyota, who have access to some parts of – one could say – its "knowledge capital"), the firm encourages subcontractors (who are in a situation of "managed competition") to carry out specific investments that could only be valorized through the firm. On the one hand, it is access given to certain key resources that will give the firm more power, and, on the other hand, the dependence of the subcontractor will be strengthened alongside the large enterprise. In other words, the power and capacity of the firm depends less on the ownership of physical assets than on the capacity, via their specificity and their synergy, to appropriate the intangible assets developed in common, but within independent entities.

2.2.2.2. *Small enterprise, knowledge capital and open innovation*

The creation of knowledge capital within SMEs, and in particular their open innovation strategy, is more difficult to grasp. In order to better understand their strategy, we have used the two concepts of absorptive capacity and open innovation, which as explained previously fit nicely into our scheme of the knowledge capital (Liu and Laperche [LIU 15]).

A leading feature to put forward is that empirical research on SMEs and their absorptive capacity mostly does not focus on the distribution of absorptive capacity in terms of the firm's size but rather on its role in the enhancement of performances (e.g. Laursen and Salter [LAU 06], Pavitt [PAV 98], Schmidt [SCH 05]). Moreover, the indicators of absorptive capacity are a subject of debate. While being a multidimensional concept, the measure of absorptive has remained mainly based on R&D proxies, that is to say R&D inputs (notably R&D intensity) and outputs (especially patents) even if some recent works try to improve this measure by including new criteria (like non R&D investments linked to innovation, collaborations and knowledge management tools) (Flatten *et al.* [FLA 11], Liao *et al.* [LIA 03], Som *et al.* [SOM 13]). However, these indicators that build upon the model of innovation for large corporations are not well adapted to the practices of SMEs (Bougrain and Haudeville [BOU 02], Gallié and Legros [GAL 12], Huet and Lazaric [HUE 08]). Due to their weaker human and financial resources, as compared with larger firms, SMEs appear to be less effective in terms of absorptive capacity as measured by traditional indicators. In 2011, SMEs (with less than 250 employees) of OECD countries performed on average 32.6% of total business R&D while the other 67.4% were performed by larger firms. Although they may file more patents, in terms of the total number, than big firms, they have a lower grants rate and a higher withdrawal rate (Frietsch *et al.* [FRI 13]).

A second issue deals with the knowledge management capacities of SMEs. As a matter of fact, small firms are qualitatively different from big companies in terms of management systems, internal resources and behaviors. In particular, they are characterized by a particular "small business mindset" (remaining small to be flexible and independent) that contributes to their survival, but also limits the growth of their absorptive capacity (Anderson and Ullah [AND 14]). The number and quality of R&D personnel can have a direct impact on an SMEs' internal capacity to absorb acquired knowledge and its ability to create new knowledge. Therefore, in order to access and exploit the knowledge of outside partners, SMEs need to have qualified R&D personnel and must invest continuously in human resources (Muscio [MUS 07]). The small size of the R&D team will limit their "transformational capacities", which define their ability to transform available general knowledge into locally specific knowledge. This will also limit their "configurational capabilities", which emphasize the firms' aptitude to efficiently identify and access knowledge and to reconfigure and redistribute repositories of knowledge (Bender [BEN 08]). This explains the weakness of SMEs (in particular those in traditional sectors) in exploiting external sources due to their lack of proficiency in networking or in other forms of transorganizational interaction [BEN 08].

Concerning their open innovation strategies, the small size of SMEs may indeed be an advantage as they are more flexible than big corporations, in terms of mobilizing and exploiting external resources (Narula [NAR 04], Nooteboom [NOO 94], Rothwell and Dodgson [ROT 91]). On the contrary, their smallness also limits the development of their capabilities to exploit external resources, which condition their knowledge capital development. Since SMEs are often specialized within one family of knowledge and use less structured innovation strategies, they more frequently use collaboration and inbound open innovation processes, while large companies have more collaborative partnerships and different channels of diffusion (Parida *et al.* [PAR 12], Vanhaverbeke *et al.* [VAN 12]). Technology intermediaries are essential in helping SMEs search for and exploit new knowledge (Kodama [KOD 08], Spithoven *et al.* [SPI 11]). Moreover, compared with large corporations, SMEs prefer cooperating with market sources (clients, suppliers, customers) rather than horizontal partners, which are mainly comprised of universities, public research centers or government agencies as well as with international partners (OECD [OEC 13b], Zeng *et al.* [ZEN 10]). Finally, their capacity to involve in-/outbound open innovation is constrained by their practice of intellectual asset management. The most innovative SMEs implement sophisticated open innovation strategies, as is the case in biotechnology (Gassman and Keupp [GAS 07]). In this field, the commercialization of their technologies is one of their core competencies and provides a means of rapid growth. However, the use of outbound open innovation – which is largely built upon the exploitation of IPRs – is restricted by their general lack of IPR awareness and IPR strategy and their preference for non-statutory methods (mainly trade secrets) (Gallié and Legros [GAL 12], Ollivier and Simon [OLL 13]).

To cope with these disadvantages, SMEs need to look out for new resources and opportunities, which they usually find within innovation networks. Being part of an innovation network provides SMEs not only with new knowledge for product development but also channels of commercialization. By joining a business group for example, SMEs can overcome their natural constraints (financial and human resources), make up for the shortfall in terms of economies of scale and improve the scope inherent to their small size. SMEs that belong to an innovation network, especially those that cooperate with large companies, more actively practice outbound open innovation (Vanhaverbeke *et al.* [VAN 12]). Through the collaboration with large firms, SMEs can not only reinforce their own knowledge capital but also contribute to the formation of knowledge capital in large companies.

The interest in taking into account the two concepts of absorptive capacity and open innovation in the analysis of innovation activities is illustrated by the case of French SMEs. When studying the results of European and notably French innovation, it has recently been popular to present a paradox between quite important efforts and results in term of R&D with scientific inputs and outputs, and the poor results in terms of innovation (patents, new products diffused on markets, new businesses, etc.) (Bitard *et al.* [BIT 08], Edquist and McKelvey [EDQ 98]). We have decided to use the case of French SMEs to illustrate our analysis and to see whether or not this paradox was observable when focusing on SMEs. Indicators of innovativeness for SMEs (less than 250 employees, data compiled from OECD STI Scoreboard 2013) indeed revealed the existence of a "French Paradox" (for details regarding the building of this case study, refer to Liu and Laperche [LIU 15]).

In 2011, according to INSEE, French SMEs represented 99.8% of French firms and hired 50% of total employees [INS 14]. SMEs represent only a fraction of the business R&D in OECD countries but more than their main partners. As shown in Table 2.3, in 2011, SMEs performed 22.6% of total business R&D in France (which ranks France 21st out of the 28 OECD countries studied), 21.8% in United Kingdom, 14.9% in the United States, 11% Germany and 4.4% in Japan. Meanwhile, they funded 23.6% of business R&D expenditures in France, 19.8% in UK, 9.7% in Germany, 16.3% in the United States and 4.4% in Japan. Compared with its main trade partners, French SMEs therefore make a greater effort in R&D, but their results in terms of innovation output are weaker. If we look at the output of innovation activities, measured by the number of patents, during the period of 2009–2011, French SMEs have one of the lowest proportions (57.5%) of patents owners of the total number of firms (with more than 20 employees) of OECD countries, which is only marginally better than Germany (55.4%) and Japan (27%). The share of patents filed by young firms under 5 years and the average number of patents filed by young firms under 5 years in France is also under the OECD average [OEC 14], with the exception of business-sector services (Figure 2.5). The paradox, which we call here the "French Paradox", is that the result of the innovation activities of French SMEs does not correspond to their efforts.

	FRA	UK	GER	USA	JAP
Business R&D performed*	**22.6**	21.8	11	14.9	4.4
Business R&D funded by firms*	**23.6**	19.8	9.7	16.3	4.4
Patents**	**57.5**	62.4	55.4	61.8	27
Trademarks**	**68.8**	64.6	65.9	84.7	17.3

*Of SMEs (1–249 employees), as percentage of total business sector, in 2011.

**Firms (20–249 employees) with trademarks and patents as % of firms with more than 20 employees, 2009—2011.

Table 2.4. *Selected indicators of the innovativeness of SMEs in selected OECD countries. Source: Data compiled from OECD STI Scoreboard 2013, OECD StatExtrats and Eurostats*

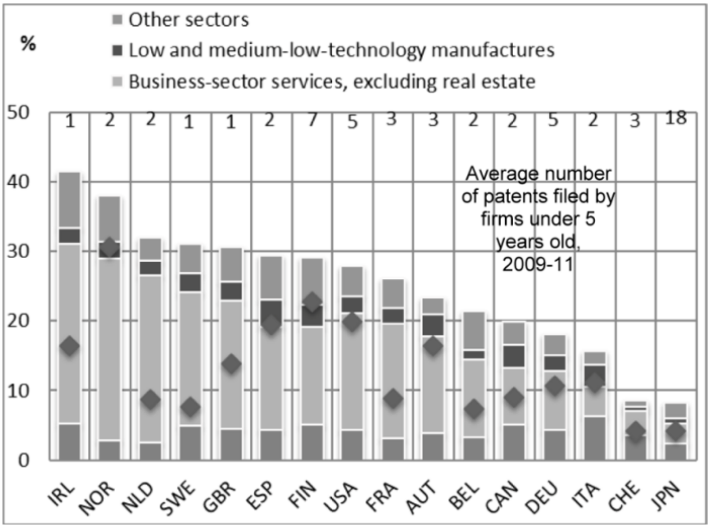

Figure 2.5. *Patenting activity of young firms by sector, 2009–2011*

To explain this paradox, we decided to go deeper into the analysis of the knowledge capital of SMEs in order to ascertain if there are some specific characteristics in terms of both absorptive capacity and external partnerships (open innovation). According to us, this identified French Paradox may be explained by the following:

– *Structural characteristics of SMEs in general and hence of French SMEs:*

A major explanation of the paradox is that the innovation performance of French SMEs is underestimated due to the difficulties of collecting data related to SMEs' R&D efforts and the lower visibility of incremental or non-technological innovations (Reboud and Mazzerol [REB 14]). Performance of French SMEs reveals they operate better in marketing and organizational innovation than in product and process innovation. Indeed, incremental and marketing innovations, as measured by the trademarks, although not directly contributing to technological progress (measured by patents), involve the use of new technologies and knowledge. The low results in terms of patents can be partly explained by the fact that countries with a strong services sector, like France, tend to use more trademarks for protecting their intellectual assets [OEC 10].

Moreover, the poor results of French SMEs in terms of patents might be biased by their intellectual asset practices since they prefer non-statutory methods, in particular trade secrets, to protect their knowledge capital (Gallié and Legros [GAL 12]). Moreover, the traditional indicators for absorptive capacity that are developed for big firms do not reflect the reality of SMEs [HUE 08]. Instead of having an R&D department like big firms to generate radical innovation, they instead have a *design office* consisting of engineers and technicians with a focus on incremental innovations. This helps them to better extract the benefit of innovation collaboration (Bougrain and Haudeville [BOU 02]).

Hence, the capacity of cooperation of SMEs is more closely correlated to skills and strategy than R&D intensity. The decision to collaborate in SMEs is related to their capacity for interaction, which is conditioned by their transformational capabilities and cognitive distance (Nooteboom [NOO 94, NOO 00]). Therefore, French SMEs will cooperate more easily under the condition of cotechnological development and through the similarity of skills (Huet and Lazaric [HUE 08]). Moreover, their configurational capabilities are also essential, since SMEs with effective knowledge management are better organized for networking and interacting with external resources because they know where to find knowledge and what to do with the knowledge once it is acquired (Boly *et al*. [BOL 14]).

The structural characteristics of SMEs, mostly related to absorptive capacity, appear to be a major factor in explaining the French Paradox. However, another important part of the explanation stems from their particular place within innovation networks, as revealed by the review of their open innovation practices.

– *Innovation policies and their impact on the knowledge capital of SMEs:*

One main explanation of the French Paradox is that SMEs do not valorize their knowledge capital themselves but through innovation networks. Their efforts in terms of investments thus may not be visible. This can partly be explained by the evolution of innovation policies. In the past, these policies were mostly focused on large companies (the "national champions" in the period of growth following the Second World War), but in the 1980s, they were directed more toward SMEs. In addition, the current evolution of these policies (in France and the world over) is orientated toward the building of networks and is considered as the main tool for innovation performance (Laperche *et al*. [LAP 10]).

As a matter of fact, the French innovation policies toward SMEs have been criticized as concentrating on the reduction of costs of innovation by favoring the "individual growth" of firms (direct and indirect measures, public procurement) and static efficiency through the sharing of equipment (Carré and Levratto [CAR 09]). Indeed, French public policies put an emphasis on entrepreneurship and in particular, high-tech start-ups. This is still the case ever since the late-2000s with the promotion of start-ups and innovative SMEs through various instruments such as direct financial support (or indirect, exoneration for venture capital or business angels, research tax credit, etc.), coaching and networking services (incubators, clusters, technological transfer services, etc.) or public procurement policies ([LIU 13a, LIU 13b], Uzunidis *et al*. [UZU 14]). However, under the new French innovation policies that have been in play since 2005, SMEs are pushed to collaborate with other firms, in particular the bigger ones, on R&D projects with the aim of increasing managerial know-how and to intensify links between firms, most notably through clusters.

These elements lead us to consider that the French innovation policy, favoring the collaboration between SMEs, intermediate-sized enterprises and larger companies, contributes to the explanation of the French paradox. SMEs are indeed part of the open innovation strategies of large companies, as explained above. An accurate analysis of innovation networks in France reveals that innovative SMEs are indeed strongly linked with larger corporations. These strong links may offer an explanation for the French paradox: the poor results in terms of innovation would not reveal poor competences in terms of the valorization/use of their knowledge capital but rather a valorization of SMEs' knowledge capital through networks built by large companies. In other words, the knowledge capital of small French innovative companies would be used to enrich the knowledge capital of other companies. These strong links are shown first by the role of corporate venture capital in the birth and growth of small innovative businesses, and second, by the structure of innovative collaborative projects, which are mostly carried out in the framework of French clusters (*pôles de compétitivité*). Moreover, the buyout of young French technological firms by French or foreign groups appears to be frequent (Barrot *et al.* [BAR 11]).

The influence of large corporations is also observable in partnership and collaboration practices. In France, it is through research programs at the national and European levels, or through clusters, that SMEs are encouraged to work with large groups. Although there are various schemes that support collaborative innovation such as the cluster policy (*pôles de compétitivité*), the national research agency (ANR) or strategic industrial innovation fund (ISI), the clusters provide the most important sources of partnership and funding for collaborative SME projects.

Large companies weigh in heavily when it comes to the governance of clusters, largely due to their financial capacities to support the operation of the cluster and the visibility that they bring (Bearing Point [BEA 12]). As the figure below shows, the two most common forms of partnership between firms and public research partners in French clusters are (1) one or several large companies as the leader(s), surrounded by partner SME(s) and public research institution(s) and (2) SME(s) as the leader(s) collaborating with academic partner(s). These two forms often coexist within a cluster where the "subclusters" that are based on different research projects can be easily identified, as in the case of microelectronic and IT system solutions (Dang [DAN 11]).

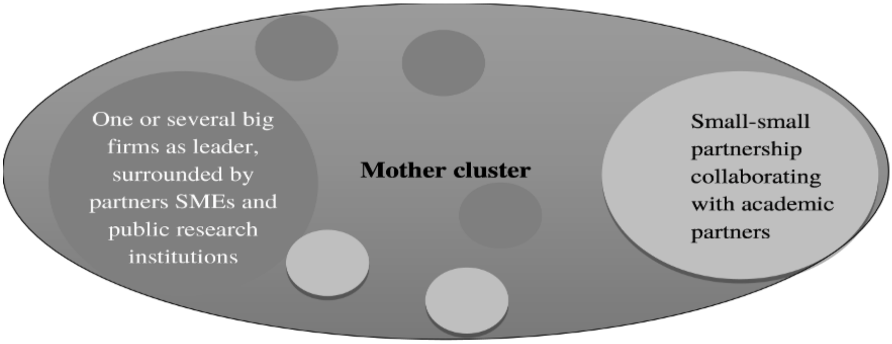

Figure 2.6. *Forms of partnerships within competitiveness clusters. Source: Liu and Laperche [LIU 15] based on Dang [DAN 11]*

In the first form, the large firm often plays a crucial role in the governance of clusters, as is the case with the Valéo, Saint-Gobain, Renault or PSA projects, where they have initiated R&D programs involving SMEs (Laperche and Lefebvre [LAP 11]). SMEs in these clusters are often in the position of subcontractors, which lead to interdependencies. SMEs innovate and are specialized in high-quality services or products in order to satisfy the needs of big firms. Their technological specialization is built around the core technology of the cluster (Dang [DAN 11]). In the second form, while academic partners are the key source of knowledge for SMEs (Bearing Point [BEA 12]), the latter executes wider searches for partnerships and opportunities outside the existing network [DAN 11].

The explanation as to the poor results for the valorization of SME knowledge capital is that one part of the French SMEs' knowledge capital is not directly valorized on the market. SMEs belonging to innovation networks dominated by large firms are involved in their innovation processes and it is through this that their knowledge capital is valorized. The question of the consequences of these strong ties between innovative SMEs and large companies may yet arise.

For an SME, taking part in the innovation strategy of a larger company may be an essential means by which it improves its technological product in terms of process development, since it may benefit from the financial, technological and marketing support of the large company, which in turn will reinforce the SMEs knowledge capital. It is thus for them a powerful means to be profitable and even sometimes a way to survive. However, this collaboration may be difficult due to the unequal and asymmetrical power relations between the two partners. In the case of conflicts, for example dealing with the intellectual property rights of co-developed products, the SME may be at a disadvantage due to its weaker resources. The strong links developed within a "closed" cluster built upon large companies will increase the SMEs' dependency on large companies to valorize their intellectual assets, and thus reduce the scope for alternative channels of commercialization.

2.2.3. *Public research in the service of knowledge capital*

The relationship between public research and businesses today is a very close one. Currently, scientific work is the activity of academics and researchers in major public research institutions. The space within which this work is carried out is constantly expanding, and collaboration is gradually going beyond the compartmentalized body responsible for the majority of scientific and technical advancements. Science throughout the 20th Century flooded the market with the advent of salaried employment for researchers within companies, although in many cases this was above all due to the alliance with the State, which helped to finance this transition immensely. At present, the market is knocking at the doors of universities and public research centers, attempting to imprint its own terms on the execution of scientific work, under the consent of the State and the researchers of course. It was during this period that the modern sense of research commercialization has emerged. This can be defined as the process of transforming basic knowledge into new markets, new goods or services. Valorization (literally the process by which value is assigned) is achieved through collaboration between public research and business, or the mobility of researchers. It usually stipulates a private appropriation (exclusive or not) of the products of the research.

