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Patent regimes and the commodification of knowledge

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Patent regimes, firms and the commodification of knowledge

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Abstract

This paper analyses the evolution of the intellectual property regime (IPR), and more precisely the patent regime, in the USA since the 19th century. To do so, we consider intellectual property laws within the context of wider changes in capitalism, focusing on two main historical phases: firstly, the period covering the formation and development of 'corporate capitalism' dominated by large corporations and then the new phase, which opened up in the 1980s, marked by the rise to power of finance. From a perspective of institutional complementarities, we seek to show how the characteristics and implications of patent regimes can only be understood in relation to changes in the main institutional forms of capitalism: forms of the firm, the status of labour (the 'wage-labour nexus') and market forms.

Keywords: firms, financialization, institutional complementarities, knowledge based economy, labor law, property rights.

JEL classification: O34 intellectual property rights, P1 capitalist systems

Introduction

Describing our economies as 'knowledge-based' is now a commonplace. This paper does not set out to examine the precise content or pertinence of this view of modern capitalism. Let us simply observe that the importance of knowledge—and more specifically of scientific and technological knowledge—is an essential dimension of industrial development and has been for a long time. It has been one of the distinctive features for two centuries or more, as numerous authors, like Kutznets (1966), have pointed out.

In this context, saying that an economy is 'knowledge-based' does not mean that economic activity uses 'more' knowledge than it did before. Rather, it means that the conditions of production and use of knowledge, in its different forms, has changed: knowledge has become *an economic good which, under changed conditions, can circulate as such*; in the words of Winter (1987), it has become a 'strategic asset'. The question then arises: under what conditions can economic agents control and appropriate knowledge and turn it into a source of revenue? The answer lies in an analysis of the legal and institutional framework governing the conditions of production, circulation and use of knowledge. And intellectual property systems lie at the centre of this framework.

The unprecedented development of intellectual property has been one of the most important factors in the transformation of capitalist economies over the last 20 years. The major changes in the intellectual property regime in the United States and the world-wide TRIPS (Trade-Related Aspects of Intellectual Property Rights) agreement, signed in 1994 under the aegis of the World Trade Organisation, bear witness to this. We shall adopt a historical perspective here to grasp the significance and scale of these transformations: our aim is to analyse the evolution of the intellectual property regime, and more precisely the patent regime, in the USA since the 19th century. To do so, we shall consider intellectual property within the context of general transformations in capitalism, focusing on two main historical phases: firstly, the period covering the formation and development of 'corporate capitalism' dominated by large corporations, also referred to as the 'Fordist' period; and then the new phase, which opened up in the 1980s, marked by the rise to power of finance. From a perspective of institutional complementarities, we seek to show how the characteristics and consequences of IPR regimes can only be understood in relation to transformations in the main institutional forms of capitalism, and more precisely in the forms of the firm; the status

of labour (the 'wage-labour nexus', following the terminology of the French Regulation School); and market forms (product markets and financial markets).

The paper is organised as follows: after briefly recalling the patent regime established in the USA in the 19th century during an entrepreneurial (or pre-corporate) phase, the next two sections describe how corporate capitalism radically altered the nature of the patent system, and then how the 1980s, in turn, saw the transformation of intellectual property, with the disintegration of Fordism and the rise of finance-led capitalism.

Patents and the market for technology in 19th century USA: the 'pre-fordist' regime

To understand how the intellectual property regime of corporate capitalism formed in the 20th century, it is worth starting by looking at the situation at the end of the 19th century, in what can be described as the 'pre-Fordist' phase. The evolution of the patent system was far from linear, but after a period marked by a powerful anti-patent movement, the advocates of the patent system finally won the day, in both Europe and the United States.[1] This resulted in the establishment of a 'modern' system of patents in most countries.[2] In the United States, a profoundly new system emerged as early as the first half of the 19th century on the foundation of the 1936 Patent Act. This deserves particular attention, as it helped to form the basis of the new capitalism that emerged towards the end of the century.

If we focus on the patent system—and this is indeed where the central issues played themselves out, with the increasingly important role of invention and innovation in growth—we can identify a number of major features (Noble, 1977; Khan and Sokoloff, 2001): low registration fees and an impersonal application procedure; the creation of *an examination system*, by trained experts, replacing the previous simple registration system (1836 Patent Act); and the attribution of an exclusive property right.[3] The legal system gradually defined a set of rules and principles protecting the rights of patentees and of those who purchased or licensed patented technologies (Khan, 1995). The federal courts were responsible for enforcing the new patent system.

One crucial dimension must be highlighted: initially, the aim of this system was to favour *individual* inventive activity. The patentee had to be *an individual*. Only the individual inventor could receive a patent; firms could not receive patents directly for inventions

developed inside the firm (Noble, 1977; Lamoreaux and Sokoloff, 1999). Until the end of the 19th century, firms had no automatic rights over patents registered by their employees.[4]

These reforms resulted in strong growth in the number of patents registered between 1840 and 1870, with most applications being made by *individual inventors*.[5] This movement was accompanied by the formation of a veritable market for technology.[6] According to Lamoreaux and Sokoloff (2001), this market was essentially based on 'arms-length transactions' between individual inventors and firms. Between the two parties, specialist intermediaries, mainly lawyers and 'patent agents', played an essential role in the formation of the market, a role that gradually grew from about 1840 onwards (Lamoreaux and Sokoloff, 2001, 2002). It was also during this period that the first 'patent pools' were formed,[7] although this form only really became significant in the 20th century with the development of corporate capitalism. This configuration can be understood in terms of the corporate practices prevailing at the time: firms tended to acquire inventions from outside, rather than seeking to develop them 'in-house'. The behaviour of Bell represents an extreme example of this.[8]

The evolution of US capitalism steadily eroded this system. Firstly, early in the 20th century, 'a trend towards long-term attachments between highly productive inventors and particular firms' appeared (Khan and Sokoloff, 2001), implying a form of relation quite different from the 'standard' market one. This trend continued during the greater part of the 20th century. But the most important evolution involved the industrial structure: the move towards a system dominated by large corporations, where innovation is based mainly on in-house R&D, and the decline of the individual inventor and the market for technology.

And this led to a radical transformation in the nature of the intellectual property regime.

Research, innovation and IPR in the era of corporate capitalism

3.1 The emergence of corporate capitalism and the new modes of innovation and invention

To appreciate this transformation in the patent regime, we must situate it within the context of the changes in capitalism from the end of the 19th century, which led to the formation of corporate capitalism. These changes affected not only the structure of the industrial system, but also the conditions of production of technological and scientific knowledge on which the system depends. They contributed to a transition from entrepreneurial capitalism to a capitalism dominated by large corporations.

The first major event was the emergence of a new institutional form at the centre of the capitalism system: the large corporation. This is a complex institution, founded on: a *hierarchical structure* and the *centralisation* of assets and activities within large multi-unit entities; centralised control, hierarchical and functional internal organisation, and *vertical integration*; and a specific mode of labour organisation and management [The 'Fayolian-Taylorist heritage' (Hatchuel, 2004)] based on administrative control, with a high degree of integration of the workers within the firm.[9] This last aspect is particularly important. A high level of employee integration within the firm is one of the chief characteristics of this industrial evolution. It went hand in hand with the construction of the wage-labour nexus. It required the creation and implementation of the legal and organisational instruments of a new system of labour control, and of the *management of knowledge and skills within the firm*. As we shall see, the development of the IPR regime was one component of this evolution, related to a trend towards the *internalisation of the inventive activity*.