Public research is called upon to meet the objectives of profit and growth of enterprises (Uzunidis [UZU 01]). The transfer of scientific resources is at the heart of the creation of innovation networks that feed into the production potential of a given country as well as the knowledge capital of firms. The main forms for the commercialization/valorization of public research that can be identified are as follows:

– scientific collaboration: joint programs carried out in partnership between universities or public research centers and enterprises;

– exploitation of research results (patenting by universities and negotiation of operating licenses bringing in revenue for universities);

– the mobility of researchers: young doctoral students belonging to a public research laboratory will prepare their thesis in a company (the thesis is financed in part by the company); a researcher or a team of researchers provides scientific assistance or advice to a company, etc.;

– the creation of companies by the researchers themselves (academic spin off). The researcher must take on the role of entrepreneur.

All these methods of research commercialization have a contractual basis that crystallizes the power relations between the academic and corporate worlds. However, these forms of valorization are not at all new. Research contracts between universities or public research centers and companies have existed for a long time, although they were rather difficult to implement in some countries due to differences in accounting (private and public). Similarly, the cofinancing of theses is not new, but mobility now extends to other categories of personnel (such as public sector researchers). The two truly new forms of research commercialization are first, the ability to file and exploit industrial property titles, and second, the creation of enterprises based on academic research. The phase of intense rapprochement between public research and enterprise started in the last 20 years of the 20th Century and was partly based on the advancement of knowledge at the frontier between science and technology, which broadens the fields of patentability (Jaffe [JAF 00], Mowery *et al*. [MOW 01]). In addition, these developments were also stimulated by a transformation of the regulatory frameworks.

Indeed, the current rapprochement between public research and business is not a natural or spontaneous process. It has been facilitated by the introduction of a new set of laws and rules by public authorities. In the United States, where relations between universities and companies are traditionally narrow, the Bayh Dole Act, adopted in 1980, has enabled universities and public R&D bodies to valorize their results, specifically empowering the researcher to file patents that come about as a direct result of publicly funded research (Etzkowitz [ETZ 98], Grimaldi *et al.* [GRI 11], Henrekson and Rosenberg [HEN 01], Jaffe [JAF 00], Mowery *et al.* [MOW

01, MOW 04]). This law, which provides a framework for national action (or institutional framework) is conducive to collaboration between universities, public research bodies and private companies, and has become the model for many European countries.

In France, for example, the 1999 Act on Innovation and Research (loi Allègre) adds a third mission of commercialization to the traditional research and teaching activities. It gives universities and public research centers the opportunity to file patents, and makes contractual relations with companies more flexible. It also allows researchers to set up their own business, and to advise or participate in the capital of companies. The various laws in France have changed the way research is assessed and financed, as well as the status of universities (2007) and the organization of technological transfers (the creation of technology transfer organizations). These are part of a continuous trend toward the institutional strengthening of the ties between universities and enterprises (Laperche and Uzunidis [LAP 11]). These policies have thus contributed to the rapprochement between science and the market through the development of the knowledge market. Many other countries have undergone significant changes in their university system: Europe (see, in particular, Vol. 13, No. 3 of the *Management Review of Higher Education of the OECD*, 2001 (Wright *et al.* [WRI 07]), Asia (Kodama [KOD 08]), Latin America (Arocena and Sutz [ARO 01]), Canada (Menzies [MEN 00]) and so on. The time has come for contracting to be the foundation for innovation.

As a result, universities have adopted entrepreneurial standards; these become, according to the expression of Clark [CLA 98], "entrepreneurial universities" by integrating market requirements into their operations (commitment to results, competition and emphasis on applied research) while trying not to neglect their day-to-day functions (education and basic research). They have set up Technology Transfer Offices, incubators and science parks. This third mission, that of research commercialization, gives birth to the figure of the "modern scientific entrepreneur" who, with no bad conscience, makes the link between basic research (and the search for truth) and industry (see Etzkowitz [ETZ 98, ETZ 03], Laperche *et al.* [LAP 08]). The most recent research focuses on the diverse forms of researcher' involvement, which are not only reflected in the application of industrial property titles or the creation of enterprises, but also which takes place through informal or individual collaboration, such as collaborative research consulting, joint thesis management, etc. (Perkmann and Walsh [PER 08], Perkmann *et al.* [PER 13]). Student entrepreneurship, a topic less studied, is nevertheless a form of university relations with industry and society. In

France, the PEPITE system (see Box 2.8), is designed to make it easier for a student with a business project to become a student entrepreneur. As companies, universities and higher education establish open and collaborative spaces (*open labs* or *fab labs*) that are aimed at encouraging exchange and creativity through innovation (Capdevila and Mérindol [CAP 17], Le Roux and Morel [LE 16]).

After a trial phase, the PEPITE project (*Pôles Etudiants pour l'Innovation, le Transfert et l'Entrepreneuriat* or *Student Hubs for Innovation, Transfer and Entrepreneurship*) was born in 2013, with the aim of encouraging students to think about entrepreneurship and, eventually, create their own. It has resulted in (1) the creation of 29 PEPITE projects in the whole of higher education sites and (2) spreading of awareness and training to entrepreneurship and innovation at the bachelor, master and doctoral levels in universities and *grandes écoles*. In 2015–2016, 120,000 students were sensitized. (3) The creation of a PEPITE prize for student projects to reward participants for their creations. So far 145 regional winners and 53 national winners are listed (4). In addition, an entrepreneur student status for undergraduate students or graduates was created. This status is increasingly demanded by students: in 2014–2015, 645 students were admitted, in 2015–2016, 1,427 students, and in 2017, there are 2,191 holders of this status (as of 15 February).

Box 2.8. *The PEPITE system in France. Source: Boissin [BOI 17]; http://www.enseignementsup-recherche.gouv.fr/cid79223/pepite-poles-etudiants-pour-innovation-transfert-entrepreneuriat.html.*

Many concepts have been developed to study the changes induced by this third mission – of research commercialization – given to academic institutions and added to their historical missions of education/teaching and research. Of course, the national innovation system, to which we referred before, already focused on the systemic ties needed between science, industry and governments at the national level. However, specific concepts have been developed, notably by sociologists, to study more accurately the changes that occurred in the production of knowledge.

For example, modes 1 and 2 of knowledge production (Gibbons *et al.* [GIB 94], Nowotny *et al.* [NOW 01, NOW 03]), mostly study the radical transformation in the production of knowledge (the title of the first book in 1994 was *"The new production of knowledge"*), from the perspective of academic institutions. The authors study how what they call Mode 1 of scientific discovery, characterized by the "hegemony of disciplinary science", with its strong sense of an internal hierarchy, and driven by the autonomy of scientists and their host institutions, the universities, was being superseded by a new paradigm of knowledge production (Mode 2), which was socially distributed, application-oriented, transdisciplinary and subject to multiple accountabilities [NOW 03].

Table 2.5 summarizes the major differences between Mode 1 and Mode 2. Whereas in Mode 1, pure research is generated in a theoretical and experimental context, in Mode 2, the emergence of research questions, methodological choices and the dissemination and use of results are immediately defined in an "applied context". The second characteristic of Mode 2 is that of the transdisciplinarity generated by the type of problem to be solved, leading to appropriate combinations of research teams and methodologies; therefore, in Mode 2 the links focus less on the ties between preexisting disciplines. The third characteristic refers to the diversity of places for the production of knowledge in Mode 2, and to the greater interactions offered by information and communication technologies. The diversity of places for the production of knowledge also refers to the greater openness of the scientific community and therefore to the fact that knowledge can be produced in different organizations such as think tanks, consultancy groups, associations, etc. The fourth characteristic is that the production of knowledge in Mode 2 is a dialogical process, that is, an "intense conversation" between actors and subjects and no longer an objective analysis of the natural world or of society. The fifth feature refers to new forms of quality control. The role of the peers as the only actors in quality control is called into question by the various actors and disciplines involved in the research. The quality criteria themselves become fuzzy.

Mode 1	Mode 2
Process of application	Context of application
Inter- or multidisciplinarity	Transdisciplinarity
Homogeneity of place. Interactions limited by technical constraints	Diversity of sites of knowledge production – growing interactions between them
Objective investigation of the natural (or social) world	Highly reflexive knowledge/dialogic process
Quality control: Role of peer/scientific excellence	Novel forms of quality control/multiple definitions of quality

Table 2.5. *Comparison between Mode 1 and Mode 2 for the production of knowledge. Source: Author, based on Nowotny et al. [NOW 03]*

Critics of this approach emphasized that Mode 2 was not as new as the authors claimed and that Mode 1 had not completely disappeared either. Another criticism focused on the low empirical content of this approach, when compared with the triple helix approach, which was based on empirical work presented at dedicated international conferences [SHI 02].

The Tripe helix model (Etzkowitz and Leydesdorff [ETZ 00], Leydesdorff and Etzkowitz [LEY 98], [VIA 10]) insists on University + Industry + Government networks. The authors consider that the university plays a key role in knowledge-based societies. The modes of organization of the relations between university, industry and the State have evolved over time. The authors put forward three different modes. In the first (noted as "A" below), the State encompasses and directs relations between universities and industries; according to the authors, this model corresponds with the mode of organization prevailing in the former Soviet Union, in Eastern Europe countries before their transition to the market economy, as well as certain Latin American countries, and certain European countries, such as Norway. The second model (noted as "B") corresponds to distinct spheres that communicate with each other through well-defined relationships. Finally, the third model (noted as "C") generates a knowledge infrastructure that translates into overlapping institutional spheres, where each plays the role of the other, and where hybrid organizations emerge at the conjunction interface [ETZ 00, p. 111].

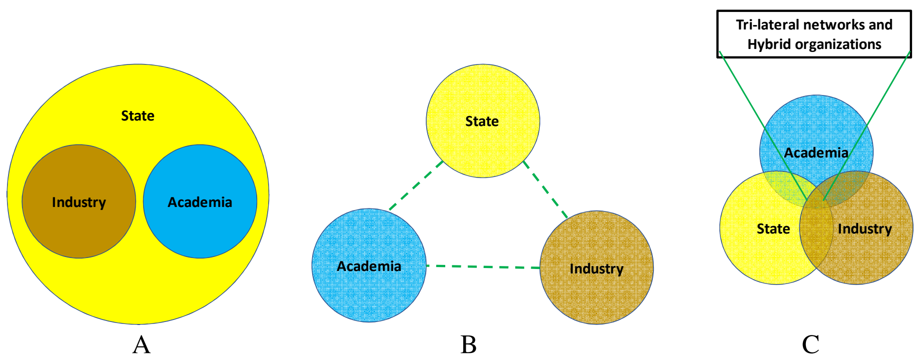

Figure 2.7. *Models of triple helix organization. Source: [ETZ 00]*

Most countries are now seeking to move closer to the third organizational model, notably through the support (as opposed to the pure and simple direction) of States. The objective is to foster the development of university spin-offs, partnerships and initiatives involving all three spheres, with the aim of stimulating economic development by building on knowledge. In the triple helix, there is a superposition of communications among networks and organizations within the helices that inspire the image of the DNA double helix (Figure 2.8). In the transition to Mode 2 of knowledge production, the helices approach and overlap with one another, facilitating the continuous emergence of intention, strategies and projects that are varied and not decided *a priori*. This is why, from an evolutionary perspective, the authors refer to an "endless transition".

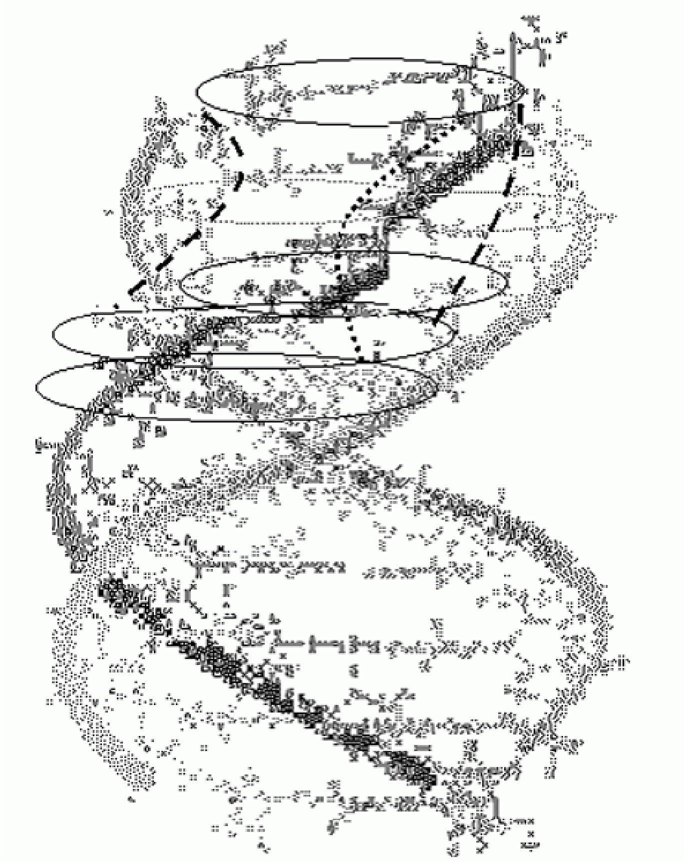

Figure 2.8. *The triple helix of communications and network-wide expectations (overlay of communication and expectations at the network level guides the reconstruction of institutional arrangements). Source: [ETZ 00]*

Some authors propose adding several helices in order to include democracy/civil society and the environment in the analysis of the networks needed to develop knowledge (Carayannis and Campbell [CAR 09]).

The authors therefore recognize that the relations between science and industry are older than the explanatory models they develop. As we have previously pointed out, Marx had already revealed the connection between science and technology in the capitalist mode of production. From the moment when the scientist is himself integrated into the production process, his work is thus appropriated by capital, and in this way he becomes separated from his working means (his competences and knowledge). However, although this rapprochement is not new, the end of the 20th Century was, nonetheless, marked by a growing socialization of work that is producing scientific and technical knowledge. Here, we mean by socialization the fact that scientific and technical knowledge is produced in many places and institutions in an interactive and open way. It is mainly the idea defended by the authors of Mode 2, who consider that Mode 2 is "an example of the social distribution of knowledge" (see [NOW 03, p. 180]). Nevertheless, we believe it is important to consider the fact that this socialization movement corresponds to a movement that is just as powerful, the appropriation of scientific work by the industrial firm, with the aim to enrich its knowledge capital.

Public research is called on to satisfy the objectives of growth and profit of firms. Its orientation, through its financing (whether public or private), and evaluation (according to economic criteria) are defined not so much according to social needs and the challenges which confront humanity, but, in a crucial way, depend on the firms' profit outlook. These challenges can merge at certain moments, but more often than not they are incompatible.

Scientific work is embedded into the economic and social structure. As such, it imposes its operational standards on all the institutions that are part of this. Nowadays, the organizational logic and the objectives of the firm extend beyond its boundaries. The collective worker of the past, limited to the boundaries of the firm, defined by the ownership of the assets, is now extended to the social system within which the firm builds its knowledge capital. Partnerships, which are now essential for academic structures mean that not only the results of scientific production, but more fundamentally its orientation, are largely defined according to economic and financial interests. This phase of the organization of production is, therefore (which can be considered as the fourth phase, see Laperche & Uzundis [LAP 18]), that of the unprecedented socialization of knowledge production, but also, paradoxically, that of its private appropriation.

This private appropriation needs to be placed in parallel with the increasing privatization regarding the generation of knowledge. In a recent paper, Archibugi and Filippetti [ARC 16] show that, from 1981 to 2013, the share of public-financed R&D to GDP in OECD countries was reduced from 0.82% to 0.67%. By contrast, the industry-financed R&D was increased from 0.96% of GDP to 1.44% during the same period. Moreover, while public research remains predominantly funded by national governments (around 90% in OECD countries), the share of industry funding for public research has increased since the 1980s, with universities taking the lion's share of private funding, through public–private partnerships [OEC 16]. According to Archibugi and Filippetti [ARC 16], this growing privatization of knowledge can have adverse implications for long-term innovation and economic welfare. Comparing the *public-generated knowledge* to the *private-generated knowledge* under the prism of the public good approach, they consider the differences in terms of resource allocation, excludability in consumption and excludability in production. They show the possible negative impact of such privatization: first, "there is no guarantee that market-led opportunities correspond to societal needs and priorities. Second, an excessive privatization of knowledge reduces the possibilities for the diffusion of knowledge. Third, because long-term technological opportunities, especially when they are radical, are often associated with major scientific break-throughs, generated by basic research carried out in public institutions" [ARC 16, p. 20].

Certainly, therefore, the university and, more generally, public research in the 21st Century can no longer be considered as distant from the preoccupations of the economy and enterprise. The evaluation of training, laboratory activity and individual research by researchers integrates systematically dedicated indicators. Funding for research, whether private or public, is carried out through the calls for projects that very often require the involvement of private players such as companies. If the consequences of these changes are debated on the short-term or long-term advantages or limitations of such rapprochement, it is in any case certain that they will allow firms to draw on knowledge and enrich their knowledge capital. Moreover, this enrichment of knowledge capital does not take place solely on a national basis. Today, companies are locating their research activities worldwide and building complex scientific and technical networks with companies, research centers and universities around the world.

3

The Knowledge Capital in Global Networks

In this chapter, we study knowledge capital formation and appropriation in global networks. Here, the two parallel and contradictory processes of socialization and appropriation of knowledge capital are revealed and confronted. First of all, we present the various stages in the globalization of the company's strategy and in particular the globalization of their R&D activities. Network firms are spinning their web around the world in order to collect scientific and technical resources that will enrich their knowledge capital (section 3.1). In this context, the issue of protecting this core element of their strategy is thus reinforced. In this regard, intellectual property rights (IPRs) have been considered as key tools, nevertheless they have also been at the center of controversy, associated with their traditional roles of protection and of incentive to innovate, and their impacts in terms of the construction of barriers to entry. We study these conflicting roles from two perspectives, multi-partner innovation and the extension of IPRs at the global level and to new areas. They appear not only as instruments of coordination, but also as tools used to create a hierarchy of actors within networks (section 3.2).