The transformations of the firm are interlinked with a general process of institutionalisation and professionalization of innovation and R&D (Noble, 1977; Mowery and Rosenberg, 1998). The production of knowledge is structured around two domains: on the one side, companies—essentially large corporations, the central site for the production of *technological* knowledge and for inventive and innovative activity, and on the other side, the predominantly public system of research—made up of universities and public research centres—where the *scientific* activity is concentrated. The scientific system is built on totally different institutional foundations to those underlying the corporate sphere—namely, non-profit organisations oriented towards the production of freely-circulating public knowledge, and it is governed by its own specific rules. This system makes the rapid disclosure of knowledge, through publication or oral presentation, driven by a priority reward system and accompanied by practices of free cooperation and peer review, which is the behavioural norm for the scientific community.

So, it would be fair to say that the institutionalisation and professionalisation of innovation and research in the 20th century were initially based on *a dual property regime*, a combination of the 'kingdom of technology' and the 'republic of science' (Dasgupta and David, 1994). This dualism found expression, notably, in the demarcation of the field of activities covered by patenting: patents could be registered on *inventions* (i.e. technical devices) but not on *knowledge*, especially fundamental scientific knowledge.

Intellectual property, and the patent system in particular, must be examined within the context of these institutional transformations. Its development is closely linked to the growing importance of the large corporation in the production *and appropriation* of productive skills and knowledge and in the inventive and innovative activity which gave corporations an increasing capacity to use IPR for their own strategies, even as there has been continual opposition to IPR-based monopolies, from the beginning of the 20th century until today.

3.2 The evolution of the patent system: from an individualistic to a corporate intellectual property regime.

Formally, there was little substantial change in the foundations of the patent system as described above, and yet the nature and content of the system changed radically. The focus of the system shifted from the individual to the firm, which became the central place of invention and innovation. To understand this shift, we need to analyse it from the perspective of institutional complementarities. Following Amable (2003, p. 59), we consider it "necessary to consider the influence of institutions on the whole economy not in isolated ways, […] but in terms of the joint influence of institutions'.[10] The nature of the patent system and its economic implications cannot be fully grasped by considering it in isolation, but only by taking into account the way this system is interrelated with other 'institutional forms' that structure the economy. The first of these is, of course, the large corporation and, as we shall see, the formation of the wage-labour nexus and the structuring of the (product) markets; another aspect that was to become essential in the later, 'post-Fordist' phase was the rise of finance-led capitalism and the structuring of the financial sphere.[11]

At the end of the 19th century, the business world began to recognise the importance of technological knowledge as a strategic asset, mainly in the first science-based industries of the time: the electric, electronic and chemical industries. The conditions of appropriation and exploitation of this knowledge by firms therefore became essential. This led to two major problems: (1) how to obtain and maintain control over technological knowledge and skills, and more particularly those produced and possessed by employees; and (2) how to exploit the monopoly power provided by intellectual property, particularly given the rise in antitrust policies in the US following the 1890 Sherman Act.

In the US, the end of the 19th and beginning of the 20th centuries were marked by both a decline in individual, independent inventors (Lamoreaux and Sokoloff, 2005),[12] and, as we have just recalled, the integration within large corporations of invention and innovation

activities. This found expression in the appearance of in-house R&D, accompanied by the rationalisation and 'routinisation' of inventive and innovative activity. More generally, the rise of the large, integrated corporation and new forms of industrial organisation, with the accompanying high degree of employee integration within the firm, raised the problem of the appropriation and control of the knowledge and skills—the 'human capital'—of the employees by the emerging managerial apparatus. The appropriation of skills and *tacit* knowledge became the subject of new forms of organisation, and particularly of Taylorist methods. The appropriation of more formalised technological knowledge (leading to patentable inventions) developed by the employees and of intellectual skills specific to the new categories of employees assigned to innovative activities was partly achieved through changes in labour law, especially the law governing the ownership of patents. More generally, the evolution of 'the rules governing the creation and assignments of patents, copyrights, and trade secrets all entail or have evolved to provide significant employer control of firm-specific intellectual assets' (Burk and McDonnell, 2007, p. 594).[13] This is the aspect that particularly interests us here.

The appropriation of employees' patents by their firms gradually became established over the 19th and 20th centuries.[14] When inventive activity is performed within the firm, the question arises of *who will own the knowledge thus produced*. The fact that patents could still only be legally registered by individuals had little influence on the question of who the subsequent owner would actually be. During most of the 19th century, it appeared to go without saying that the inventor himself retained ownership of the patent, and thus all the rights over it, *even if he was employed by a company*. This was in keeping with the individualist conception of intellectual property rights, founded on the individual's natural right to the fruits of his labour and personal skills, and on a 'heroic' view of the invention, specific to the pre-Fordist era, as a product of individual genius. And this was consistent with the predominance, described above, of individual, independent inventors. This upholding of the principle of an inventor's ownership of his invention, even when he was employed by a firm, was supported by the idea that ownership of the invention was governed solely by the legal principles of intellectual property rights.[15]

The situation was to change radically with the rise of corporate capitalism: appropriation of the invention by the company then became the rule. In the US, recognition of an employer's rights over his employees' patents emerged in two main stages, corresponding

to two principles: the 'shop right' and the 'preinvention assignment agreement' that prevails today (Cherensky, 1993; Fisk, 1998; Merges, 1999).[16]

During the first stage, which started in the mid-19th century, companies became able to acquire an exclusive license over their employees' inventions. To begin with, this possibility, which later become a right, was simply based on the idea that if an employee allows his employer to use his patent, then he has implicitly granted his employer a license. The company thus has a right to a license, on the basis of the employee's (implied) consent. Subsequently, at the end of the 19th century, the employer's right was justified by the courts in quite a different fashion by the fact that the employee had produced his invention within the context of working for his employer. This led to the 'shop right' doctrine, emphasising the fact that the employer had borne the costs of the invention by paying the employee's wages and providing his working tools. This gave the company the right to use an employee's invention without paying him royalties, while leaving him ownership of the patent (Fisk, 1998).

The coexistence of this movement gradually affirming the 'shop right' over employees' inventions with the introduction and extension of Taylorism in the firm cannot be overlooked. Several works have shown that Taylorism acted as a massive process of expropriation of trade workers' skills, which were then parcelled out and redistributed to unskilled workers.[17] Indeed, until the arrival of Taylor, production skills were first and foremost the property and 'monopoly' of skilled workers. Taylor's scientific management brought this situation to an end by imposing modes of work division and organisation that were now decided by the management. The organisation of work was then claimed by employers' organisations as a 'management right'[18] in the face of long-running protests from skilled workers—and their unions—claiming the right to choose what they deemed to be the most efficient operating modes. Thus, the struggle for the establishment of the 'management right' and the 'shop right' were closely connected. This confirms the strategic importance of confrontations over the content of the wage-labour nexus and its codification in the control and appropriation of skills, and indeed inventions, in manufacturing activities.