3.1. The constitution of knowledge capital within global networks

The last three decades have borne witness to profound changes in the behavior of multinational firms. Today, their international activities concern

Enterprise Knowledge Capital, First Edition. Blandine Laperche.

not only trade and production, but also the research and development that has traditionally been retained in the country of origin. This last development has been particularly remarkable since the second half of the 1990s, especially in the context of the knowledge economy: on the one hand, more and more R&D is being carried out outside the country of origin. Therefore, subsidiaries of foreign firms play an increasing role in the R&D of OECD countries. In 2013, they accounted for one-fifth of the total business R&D expenditure in several of these countries (OECD [OEC 15b]). Patented inventions are also increasingly emerging from international collaborations. On the other hand, some emerging countries (such as India and China) have become flagship destinations for foreign R&D (UNCTAD [UNC 05]). Foreign investment from emerging countries is also increasing. For example, foreign investments from BRIICS have more than tripled between 2002–2007 and 2008–2013 (OECD [OEC 16a]), accounted for by their place in globalized value chains but also through the development of their technological capabilities. Knowledge creation and accumulation is a collective phenomenon that transcends the borders of national economies and develops into technological cooperation networks around the planet in order to collect quantities of information that can then be transformed into knowledge and innovation.

While at the beginning of the 1980s there was no doubt that the location of R&D activities outside the home country was only intended to adapt the product to the local market, there has since become a real integration of global R&D activities that we are currently still witnessing. Collaboration networks between firms, and between firms and/or research centers, located in various countries across the planet have developed. Multi-partner innovation is an international phenomenon. The internationalization/globalization of R&D activities follows a process comparable to that which characterized production. The multinational corporations (MNCs) have been induced to increasingly locate their knowledge-intensive industrial activities abroad and to connect them through global networks. The development of these global networks of R&D activities is transforming the MNCs and innovation processes. From a vertical hierarchical organization to a decentralized, networked organization, the MNCs (in both developed and emerging countries) are extending and locating their activities in every continent. Knowledge capital is based on global knowledge resources. However, the globalization of the firms' innovation strategy is not limitless and depends largely on the social and political economic context that characterizes the various territories.

3.1.1. *From multinational to global production*

The history of multinational production is long (Uzunidis [UZU 14]). The first large wave of capital exports can be dated back to the end of the 19th Century. However, the first multinational corporations started to appear during the Renaissance. At that time, entrepreneurs were looking for precious wood, spices, labor, etc., in other words, resources that Europe was deprived of. Their counterparts at the end of the 19th Century were actors occupied by a comparable process, everything else being equal, ever since this first wave of capital exports gained an advantage thanks to lower transport costs. These were due to the appearance of steamboats and the rapid development of the railways, as well as a means of telecommunication with the invention of the telegraph and then the telephone, which helped accelerate the speed of information flow. This resulted in the commitment of initial MNCs to the "sourcing strategies" which allowed access to existing natural resources outside their countries of origin.

After the Second World War, capitalism was hierarchically organized under the undisputed and indisputable power of the United States. The MNCs were mainly American firms. The Ford model prevailed in developed (capitalist) countries and was dynamically centered on a close correlation between productivity gains and income growth, hence the emergence of new national and international markets. Until the 1960s, market strategies were adopted by many MNCs in order to bypass obstacles to international trade or seek more direct access to foreign consumers. The aim was to create "relay *subsidiaries*" (Michalet [MIC 85]) in charge of a range of goods that reproduce, in whole or in part, those of the parent company according to the characteristics of local demand. These strategies are referred to as *multidomestic* (Porter [POR 86]). This multidomestic configuration concerns countries and regions with an equivalent level of development, more precisely the more developed ones. In terms of location, the MNCs are North-North and because of this market strategies can be termed as *horizontal* (Michalet [MIC 99]). In the context of market strategies, production abroad was perceived as a substitute for, or an extension of, previous MNCs' exports and was still far from being consistent with the globalization of production.

Beginning in the 1960s, the increase in production costs in developed countries prompted MNCs to initiate cost minimization at the forefront of their strategies. At the same time, some less developed countries and regions with very cheap labor and inputs began to participate in the world economy by opening up their markets and pursuing policies favorable to foreign investment. This, alongside the continuing decline in transport costs, led to the implementation in the mid-1960s of strategies that rationalized the production of MNCs. In contrast to market strategies, these strategies consist of the creation of "factory *subsidiaries*" [MIC 85], whose aims are to take advantage of lower production costs in host countries and to benefit from economies of scale due to the strong specialization of subsidiaries in production. Strategies to rationalize production generate North-South investment flows (so-called *vertical* strategies: [MIC 99]) and lead to an International Division of Productive Processes (Lassudrie-Duchene [LAS 82] allowing for different parts to be produced in many countries according to their comparative advantages.

With production rationalization strategies, MNCs may decide to segment production operations and relocate some of them. The more complex a product, the more it is organized into components or modules that can be manufactured independently from one another. This international decomposition of the product results in an international trade of semi-finished products and re-exports of finished products after assembly. This type of production requires the adoption of a transnational architecture with conditions for the product being manufactured and then distributed, and is more internationalized than a multidomestic production that is linked to market strategies. It is, however, the embryo of globalization for MNC production, since the majority of cases correspond to regional production integration that involves a given number of countries. These are *banal strategies* as opposed to *global strategies*, which began to emerge in the 1980s (Andreff [AND 03]).

"The logic of the global economy as a new configuration of globalization has become essential from the early 1980s" (Michalet [MIC 99, p. 32]). The 1980s were characterized by a reduction in protectionist measures, and the policies aimed at liberalizing economic activities were widespread in a large majority of countries, irrespective of their level of development. Regional integration (European Community, North American Free Trade Agreement, Asia-Pacific Economic Cooperation) was also strengthened and the globalization of the market experienced a major boom. Many MNCs adopted strategies that targeted globalization or transregional integration by merging market strategies with strategies focusing on the streamlining of production. A few characteristics can be used to characterize the globalization of MNCs production since the 1980s:

1) an increasing number of MNCs (7,000 in the late 1960s compared to more than 100,000 in the mid-2010s) deploy production activities worldwide, beyond regional boundaries;

2) the opportunities for MNCs are increasingly global largely due to the standardization of products and the convergence of consumption patterns;

3) some subsidiaries evolve beyond the level of a locally specialized subsidiary by obtaining a regional or global mandate;

4) the production process involves not only the internal coordination of the multinational group, but also global cooperation with other organizations.

During this period, technology and knowledge intensive sectors emerged and the production of MNCs begins to be dominated by post-Fordist technologies (flexible automation and information and communication technologies (ICT)). Technical evolution, new materials and new technologies have come about, especially in developed countries, which play an essential role in new production processes. This has led to the reorganization of the firms' international production activities. Global firms are reorganizing in order to integrate new technological resources being offered by the Triad (North America, Western Europe, and East Asia), the BRICs (Brazil, Russia, India, China), or by any other country in which a sectorial innovation system emerges. The decision to invest abroad is no longer just a function of low production costs in less developed countries and/or geographically close regions.

Streamlining production not only reduces costs, but also facilitates access to new productive resources (such as new knowledge). This trend gained ground in the early 1990s with the implementation of ICT, the evolution of the global logistics system and, at the same time, the increasing role of finance. The former MNCs, organized as a hierarchical pyramid and controlled from headquarters, were obliterated by the introduction of a global structure in the form of a network that could realize (and finance) complex production projects. As some products require specific scientific and technological knowledge that belongs to other firms or organizations that are globally dispersed, the proliferation of strategic alliances between firms, particularly in the high-tech sectors, has been part of this trend.

One of the important consequences of globalized production is that certain subsidiaries of the MNCs become centers of profit and development, both financially and technologically. The responsibilities of these subsidiaries exceed those of *relay subsidiaries* and *factory subsidiaries*; these maintain relations not only with the parent company and other subsidiaries abroad, but also with suppliers, customers and local institutions. The globalization of production corresponds to the maturation of many MNCs that now operate as a network with multiple subsidiaries and multiple partnerships around the world. At the same time, globalization is bringing about profound changes in terms of the innovation process at the international level. Technological innovation for the whole of a multinational group is no longer simply linear or in the form of technology transfer, but follows an interactive process.

The former model of innovation for MNCs kept with the logic of linear innovation, that is to say, in line with the vertical organization for the transfer of technologies and knowledge from the parent company to the subsidiaries abroad. In this case, technological innovation for an entire MNC was based solely on the innovative capacities of the parent company's research centers, which exclusively controlled the pace of innovation by using stocks of scientific and technical knowledge available to the country of origin.

More specifically, in the context of "market strategies", general production targeted local demand with the same product range as that of the parent company. The creation of new products and technologically superior processes was totally concentrated in the MNC's country of origin. In terms of strategies aimed at rationalizing production, the research units in host countries have appeared to adapt products to local markets, and/or carry out support, and/or engineering operations abroad. However, these units attached to the subsidiaries had very little autonomy and their activities were essentially based on the knowledge base transferred by the parent company.

Changes in the innovation process of MNCs have been accelerated by the globalization of production over the last two decades. These cover three main aspects: the shift to a series of problem-solving processes located within both the parent company and the subsidiaries abroad; the deepening of the globalization of value chains, which means that a growing share of exported goods and services use inputs from other countries (see Figure 3.1); the new interactive dimension of technological innovation for the entire multinational group. This new model of MNC innovation can be seen as a process composed of a set of subprocesses embedded in the subsidiaries that are distributed worldwide. The internal and external networks woven by multinational firms are sources of new technological capabilities and promote the transfer of knowledge (Blomkvist *et al.* [BLO 17], Ietto-Gillies [IET 15]).

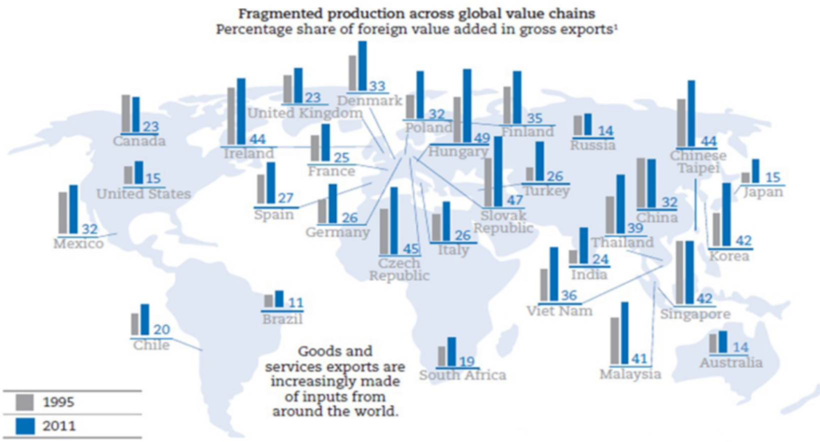

Figure 3.1. *The globalization of value chains. Source: [OEC 16a]*

Let us return to the main steps that have led to the current organization of MNCs and to the current importance of the phenomenon that is R&D globalization.

3.1.2. *Globalization of R&D and the broadening of the firm's boundaries: the importance of networks*

It is possible to present with a diagram the major stages for the globalization of research by four overlapping sequences, as detailed below. The first "non-globalization of R&D" prevailed until the 1980s. The 1980s and 1990s were marked by the internationalization of R&D, essentially localized in the countries of the Triad. During this same period, the location of R&D in emerging countries developed to the point where it is presently (in the 2010s), questioning whether a fourth phase has emerged, characterized by the reversal of the innovation process (see Figure 3.2). Our categorization is close to that presented by Archibugi and Filippetti

[ARC 15]. The four categories that the authors have identified differentiate the ways in which knowledge is produced and disseminated on a global scale: (1) knowledge confined to the national level, (2) dissemination and international exploitation of knowledge and innovation generated at the national level, (3) scientific and technical collaboration on a global scale and (4) the global generation of knowledge. The difference between this categorization and ours is that the former applies to the production and dissemination of knowledge in general (by private and public actors), while we focus on corporate strategy. According to Archibugi and Filippetti, examples of practices falling into these four categories can be found very far back throughout history. Other examples of practices belonging to each category can also be found in the current period. It is however certain that the first category (knowledge produced and diffused at the national level) is marginal today, while the second category would always dominate quantitatively, with the latter two becoming increasingly important in both the public and private spheres [ARC 15].

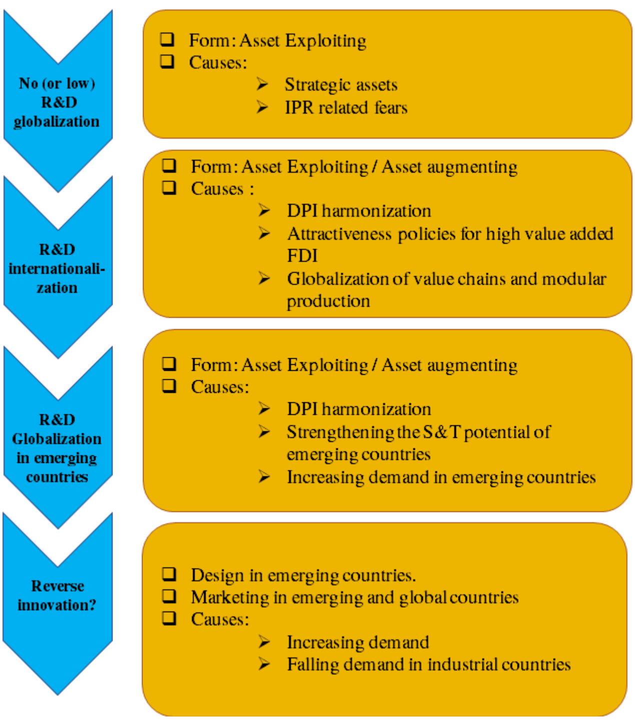

Figure 3.2. *Stages in the globalization of business research and development. Source: Laperche and Lefebvre [LAP 12]*

Until the early 1980s, innovative activities were generally concentrated in the MNCs countries of origin (Patel [PAT 91] and Pavitt [PAV 99]). This is due in part to the fact that R&D, considered a strategic asset, was managed more securely at the national level, especially as the rules on intellectual property were not standardized at that time. In the first instance, the internationalization of R&D was limited to the export of innovative products, the sale of patents and licenses, and the overseas production of goods with a basic or mature technological content. These forms of internationalization correspond to the exploitation in host countries of assets specific to the firm (*asset exploiting*), that is, innovations produced in the country of origin (Archibugi and Michie [ARC 97], Dunning and Narula [DUN 95]). The foreign operation of the firm-specific asset is carried out according to the lifecycle logic of the product developed by Vernon [VER 66]: in the emergence phase, the product generates no international trade and satisfies domestic consumers with incomes high enough to acquire the product. In the growth phase, the product manufactured *en masse* sees its price falling. The innovative firm, faced with imitations, seeks to maintain its monopoly by exporting to partner countries. In the mature and declining phases, the product that had become commonplace is gradually produced in other countries, at first under license, for the lifetime of the patent. Trade flows are reversed as production shifts to less developed countries that become exporters.

In the 1990s, however, the globalization of the firm's strategy was more pronounced regarding R&D activities, which experienced a major shift, resulting in more technological production taking place abroad, and more specifically within the Triad. The presence of firms in world markets is no longer limited to commercial and productive units, and also involves research laboratories (Cantwell and Janne [CAN 99], Madeuf *et al.* [MAD 97], Mouhoud [MOU 08]), which have various tasks: on-site adaptations of products designed by the parent firm (local support laboratory), technological monitoring and/or proximity innovation and the complete design of the products intended for global distribution ("Centre of Excellence"). While the first type of laboratory is often located in the vicinity of subsidiaries – factory or relay – of multinational firms, centers of excellence more specialized in the upstream phases of R&D are more independent.

This internationalization of R&D is explained, from the point of view of firms, by the need to adapt the products conceived in the country of origin to the national norms and specific characteristics of the demand, and has often been popularized with the term "glocalization". However, it can also be explained by the willingness of firms to tap into the existing scientific and technical resources of industrialized countries (Cantwell [CAN 97]) thereby augmenting specific assets (*Home-Based Augmenting* according to Kuemmerle [KUE 91, KUE 99]). On the receiving side of these investments, in a context of global competition based on the capacity to innovate, the regions try to foster innovative environments in order to attract foreign investments with high added value. They develop policies that promote structural attractiveness aimed at the creation and enrichment of scientific and technical resources. This has resulted in the worldwide dissemination of "cluster" policies (Boutillier and Uzundis [BOU 09], Porter [POR 98], Uzunidis [UZU 08]).

The result is a two-pronged movement of internationalization and concentration of scientific and technology resources in specific areas. On the one hand, new capacities for disseminating knowledge have reinforced this phenomenon of locating R&D activities internationally: in the "knowledge-based" economy, information and communication technologies facilitate global exchanges of information and its codification increasingly affects larger areas of knowledge. Remote work in the scientific and technical fields is becoming easier, especially for the downstream phases of R&D and in this way encourages its internationalization, especially since the development of new technologies (in particular electronics, biotechnologies, information technologies and new materials) is done in a "modular" way, that is in independent systems that can be decoupled from production and positioned in different locations. Efforts to harmonize IPRs in the 20th Century also created a climate of confidence for investors (see section 3.2.2.1). On the other hand, the tacit content of emerging technologies justifies internationalized research, localized in specific areas that concentrate scientific and financial resources, that is clusters located in major cities. Firms benefit from local externalities (sharing of information, equipment and the implementation of learning processes) achieved through the concentration of scientific and technical activities in resource-rich environments. "Clustering" therefore largely explains the internationalization of private R&D through the location choices for innovation and engineering activities of large firms (Krugman [KRU 91]).

The internationalization of R&D, although concentrated mainly in industrialized countries, increasingly involves emerging countries (Fu and Soete [FU 10], Lundvall [LUN 09]). We can thus speak of globalization insofar as the geographical space concerned by the location of R&D is broader. This demonstrates the freedom that firms have to establish their scientific and technical assets throughout the world, the value chains of firms being more and more globalized.

The reasons for R&D globalization and the growing importance of emerging countries include the strengthening of the scientific and technical potential of emerging countries, coupled with the lower cost of scientific and technical human resources, the globalization of IPRs, the increase in demand in some emerging countries and the stagnation of demand in industrial countries.

This globalization of R&D is not only reflected in the establishment of dedicated subsidiaries, but also in the multiplication of international technology alliances or Strategic Technology Partnerships (STP) (Narula and Duyster [NAR 04], Narula and Martinez-Noya [NAR 15]). These forms of cooperation are not new but extend to the point of giving rise, according to Dunning [DUN 97], to "the age of alliance capitalism". In the field of R&D, which is by nature uncertain and risky, these strategic partnerships often become the preferred solution when compared to vertical integration (by *ex nihilo* creations or mergers and acquisitions) and their growth has been exponential since the end of the 1980s. These strategic alliances focus in particular on high-tech sectors (Hagedoorn [HAG 02]) and link leaders within the different sectors of activity. Unlike other cooperation agreements, which may relate to production and marketing, these are not solely intended to reduce costs in the short term, but aim at developing and capturing new scientific and technical assets that will in turn enrich the knowledge capital of the cooperating companies. Of course, these strategic alliances remain complementary to the internal R&D of the groups. "By associating complementary resources and competencies STP makes it possible for firms to explore and exploit new technological opportunities and expand the boundaries of their knowledge base" (Narula and Martinez-Noya [NAR 15, p. 152]).

Finally, a fourth stage in the globalization of R&D is sometimes considered to be emerging. The term "reverse innovation" was proposed by Immelt, Govindarajan and Trimble in an article published in the *Harvard Business Review* entitled "How GE is disrupting itself". According to the authors (one of them is J. Immelt, CEO of General Electric) "To tap opportunities in emerging markets and pioneer value segments in wealthy countries, companies must learn reverse innovation: developing products in countries like China or India and then distributing them globally" (Immelt *et al.* [IMM 09, p. 2], see also Govindarajan and Trimble [GOV 12]). The authors therefore anticipate an increase in the location of R&D in emerging countries. It would no longer only be the downstream phases of R&D, but the complete product design that would be carried out in emerging countries. These products would be targeted at emerging countries as well as the rest of the world. This is the strategy of General Electric Healthcare in India (see Box 3.1). In all cases, the foreign subsidiaries of groups dedicated to R&D located in emerging countries are more numerous (see Holmes *et al.* [HOL 16] for the case of China). The establishment of subsidiaries that are owned by the groups is still the main strategy of expansion in emerging countries, as compared with technology partnerships. According to Narula and Martinez-Noya [NAR 15, p. 156], the fact that firms do not mainly resort to STP in emerging countries is due to the fact that local firms are not at the same technological level as foreign groups; however, the increase in technological capacities could lead to the development of this type of presence in emerging countries. In the host country, firms tend to reconstitute innovation ecosystems, collaborating with other foreign firms as well as local firms (see Patra and Krishna [PAT 15], for the case study on information technology in India).

Reverse innovation is seen as a strategic response to new global market norms: the development of new markets in emerging countries; the emergence of new competitors from these same countries. In many emerging countries, therefore, there is a large market of potential consumers, but they are still very poor and are thus left behind by their industrial competitors. Henceforth, engaging these markets by adapting to their economic needs and constraints could prove to be an interesting challenge, especially since a good quality workforce has developed in some of these countries, favoring the emergence of local businesses.

As the second group of the Medical Health Systems (MHS) in the 2010 world ranking, GE HealthCare (GE HC) specializes in medical diagnostics and more particularly in medical imaging, ultrasound scans and electrocardiograms as well as in the production of biopharmaceutical products. GE HC is a division of the General Electric Company.

GE appears as a pioneer in reverse innovation strategy. The reasons include a decrease in demand in industrial countries, increasing opportunities in emerging countries as well as the obvious determination of Immelt, the CEO, to speed up the group's internal growth at the expense of acquisitions that were previously at the heart of the company's strategy throughout the 1990s. The idea is to locate the research centers in developing countries in order to design technologies that could make 50% of the performances of devices that are targeted to industrial countries for 15% of their costs. Such technologies allow them to meet the needs of emerging markets by developing attractive products. In order to do this, it is necessary to change the paradigm. Development teams work on-site with local resources and encounter the inherent constraints of that environment. In some cases, these teams have access to the highest technologies within their group, which is largely globalized as they test out and learn on-site in line with other criteria: low-cost solutions cannot be inspired by "ancient" solutions. Low cost does not mean low quality! The challenge does not consist of decreasing the quality of the existing products but to innovate whilst being able to respond to requirement constraints: simplicity, sturdiness, standby time, low energy consumption, etc. All these constraints lead to a very good quality final product. The aim is also to create product offers that are adapted to the new realities of the developed markets affected by strong competition and increasing demand.

GE Healthcare: three great success stories regarding reverse innovation – the portable ultrasound scan and electrocardiogram, and a low-cost steam turbine

GE Healthcare is one of the world leaders in medical imaging. At the end of the 1980s, they chose to work on ultrasounds in the specific field of ultrasound scans. At the beginning, the heavy and expensive equipment was designed *in* industrialized countries and *for* industrialized countries. In 2002, the company launched their first compact tool – which combined a portable device and software – and which cost $30,000; however, in 2007, the new generation of portable devices cost only $15,000, that is to say 15% of the cost of a "heavy" machine. Indeed, that new product – which was not an adjustment of the products that were designed previously – was developed in China and was tremendously successful in rural clinics wherein it was used by doctors for simple applications. At the same time, the product permitted the development of new applications for western markets, where portability was an important criterion in some emergency situations: to be used by the welfare services that came out to see patients in wealthy countries. These compact devices were designed from scratch, even if they were based on an existing R&D effort – in particular on a new product architecture developed in Israel throughout the 1990s but which had not been accepted by the company at that time.

The first ultra-portable electrocardiogram (ECG) was fully designed, worked out and produced in India to meet the needs of a large number of remote rural inhabitants who had to be visited by fully equipped doctors. In response to the frequent power grid failures occurring in many Indian regions as well as a severe shortage of healthcare professionals, the Mac i was designed with in-built batteries and easy use. It was portable and light thereby allowing doctors to access patients living in remote areas. In order to make its maintenance easier and at the same time reduce costs, it was delivered with components that were made available in stores – instead of made-to-measure and specific parts. A variant of the Mac 400, the first portable ECG, was sold for half the price of the latter. A year later, in 2009, an improved version was launched in the United States: the Mac 800.

In 2010, in another field of activity – steam turbines – GE can boast yet another success story with regard to reverse innovation. In 2010, GE's Indian subsidiary formed an alliance with the Indian company Triveni Engineering and Industry Ltd. in order to design and successfully produce steam turbines for agricultural machinery (range 30–100 MW). The company aimed to take advantage of the low costs of the inputs invested in the manufacturing with the plan of exporting these products to Western Asian markets, Indonesia, Europe and Latin America.

GE India's new organization

General Electric organized their R&D at two levels: the entire basic research is carried out in the group's central research laboratory located to the North of New York. The laboratory, which works for all the group's units, employs 2,500 engineers specialized in new materials, nanoparticles, and also electronics, material physics, particle physics, chemistry, etc.; basic research follows cycles of 10–15 years. At the same time, the engineering teams of the different business units located all around the world contribute to the group's innovation effort via development. Applied research follows cycles of 1–3 years.

At GE Healthcare, GE's health division, product innovation is the most important element: the division produces a small number – about 100 machines per year – of complex products that are also based on high and multiple technologies.

GE carried out organizational changes in India and the Indian subsidiary increased their visibility within the group. In January 2009, GE Healthcare India became a distinct geographic division. At the beginning, they were a member of the Asia Growth Markets, which reported to Europe. In a communiqué, Immelt declared: "We are going to treat GE India as we would treat any other GE company that has its own growth, development and budget strategies". GE has invested a lot in its facilities in India. The medical device activity engineers who worked in different parts of the country are now housed in a new establishment, the John F. Welch Technology Center (JFWTC), which is located in the Whitefield district in the middle of Bangalore, the Indian city with a science and technology park, a real-life "innovation ecosystem". This is GE's first and largest multidisciplinary R&D laboratory to be located outside the United States; it works on all the range of products of GE Healthcare. From 2010 to 2014, the team went from 600 to 1,100 engineers, becoming the second unit of the group in terms of the number of engineers, the first being Milwaukee.

Box 3.1. *General Electric Healthcare: a pioneer in reverse innovation. Source: Laperche and Lefebvre [LAP 12]*

The location of an increasing share of R&D within emerging countries is also part of companies' desire to design and produce goods adapted to the purchasing power of the populations in emerging countries, or more generally of less affluent populations situated at the "bottom of the pyramid" (Prahalad [PRA 04]). Reverse innovation thus joins other concepts dedicated to characterizing innovative solutions, such as that of "frugal innovation" (Basu *et al.* [BAS 13]) or "jugaad innovation" (Radjou *et al.* [RAD 12]). They emphasize a simpler innovation process that is adapted to the needs of developing countries, sometimes relying more on resourcefulness and the D of R&D, rather than on real R&D. In any case they mean "to do more with less". Frugal innovation is also related to low-cost innovation, where the minimization of costs is imperative. Renault's strategy, especially in the case of its ultra low-cost model – Kwid – that was designed in India, corresponds well to the willingness to adapt to features characteristic of high growth and low purchasing power markets of emerging countries (see Box 3.2). Nevertheless, it required a completely new design to be achieved at the lowest costs. It is not impossible for this model to be converted to Western standards in the future in order that it might be distributed in industrial countries.

If the French automotive group has a tradition of centralization in France (within the Technocentre) of its design activities (see Laperche and Lefebvre [LAP 12]), the case of Kwid marks a significant break in tradition, since the design process of their product was in this instance reversed and debuted in emerging countries, thus satisfying markets with strong growth and fulfilling an overarching ambition to distribute new products internationally. The Renault Kwid was developed by the Renault–Nissan alliance, designed and marketed since late 2015 in India from as little as 3,500 euros. This case study is discussed in detail by Midler *et al.* [MID 17].

The authors describe the genesis and management of the project, from the advent of the Kwid concept in 2010, through to its product and process development, the industrial start-up phase, the commercial launch and its consequent international deployment prospects. They demonstrate how the Kwid project benefited from the experience and skills developed in the implementation of the Logan project and more broadly from the Renault's Entry Range, the Kwid project leader within the Renault–Nissan alliance. Of interest is the analysis of the disruptions that took place under the alliance. First, these occurred within the organization, which found it necessary to assert an autonomous and "intrusive" project management of the 2ASDU unit, created in India and placed under the sole authority of Renault-Nissan Alliance Chairman and CEO Carlos Ghosn in order to avoid tensions and strategic misunderstandings between the two branches of the alliance. This is a real break from tradition for the Renault group, whose vehicles are usually designed and managed at the Technocentre based in the Paris region (as was the case for the Logan), despite the rise in remote engineering. Disruptions also happened in the technical section: the creation for the first time of a joint platform for a range of Renault and Nissan products; design-to-cost not only required an adaptation of existing components, as was the case for Logan, but completely new components (such as the engine or gearbox); mechanical production was also carried out in India in a frugal factory "without walls or doors", etc. In order to carry out its project, the company has developed a partnership network characterized by "indigenization", that is to say the massive use of local suppliers that the team works alongside in order to satisfy quality requirements (improving competencies) while respecting the cost criteria. All to adapt to the Indian institutional context, well summarized by the formula "India, it is Crozier on the scale of a continent" (p. 60). The commercial dimension is also impacted by the simultaneous search for lower costs and marketing innovations favoring the modernity being sought after by Indian consumers in particular.

For the authors, Kwid corresponds to what they call "fractal innovation". It is defined as a process of systematically challenging the definition of the product, at the same time dealing with all the design variables (product, process, location, industrial options, suppliers, modes of marketing) and implemented at all scales: from the global dimensions of the project, to the characteristics defining each element.

Box 3.2. *Renault's Kwid and reverse innovation. Source: (Midler et al. [MID 17])*

Although reverse innovation practices (in the sense that a firm in an industrialized country designs and markets a good in emerging countries, to be first marketed in that country and then adapted for industrialized markets) are multiplying, they are nevertheless marginal in relation to all other forms of R&D globalization. Moreover the definition of reverse innovation is not yet standardized in the literature on this theme, wherein there are multiple definitions, approaches and realities observed (see Hussler and Burger-Helmchen [HUS 16], Le Bas [LEB 16], Zedwitz *et al.* [ZED 15] and the special issues: *Innovations, Revue d'économie et de management de l'innovation*, no. 51, 2016/3 "Innovation sur mesure" [INN 16a]; *Journal of Innovation Economics & Management* no. 21, 2016/3 "Grassroots Innovation Processes" [INN 16b]).

However, the process of R&D globalization no longer corresponds merely to the logic behind resource allocation. It rather demonstrates the application of a logic based on resource creation at the global scale. It implies that information and knowledge not only circulate between the central laboratories and those located abroad, but also between laboratories scattered across the globe. These new laboratories take on a very different trait to that of support laboratories. Some become *locally integrated laboratories* that rely on an important production and marketing subsidiary to develop products or processes for which they have a regional or international mandate; others are *internationally independent laboratories* without a local relationship with the company's production site, but with ties to regional players in its territory and direct cognitive exchanges with other laboratories within the same multinational group (Pearce and Singh [PEA 92]). As part of a strategy to create resources, this strategy advances international R&D organization according to the model of an *integrated R&D network*.

Finally, the globalization of production (involving R&D) corresponds to a networking of MNCs at a global scale. The networked coordination structure is characterized by the interdependence of actors, which transcends the boundaries of the firm and brings about a new mode of interaction between the participants (Powell [POW 90]). It is in this sense that the emphasis is no longer on hierarchical levels but on the pooling of skills in order to carry out projects that can be beneficial to all (or at least to the initiator(s) of the network). In this new organization, the MNCs' subsidiaries play an increasingly dynamic role in technological innovation, as they directly maintain relations with an increasing number of economic and scientific players of different nationalities. They help to increase the knowledge capital of the whole group and facilitate its implementation according to the scientific and technical advantages of a particular national or local innovation system (Ietto-Gillies [IET 15]).

Given the increased specialization in the production and development of their own technological trajectories, MNCs subsidiaries are no longer solely engaged in a vertical relationship with the parent company, but also able to engage in multiple and integrated functions. They conduct open innovation strategies on an international scale. The aim is to collaborate with a large number of players (suppliers, customers or competing companies) on technological innovation thereby ensuring the quality of supplies on the one hand, and on the other to adhere to the needs of the client group and test the results. Interactions may also involve partnerships between these subsidiaries and local research organizations to improve efficiency in the development of complementary knowledge. When such an interactive structure is implemented, the MNCs' technological innovation must take into account the existing interdependencies at the level of subsidiaries abroad and integrate them into the global innovation process. Networks also change the relationship between competitors at the international level. Even if competition remains, collaborative relations become favorable as they make it possible to assemble the necessary means, which was the prerogative of large firms, without suffering from the drawbacks of large structures generating high organizational costs (Teece [TEE 92]).

One of the most important consequences for the development of a knowledge-based economy organized into networks concerns the way in which the boundaries of firms have become blurred, in particular due to the importance of networked knowledge. The creation of knowledge is increasingly a collective and socialized phenomenon, a process in which a growing number of actors participate. The boundaries of the firm have thus become increasingly vague according to the cooperation agreements linking different partners: the modern firm, as we saw in the previous chapter, itself becomes a network.

3.1.3. *Opportunities and limits of R&D globalization*

The process of "permanent innovation" is the main characteristic of the global firm. It is defined as a company whose organization is integrated by multiple information and financial flows and whose structures are largely deconcentrated: a network firm with multisubsidiaries, multiple subpartnerships and co-contracting; a company which has large financial magnitude within the industry and services, with high scientific and technical potential and sources of externalities (clusters). It has a strong capacity to innovate and constantly modifies its structures and organization. It takes advantage of the comparative and specific advantages of different locations. It integrates all the fragmented activities it carries out throughout the world into a "value chain" (R&D, logistics, innovation and financial engineering, manufacturing, assembly, marketing and other various services).

The decentralized management possibilities available to the firm, in addition to the structural and short-term advantages offered by States and local authorities, determines the location of the innovation activities of the global firm. Indeed, one of the key factors in the location of firms is their ability to access knowledge externalities (Lahiri [LAH 10]); this in itself gives meaning to the development of the region in question. Since markets are open but concentrated, characterized by differentiated and diversified demand (by high, medium and low incomes), large enterprises follow a policy of global and permanent innovation which leads them to invest in the continuous enrichment of their potential for innovation. The regions (territories) with high scientific and technical potential attract these types of companies, which, through a strategy of diversifying their investment portfolio and their partnerships, make the "cluster" the preferred means of accessing new productive resources originating in such and such a "territory".

The company's territorial anchorage allows it to build up a reservoir of resources (and sometimes a market) to cushion, in a constantly changing economy, the costs inherent to its investments. However, this territorial anchorage depends on the quality of the reservoir with regard to the company's expectations for innovation and commercial expansion. Hence the need for governments and local and regional authorities to systematically organize the development of resources in order to create multiple innovation processes that take into account competition and cooperation between similar actors in the open economy. It is a system of supplying productive resources that are capable of engendering technological entrepreneurship and attracting large companies with strong performances in terms of innovation. The technological strength of the territories thus constitutes both an opportunity and a constraint to the global innovation strategy of firms.

The globalization of R&D of the MNC also encounters an important limitation where it concerns the management of the innovation process. On the one hand, while the development of ICT facilitates the flow of information and knowledge, the management of this type of global R&D network can prove very complex and generate high coordination costs. On the other hand, the cognitive division of labor and the complexity of modern technology do not allow the MNC to possess all the categories of knowledge and skills necessary for production and innovation. This pushes for an increased globalization brought about through the extension of networks, but at the same time increases the complexity of managing innovation processes. According to the OECD [OEC 16a], the globalization of value chains can therefore be hindered in the future by "hidden costs". These, not foreseen at the time when the decision (for partnership or relocation) was taken, may result from risks in terms of procurement availability, intellectual asset leakages (see Holmes *et al.* [HOL 16]), or the increase in labor costs in some countries, such as China. International strategic alliances based on science and technology also have high failure rates (70%) and even when they are successful, they last for a limited number of years (Narula and Martinez-Noya [NAR 15, p. 159]). This uncertainty associated with R&D, but also the risks of knowledge leaks and opportunism within global networks, are important explanations. The authors refer to "appropriability hazards", which means "the risk of inadequate uses or modifications of technology and knowledge transferred, not intended in the contract, and injurious to the transferor" (p. 159).

On the other hand, the current economic context, marked by the crisis taking place in old industrial countries, may appear as an opportunity for a deeper globalization of R&D (from industrial countries' MNCs) and in particular expanding toward emerging countries. This raises questions about competitiveness policies based on the strengthening of the knowledge economy in industrial countries (Laperche *et al.* [LAP 11]). Moreover, will such a globalization of R&D encourage the emergence of a new wave of major innovation to boost growth?