A major change then occurred when the firm became able to obtain *ownership* of the patent and all the rights associated with that. From the end of the 19th century, certain court rulings affirmed the employer's right to the ownership (and not simply the use) of an invention from the moment that the employee had been recruited and paid to invent. But it was essentially after 1920 that a doctrine founding the ownership of inventions *on the*

contract (of employment) became established. In 1933, a Supreme Court ruling presented it as an obvious principle that 'the respective rights and obligations of employer and employee, touching an invention conceived by the latter, spring from the contract of employment'.[19]

More generally, and looking beyond manufacturing activities, the content of employment contracts (and labour law) also shaped developments in the regime of patent ownership. As Fisk put it (1998, p. 1181): 'Employers created, lawyers emphasized, and courts enforced express agreements that any employee's inventions would belong to the employer'. The agreement giving ownership of an invention to the employer can be explicit or implied. This constitutes the principle of the 'preinvention assignment agreement': through his contract of employment, the employee undertakes to assign to his employer (the firm) all rights over future inventions created within the context of his work using resources provided by the employer. Today, we can consider that nearly all employees involved in scientific and technological work are subject to this type of agreement (Cherensky, 1993). And the contract often contains a 'trailing clause', by which the firm can claim ownership of any patent registered by one of its ex-employees during a certain period after the employee has left the firm (Nobel, 1977).

Today's legal system in the United States combines the right of the company to ownership of the invention, where the inventor has been 'employed to invent' (the principle of the preinvention assignment agreement), with the right to a non-transferable license, where the inventor has not been expressly recruited for that purpose (the principle of 'shop right'), mainly concerning employees working outside of R&D (Merges, 1999). This completed the emergence, in the United States, of an intellectual property system founded no longer on the individual, but on the company.

This fundamental transformation calls for three observations. The first concerns the importance of the role played in this change by the formation of what the French regulationists call the wage-labour nexus.[20] With the rise of corporate capitalism, a new system of relations between company and labour emerged, built on a certain status of labour: the wage-earning system. The latter is based both on the integration of workers into the firm, accompanied by the introduction of internal labour management and control systems (the Taylor-Fayol system), and on a specific legal framework: the contract of employment by which the company controls the activity of the worker and appropriates the results of that activity. The principle of the preinvention assignment agreement is one component of this new employment system, applying more particularly to a new category of worker, the

'employee/inventor'. It worth noting that this new status does away with any automatic system of reward for the inventive activity *of the individual*, which was supposed to be an essential justification for the patent system. The firm can define the mode of remuneration of the employee-inventor in an entirely discretionary manner, and the 'reward' becomes a simple component of its pay policy. This once again illustrates the profound shift of the intellectual property regime towards a company-oriented system.

Our second observation concerns the social efficiency of such an evolution. The underlying problem relates to the impact of the distribution of ownership on economic efficiency[21]: is it possible to determinate the 'best' rules for the assignment of patents (as well as copyrights) between the employer (the firm) and the employees? Merges (1999), for example, seeks to demonstrate that most theoretical arguments are in favour of firm ownership, rather than employee ownership. Burk and McDonnell (2007, p. 634) have a more ambivalent position: 'Indeed, it is even possible that the law rather pervasively and systematically provides too little protection for employees vis-à-vis firms'. The economic effects of patent ownership, and more globally of the rules governing the assignment and transfer of intellectual property rights, are certainly difficult to assess, involving a trade-off between the firm's capacity to control and coordinate strategic intangible assets (a condition of long-term strategy), the need for incentive systems supporting the motivation and creativity of highly skilled workers and the efficacy of employee (and knowledge) mobility, as regards competition and dynamic efficiency.[22] In any event, the predominance of firm ownership can be considered to be in accordance with key characteristics of the so-called 'Chandlerian' firm: the centralisation of assets and a strong and lasting integration of the workers within the firm.

This leads us to our last observation. One consequence of the change we have just described is that the patent has become primarily *a strategic corporate tool*. The nature and economic consequences of the patent system are therefore determined by the way in which companies exploit it. For companies, especially the large corporations, the patent system is first and foremost a tool for controlling markets. This aspect became established at the very beginning of the 20th century, as demonstrated, for example,[23] by the strategies of Bell System and then AT&T (created in 1900 by the integration of Bell's different interests). Through an active policy of building up a patent portfolio, Bell gained domination over the whole telephone and communication sector. Another example is General Electric, which aimed, in the same way, to control the whole technology of the filament light bulb (among other domains) during the whole first half of the 20th century. The development of 'patent

pools', initiated by companies, which accompanied the rise of corporate capitalism, is also and above all a tool for cartelisation and for controlling an industry through the construction of entry barriers.[24] This also radically changed the nature of the intellectual property system. And this raises another question: that of the relation between the patent system and anti-monopoly regulations.

3.3 Patent system and anti-trust policy

Prindle, a mechanical engineer and patent lawyer, influential at the beginning of the 20th century, expressed the industrial world's view of patents very clearly and explicitly: 'Patents are the best and most effective means of controlling competition. … patents are the only legal form of absolute monopoly'.[25]

As we have seen, the large corporations, especially in the new industries of the time, were soon putting Prindle's teaching into practice, making systematic use of patents to control competition. By their very nature, patents offer their owners a (temporary) monopoly. Admittedly, they do not usually give the firm a perfect monopoly position, given the possibility of close substitutes, but they can give the firm a significant competitive advantage —provided, obviously, that the new technology is a success. But this went much further. Companies systematically exploited their possession of a portfolio of patents (constantly renewed) to obtain control over a market, a technology or an industry, either alone or with a group of companies (via a patent pooling agreement, for example)[26]. As Machlup (1958) noted, different methods were used to prolong this control beyond the patent's period of validity: using the invention before registering the patent, applying for successive patents for improvements on the invention, license agreements extending beyond the period of validity, registering broad-scope patents covering a whole industry ('umbrella patents') and so on. These methods were developed from the earliest days of corporate capitalism.

Of course, this could not but raise questions about competition regulation. The room for manoeuvre allowed to firms and the functioning of the intellectual property system itself depend on anti-trust policy. The conditions of application of the Sherman Act varied widely over the course of the 20th century. If we focus on the interrelation between intellectual property practises and anti-trust policy, drawing on the work of Noble (1977) and Kovacic and Shapiro (2000), we can identify three different periods.

Broadly speaking, up until the beginning of the 20th century, the Sherman Act was only loosely applied. During this period, patent holders suffered little constraint in the

exploitation of their position of monopoly. Thus, in 1902, the US Supreme Court ruled that: "'The general rule is absolute freedom in the use or sale of patent rights under the patent laws of the United States. The very object of these laws is monopoly".[27]

Antitrust policy was even more lax during the period that followed, from 1915 on. The rulings of the Supreme Court reflected a relatively tolerant attitude towards practices of collusion and cooperation. This can be related to a comparative decline in the liberal credo, particularly after the Great Crash of 1929 and the 'ascent of the "associationalist" vision of business-government relations', linked notably to the experience of the First World War (Kovacic and Shapiro, 2000, p. 46). This explains why we can observe, during this period, both private patent pools of an anti-competitive nature and patent pools encouraged by the state, often coupled with compulsory licenses, promoting cooperation between firms judged to be in the national interest. A good example of the first type is provided by the 'radio patent pool agreements' of the 1920s, bringing together AT&T, GE, RCA, United Fruit, American Marconi and Westinghouse (Noble, 1977, p. 93). Patents pools of the second type were promoted by the federal state, especially during the two World Wars, as a means of obliging firms to cooperate to accelerate the development of new weapons. Thus, during World War I, for example, the Patent Board of the War and Navy Departments encouraged patent pools in the munitions and aircraft industries (Noble, 1977, p. 106).