The globalization of R&D follows a process comparable to that of production. Firms are forced to (re)locate their R&D activities to all areas rich in scientific, technological, financial and infrastructural resources across the planet. These strategies lead to a cognitive division of labor and to the formation of complex networks in which the boundaries of firms become blurred and vary according to acquisitions, mergers and, above all, the multitude of contracts signed with increasingly diverse partners. If the organization of economic activities is profoundly altered, confirming the advent of a networked society (Castells [CAS 98]), questions remain about the impact of these strategies on innovation itself. Are they, through the research and development connections of the global village, a means through which to increase the performance and global distribution of innovation, thereby stimulating growth and economic development? Or are they guided by the fixed profitability targets imposed by global finance, which thus weaken their innovative potential? To answer this question, the appropriation of knowledge capital and the value it creates must be integrated into the analysis.

3.2. Intellectual property rights (IPR) and knowledge capital

The first privileges to share some of the characteristics with today's patents (exclusive right of use, disclosure of information) appeared with the creation of European States. These were originally cities, as was the case of Venice, which promulgated in 1474 the first law protecting industrial property. The first privileges were conferred on inventors with the aim of attracting the most advanced techniques. Scientific and technical knowledge and its materialization in invention were considered as tools of economic and political power. The English *Statute of Monopolies*, dated 1624, awarded the possibility of protecting an imported technique. In France, the royal privileges of the 17th Century were integrated into State policy with a developmental aim, influenced by mercantilist ideas, which notably remained faithful to Jean-Baptiste Colbert's ideas of attracting the best technicians. The French Revolution put an end to privileges; however, the Republic accorded property the first rank of human rights. The French Patent Law, instated on January 7, 1791, protected national inventions and imported patents on national territory. The economic and political competition between States largely explains this fact, as France, lagging behind Great Britain (which was beginning its industrial revolution) was trying to catch up (Beltran *et al*. [BEL 01], Boldrin and Levine [BOL 08], Hilaire Perez [HIL 00]).

According to the contemporary definition, IPRs include industrial property rights, that is to say, patents, trademarks, industrial models and the protection of trade secrets. They also include copyright protection. The patent is a temporary monopoly (which lasts 20 years) and is granted to an inventor in acknowledgment of the invention created, whether it be a product or a process, in all fields of technology, provided that it is new, involves an inventive step, and is useful or capable of industrial application. A trademark protects words, names, symbols, sounds or colors that distinguish goods and services from those manufactured or sold by others and indicate the source of the goods. Trademarks, unlike patents, can be renewed forever as long as they are being used in commerce. An industrial design may be granted to anyone who invents a new, original and ornamental design for an article of manufacture. Trade secret laws protect individuals and businesses against the misappropriation of trade secrets by improper means. Copyrights protect works of authorship, such as writings, music and works of art that have been tangibly expressed.

Throughout industrial history, controversies have multiplied on the role of IPRs, in particular on the intrinsic dilemma they pose between the constitution of a monopoly (albeit temporary), and the dissemination of information and knowledge, which is essential to the cumulativeness of technological progress (Foray [FOR 04], Stiglitz [STI 08]). The economic properties for the products created by the mind justify the existence of IPRs. These goods are hardly excludable and non-rival and, therefore, are sources of externalities. Patents, in line with Arrow's analysis of technology [ARR 62a], are considered for their ability to exclude, and are therefore an answer to the existence of technological externalities. As a counterpart to the individual appropriation that patents provide for, the patent's owner has the obligation during the life of the patent to disclose the content of his invention, so that anyone may use the content to advance knowledge and technology. This patented invention can however only be freely reproduced when the patent has fallen into the public domain and, during the patent life, its use is submitted to an agreement of the patent's owner (license). The trademark, which is usually a graphic sign, is also a valuable tool for the entrepreneur. Acting as a right with which to rally the customer, it is a form of "mental patent" (Kapferer [KAP 07]), which can make the company all-pervading. It therefore encourages entrepreneurship by differentiating products. Designs and copyrights also play the role of barrier to entry: the former by initiating infringement proceedings against the use of visible forms of the protected designs, and the latter by conferring on the author and his beneficiaries perpetual moral and patrimonial rights, which are limited in time and subject to the originality of the author. Trademarks, designs and copyrights are particularly important in the services sector, which has become an important source of entrepreneurship and innovation (Gay and Laperche [GAY 17]).

In this part, we highlight two current illustrations of these controversies surrounding IPRs: on the one hand by studying the role of IPRs in the context of multi-partner innovation and, on the other, the globalization of property rights. In the first case, multi-partner innovation reveals a "paradox of openness" (Laursen and Salter [LAU 14]), insofar as when the company opens up to the outside, it reduces its power to appropriate the income associated with knowledge developed with partners. However, in this context, IPRs acquire a new role as a coordination tool between partners, thereby justifying their use. In the second case, the expected benefits of IPR globalization are the promotion of technology transfers and better access for developing countries to the scientific and technical developments of more advanced countries. We emphasize in both cases the ambivalent effects of IPRs. The use of IPRs in multi-partner relationships goes hand-in-hand with the multiplication of opportunistic behaviors and creates a hierarchy within networks. The globalization of intellectual property strengthens the appropriation of scientific and technical resources at the global scale through the most powerful multinational firms. There is thus an oligopolistic appropriation of knowledge capital.

3.2.1. *The new roles of intellectual property rights: between incentives, coordination and offensive use*

In the context of multi-partner innovation at the international level, intellectual property and patents in particular acquire the role of coordination tools, which provide an additional incentive for the collective formation of knowledge capital.

3.2.1.1. *The role of coordination in multi-partner relations*

Multi-partner innovation is not a spontaneous process, but an organized or even institutionalized process (Laperche *et al.* [LAP 13]). Objectives, expectations, cognitive distances and organizational routines (Huet and Lazaric [HUE 08]) are sometimes extremely varied and increase the complexity of the implementation and achievement of the transaction. The operation of cooperation agreements depends on the ability to find the right partners, to stabilize relations or to reduce the risks of opportunism that may arise in the creation of shared knowledge and new technologies. Partnerships between different entities pose a dilemma: on the one hand, partners must increase the degree of sharing and dissemination of their intellectual assets at the service of the partnership so that it will be successful and, on the other, they must guarantee both the ownership of these assets (avoiding a situation where the partner exploits them in other individual projects) and define the rules for the distribution of the results brought about by the multi-partner innovation.

IPRs are defined within contracts that link partners: stakeholders define the objectives of the collaboration, their respective contributions and the distribution of IPRs upstream and downstream of the results of the collaboration. This is why IPRs can be considered as essential mechanisms to the governance of partnership relations. Governance devices are defined by Ménard as "devices that infuse order in joint activities through the allocation of assets and rights, so as to mitigate conflicts while allowing benefits from mutual gains" ([MÉN 12, pp. 1066–1108; this definition being inspired, as recalled by the author, by Williamson [WIL 96]). We therefore consider that the IPR system as part of these governance devices capable of "infus[ing] order within joint activities", builds on the definition of the rights and obligations of partners and more by promoting the establishment of a climate of trust between the partners, thereby mitigating the risks of conflict. It is in this manner that mutual gains are most likely to occur as a result of the exploration and exploitation strategies being carried out by the partners.

The role of IPRs as a governance mechanism for partnership relations arises from their coordination role, that is the organization of transactions between economic agents to reduce transaction costs and make efficient the allocation of resources and earnings. Since Adam Smith, the notion of co-ordination has been at the heart of economists' preoccupations seeking to understand how decentralized individual economic actions can be made compatible and produce a desirable collective outcome. The issue of coordination is all the more important in the context of the network firm. The networked enterprise means the reintroduction of the *market* in the operations of the firm, as compared to integrated firms where *hierarchy* is considered as an alternative to the *market* (Coase [COA 37]). This reintroduction of the market reveals transaction costs, which are caused by the imperfection of markets: the search for information, sourcing suppliers, negotiation and execution of contracts, etc. (Coase [COA 37], Williamson [WIL 75]).

In this context, IPRs play an important role in the coordination of activities (Pénin [PÉN 05]), clarifying the relationship and thus reducing the transaction costs between the central firm and the different units that compose the network firm. The ownership of trademarks for example – but also, of course, of patented inventions or design – acts as a signal for the central firm or for potential suppliers, as it shows the quality of the enterprise's products and services. In other words, trademarks may increase the reputation of the central firm and potential suppliers that would be chosen because of the IPRs they own. In the case of subcontracting and franchising contracts, licenses allow different entities to use the patented invention, protected trademark or design, usually owned by the central firm. Licenses are most commonly considered as generating productive efficiency (to produce proprietary products efficiently; to let others use the intellectual property as inputs to innovation - research tools - to resolve blocking situations and to enable the development of complementary inventions). This third reason is the most important in the context of collaborative innovation (Scotchmer [SCO 04, p. 162]). IPRs thus allow for the diffusion of technology within the company and provide incentives for the production of specific assets. In the case of R&D partnerships where specific assets are built jointly (co-contracting or contracts between the central firm and a research lab for example), shared patents reduce the possibility of opportunistic behaviors (hold-up situations) between the co-contractors. As a matter of fact, IPRs clarify the relationships between the co-contractors (coordination), and therefore, through the reduction of transaction costs, provide incentives to the collective building of knowledge capital by protecting the tangible and intangible elements that constitute it. Moreover, the temporary monopoly conferred by industrial property rights allows for the possibility of taking the issue to court in the event of infringement. IPRs thus secure merchant relations and give an incentive for joint investment efforts and the internal transfer of technology. Within the firm, IPRs are a tool used by firms to replace control that is based on the ownership of tangible assets with a control that is rather based on the ownership of intangible assets. Finally, IPRs give a value to R&D investments, in a context where profitability has become an imperative. Filing and holding patents transforms potential inventions into valuable assets, which in turn instills confidence among investors and shareholders with regard to the profitability of the firm's investments.

Taking a classical distinction, Pénin [PEN 12] considers that the coordination role played by IPRs in multi-partner innovation can be approached in two different ways: (1) non-market coordination facilitating the process of formal and/or informal collaboration between organizations and (2) market coordination in the sense that they allow for the structure of trade in technology through patent licensing agreements. We have proposed (Laperche *et al.* [LAP 13]) another reading of coordination that is more closely linked to the temporality of the innovation process, and which makes it possible to distinguish the role of coordination of IPRs upstream of the partnership relationship (*ex ante* coordination), during the partnership and downstream of the partnership relationship (*ex post* coordination).

3.2.1.1.1. *Ex-ante* coordination

Upstream of the process of the multi-partner innovation process, IPRs appear as signaling tools that show the positioning of partners and evaluate the available resources. They constitute a lever for the negotiation in the power relations that take place within the assembly of partners. The patent portfolio available to a partner can both have an impact on negotiation but also be used as an indicator of competence. The supply of resources protected by a patent makes it possible to guarantee the non-use of an invention by partners outside the contract while promoting the sharing and availability of knowledge useful to the partnership. Patents also make it possible to delineate ownership rights in terms of both the commitment of the initial resources by the partners, as well as to clarify the objectives and expectations of the partners. In so doing, they contribute to reducing the uncertainty on the quality of the partnership and guarantee a minimum level of expertise. Patents also signal the value of inventions to partners.

According to Arora *et al*. [ARO 16], this is this way that the "paradox of the openness" is resolved. In order to reduce the risks associated with openness, firms engaged in multi-partner relationships tend to file more patents to protect their key inventions and the elements of knowledge capital used to develop them. In the case of the United Kingdom studied by the authors, this is particularly the case: the leading companies in networks have a richer knowledge capital to protect and patent more compared to lagging firms, which have less of an interest in patenting.

IPRs also appear as a helpful coordination tool for linking heterogeneous partners. This *ex ante* coordination role is particularly important in the context of public–private partnerships (Lhuillery and Pfister [LHU 09]). Upstream negotiation manages the tensions between private companies prone to protect their inventions through secrecy or patent filing, and public researchers are more inclined to disseminate the results of their research through scientific publications. In these cases, academic publications are more often than not postponed when universities are in partnership agreements with companies (Cohen *et al*. [COH 98], Veugelers and Cassiman [VEU 05]) because of the confidentiality clause that can sometimes extend up to 5 years after the closure of a public–private partnership. A clear definition of IPRs can reduce the tensions.

3.2.1.1.2. Coordination during the partnership

In a large number of technological fields, the combination of scientific and technical advances coupled with greater patentability leads to the filing of large numbers of patents and to the situation referred to as the "patent thicket" by Shapiro [SHA 01]. This dense web of overlapping patents is likely to create blocking situations insofar as the implementation of a new innovation process requires the signing of multiple and expensive operating licenses. These situations have become much more common with the growing number of very restricted patents delivered notably by the USPTO (United States Patent and Trademark Office) since the 1980s (Gallini [GAL 02]). They are numerous in the network industries such as telecommunications (Lewis and Mott [LEW 13], West [WES 06]) or in the biotechnology sector. A good example of the blocking impact of a patent thicket in the biotechnology sector is the case of Golden Rice, a variety of rice produced through genetic engineering to biosynthesize beta-carotene, a precursor of pro-vitamin A in the edible parts of rice. While created at the University of Zurich, Golden Rice uses technological means protected by patents. Its exploitation necessitated the negotiation of licenses with more than 70 patent owners (Joly and Hervieu [JOL 03]).

To deal with the "patent thicket", legal solutions have been devised such as compulsory licenses or non-exclusive licenses, or the modification of the duration and scope of patents (O'Donoghue *et al.* [ODO 98], Scotchmer [SCO 04]). Nevertheless, other solutions such as the creation of patent pools can also be considered as solutions to these blocking situations. This is an approach in which several firms agree to surrender cross-licensing in order to reduce their transaction costs. This strategy of grouping patents leads each firm to make its patented invention available to the group, that is to say, available to the "pool".

Patent pooling is not new. For example, multiple patents were filed in the United States on the various components that constitute the sewing machine. Isaac Singer assembled all these inventions and filed a patent in 1851 for which he had to deal with more than 20 lawsuits from patent holders of the components of the sewing machine. The "sewing machine war" was resolved through one of the first private pools of patents named "Sewing Machine Combination of 1856" (Mossof [MOS 11]). Boldrin and Levine [BOL 08, p. 69] also recall the case of the patent pool established in the 1870s around Bessemer steel known as "The Bessemer Association". This association was created because of the difficulties of patent ownership by several companies, hindering innovation in the sector. Two other cases are also significant, the cases of the "Manufacturer's Association" formed in 1914 and the radio broadcast pool undertaken by RCA in 1920 (see Scotchmer [SCO 04, pp. 174–176]). This practice was often regarded as a threat to competition (notably in the United States under antitrust laws), but in the two cases mentioned above, the U.S. Navy supported the patent pools for defense purposes. In fact, two cases may be distinguished: when patent pools or cross-licenses concern technology substitutes, they are considered as part of a strategy of cartelization (Shapiro [SHA 01, p. 139] gives the example of the laser eye surgery attempted by Summit Technology Inc. and VisX Inc., see also [SHA 03]). In these cases, patent pooling can encourage the development of monopolistic behaviors (such as high prices, imposition of "invalid" technologies and technology Malthusianism). When patent pools concern complementary pieces, they may be considered positively, as a solution with which to resolve blocking situations (the famous cases of MPEG-2 video compression technology, the DVD standard, and DVD video, are often cited in the literature).

Since the beginning of the 1980s, discussions have gained ground on the positive impacts of patent pooling and led to the *Antitrust guidelines for the licensing of intellectual property* in 1995 (issued by the US Department of

Justice and the Federal Trade Commission) that recognizes that “patent pools can have significant pro-competitive effects” (Clark *et al.* [CLA 00, p. 6]). According to this guideline, an intellectual property policy is pro-competitive when it integrates complementary technologies, reduces transaction costs, clears blocking positions, avoids costly infringement litigation and promotes the dissemination of knowledge. The same report states that the benefits of such a strategy are the elimination of problems caused by blocking patents, the increase in the disclosure of information between patent pool members, the reduction of licensing transaction costs and the distribution of risk: “Like an insurance policy, a patent pool can provide incentive to further innovation by enabling its members to share the risks associated with research and development. The pooling of patents can increase the likelihood that a company will recover some, if not all, of its costs of research and development efforts” [CLA 00, p. 9]. The Antitrust authorities have thus adopted a balanced approach. They recognize the pro-competitive approach of pools of complementary patents while remaining cautious of those that admit substitute patents. Patent pools have then emerged as a dominant mechanism for sharing intellectual property (Gallini [GAL 14]). This was, for example, the solution chosen to solve the problem of the exploitation of Golden Rice, the case referred to above (Bonneuil *et al.* [BON 06]).

3.2.1.1.3. *Ex post* coordination

Downstream of the process, patents filed by the partners within the pool also ensure an equitable distribution of the commercial benefits of innovation between them and a relatively effective exclusion (according to the patent protection potential) of free-riders (Sinha and Cusumano [SIN 91]. More generally, the definition for the assignment of licensing contracts allows the pool of partners to decide how to use the results of the partnership commercially. The decision to conclude licensing contracts depends on the firm’s intellectual property strategy, that is the strategy defining the role of IPRs for both the firm in question and for its potential contractors (Chesbrough [CHE 03]). The diffusion of patented technologies through licensing contracts remains a risky strategy insofar as it is associated with significant positive externalities. As a result, Bell Transistor, after having signed licensing agreements with most of their competitors, reported that they had incurred a loss of revenue due to competitors’ use of the technology once it had been distributed. Indeed, an invention can be valued in different ways (West [WES 06]), either by transferring technology via licensing agreements, by virtue of which it is incorporated into the products and components of other firms (the example of Qualcomm in the mobile technology sector is particularly revealing), by incorporating technology into components that compete with similar ones from other companies (e.g. Intel's microprocessors) or by the vertical integration of technology (e.g. IBM).

If IPRs encourage multistakeholder innovation, the impossibility of defining IPRs and of patenting the fruit of a partnership may, on the contrary, discourage the partnership, especially in the case of competing companies for which the risk of opportunism seems too high. Faced with this, alternative strategies such as incorporation into other patentable innovations exist (e.g. the Internet Explorer package with Windows 95 by Microsoft, or the iPhoto package with OS X by Apple), but they tend to foster vertical integration at the expense of multi-partner innovation [WES 06]. Moreover, as is well known, in the face of the limitations of IPRs, companies use protection portfolios that combine secrecy and lead strategies over competitors and the traditional IPRs to protect their knowledge capital (see Cohen *et al*. [COH 00], Levin *et al*. [LEV 87]). This leads us to the offensive role of IPRs within innovation networks.