The period that started in about 1940, and which continued up until the 1970s, is particularly interesting and important. This was the period during which antitrust policy was most stringent. Practices of cartelization and the abuse of dominant position were punished much more severely, and merger and takeover operations were controlled more rigorously. This was bound to have repercussions for intellectual property. And indeed, the post-war period was characterised by a particular configuration, reflecting the importance of institutional complementarities, and essential for understanding the dynamics of innovation. It combined (Mowery and Rosenberg, 1998):

-- A strict antitrust policy, as we have just noted. This made it difficult for companies to take over firms in connected activities and technologies, leading to increased reliance on in-house R&D, especially in the large corporations.

-- A relatively lax intellectual property regime. This was due partly to actions by the State, which often imposed compulsory licensing systems (as in the case of the transistor), but also to the behaviour of companies subjected to the threats of the antitrust policy. As Mowery and

Rosenberg (1998, p. 43) observe: 'Liberal licensing and cross-licensing policies were by-products of antitrust litigation'. This favoured the diffusion of technological knowledge and the emergence of new firms, particularly in the newly emerging high-tech industries (microelectronics, micro-computing and software). And we know the effect this situation had on the dynamics of innovation in the United States.

The economic and political changes that started to take shape in the 1970s, with the growing influence of the Chicago school, which became firmly established in the 1980s, overturned this regime, sending it in an almost diametrically opposite direction. And this, coupled with the rise of finance-led capitalism, led to what we can consider to be a new intellectual property regime.

The 1980s: a new patent regime and the role of finance

Here, as in the previous section, we must approach the changes in intellectual property from the perspective of the broader transformations in industrial structures. At the centre of these transformations lay a series of changes, marked by what appears to be a relative decline in the 'Chandlerian' firm, i.e. the large *integrated* firm, as the centre of the productive system. Firstly, there was a movement of vertical disintegration within the large corporations, tending to concentrate on a limited number of what were considered 'strategic' or 'core' activities. Secondly, there was strong growth in smaller companies, often highly specialised and not integrated, particularly in the high-tech, science-based industries. This includes start-ups, which became a mainspring in the dynamics of innovation. These companies are essentially—and sometimes exclusively—based on a certain capital of technological or strictly *scientific* knowledge.[28]

To a certain extent, this development can be interpreted as the opposite of what had marked the establishment and subsequent hegemony of the Chandlerian firm. There was a move towards greater externalization of the inventive activity. On a more general and fundamental level, there was also a decline in the role played by the 'visible hand' of managers. This was manifested in an increase in transactions between companies, especially involving technologies, knowledge and skills. Another central feature of these transformations is essential to our purpose: in this new industrial configuration, the accumulation and allocation of capital or the choice of investments (including in R&D), which, in the

managerial capitalism of the Fordist phase, were carried out essential *inside* the large corporation, were now performed to a far greater extent by financial players exploiting the opportunities offered by financial transactions and markets or operating through the newly designed Boards of Directors where shareholders became more influential.[29]

This is the context within which we must situate the transformations in the patent regime if we are to understand how they took place. Three features characterise the new period: firstly, legal and jurisprudential changes led to a spectacular extension of the field of patentable objects and a strengthening of the rights granted to the owners of patents and other IPR. Secondly, substantial modifications were made in the regulation of financial markets. Finally, the type of patent regime that had hitherto only prevailed in the most developed countries was extended world-wide; this process of global harmonisation of IP laws reached a peak in 1994 with the signing of the TRIPS agreement, marking a significant upward harmonisation of the IP regime at world level.[30]

In the next section, we describe the novelties marking the period since the 1980s and how they characterise the emergence of a new patent IP and then identify some of the most important consequences of this new regime with regard to the development of the market for knowledge.

4.1. The distinguishing features of the new patent regime

As noted above, the new regime became established through the combined effects of legal and jurisprudential changes. The most influential changes can be presented as follows.[31]

Legislative changes

One important change was the opening-up of the domain of patents (and of IPR in general) to new players. In practice, these are *universities and academic research laboratories, authorised by new legislation to register patents on the products of their research*—even, quite remarkably, when the research has been publicly funded. This step was taken in 1980 with the passing of the Bayh-Dole Act. This major law (the significance of which is still fiercely debated)[32], introduced a set of new, complementary measures. Firstly, it authorised the granting of patents on the results of publicly-funded research, which had hitherto been permitted only in exceptional circumstances. Secondly, it provided for the possibility of

universities and public laboratories selling *exclusive licenses* to private firms or of setting up 'joint ventures' with them with the objective of exploiting the knowledge concerned, either through direct trade (by selling it to third parties in the form of licenses), or by using the knowledge to develop marketable products. The rationale underlying these measures may be debatable,[33] but its practical impact on the multiplication of the number of patents registered by university laboratories has certainly been spectacular, although these patents have been concentrated in a relatively small number of universities (Mazzoleni and Sampat, 2002; Mowery *et al*., 2004)

In many publicly-funded laboratories, the race to register patents became an organised activity. Thus, Technology Transfer Offices (TTOs) were set up to sell patents to third parties (often venture capital-financed firms)[34] or to set up joint ventures with them to exploit the patents. Around the universities most committed to basic research (and often the best-performing), there has been a spectacular boom in 'spin-offs' from a small number of academic laboratories.

The trends initiated by the Bayh-Dole Act were further energised by another major legislative initiative, with the establishment by the US Congress of a specialised jurisdiction for IP. This is presided over by the Court of Appeals for the Federal Circuit (CAFC), now responsible for judging all cases of litigation involving patents. This initiative has turned out to have important repercussions. By removing all powers of arbitration on patents from the traditional courts, often strongly marked by the anti-trust doctrine and openly opposed to the defence of patent-based monopolies, the introduction of the CAFC opened the door to the affirmation of 'pro-patent' doctrines and rulings. As one analyst observes in a long article analysing the doctrines promoted by the CAFC:

> The FC has steadily dismantled doctrines denying patents to such inventions as math algorithms, mental steps, printed matters and methods of doing business. Stripped of limiting principles, the subject matter for patenting in the US now appears as broad as the range of human experience. (Thomas, 2006)

Supported by the new jurisprudential approach (often initiated or confirmed by the US Supreme Court itself), these modifications affected every dimension of IP, always strengthening the nature and depth of the rights given to patent holders and the penalties and sanctions imposed on 'imitators'.[35]

Jurisprudential changes

The major changes stem from the fact that in two key domains (corresponding to the great scientific and technological revolutions of the end of the 20th century), patentability was opened up to objects that had previously been explicitly excluded. These were *software and computer programmes* on the one hand, and *genes and living matter* on the other. It is obviously significant that these were the two key domains in which major technological discoveries and innovation took place during the 1980s.[36]

In the domain of software and computer programmes, a series of rulings by the courts introduced a radically new situation. First, software, which had been protected only by copyright, could now be protected by patents. And these patents steadily spread outwards, ultimately covering even *algorithms corresponding to the use of simultaneous equations*. Then, in the 1990s, and particularly after the famous *State Street vs. Signature Financial* ruling (issued in 1998 by the CAFC), the evolution continued with the extension of patentability to business models, i.e. automated processes relating to commercial methods or financial services.[37] The American firms that were often pioneers in these fields found themselves endowed with an abundance of patents representing exclusive rights to exploit processes that had often been widely used by the computing community.[38]

However, it was in the domain of the life sciences that the evolution was the most radical and the most influential. Here the breach was first opened by the famous Chakrabarty ruling, authorising General Electric to patent a genetically-modified micro-organism that could eat up oil slicks. This decision was made by the US Supreme Court in the same year as the Bayh-Dole Act (1980) and after many years of legal battles and a long succession of decisions by different courts. It ultimately led to the patentability of living matter, including isolated elements of the human body such as genes and partial sequences of genes. So, as the US Patents and Trademark Office put it: 'Whoever discovers a gene may obtain a patent on that gene and on several possible applications, even if their use has not been demonstrated or one sole use has been disclosed' (US Patent and Trade Mark Office, 2001).

There was nothing linear about the changes we have just summarised, and they were in no way the result of any organised, deliberate action by a visible hand. But in the particular climate of the 1980s, there was a succession of changes which, by entering into resonance and complementarity with each other, opened the way to a veritable commodification of knowledge. Whether this concerns generic knowledge (e.g. the algorithms used as a basis for

computer programmes) or, even more importantly, 'basic research' (the human genome), whole domains of knowledge that had previously belonged in the realm of open science were swallowed up by exclusive appropriation and have consequently become the objects of financial transaction on markets.[39] One of the most striking aspects of these changes is that they have affected the behaviour of small firms specialising in research (particularly in the biotech sector) just as much as that of the large, established firms. Thus, in the IT sector, the first beneficiaries of the new laws allowing for the extensive patenting of software and/or business methods were the large incumbent groups (IBM, Hitachi, Samsung etc.).

4.2. New institutional complementarities between finance and IPR, and a new boost to the commodification of knowledge

The transformation of knowledge into a commodity (in the form of marketable IPR promising future revenue) created the permissive conditions for financial capital to enter into the production of knowledge. From the moment that the new start-ups (often originating in university laboratories, thanks to the Bayh-Dole Act) possessed marketable rights (via patents, copyrights and other IPRs), an opportunity opened up for the activity of financial capital.

Moreover, financial regulations were modified to facilitate the entry of players from the world of finance into the sphere of research and even *basic* research. The most important move was a decision by the NASD[40] in 1984 to authorise the listing of *loss-making firms,* provided they possess a high level of 'intangible' capital, in practice most often constituted by IPRs. Thus, the regulation known as 'Alternative 2' enabled this type of firm (loss-making, but with a stock of IPRs) to be listed, no longer on the OTC ('over the counter') market, an illiquid and unattractive market, but on the First Market of the National NASDAQ Market, the leading and most attractive NASDAQ market.[41] These changes allowed not only the launch of biotech start-ups (some of which, like Genentech, Genzyme or Myriad Genetics, have become fully-fledged players in biopharmaceuticals), but also the launch of most of the current world leaders in the high-tech sector (Microsoft, Apple, Yahoo, Google, Intel etc.).

Other legislative and regulatory changes in the financial domain then played a key role in ensuring financial resources for this market in loss-making but high-potential innovative firms. In particular, the 'prudent man' legislation imposing certain constraints on pension funds was modified to allow them to *invest part of their funds in high-risk bonds and assets,*

something that was previously forbidden to them. In this way, some of the huge liquidities concentrated in pension funds, which boomed during this period, particularly after introduction of the 401k regulation, were used by the financial markets to promote hundreds of new firms which, although loss-making, were considered 'high potential' because of their intangible assets.[42]

The combination of these two series of changes has strongly revitalised the venture capitalist industry. This explains the boom in a new generation of firms, often specialising in basic research and living from the sale of their patents and property rights. In the biopharmaceutical sector, which has been profoundly impacted, a new division of labour has taken shape. The big pharmaceutical companies have often de-verticalised part of their research activity, letting the new biotech firms specialize in many sub-segments of the research activity.

Complementarity between financial markets and IPR

This has led to the emergence, originating in the United States, of new 'institutional complementarities' between IP laws, on the one hand, and financial market regulations, on the other. These new complementarities function according to the following protocols:

- the extension of patentability to the results of publicly-funded research, completed by the CAFC rulings that authorised patents on the products of basic and/or generic research, gave university laboratories (or joints ventures emanating from public labs) unprecedented opportunities to commodify the fruits of their activities.

- the possibilities given to pension and other mutual funds to invest in high-risk activities gave a powerful boost to the supply of venture capital, while at the same time the new NASDAQ regulations opened up new exit possibilities for firms financed by venture capitalists.

The effects of these complementarities were spectacular. The combination of a new patent regime with the NASDAQ 'Alternative 2' regulation allowed the launch of firms of a very particular type, built on totally new business models.

A new stimulus and new supports for the commodification of knowledge

Two series of changes call for attention here. Alongside a market for *licenses* which has become much more complex, a market has also formed for f*irms* specialised in the production of knowledge.

Regarding the first point (the *complexification* of the market for property rights), the major change is that *new categories of players* have emerged, whose activity testifies to an important change in the world of patents. The key novelty lies in the development of players whose activity consists in the mass purchase of patents, *not to use them, but, based on carefully organised monitoring, to take out lawsuits against alleged infringers* with the sole aim of obtaining financial compensation. Faced with these new players, often referred to as Non-Practicing Entities (NPE), other organisations have developed a business model based on the *preventive purchase* and pooling of licenses. The access to and benefits from this preventive action are supplied (in return for the payment of an annuity) to companies and organisations wishing to protect themselves against attack from NPEs. The result is a booming market in the race to litigate and/or to avoid litigation, a market driven by specialised firms, none of which have any intention of using the licenses they trade for practical inventions.[43]

Regarding the second point (the constitution of a market, not of rights and licenses but of research-intensive *firms)*, two aspects are striking. Firstly, we have seen the emergence of firms specialised in research. As Rosenberg (1990) notes, this is a powerful 'anomaly'. For the first time in history, a series of new firms were created and launched in market activities, with basic research as their central activity. This was made possible because the new regime, by authorising patents on basic research, also enabled the sale of IPRs on research results, which became the primary commercial activity for this new type of firm. One peculiarity of these firms is that most of them are built around 'star scientists' (Zucker and Darby, 1996).[44] As Darby *et al*. (1999) observe, the inclusion of scientists among the founders and shareholders of these firms is an important point. As in the previous phases (described above), this new change in the IP regime has been accompanied by new codifications of the employment relation. Most of the scientists involved in setting up joint ventures are not simple 'employees'; neither are they 'hired to invent', as in the past. The novelty is that they are veritable *shareholders* owning a percentage of the share capital of the firm. The aim is both to win the confidence of investors when the firm goes public and to provide an efficient incentive; the researcher-scientists will only be rewarded if—and to the extent that—their

activity leads to the marketing of discoveries. Secondly, a 'market' has grown up whose main activity is the evaluation (notably in relation to IPOs) of those firms which lack marketable products and profitable activities, but which are considered 'high potential' because of the patents they possess.[45] This market is organised around a series of intermediaries and follows its own specific protocols. 'Analysts' specialised in patent evaluation have been recruited by the big financial services firms who supply investors with information. These evaluations are quoted in IPO prospectuses. However, although the formation of this market has had significant consequences, endowing the financial community with the unprecedented power to evaluate the quality of discoveries, there is nothing to guarantee the validity of the judgements and choices made. The extraordinary over-valuations of certain biotech firms to which these protocols have given rise—far greater than the over-valuations to be observed in the general market of NASDAQ firms—provide a spectacular illustration of the excesses to which this can lead (more on this point in Coriat *et al.*, 2003).