3.2.1.2. *IPRs within a multi-partner innovation model: a source of opportunism*

Despite their role as a governance mechanism, the risks of opportunism inherent in partnership relationships are numerous and can be a barrier to knowledge sharing and technology transfer. Contracts that link partners in the multi-partner innovation model are – like all contracts – incomplete in nature, as it is impossible to predict all the results of the research, as well as the behavior of each of the co-contractors engaged in complex games of cooperation and competition. As Bessy and Brousseau [BES 01] point out, "we refer to the incompleteness of IPRs to describe the fact that the usage rights of intangible resources are imperfectly defined by public institutions and any infringement is not necessarily identified and dealt with by the same institutions. In these circumstances, an IPR can only protect its owner imperfectly, and they must instead make individual efforts to protect themselves". Two forms of opportunistic behavior linked to the incompleteness of IPRs can be identified: internal opportunism and external opportunism in relation to the multi-partner innovation.

3.2.1.2.1. Internal or "intraorganization" opportunism

Internal or "intraorganization" opportunism originates within the cooperation agreement as defined by the partners when, for example, one of the participants tries to take ownership of the results from the partnership by exploiting the incomplete nature of the contracts (Bogers *et al.* [BOG 11]). It is crucial for partner firms to strike a balance between benefits (in terms of costs but also in terms of the sharing of knowledge and technologies) and opportunistic risks from collaboration (Almiral and Casadessus-Masanell [ALM 10], O'Connor [OCO 06]).

Intraorganizational opportunism can also be employed to mean an advantage taken by the organization over the whole sector(s) in which the partnership takes place. In this case, all the partners (of a patent pool) benefit from the multi-partner situation in order to reinforce barriers to entry vis-à-vis third parties that are not part of the pool, but which have sometimes contributed to scientific or technical development in a more or less informal way. While this strategy of patent pooling allows for the development of complex technologies by the mitigation of blocking situations, it often contributes to the concentration of knowledge within companies in the pool, and can lead to more pronounced domination in the markets (Shapiro [SHA 03]). This is particularly the case if newly patented technologies are used as the basis for defining new standards. As early as the 1980s, the various forms of anticipatory standardization were pointed to as examples (Foray [FOR 90]). This form of standardization, anticipating the distribution of products and services on the market, lead to the fact that the consensus that is normally behind the definition of a new technical standard is most often restricted to the holders of those technologies. These associate in order to foist the technology that was developed and produced jointly (as a result of the pooling of their patents). Ownership of patents essential to the definition of standards is now crucial for companies and leads to the development of aggressive strategies to be part of the consortia which define the standards for new products and services (see Box 3.3).

Patents essential to the definition of standards (or essential patents) are defined as patents that have no substitute. This means that anyone who uses this standard without having first signed a license with the owner(s) of the corresponding patent(s) would be in a situation of infringement. By extension, these also concern patents that are necessary to implement a standard that is recognized by a standardization institution (such as the GSM standard for mobile telephony by ETSI). Companies that hold essential patents enjoy significant benefits such as the possibility setting the price of licenses, giving them significant weight in cross-licensing negotiations. They are also associated with increasing business income, including in financial markets; the non-competitive practices of blocking patents and royalty stacking are also related.

The biggest companies seek to hold such essential patents and are ready to invest large amounts of money. Kang and Beckers [KAN 15] give a few examples: that of the consortium formed by Apple, Microsoft, Ericsson, Sony and BlackBerry, which acquired in 2010 part of the former patent portfolio of Canadian firm Nortel for the sum of US$ 4.5 billion, believed to contain patents essential for 4G mobile telecommunications; that of Google which, by purchasing Motorola Mobility in 2011, obtained a patent portfolio valued at 5.5 billion U.S. dollars.

Companies also seek to develop such technologies and become part of the consortia that leads to the definition of standards. In an increasing number of cases, the company seeks to include patents in consortia at the time of, or just before, a meeting with the technical committees responsible for standardization: in the words of Kang and Bekkers [KAN 15], these are called just-in-time patents. If these patents are useful for the definition of the standard, this may be positive, but these patents may also be of poor quality or little use for the development of the standard. The purpose of these companies is to include these patents in patent consortia that are essential to standards. Such practices associated with patents involved in setting standards increase the risks of non-competitive practices (high prices, barriers to entry for potential competitors, etc.).

In the face of these essential patent practices, standardization organizations seek to impose licensing on the basis of fair, reasonable and non-discriminatory pricing, as well as specific conditions for the holders of essential patents (FRAND: Fair, Reasonable And Non-Discriminatory). Nevertheless, there are of course many lawsuits relating to non-compliance with these conditions.

Box 3.3. *Patents essential to the definition of standards.*
Sources: Gallini [GAL 14], Kang and Bekkers [KAN 15], Shapiro [SHA 01].

For companies participating in the definition of standards, it is a means of generating incomes that will be reinvested in new processes of knowledge accumulation and which will strengthen their technological leadership (Laperche [LAP 11]). Patent pooling is thus today commonly presented in relation to its pro-competitive effects (see section 3.2.1.1) but according to us, even in the case when complementary technologies are involved, patent pools support the idea of a growing private and oligopolistic appropriation of “knowledge capital”. As a matter of fact, even if the formation of knowledge capital depends on interdependent relations between increasing numbers of institutions (big firms, small concerns, research labs, etc.), only a few firms appropriate the return of their investment, because of the patents they own separately and/or collectively and which they license to each other. The other members of the innovation networks (the users: clients, suppliers, subcontractors, etc.) are not the owners of the technology, and have to pay a license fee to use the technology and/or produce the products and services that derive from this technology. This is true even if they have participated, in more or less easily observable ways (competencies, consulting, informal exchanges of information, etc.), in the constitution of the knowledge capital from which the licensed technology (or set of technology) emerges. What is important here is that the practice of patent pooling, notably resulting from *ex ante* cooperation processes and the definition of standards, contributes to defining the hierarchy of firms within the networks. This is expressed well by Boldrin and Levine [BOL 08] "Unfortunately, while patent pools eliminate ill effects of patents within the pools – they leave the outsiders, well, outside!" (p. 70).

The members of the patents pool, that is, those which own the separate or shared patents, are the leaders of the networks. Because of the power conferred by the ownership of IPRs, they build barriers to entry aimed at protecting the highest level of networks (the leaders). These protected leaders can also keep their lead over competitors by reinvesting the income they receive from the trading of licenses in R&D processes meant to develop the next generation of technology. This strategy clearly shows the offensive role of IPRs within innovation networks.

3.2.1.2.2. External or "extra-organizational" opportunism

External or "extra-organizational" opportunism originates from outside the pool of partners, when for example a third party seeks to take advantage of the imperfections of contracts. In an indirect way, by promoting innovation and patenting, hybrid institutional arrangements contribute to the development of extraorganization opportunism.

With the development of the knowledge economy, the role of IPRs has evolved considerably, in particular that of the patent [GAY 12]. IPRs have become strategic devices. They are a means of managing and influencing the competitive environment, but also a way of valuing financially the intellectual heritage of the company. In a context of shorter product lifecycles and the development of complex products, the patent is used less to prevent access to a market than to make a "technological dam". It is less a means of appropriating "monopoly rents" than "Ricardian rents", thereby making it possible to differentiate products, or "Schumpeterian rents", in turn making it possible to reconfigure resources in a disruptive R&D strategy (Corbel [COR 06]). The objective of IPRs is to protect the company's knowledge base and produce new practices through blocking patents, patent dumping, minefields, patent closure, etc. At the same time, in an economy where innovation is increasingly open, IPRs are used to obtain knowledge and skills developed by others. These are integrated into a technological and competitive intelligence strategy. As a result, IPRs are increasingly offensive, structuring the competitive environment and capturing value, sometimes favoring large companies but also sometimes favoring business models based on patent litigation (patent trolls) developed by small firms with no productive structure.

Surfing on the wave of strategic patents (Le Bas and Corbel [LEB 12]), some companies, notably those in the United States, have indeed built their business models on intellectual property litigation: the "patent trolls" (Lallement [LAL 10], Penin [PEN 10]). These practices result in the creation of "non-practicing entities" whose economic model is based on intellectual property litigation. More often than not, these constitute patent portfolios (more often bought rather than resulting from any of their own investment in R&D), which have not been industrially exploited. The purpose of these entities is to identify cases of any patent infringement of those held by them and to instigate infringement proceedings against the offending competitor. In order to take advantage of this situation, patent trolls propose to operate license agreements with these companies, but on abusive conditions, particularly in terms of price. These practices, which reflect a certain type of opportunism, stem from the imperfection of the IPR system. Indeed, these are only possible if the IPR legislation permits the patent holder's non-industrial exploitation of the patent (which is explicitly the case in the United States) and the patent is considered to be a "sleeping patent" (Weeds [WEE 99]) that will not be commercially exploited. Besides its anticompetitive nature, this practice has a negative impact on the incentives for innovation, the knowledge market, and the development of inter-institutional partnerships. Walsh *et al.* [WAL 16] study the case of patents not being utilized in the United States and found that 55% of the triadic patents during the period from 2000 to 2003 were not being used. In addition, they define a typology of why they are not used by companies. The non-use of patents can have a preemptive purpose – blocking other firms by essentially preventing new developments from taking place around the key invention. However, this can also have a prospective objective (exploration of commercial possibilities, etc.) or more simply correspond to inventions that have failed, because they are of poor quality or have since become obsolete. These unused patents can also meet several or all of these objectives simultaneously. Therefore, 40% of these unused patents (17% of them being triadic patents) over the stated period were not being used for partially preemptive reasons, whereas 6% of the unused patents (3% of the triadic patents) had only this objective. Although they are less common than patents that were not being used for prospective or failed reasons, patents not being used for preemptive reasons account for a significant share of protected inventions. According to the authors, unused patents need to attract the attention of the public authorities, through differentiating the reasons for their non-use.

3.2.1.2.3. Governance of multi-partner relationships and attempts at reducing opportunism

If IPRs favor multi-partner innovation by facilitating the coordination of heterogeneous partners, they are nonetheless objects of opportunistic behavior. Incentive/defensive roles, coordination and offensive uses of IPRs are therefore linked (see Table 3.1).

Role	Explanation
Defensive/incentive role	– Protection of the socialized knowledge capital – Incentives to the diffusion of technology and to investment in the constitution of "knowledge capital" – IPRs give a value to R&D investment (secure the shareholders)
Coordination role	– Reduction of transaction costs within the networked enterprise and within the networks of firms (patent pools) – Solution to patent disputes (cross-licensing, patent pools) – Reputation within innovation networks (trademark)
Offensive role	– Definition of the place of the enterprise within the innovation network (hierarchy) – Oligopolistic appropriation of knowledge capital and consolidation of barriers to entry – Lead time

Table 3.1. *Role of IPRs in the networked enterprise and in innovation networks. Source: Laperche [LAP 11]*

Faced with this, various public policy measures seek to limit internal and external opportunistic behaviors. These measures concern both the legal framework for IPRs and other aspects of the institutional environment. They involve the design of IPRs as part of a more comprehensive governance of partnership relationships.

Foremost, it appears that a policy that strengthens the quality of patents is an essential element of protection against the various forms of internal and external opportunism. The proliferation of patents filed and issued within the main intellectual property systems, and the concomitant increase in lawsuits and litigation, raises doubts as to the quality of patents (also see section 3.2.2). According to the OECD [OEC 11b], the quality of patents has thus fallen by an average of about 20% between the 1990s and 2000s. The quality of a patent "refers in large part to the way in which the examination of patentability is carried out, so that a quality review induces a very strong presumption on the validity and low probability of cancellation, particularly by the courts" (Lallement [LAL 08, p. 101]). In the United States and in Europe, deliberations on the quality of patents were initiated in the 2000s. In the United States, the Smith-Leahy America Invents Act (2011) strengthened the review process, notably by empowering the public to increase the diffusion of information about the prior state of the art during the examination procedure and by introducing new processes for review. In Europe, a report by the European Parliament 2007 highlighted the European Patent Office's (EPO) heavy workload and the negative consequences of the examination of patent quality. The European Commission has sought to develop an industrial property strategy in order to improve its quality and improve upon SMEs' access to it, in particular, by reducing the cost of filing and systematizing the signing of operating licenses. Deliberations on these points have continued in the context of negotiations on the implementation of the community or unitary patent (see section 3.2.2). Ensuring better patent quality and implementing a policy that is less systematically favorable to property rights holders (particularly in the United States) aims to limit the abusive practices of companies whose business model is that of intellectual property litigation (Pénin [PEN 10]). In the case of essential patents, the rules imposed by the standardization organizations referred to above (FRAND) are also heading in the same direction.

On the other hand, new IPR management practices have been developed through non-commercial patent pools: patent pools, common patent platforms, open licenses, clauses for reclamation of rights in cases of unused patents are beginning to appear, being entered into by the holders of the IPR on their own volition. The phenomena of patent donation, the use of compulsory licenses or the obligation to provide patented techniques on the grounds of public interest have also begun to emerge. What are the reasons for companies to engage in this type of practice? Studying 26 of these type cases (patent release cases), Ziegler *et al*. [ZIE 14] point to four main motivations: profit making, cost cutting, catalyzing innovation and facilitating technology (see Figure 3.3). The identification of these motivations arises from a typology that distinguishes between core patents that play a role in the company's strategy and non-core patents, which are no longer used by the company. This typology also distinguishes between direct financial objectives (cost reduction, increased profits, tax deduction) and (indirect) non-financial objectives, such as the social responsibility of the company, or the access to knowledge of a particular community. Nonetheless, the authors acknowledge that "One can argue that any firm has financial motives in its actions" [ZIE 14, p. 21].

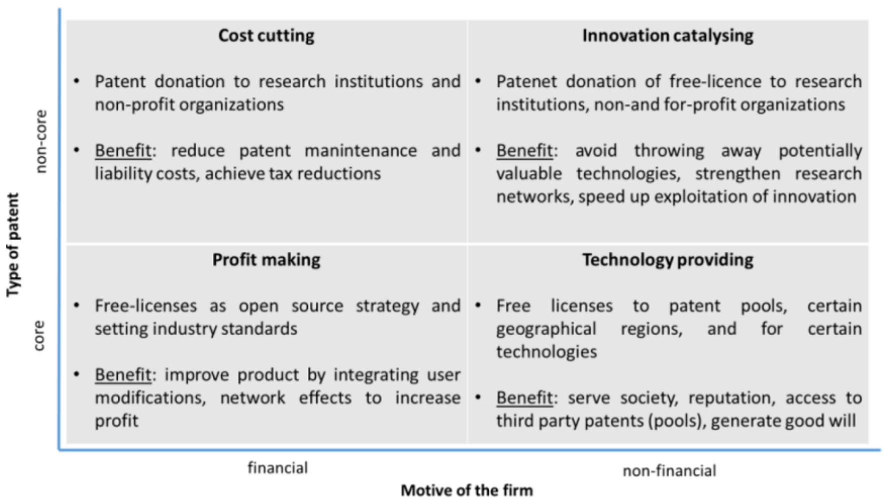

Figure 3.3. *Business motivations in the case of non-profitable strategies for assigning patents. Source: [ZIE 14]*

These new practices appear *a priori* as evidence of the fact that patents are not always used as tools for enhancing the private appropriation of knowledge and techniques. However, we must ask ourselves the following questions: who ultimately appropriates the value produced? Who are the beneficiaries, consumers and citizens who benefit from technologies that are more efficient, accessible or adapted to their needs? Or for that matter, the large companies which, because of their economic weight, will now be able, in one way or another (new patents filed, redemptions), to benefit from the new developments that will result from this free distribution of patented inventions? In this hypothesis, these alternative forms of intellectual property management in the context of collaborative innovation can be considered to contribute to the flow of information, to the creativity necessary for the "permanent innovation" of the dominant companies in the networks.

Finally, the advantage of filing a patent is also partly conditioned by the ability to enforce the rights derived from this title. The evolutions of national and international laws and the international harmonization of intellectual property systems are all elements designed to promote the respect of IPRs. All these institutional transformations (expansion, loosening, and globalization of IPRs) create a climate of confidence conducive to international investment and agreement between actors. They can therefore be considered as one of the key drivers of multi-partner innovation. Nevertheless, as we shall see in section 3.2.2, they are also not exempt from contradiction.

3.2.2. *The expansion of intellectual property*

Intellectual property law has undergone major changes since the early 1980s. On the one hand, the rules on intellectual property have been harmonized and extended internationally. On the other hand, patentability has caught on in new fields and, as seen, in new institutions (universities and public research centers). Again, the controversy between incentives, dissemination and ownership is central.

3.2.2.1. *Harmonization and international extension of intellectual property*

The patent is a national title, which works according to the saying, "a patent, a country", as taught by lawyers. However, it is possible to distinguish three main steps in the harmonization of industrial property rights at the international and regional scales, which correspond to important phases in the globalization of economies (see Figure 3.4).

The first step took place in the 19th Century when the first international conventions were signed, like the Paris Convention (1883) for the protection of industrial property and the Berne Convention (1886) for the protection of literary and artistic works. The national particularities of industrial property laws were considered as barriers to trade. This approach gained ground at the end of the 19th Century, notably due to the development of communications (railways, telegraphy) that accelerated the diffusion of goods and ideas. In this period, the numerous universal exhibitions aroused the apprehensions of exhibitors about the possibility of copying the techniques and stimulated international negotiations. The aim of these conventions was to promote non-discriminatory behaviors: in terms of IPRs, both foreign and domestic citizens were to be treated the same way. The first international agreements concerning the *International Registration of Trademarks* (1891), *Industrial Models* (1925) and the *Protection and International Registration of Appellations of Origins* (1958) were also signed in the first part of the 20th Century.

The second period in the harmonization process of IPRs began after the Second World War and continued up until the end of the 1970s. During this period the international system of patenting (the Patent Cooperation Treaty, PCT, 1970) was created as an answer to the growing number of patent applications coming from abroad. The World Intellectual Property Organization (WIPO) was established in 1967 as a specialized agency of the United Nations dedicated to the promotion of intellectual property throughout the world and to the administration of intellectual property treaties. It was also during this period, more exactly in 1973, that the European patent system (European Patent Convention) was established. Despite the adoption of the *Convention for the European Patent for the Common Market* (Community Patent Convention or CPC) on December 15 1975, the building of a common patent system in Europe has been a long process (Ilardi and Laperche [ILA 08]) and has ended with the creation of a unitary patent, the "European patent with unitary effect". It will be established by two regulations which were entered into force in 2013 and which are applicable in the 25 Member States from the date of the entry into force of the Agreement on a Unified Patent Court.

The third period began in the 1980s and is characterized by the globalization of IPRs, which culminated with the conclusion in 1994 of the agreement on *Trade Related Aspects of Intellectual Property Rights* (commonly known as the TRIPS Agreement). This unprecedented harmonization of IPRs among all the Member States of the World Trade Organization (WTO, which replaced GATT in 1995) corresponds to the third step in the globalization process. The scope of industrial property rights was widened with the TRIPS since this agreement allows for the patentability in all technological fields and harmonizes the protection period covered by patents to 20 years. This agreement is managed by WIPO and WTO, and any infringement to this agreement can lead to commercial retaliations. In this way it creates a favorable context for the global diffusion – within the networked enterprise and/or within innovation networks – of patented technology (Maskus and Reichman [MAS 04]). The rationale for this agreement is well stated by Filippetti and Archibugi [FIL 15, p. 435]: "The deal offered by developed to developing countries was clear: we open up our markets to your merchandise, but you should guarantee our IPRs in your countries. TRIPS moved an important step from harmonization to standardization". These authors distinguish a fourth phase in the establishment of a global intellectual property regime, characterized by the national implementation of the agreements. The contradictory interests of these countries, but also the lack of such resources for developing countries, does indeed explain the absence of an identical regime of intellectual property at the global scale.

This period also includes the signing of the global Convention on Biodiversity, which is not directly related to intellectual property but is linked to it through the extension of intellectual property protection to the domain of life (see below). The concept that prevailed in the 1970s was to consider these resources as part of the common heritage of mankind. However, the growing need for genetic resources in the life sciences industries, coupled with the expansion of patentability to living beings, has put biodiversity conservation at the forefront of the international arena and has led to a more liberal conception, one which aims for conservation and commercialization to be compatible. Concerns have essentially been twofold: to ensure the constant replenishment of a stock of raw materials that can be used by industrialists and to foster a fair return to the countries of the South which hold the largest share of biodiversity (Brahy [BRA 08]). The Convention on Biological Diversity (or CBD), signed in June 1992, is the first global convention on biodiversity (specialized texts on certain aspects of biodiversity existed before). In keeping with the above concerns, affirming the sovereignty of States over biological resources and recognizing IPRs and the rights of indigenous and local communities, in turn makes the market an essential tool for the preservation of biodiversity and the traditional knowledge associated with it (Boisvert [BOI 00]). Contracts – bioprospecting contracts – should enable "the fair and equitable sharing of benefits arising from the utilization of genetic resources", one of the objectives set out in this Convention alongside "biodiversity conservation" and "sustainable use" [CBD 92, art. 1).

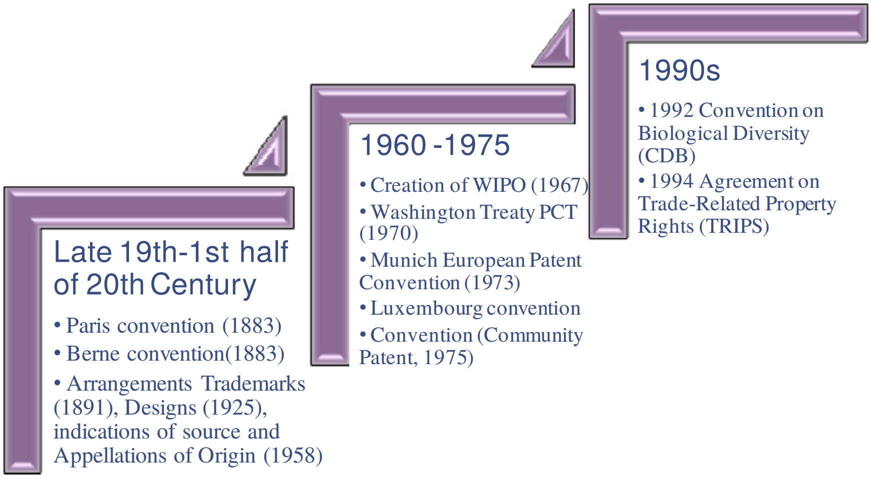

Figure 3.4. *The three stages for the global harmonization of intellectual property rights. Source: Author*

3.2.2.2. *Patentability extended to new domains*

The recent trend toward extending patentability to new fields and closer to the scientific frontier can be regarded as an answer to this growing need for protection (Coriat and Orsi [COR 02], Gallini [GAL 02]). Back in the 1980s, in a context of decreasing competitiveness and serious challenges arising from Japanese competitors, the United States made substantial changes in IPR, notably in the fields of biotechnologies and Information and Communication Technologies (ICT), that is the embryonic generic technologies of the time.

With respect to information technology, significant changes also apply to software and business methods (Lerner [LER 02], Liotard [LIO 02]). In the early 1980s, software, composed of mathematical algorithms, was excluded from patentability, in the same way that natural laws, scientific theories, natural phenomena, abstract ideas, formulas and methods were exempt. However, American software publishers considered this development to be insufficient owing to the difficulty of coping with possible imitations. It was at this point that the evolution of the case law (through the US Court of Appeals for the Federal Circuit) resulted in the acceptance of the patentability of software (*Diamond vs. Diehr*, 1981). Computer program patentability ensued because of the explanation that a computer program represents an invention (in terms of process) and from the fact that it produces a useful, concrete and tangible result. The patentability of computer programs paved the way for the possibility to patent business models (*Street Bank vs. Signature*, 1988). In the United States, business models are now broadly understood as they concern educational methods, methods of organization, e-commerce, advice, financial methods, etc.

In Europe, the legal framework is more constraining, although the trend toward the acceptance of software patents is increasingly noticeable. The Munich Convention of 5 October 1973 in Article 52 (2) excludes the patentability of computer programs as such, as they are considered to be protected by copyright, but the debates surrounding this have multiplied. The EPO has for many years granted patents for software designed as technical processes, that is to say as technical inventions; however, software (mathematical algorithm) is excluded from patentability.

The extension of patentability to the domain of living organisms is also being sought out on the other side of the Atlantic, and case law is the vector of mutations (Coriat [COR 02]). The first important decision is the US Supreme Court's Chakrabarty judgment, when General Electric's employee (Ananda Mohan Chakrabarty) filed a patent in the early 1970s for a genetically modified microorganism to absorb oil from the tides, The United States Patent and Trademark Office (USPTO) opposed its issuance on the basis that a microorganism, as a product of nature, cannot be patented. After numerous appeals, the Supreme Court of the United States pronounced in favor of the patent, stipulating that this microorganism is not a pure product of nature, since it required the hand of man in order to be brought into the light.

This decision therefore constitutes the basis upon which patents on living things will be granted to the United States: in other words, all living beings from an unnatural process (with the exception of man) can henceforth be patented. Following from this was the patent granted to Stanford University in 1980 on recombinant DNA, but truly an echo of the Chakrabarty judgment was another granted to Harvard University in 1988 for a transgenic animal (the "oncogene" mouse) and which should serve as a basis for the field of cancer research. From the 1990s onwards, the debate concerned the patenting of human genes and "research tools" (also see [CAS 01]). In 1991, the US National Institutes of Health had filed patents on 2,500 partial DNA sequences, justifying them for their "usefulness" in research purposes (these Expressed Sequence Tags, or ESTs, are used for the identification of genes). It is this type of utility, too remote from the world of commerce, which pushed the USPTO to initially refuse the granting of patents. However, the USPTO will soon review the *Utility Examination Guidelines* published from 1995 until 2001 and eventually grant patents on partial DNA sequences considered useful (search tools) and on genes involved in the onset of diseases.

In Europe, debates on the patentability of living organisms increased in the 1990s and resulted in *Directive 98/44/EC* of the European Parliament at the Council of July 6, 1998, which paved the way for the patentability of genes and partial sequences of genes. The first paragraph of Article 5 of that directive states that the sequence or partial sequence of a gene is not a patentable invention. The second paragraph, on the other hand, states that "an element isolated from the human body or otherwise produced by means of a technical process, which is susceptible of industrial application, including the sequence or partial sequence of a gene, may constitute a patentable invention, even if the structure of that element is identical to that of a natural element".

Scientific advances (genetic engineering) have also enhanced the possibilities for plant ownership (Laperche [LAP 09]). Certificates for plant breeder's rights issued by the UPOV (International Union for the Protection of New Varieties of Plants) still exist and the scope of protection granted has also increased. The UPOV was first signed in 1961 between European countries (entering into force in 1968) and was later extended to all applicant countries. It was amended in 1972, 1978 and again in 1991. The purpose of this agreement is to grant exclusive rights to breeders of new plant varieties (Plant Breeders' Rights). The peculiarity of this type of protection is that it offers "research exceptions", which means that the new variety is made available and is therefore usable by all those wishing to create other varieties, including those for commercial purpose. It also includes the "farmer's privilege", which means that the farmer is free to reseed his field with the product of protected plant varieties (Brahy [BRA 08], Trommeter *et al.* [TRO 07]). The amendment of UPOV in 1991 resulted in the limiting of research exceptions and greatly reduced the farmer's privilege, who are prohibited (in some States) from reseeding their field with a protected plant variety.

The Agreement on Trade-Related Intellectual Property Rights (TRIPS) harmonized IPRs in all WTO countries and allowed the patenting of living organisms. Article 27.3 (b) states that "parties may exclude from patentability plants and animals other than microorganisms and essentially biological processes for the production of plants or animals other than non-biological and microbiological processes". These various clauses make it possible to patent genetically modified plants and animals. Wright and Pardey [WRI 06] also point out that plant and animal exemptions are commonly abandoned in the bilateral negotiations "TRIPS +" between industrial and developing countries. Plant variety protection is also provided for in Article 27.3 (b) "either by patents or by an effective *sui generis* system [the type of plant breeder's right] or by any combination thereof".

At the end of the 20th Century, via genetic engineering, patents on indigenous knowledge and plants, microorganisms, genes, animals, and human cells and proteins multiplied. Several examples can be cited, such as patents filed on products using the properties of Indian *neem*, on oil extraction processes, chocolate recipes based on *cupuaço* (a tree of the cocoa family endemic to the Brazilian Amazon), on a variety of *quinoa*, or on a variety of *ayahuasca* (a sacred plant endemic to Ecuador), on *curcuma* (Curcuma longa L) etc. These contested patents have been at the heart of the dispute regarding the patenting of living organisms and "biopiracy", particularly by international NGOs such as the Third World Network, the RAFI/ETC and Grain groups (Aubertin *et al*. [AUB 07]). Biopiracy can be defined as the unauthorized commercial use of biological resources and/or associated traditional knowledge, or the patenting of inventions based on such knowledge, without compensation (Mgbeoji [MGB 06, p. 13]). Bioprospecting contracts provided for under the biodiversity convention are expected to reduce biopiracy cases, but in many cases the impact on indigenous peoples or tribes is often weak (Efferth *et al*. [EFF 16]). The Nagoya protocol, dedicated to the protection of indigenous knowledge and backed by the convention on biodiversity, signed in 2010 and entered into force in 2014, has not yet been ratified by many countries. The case of *stevia* is also interesting. The *stevia* leaf has been known since the late 19th Century by the Guarani people (Amazonian region) and used as a sweetener in the global agri-food industry. Multiple patents using or producing *steviol glycoside* have been deposited by Pure Circle, Cargill, DSM, Pepsico and Evolvia with few benefits having been recorded for the Guarani people despite the signing of the CBD and the Nagoya Protocol (Berne Declaration *et al*. [BER 16]).

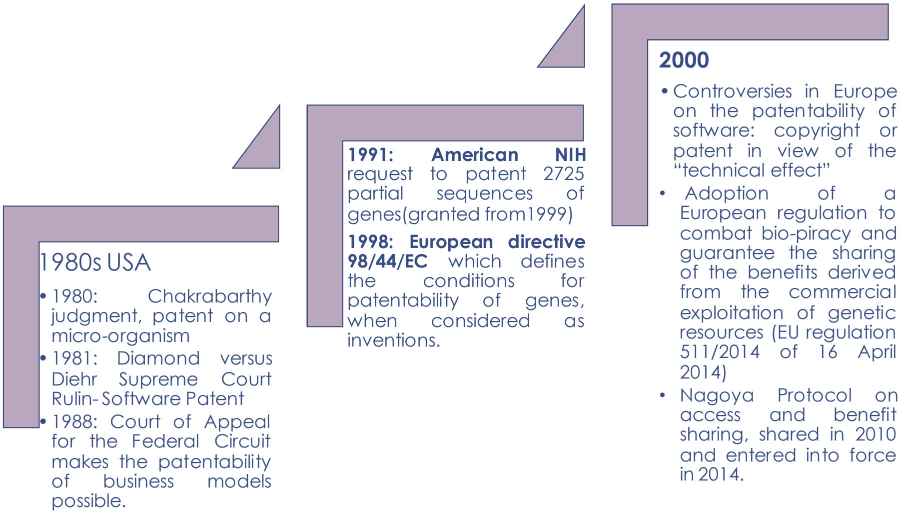

Figure 3.5. *Expanding patentability into new fields. Source: author*

According to us, all of these institutional changes are evidence of a greater need for protection, which is being requested by the firms themselves. This greater need for appropriation can be linked to what we have called the "profitability imperative". Global corporations have to innovate in order to remain competitive. The rapid pace of technological progress ("permanent innovation") leads to the increase in the costs, the complexities and hence the risks inherent to the innovation process which, nonetheless, have to be reduced if firms wish to keep their precious investors. To reduce the cost, the risk and the duration of the innovation process, firms rely on their own capabilities as well as the resources offered within their networks. However, in being more open to their environment, they become more vulnerable, all the more so when the appropriability regimes differ between the countries in which they are active. This is why corporate lobbying is a major explanatory element of the evolution of IPR laws, as reported by S. K. Sell in the case of the TRIPS Agreement [SEL 03].

3.2.2.3. *Expected benefits and challenges from expanding intellectual property*

The expected benefits of the geographical expansion of intellectual property protection and its extension into new fields are well known. For their promoters, it is a matter of encouraging private initiatives and the ability of entrepreneurs to make profitable investments using a traditional approach to the role of incentives for IPRs and patents in particular. This incentive should be valid for both new sectors of activity that have emerged in the context of scientific and technological progress, that is in the field of ICT, as well to in the domain of life. At the international level, these institutional transformations should contribute to an easier access to modern technologies and a greater capacity for innovation in developing countries.

Theoretical and empirical studies on the impact of strengthening IPRs in both industrial countries and developing countries (static and dynamic effects, impact on international trade), show positive impacts on technology transfer (Branstatter *et al.* [BRA 10], Dinopoulos and Sergestrom [DIN 10]), while others point to controversial results (Combe and Pfister [COM 01], Helpman [HEL 93]). In industrialized countries, the expansion of intellectual property has been accompanied by a proliferation of patents mainly filed by the largest companies, often increasing litigation and leading to high-profile patent wars such as those between Apple and Samsung or Apple and HTC. The high legal costs that these patent wars beget can inhibit innovation in the dissemination of products. However, for some, they favor a better organization of the market via patent pools (e.g. in the case of Apple and HTC, see Trappey *et al.* [TRA 16]). In the field of technologies that mitigate climate change (energy efficiency, carbon capture and storage, renewable energies, etc.), patents appear to be a strong incentive to invent (as measured by the increase in patent filings in these technological areas), while their dissemination, via licensing in particular with developing countries, is slower. This is very damaging given the urgency of the climate change agenda (Raiser *et al.* [RAI 17]). Some initiatives exist to promote this dissemination through an *Eco-Patent Commons*, a patent pool launched in 2008 and which brings together the eco-innovation patents of 13 firms (including Bosch, Dow, Dupont, Fuji Xerox, Hewlett Packard, etc.), and which allows non-members to use them without incurring the associated costs. In this way, member firms seek to take advantage of greater creativity and reputation ([RAI 17], Ziegler *et al.* [ZIE 14]) (see also section 3.2.1.2).

For developing countries, one of the expected effects of IPR enhancement is the readiness of technology to meet the needs of developing countries, brought about by a stronger incentive for industrial countries to innovate. However, in the field of health, as in agriculture, existing studies do not provide a definitive answer (Laperche *et al.* [LAP 09]). For example, in the agricultural sector, innovations (arising from the incentives given by property rights) would solve hunger problems worldwide by increasing and adapting agricultural production to the climatic and natural conditions of the different territories. Seed production resistant to certain diseases would have a positive effect on agricultural yield. However, the problem of hunger is not a problem of insufficient production but rather a problem of distribution arising from economic power relations. In addition, the cost of genetically modified plants protected by patents is such that they are often inaccessible to developing countries (Beauval and Dufumier [BEA 06]). Moreover, the adaptation of these technologies to the needs of developing countries is contested due to the scientific uncertainties surrounding genetically modified organisms.

Patent filings by large seed producers on genetic sequences that promote climate change adaptation confirm the positive impact of IPR enhancement on the incentive to develop innovations tailored to developing countries (e.g. drought-resistant crops). However, the same argument about price, difficulty of access and shortcomings, as compared to other alternatives (such as the support of food production) counterbalances the positive arguments [ETC 08]. Generally speaking, the privatization of plant resources for legal and technological reasons reinforces farmers' dependence on "Northern" multinational firms. Up until now, agricultural practice consisted of the replanting of seeds the following year, or the exchange of seeds among farmers in order to improve varieties. The current regulations (UPOV, 1991 version) tend to put an end to this type of practice. This dependence is further accentuated by technological advances. Indeed, the seeds have been modified so as to be "sterile" (the famous Terminator), that is to say the seeds produced for this strain of plant can only be used for one season. This dependence can lead to an increase in imports, which will weigh on the debt of the poorest countries and exacerbate their poverty.

Another argument in favor of property rights is that the establishment of a system of industrial property protection in developing countries will stimulate their own capacity for innovation. This is the argument that has been used to persuade developing countries to accept the extension of patentability in all technical areas included in the TRIPS Agreement. In the field of drugs, for example, many countries did not recognize patentability, which enabled them to develop a strategy for the production of generic medicines (see Yacoub [YAC 12] for the case of Tunisia). However, this does not take in account the fact that the signing of the TRIPS agreement forced countries wishing to continue their production of patented medicines to sign expensive licenses or to abandon these productions in order to concentrate on the manufacture of medicines, for which the patents have fallen into the public domain. It also does not make mention of the practice of secondary patents filed by patent holders for alternative forms of molecules, different formulations, dosages and new uses (Sampat and Shadlen [SAM 17]). Such practices result in longer periods of protection.