Finally, we can say that the new patent regime has given rise to a highly paradoxical situation. The paradox lies in the fact that as the market for knowledge has been considerably *enlarged and extended*, it has evolved towards an ever more imperfect market of highly questionable efficiency. The low quality of patents granted has led to a sharp increase in litigation costs. And even when open conflict does not erupt, innovators are confronted with a situation of great uncertainty about what has and has not been patented. Navigating the 'patent thicket' (Shapiro, 2001) has become an undertaking on which many firms, particularly in the ICT sector, have given up, exposing themselves to risks against which they seek protection, wherever possible, by forming 'patent pools' with their partners or even with their competitors.[46] In the biotech sector, the exclusivity granted over certain gene sequences and research tools threatens to create an anticommons phenomenon (Heller and Eisenberg, 1998) that will be highly prejudicial to innovation. Even if some observations suggest that the anticommons phenomenon is less widespread in the biotech sector that might have been feared (Eisenberg, 2006), spectacular cases (like the one concerning tests for predisposition to breast cancer, opposing Myriad Genetics and a consortium of European institutions) act as regular reminders that the expansion in patenting rights to cover basic research constitutes a serious threat that must not be underestimated (see fn 43).

Conclusion

The first point our investigation has brought to light is the wide historical variability in the nature and content of intellectual property rights. Over the period examined, we have identified no less than three very distinct patent regimes. An investigation of the history of patent systems in countries other than United States would show all the more clearly how diverse intellectual property systems can be, and the recurrent questioning they have provoked[47]. The present patent system thus appears as a very peculiar and extreme, historical experience. Another lesson is that the successive systems of property rights have only become established by entering into tensions and complementarities with other regulatory regimes and systems of laws governing other dimensions of economic and, particularly, corporate activity. Labour law—or more broadly the wage-labour nexus, on one side, and competition laws, on the other, have often played a decisive role (often through their own transformations) in defining the nature and scope of the IP rights defined by law or jurisprudence. Finally, if we focus on the most recent trend, starting in the 1980s, it is clear that although the shift towards commodification of knowledge—notably due to the rise of finance-led capitalism—is a striking and important phenomenon, there is nothing to guarantee the long-term sustainability of the new regime. The new 'markets' for knowledge that have recently emerged are highly imperfect, raising many obstacles to the diffusion of knowledge. They are also highly dependent on financial arrangements whose fragility is at present perfectly clear.

One last point deserves particular emphasis. The imperfections and obstacles that have emerged with the dissolution of the 'open-science' regime have provoked a multiform reaction calling for the re-establishment of some of the conditions that prevailed before or the creation, within this new context, of conditions favourable to an easier circulation of scientific and technological information. Thus, the open-source movement—which first emerged in the field of software—is now spreading to the domain of biotechnology. At the same time, a number of different initiatives have been implemented to protect or even extend the public domain. Finally, under the name of 'creative commons', initiatives are being implemented in the literary and artistic domains to escape from the restrictions of exclusive property that recent extensions in copyright law have sought to impose.

These initiatives reveal the difficulties faced by the new regime in establishing itself. They demonstrate the feasibility of alternative, very different, patent regimes. They may well

be the expression of a new developmen that is still seeking its way and expression, a process that the current financial crisis might well further.

References

Aoki, M. (2001) *Towards a Comparative Institutional Analysis*, Cambridge, MA, MIT Press.

Amable, B. (2003) *The Diversity of Modern Capitalism*, Oxford, New York, NY, Oxford University Press.

Berle A.A, Means G.C, (1932) *The modern corporation and public property*, Harcourt, and Brace World Inc.

Boyer, R. (1990) *The Regulation School: A Critical Introduction*, New York, NY, Columbia University Press.

Burk, D. L. and McDonnell, B. H. (2007) 'The Goldilocks Hypothesis: Balancing Intellectual Property Rights at the Boundary of the Firm', *University of Illinois Law Review*, **2007**, , 575–636.

Dreyfuss, R. C. (2006) 'State Street or Easy Street: Is Patenting Business Methods Good For Business?' In Hansen, H. (ed) *US intellectual Property Law and Policy*, Cheltenham, Edward Elgar, pp. 1–38.

Coriat, B. and Dosi, G., (1998) 'Learning how to govern and learning how to solve problems: On the co-evolution of competences, conflicts and organizational routines'. In Chandler, A. D., Hagtröm, P. and Sölvell, Ö. *The Dynamic Firm: The Role of Technology, Strategy, Organization, and Regions,* Oxford, Oxford University Press, pp. 103–133.

Coriat, B. and Orsi, F. (2002) 'Establishing a new regime of intellectual property rights in the United States: Origins, content and problems', *Research Policy*, **31**, 1491–1507.

Coriat, B., Orsi, F. and Weinstein, O. (2003) 'Does Biotech reflect a New Science-Based Innovation Regime?', *Industry and Innovation*, **10**, 231–253.

Chandler, D. (1992) 'Organizational Capabilities and the Economic History of the Industrial Enterprise', *Journal of Economic Perspectives*, **6**, 79–100.

Cherensky, S. (1993) 'A Penny for Their Thoughts: Employee-Inventors, Preinvention Assignment Agreements, Property, and Personhood', *California Law Review*, **81**, 595–669.

Dasgupta, P. and David, P. A. (1994) 'Toward a New Economics of Science', *Research Policy*, **23**, 487–521.

Danielian, N. R. (1939) *AT&T: The Story of Industrial Conquest*, New York, NY, Vanguard Press.

Eisenberg R. (2006) 'Patents and data-sharing in public science', *Industrial and Corporate Change*, **15**, 1013–1031.

Fisk, C. L. (1998) 'Removing the "Fuel of Interest" from the "Fire of Genius": Law and the Employee-Inventor, 1830–1930', *The University of Chicago Law Review*, **65**, 1127–1198.

Galbraith J. K., (2007) *The new industrial state*. Princeton, New Jersey, Princeton University Press, (first edition, 1967)

Gompers P. A., Lerner, J. and Blair, M. (1998) 'What drives venture capital fundraising?'. In Winston, C., Baily, M. N. and Reiss, P. C. (eds) Brookings Papers on Economic Activity, Microeconomics: 1998*, Washington, DC, Brookings Institution Press, pp. 149–192.*

Hatchuel, A. (2004) 'Rethinking management. A historical look at firms as institutional innovations', *Issues in Regulation Theory*, **47**, 1–5.

Hall, P. A. and Soskice, D. (2001) *Varieties of Capitalism*, Oxford, New York, NY, Oxford University Press.

Jaffe, A. B. and Lerner, J. (2004) *Innovation and Its Discontents*, Princeton, NJ, Oxford, Princeton University Press.

Hansen, H. (ed) (2006) *US Intellectual Property Law and Policy*, Cheltenham, Edward Elgar.

Heller, M and Eisenberg, R. (1998) 'Can Patent Deter Innovation? The Anticommons Tragedy in Biomedical Research', *Science*, **280**, 698–701.

Khan, B. Z. (1995) 'Property Rights and Patent Litigation in Early Nineteenth-Century America', Journal of Economic History, **55**, 58–97.

Khan, B. Zorina and Sokoloff, K. L. (2001) 'The Early Development of Intellectual Property Institutions in the United States', *Journal of Economic Perspectives*, **15**, 233–246.