More fundamentally, the argument for increasing the incentive to innovate, associated with the establishment of intellectual property protection institutions in developing countries, arises from a linear and tautological view of the relationship between patentability and innovation. The introduction of such a protection system would thus lead to an improvement in the capacity to invent, which is itself measured by patent statistics or plant breeder's right that have been filed and issued. Contemporary studies on innovation show that the ability to innovate sustainably and qualitatively results from the establishment of a network of firms and institutions operating in a systemic way (national systems of innovation – see Chapter 2; also Filippetti and Archibugi [FIL 15]). The determinants of innovation of formal technology transfers as well as those for direct foreign investment are numerous. They include an empowering environment for domestic and international investment, the existence of educational infrastructure and a capacity for research, as well as an absorptive capacity from local firms. The implementation of institutions to protect intellectual property alone will not be sufficient enough to improve the innovative capacities of developing countries. A final conclusion on the relationship between IPRs and the development of innovation capacity cannot be drawn from empirical studies, since the initial scientific and technical capacity of lagging countries varies for different regions of the world and across different sectors of activity UNCTAD [UNC 03].

Institutions that comply with those required by the TRIPS Agreement may also prove to be too rigid in relation to the needs of developing countries and thus have the opposite effects (see, in the case of plant variety protection, Tripp *et al.* [TRI 07]). The establishment of these institutions is also very costly for less developed countries and may be considered to be the cause of crowding-out effects. Finger and Schuler [FIN 00], for example, point out that these investments are less profitable than those employed to satisfy the diffusion of basic goods such as education. The strengthening of IPRs also goes hand-in-hand with an increase in royalties transferred to companies in the North, which crowd out potential investments in internal science and technology. We find ourselves in a tragedy of the anticommons situation (Heller and Eisenberg [HEL 98]), the result of a proliferation of property rights which deprives countries and populations of their resources, or creates higher costs for their use.

The transfer of plant resources from the South to the North is now taking place through property rights and is explained by the ambitions and constraints of multinational firms in a globalized market economy. Facing the fears of developing countries, since the Convention on Biodiversity plant resources are no longer regarded as the common heritage of humanity, but as a resource under the sovereignty of States. Private or collective property rights, as claimed by some developing countries (such as the group of Megadiverse[1] countries), seek to develop a resource coveted by industrialists in the North. However, as such, they are based on the same logic. The logic of appropriation is that of the market: it is driven by competition and generates concentration and monopoly. In this context, participants who do not have the financial, scientific, technical, human and legal resources necessary to exploit the resource are thus the weakest and the first to be penalized.

What are the possible solutions against the chief disappointments related to the commodification of living things? The design of biological resources as a "global public good" (Kaul *et al*. [KAU 02]), paving the way for institutional arrangements that are favorable to both industrial and developing countries, runs counter to both national sovereignty claims and ownership, and their appropriation by industry in a globalized market (Compagnon [COM 08]). Stiglitz and Charlton [STI 05] consider that a new intellectual property regime needs to be established through international negotiations so as to better balance the interests of users (in developed and developing countries) and in order that producers know more. They suggested modifying certain provisions of the TRIPs Agreement: for example, to strengthen the "universal novelty" requirement of patents in order to protect traditional knowledge, in order to allow compulsory licensing beyond national emergencies and a "refusal to trade", providing measures for the prevention of anticompetitive practices in licensing contracts and to ensure the transfer of technology from the most developed to the least developed countries. For Filippetti and Archibugi [FIL 15], despite the institutional changes that have led to the globalization

1 Established in 2002, it brings together 17 richly biodiverse countries (including Brazil, China, Colombia, Costa Rica, Mexico, India, etc.) to take advantage of their biodiversity and impose conditions that are favorable to them in the face of the industry.

of IPRs, a global IPR regime does not exist in practice. Indeed, the application of international agreements remains under the control of States, which have either an interest in maintaining a weak protection regime, or lack the human and financial resources to make it stronger. As such, the issue of catching-up for lagging countries should not be based solely on the role of IPRs.

Indeed, since the 1970s, the industrial and innovation economy ICS has put forward the determining factors for innovation in a national economy. What is being said today seems all too often to be restricted to the role of incentives for IPRs, whereas the process of innovation is the result of the systemic functioning of a much broader set of institutions including educational, research, the business sector and the definition of pro-active economic policies (Freeman [FRE 87], Lundvall [LUN 92]). Authors such as Boldrin and Levine [BOL 08] illustrate through many historical and current examples that rights are not a prerequisite for innovation, but more often a consequence, often harmful: "patents protection is not the source of innovation but rather the unwelcome consequence that, eventually, tames it" (p. 47).

The return of State intervention in the economy is advocated in the reports of international organizations such as those by the World Bank and UNCTAD [UNC 07, WBW 07], after an influence of more than 25 years of theses advocating its withdrawal from the economy. From a perspective of endogenous development, the promotion by States in coordination with the private sector, of institutions dedicated to innovation, would undoubtedly be more beneficial to developing countries, rather than deliberation based solely on IPRs.

Conclusion

> "With the growth of capitalism came the bestowing of special monopolies, first to the chartered companies, and then to the owners of special patents granted for specific original inventions. This was proposed by Bacon in 1601 and happened first in England in 1624. From this time on, it *was not the past heritage that was effectively monopolized but the new departure from it*" (Lewis Mumford [MUM 46]).

A chief observation that emerges from this book is that there is a greater socialization of the general production of knowledge capital, particularly within companies. Sources of knowledge are distributed more globally than they were a few decades ago. They are also more easily accessible, in particular due to the advancement and enormous uptake of information and communication technologies. Companies – the largest ones in particular – have forged global networks for the production and dissemination of knowledge. However, this greater distribution of knowledge sources faces contradictory forces that are reflected in the appropriation strategies being deployed by the richest firms and nations in terms of knowledge sources and the value produced.

At the companies' level, this contradiction, which is not new, but which is accentuated, can largely be explained by the constraints they face. These are of a short-term nature, for example, the saturation of markets in Western countries, repeated crises and so on, but are explained by more structural elements. The financial globalization and the liberalization of markets of all kinds (goods and services, finance, labor) since the 1980s have significantly increased the weight of finance in the definition of any corporate strategy or public policy. While global competition is based upon the ability to innovate

Enterprise Knowledge Capital, First Edition. Blandine Laperche.

on a permanent basis, the obsession with short-term outcomes forces firms to share both costs and risks of technological development, which in turn increases the socialization of knowledge. This is all the more so given the fact that technological complexity requires the assembly of scientific and technical abilities that a single company cannot develop on its own. The cost of technological development is such that the wisest strategy is to open up the company and collaborate with all kinds of partners, nationally and internationally, sharing knowledge and sometimes also patents. In this regard one understands the popularity for the concepts of open innovation, collaborative innovation, or innovation ecosystems. In order to make these strategies viable and to reduce their cost, public policy has since deployed a whole arsenal of "innovation policies" with the aim of facilitating the socialization of knowledge production: policies which open up universities and promote public research, support policies (indirect, through taxation or the definition of a suitable institutional framework) for entrepreneurship, innovation in SMEs and large enterprises, cluster policies, etc.

At the same time, companies are seeking to make the most of their investments, in a context of both global competition and in terms of saturation of Western markets. This context encourages them to turn to markets in emerging countries that are growing but where purchasing power is low, hence the development of innovation strategies that are better adapted to these markets (frugal innovation, low-cost innovation). However, the largest trend is the will to privately appropriate knowledge organized as knowledge capital. Again, changes in the institutional rules on intellectual property have been crucial in fostering these appropriation strategies, although the context of global multistakeholder innovation somewhat complicates this company strategy. If indeed there is to be cooperation in the production of knowledge capital, all firms need to see the advantages that this opens up for them. Nevertheless, they are far more reluctant to share the benefits gained from exploiting their knowledge capital, even with all the parties/institutions that have contributed to its development. This new context has revealed new roles for intellectual property rights, more acceptable than income-seeking and the creation of barriers to entry. By an extraordinary tour de force, intellectual property specialists and economists specializing in this field demonstrate that these "property rights" (words have meaning) are today essential to the smooth operation of multi-partner relations: they are the tools of coordination and they pacify relations between actors by defining clear rules both upstream and downstream of the partnership. Yet, as institutionalist economists have shown us, contracts are often "incomplete" and there is always the predisposition to privately appropriate the knowledge produced (in a single direction). The offensive role of intellectual property rights remains well established in collaborative relationships, and is superimposed on the role of incentives and coordination thereby granting them certain legitimacy.

The balance of power is far more favorable to large firms than small ones, and likewise to "rich" countries more than emerging countries, resulting in the creation of a hierarchy within the networks and an appropriation by some firms of the knowledge capital and profits from its operation. Those who benefit most from this oligopolistic appropriation are not the countries of origin or the host countries of these firms. The markets of industrialized countries (where multinational firms are still mainly coming from) but also those of emerging countries are inundated by the innovations developed by these firms: tablets and other smartphones, software is omnipresent and yet the level of education of children stagnates or falls in OECD countries [OEC 16b]. The most varied agri-food products are available, while poverty and inequality increase [FAO 15], soil depleted by chemical fertilizers [FAO 16] and diseases (obesity, diabetes, cardiovascular diseases) proliferate, in part due to the sometimes questionable quality of the products distributed by the agro-industry (for example diabetes, see [WHO 16]). Medicines are increasingly more sophisticated but also more expensive, often inaccessible, and their safety is sometimes challenged at the rate health scandals are being reported. Examples of this are manifold. Those who benefit most from this privative appropriation, which not only includes the absorption of the profits resulting from the exploitation of knowledge capital but also the upstream orientation of the direction taken by scientific and technical knowledge, are not the employees of these companies who are for many of them subject to difficult working conditions (victims of more psychosocial diseases [WHO 10]) and threatened by the generalization of precarious jobs, relocations and/or their possible replacement by robotic automatons, and artificially intelligent. The ones really benefiting from this status quo are the company shareholders, some of who are employed in top management or chief positions in major banks, insurance companies, pension funds, etc., and who play with the future and fears of populations on a global-sized Monopoly board. The number of billionaires is increasing [BCG 16] and their wealth is being built on the constitution and exploitation of the knowledge capital that our knowledge societies produce.

Faced with such a situation, the challenges are manifold. They translate into an emphasis on scientific and technical developments that are the most profitable in the short term and the least economically risky. The case of green technologies – which, in the aftermath of the 2008 crisis, represented new opportunity for accumulation by companies with which to re-establish profits, and on which States also hoped to relaunch the failed economic machine – is in this regard illuminating. The major innovations, which are capable of achieving the results expected by both companies and governments, are struggling to emerge. Despite the attractive concepts that intend to change industrial and economic organization (such as that of circular economy and developments that are more respectful of nature and society), only minor or isolated innovations appear and they struggle to make it into the "System" (Gallaud and Laperche [GAL 16], Laperche *et al.* [LAP 12]). At the same time, industrial lobbies seek to prolong the benefits of exploiting non-renewable energies by denying the risks incurred to the well-being of the planet. Innovation in this context is not at the service of society or the major issues facing mankind, such as climate change, poverty, famine or aging populations.

Ready-made solutions are not the conclusion of this book, which aims rather to intensify the debates taking place on and around these themes, and which, isolated from their context, lose much of their meaning. Innovation cannot be satisfied with a simple demand for greater capacities for private initiative, or even grander and more direct interventions by the State. It depends, in our opinion, on a broad redefinition of the objectives of society.

Postface

An innovation system describes the relationships – scientific, technological, industrial, commercial, financial and political – between institutions, whether private or public: companies, research and engineering laboratories, administrations, etc. These relationships are most often composed of financial and information flows and the movements of people. The goal of such a system is to generate innovations (new organizations, new goods and processes, new resources: new combinations of productive resources). The system is based on innovation networks containing "business clusters". A "business cluster" (or a network firm) can be defined as a set of legally and/or financially connected enterprises to a large company (pivot), which constitutes a system, an (or many) integrated production(s) into the same value chain that is under the direction of the pivot firm. The "cluster" is a network of businesses, the networks of which are formed by the interweaving of different "clusters".

In her book, Blandine Laperche shows that the current organization of production is based on spatial deconcentration in terms of the implementation of production and the centralization of decision making, financial and informational investment and marketing. The relationship between the innovation system and "clusters" is the networking of scientific research and technological development, entered into jointly by enterprises and public institutions, with the goal of generating innovation.

Innovation is characterized by the commercialization or commercial valuation of scientific work and the appropriation of these results through innovative companies. These companies innovate because they are able to create important knowledge capital. Drawing on the common heritage of knowledge that is the result of scientific research, they combine it with scientific and technical knowledge that they have already accumulated to propose to the "market", various new (consumption and/or production) goods and services.

The parameters of "time" (transfer and valuation) and "cost" of appropriation (social) of this marketable knowledge requires the joint implementation of a growth strategy and a new accumulation framework, which must ensure the coherence between the logic of the researcher and that of the entrepreneur.

The history of enterprises – the major asset of the hypothesis which Blandine Laperche defends in this book – teaches us how cartel-type cooperation agreements within the fields of science and technology, acquisitions, mergers and business alliances allow large companies to increase their market power. These growth strategies result in the broadening of the firm's boundary (see cluster theory) and the formation of networks, which have a tendency to be substituted for simple commercial transactions between independent firms. These networks present themselves both as a counterweight to the fluidity of markets and the risks that they create, as a prerequisite for strengthening the innovation capacities of the companies who are the stakeholders in the arrangement. Clusters and networks are the two tangible manifestations of a dual strategy being followed by the large company: a strategy of dimension – enrichment of both the tangible and intangible heritage – and a strategy of market power – mobilization, the acquisition and valuation of financial assets, human and technological development with a view to establishing barriers to entry. In both cases, the important thing for the company to achieve is the strengthening of its innovation potential and financial capabilities.

Innovation requires a major effort in terms of organization, but it is also the result of organization. At present, the organization of the innovation process is characterized by the importance of strategies for the appropriation of scientific and technical resources by large companies. The company tends to rely more on its environment (innovation system) than to invest, for example, in all phases of technological creation, which can certainly be explained by the fact that investments in the acquisition (appropriation) of production resources are less costly than those devoted to the production of these resources. The collective profitability of capital may be high, while the private profitability may be insufficient. The explanation of the superior social return on investments in scientific research and innovation in relation to the return on individual capital can be observed in the increase in the number of factors involved in the realization of profits.

These factors (global education, environment, health, finance, information, etc.) act on the trajectory of the marginal cost of a business or an activity and, likewise, affect the return of the capital invested. In a system of genuine or latent competition, the firm must take ownership of these factors, or at least control their impact on its performance or, better still, turn to its own advantage (abundantly appropriable resources for production, the opening new markets) the non-market logics that generate and reproduce these factors. The level of external economies that the company is capable of achieving depends on its success in terms of innovation. The act of innovating involves the implementation of new combinations of codified or tacit knowledge, the dissemination of this knowledge, but also the appropriation and integration of knowledge into a wider combination of productive resources.

The large company, through partnership and cooperation agreements, forms and maintains command over a collective of organizations that mobilize various productive (material and cognitive) capacities. It is the node of convergence and deployment of production resources. The market power of a firm (and the coordination of its functions and activities) is a factor of economic power (and the centralization of ownership of capital) that is more important than power that can be conferred on it by its own heritage (scientific, technical, industrial and financial). The "quantities" and "quality" of the knowledge capital that the firm holds determine the size of the network it deploys as well as the market power it exercises, while shaping the scope of the cluster; the latter being able to assert a dominant position within the innovation system and in the sociotechnical production system.

The market power of this company results from its financial capacity (portfolio of securities and mobilization of capital) and its knowledge capital. As Blandine Laperche points out, the knowledge and finance associated serve to constitute and manage geographically distributed and physically remote work collectives (investments in cooperative relations, protection of the technological heritage, the appropriation of scientific knowledge and the design of new merchandise, the coordination of different activities, etc.). This is a centralizing deconcentration strategy characterized by a flexible management of the assets (formation or destruction of production capacities according to the economic circumstances) and by an increase in the capacity of companies to appropriate large quantities of resources without investing in their production. The end result is the formation of clusters of innovative firms based on networks of independent firms, knowledge-producing institutions (universities, research institutes, technology-providing firms), gateway institutions (for example providers of technical services or consultancies) and customers, linked in a production chain creating added value.

In today's innovation systems, the management of knowledge and expertise is the vocation of managers. However, since information is the nerves of a business, the management of change depends on the quality of the information strategy being implemented by the company; a strategy that allows it to seize opportunities and confront routines so to engender innovation. Innovation, and hence the performance of a company, network or innovation system, depends on the extent of the learning and knowledge-building processes being achieved in conjunction with other producers and with consumers. The renewal of markets (or the opening of new markets) through innovation, fuels competition, raises the cost of investment and contributes to the formation of complex networks of companies and R&D institutions. The boundary of the company is thus apprehended by the place it occupies within an innovation cluster: the greater the knowledge capital of the company, the more extended its boundary, the more influential its power over the market will be. Innovation trajectories are traced by companies that have the capacity to constantly enrich their knowledge capital and to combat routines (often resulting from inefficient management of the capitalization of knowledge capital) while controlling the pace of diffusion and the uptake of emerging innovations. However, the innovation and market strategy of companies are not separated from the business climate, and is itself subject to the same imperatives of change.

With a strong grasp of economic (and sociopolitical) thinking, the author invites the reader to reflect on the entrepreneurial dynamics of innovation: the corporate strategy for research and innovation is centered on the triptych of genesis – management – valuation of knowledge capital. The relevance of this triptych in the study of the company is illustrated by the priorities of investment orientation: the mobilization of skills, the acquisition of multifunctional means of production, the protection of scientific and technical heritage, the combination of production resources and the distilled diffusion of signs with a view to open up new markets.

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Business Intelligence

ZANINETTI Jean-Marc
Sustainable Development in the USA

2008

CORSi Patrick, DULIEU Mike
The Marketing of Technology Intensive Products and Services

DZEVER Sam, JAUSSAUD Jacques, ANDREOSSO Bernadette
Evolving Corporate Structures and Cultures in Asia / Impact of Globalization

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AMMI Chantal
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BOUGHZALA Imed, ERMINE Jean-Louis
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Index

M, N

O, P

R

S, T, U