Kovacic, W. E. and Shapiro, C. (2000) 'Antitrust Policy: A Century of Economic and Legal Thinking', *Journal of Economic Perspectives*, **14**, 43–60.

Kutznets, S. (1966) *Modern Economic Growth*, New Haven, CT, Yale University Press.

Lamoreaux, N. R. and Sokoloff, K. L. (1999**)** 'Inventors, Firms, and the Market for Technology in the Late Nineteenth and Early Twentieth Centuries'. In Lamoreaux, N. R., Raff, D. M. G. and Temin, P. **(**eds) *Learning by doing in markets, firms, and countries*. Chicago, IL, University of Chicago Press, pp. 19–60.

Lamoreaux, N. R. and Sokoloff, K. L. (2001) 'Market Trade in Patents and the Rise of a Class of Specialized Inventors in the 19th-Century United States', *American Economic Review*, **91**, 39–44.

Lamoreaux, N. R. and Sokoloff, K. L. (2002) *Intermediaries in the U.S. Market for Technology, 1870-1920*, NBER Working Paper No. 9017, Cambridge, MA, The National Bureau of Economic Research.

Lamoreaux, N. R. and Sokoloff, K. L. (2005) *The Decline of the Independent Inventor: A Schumpeterian Story*, NBER Working Paper No. 11654, Cambridge, MA, The National Bureau of Economic Research.

McFarlane R. A. and **Litts, R. G. (2010) '**Business Methods and Patentable Subject Matter following In Re Bilski: is "Anything Under the Sun Made by Man" Really Patentable? ***Santa Clara Computer & High Technology Law Journal*****, 26,** 35–84.

Machlup, F. (1958) *An Economic Review of the Patent System*, Washington, DC, United States government printing office.

Machlup, F. and Penrose, E. (1950) 'The Patent Controversy in the Nineteenth Century', *The Journal of Economic History*, **10**, 1–29.

Mazzoleni, R. and Sampat, B.-N. (2002) 'University Patenting: An Assessment of the Causes and Consequences of Recent Changes in Strategies and Practices', *Revue d'Economie Industrielle*, **99**, 233–248.

Merges, R. P. (1999) 'The Law and Economics of Employee Inventions', *Harvard Journal of Law & Technology*, **13**, 2–54.

Merton, R. K. (1973) *The Sociology of Science: Theoretical and Empirical Investigations*, Chicago, IL, University of Chicago Press.

Moore, M. T. and Rebérioux, A. (2009) *From minimization to exploitation: re-conceptualizing the corporate governance problem of the separation between*

ownership and control, REFGOV Working Paper No. REFGOV-CG-32, Louvain-La-Neuve, University of Louvain , European Framework Programme in Research and Development 'Reflexive Governance in the Public Interest', accessed at http://ssrn.com/abstract=1324127.

Mowery, D. C., Nelson, R. R., Sampat, B. N. and Ziedonis, A. (2004) *Ivory Tower and Industrial Innovation. University–Industry Technology Transfer Before and After the Bayh-Dole Act*, Stanford, CA, Stanford University Press.

Mowery, D. C. and Rosenberg, N. (1998) *Paths of innovation*, Cambridge, New York, NY, Cambridge University Press.

Noble, D. F. (1977) *America by Design. Science, Technology and the Rise of Corporate Capitalism*, New York, NY, Alfred A. Knopf.

UNCTAD-ICTSD (2005) *Resource Book on TRIPS and Development*, Cambridge, Cambridge University Press.

Orsi, F. and Coriat, B. (2005) 'Are strong patents beneficial to innovative activities? Lessons from genetic testing for breast cancer controversies', *Industrial and Corporate Change*, **14**, 1205–1221.

Orsi, F. and Coriat, B. (2006) 'The New Role and Status of Intellectual Property Rights in Contemporary Capitalism', *Competition and Change*, **10**, 162–179.

O'Sullivan, M. (2011) 'The innovative enterprise and corporate governance', *Cambridge Journal of Economics*, **24**, 393–416.

Rosenberg, N. (1990) 'Why do firms do basic research (with their own money)?', *Research Policy,* **19**, 165–174.

Shapiro, C. (2001) 'Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard-Setting'. In Jaffe, A., Lerner, J. and Stern, S. (eds) *Innovation Policy and the Economy*, *Volume 1*, Cambridge, MA, The MIT Press, pp. 119–150.

Scherer, F. M. (2006) *The Political Economy of Patent Policy Reform in the United States*, DIME Working Paper on Intellectual Property Rights No. 26, DIME (Dynamics of Institutions and Markets in Europe) network.

So, A. D., Bhaven, N., Sampat, R. A. K., Cook-Deegan, R., Reichman, J., Weissman, R. and Kapczynski, A. (2008) 'Is Bayh-Dole Good for Developing Countries? Lessons from

the US Experience', *PLoS Biology*, **6**, 2078–2084, accessed at http://www.plosbiology.org/article/info:doi/10.1371/journal.pbio.0060262.

Taylor, F. W. (1967[1911]) *The Principles of Scientific Management*, , New York, NY, W. W. Norton & Co.

Thomas, J. R. (2006) 'Discharging the Canons of Claim Construction: Exercises in interpretation at the United States Court of Appeals for the Federal Circuit'. In Hansen, H. (ed) *US intellectual Property Law and Policy*, Cheltenham, Edward Elgar, pp. 134–163.

US Patent and Trademark Office (2001), « Utility Examination Guidelines », Federal Register, vol. 66, pp. 1092-1099.

Winter, S. G. (1987) 'Knowledge and Competence as Strategic Assets'. In Teece, D. J. (ed) *The Competitive Challenge*, Cambridge, MA, Ballinger Publishing, pp. 159–184.

Zucker, L. G. and Darby, R. (1996) 'Star scientists and institutional transformation: Patterns of invention and innovation in the formation of the biotechnology industry', *Proceedings of the National Academy of Science*, **93**, 12709–12716.

[1] See Machlup (1958); Penrose and Machlup (1950). The debate did, nevertheless, leave certain traces, notably around the question of compulsory licensing.

[2] Thus, major reforms were introduced in Great Britain in 1874, a unified patent system was created in Germany in 1872, Japan created its system in 1885 (after abolishing it in 1873) and Switzerland set up its system in 1882, after two referenda. Holland was the last country to abandon the principle of free trade in inventions, only introducing a patent system in 1912 (Machlup, 1958). Important differences remain between these national patent systems.

[3] Lowell v. Lewis [15 F. Cas. 1018 (1817)]:

> [T]he inventor has a property in his invention; a property which is often of very great value, and of which the law intended to give him the absolute enjoyment and possession . . . involving some of the dearest and most valuable rights which society acknowledges, and the constitution itself means to favor.

[4] The firm had no right over an employee's invention, even if the invention had been developed inside the firm, 'in the absence of an express agreement' (Supreme Court *Allen* C. *Dalzellet al.* v. *Dueber Watch Case Manufacturing Company*, 1893, in *United States Supreme Court Reports,* 37 *Lawyers' Edition 749.*). Contracts in which employees were required to assign their patents to the company were relatively rare (Lamoreaux and Sokoloff, 1999).

[5] According to some estimations, in 1885 only 12% of patents were issued to corporations (Noble, 1977).

[6] See Lamoreaux and Sokoloff (1999, 2001, 2002). The formation of the market appears to be evidenced by the high ratio of the number of assignments of contracts to the number of patents, which reached a maximum of 0.83 in 1870–1871(Khan and Sokoloff, 2004).

[7] Such as, in 1856, a patent pool between manufacturers of sewing-machine parts (Noble, 1977, p. 87).

[8] See Noble (1977).

[9] Another essential dimension is the system of governance, linked to the rise of managerial power. This aspect has been highlighted by the managerial theories of the firm. It is connected with the transformation of financial markets and the internal development of managerial hierarchies (see Berle and Means, 1932 Galbraith, 2007,), and based on a dominant legal form: the (public) corporation.

[10] This viewpoint is developed by several institutionalist works, notably on the existence of different forms of capitalism (Amable, 2003; Aoki, 2001; Hall and Soskice, 2001).

[11] This does not mean a perfect coupling between these diverse institutional forms. Each evolves over its own time-line. But it does mean that 'the consequence function […] in one domain may be affected by the institutions prevailing in other domains' (Aoki, 2001, p. 225). In the present case, the consequences of the IPR rules for different categories of agents (individual inventors, industrial firms, financial players etc.), and for the economy as a whole, have been radically altered by the transformations that occurred in other domains and which helped to shape the labour relations setting and financial institutional arrangements.

[12] Changes in the patent system during the early 20th century probably contributed to the decline in the application for patents by independent inventors. These reforms in the mode of operation of the patent office resulted in growing formalism, making the patent application process more complex and expensive, to the detriment of individual inventors (Noble, 1977, p. 108).

[13] And also, in fact, some intellectual assets that are not firm-specific.

[14] For what follows, see mainly Fisk (1998).

[15] Between 1840 and 1880, 'the inventor's status as an employee was irrelevant to ownership of inventions' (Fisk, 1998).

[16] As regards the legal dimension, these doctrines are 'in reliance on the law of agency and fiduciary duty' (Burk and McDonnell, 2007, p. 594).

[17] On this point, see Taylor (1911) and Coriat and Dosi (1998).

[18] A claim which was in line with the more general affirmation of managerial power. See Moore and Rebérioux (2009).

[19] United States vs. Dubilier Condenser Corp, 289 US 178, 187 (1933). Quoted by Fisk (1998).

[20] See Boyer (1990).

[21] This is a key question in the new property right theory of the firm and more generally in the New Institutional Economics.

[22] See Burk and Mc Donnell (2007) for an interesting account of these issues.

[23] See Noble (1977, pp. 91–95).

[24] The radio patent pool, created in 1920 and bringing together companies like AT&T, GE, RCA, United Fruit, American Marconi and Westinghouse, is a good example. See Noble (1977) and Danielian (1939).

[25] Edwin J. Prindle ('Patents as a Factor in a Manufacturing Business', *Engineering Magazine*, XXXI (September 1906), 809–810, XXXII (October 1906), 90) quoted by Noble (1977, p. 89).

[26] See Machlup (1958, p. 11).

[27] Bement vs. National Harrow Co., 186 U.S. 70, 91 (1902); quoted by Jaffe and Lerner (2004, p. 96).

[28] See below, where this point is developed in more detail.

[29] For a comprehensive presentation of these changes, see O'Sullivan (2011).

[30] Before the signing of the TRIPS, most developing countries could enforce the type of IP laws they thought appropriate to their needs and levels of developments. Thus, most of them (including India and Brazil, two important players in the field) did not authorize patenting in many fields, such as pharmaceutical molecules. (For a very detailed and well documented presentation of the situation before and after the signing of the TRIPS, see the 'Resource Book on TRIPS and Development' edited by UNCTAD-ICTSD, 2005). The TRIPS promoted an upward homogenisation of patent laws by making mandatory the granting of patents and fixing the right of the patent owner for a period of 20 years. Such provisions, absent from the Berne or the Paris Conventions, meant the transition at world level from a very loose international patent regime to a much more rigorous one. More on this point in Orsi and Coriat (2006).

[31] The following paragraphs are drawn from elements already presented in an earlier article (Coriat and Orsi, 2002). Here, these elements are updated and placed in the perspective of our present purpose.

[32] Anthony *et al.* (2008) present a well-documented discussion of the virtues and limits of the Bayh Dole Act.

[33] The main argument in favour of the Bayh Dole Act was that a lot of important discoveries freely available in academic publications were not developed any further by 'applied' research. Another argument was that the selling of public laboratories' discoveries could generate additional financial resources for universities and thus relieve their budget constraints. For an evaluation of this policy see Mowery *et al.* (2004).

[34] This point is examined in more detail in the following subsection.

[35] For a more precise and detailed presentation of the changes that took place, see Coriat and Orsi (2002) and Jaffe and Lerner (2004).

[36] The reasons why such changes were implemented must be sought in the political economics of the period (the 1980s), during which the US suffered a sharp decline in its competitiveness. On this point, see Coriat and Orsi (2002) and the detailed study by Scherer (2006).

[37] For a detailed analysis of the evolution of IPR on software and its significance, see Dreyfuss (2006).

[38] In 2008, an important ruling of the Supreme Court (re Bilski) overturned some of the jurisprudence established by the CAFC in *State Street*. While confirming in principle the patentability of business methods, it defines stricter patentability criteria than the CAFC. However, most observers agree that this ruling, while bringing some degree of order, has not put an end to the granting of patents on very diverse types of business methods (McFarlane and Litts, 2010).

[39] All the more so since the patents granted are often 'broad scope', in other words they do not cover inventions of proven utility, but a wide range of potential future applications. By granting patents on basic knowledge itself (the input for future inventions), the American courts protect not only the inventions actually described and disclosed, but all the potential and virtual ones that might derive from use of the patented knowledge.

The conflict between Myriad Genetics and several European research organisations, including the *Institut Curie*, provides a good illustration of the consequences of the new doctrine. On the grounds that it owned patents on a breast cancer susceptibility gene (BRCA1), the American firm tried to impose exclusive use of its test kit, taking out lawsuits against a number of laboratories throughout the world that had developed and were using their own tests, even though the latter performed better in terms of cost-effectiveness. An analysis of this case and its significance is presented in Orsi and Coriat (2005).

[40] National Association of Securities Dealers: this is the body responsible for the regulation and security of transactions on the NASDAQ, under the authority of the SEC (Securities and Exchange Commission).

[41] For a presentation of the conditions under which this 'Alternative 2' emerged on the NASDAQ, see Coriat *et al*. (2003).

[42] See Gompers and Lerner (1998) for the changes in the 'prudent man' rule.

[43] Some as-yet fragmentary information about this market can be found at http://www.rpxcorp.com/. This is the website of the company RPX, which, after estimating the value of US litigation involving NPEs at about $496 million for 2009 alone, defines itself as follows: 'RPX levels the playing field for our clients by providing them a platform to invest collectively in the patent market. RPX then applies that collective investment to buy patents before they can be asserted'. RPX thus provides an emblematic illustration of the new entities operating on the patents market and of the growing complexification and sophistication of this market.

[44] Zucker and Darby (1996) find a positive correlation between the number of stars and the market value of high-tech firms. There are two possible interpretations of this observation: (i) the probability of successful innovation really is related to the number of star scientists, or (ii) the investors *believe* that the probability of successful innovation is related to the number of star scientists.

[45] This process has been all the more vigorous since concurrent changes in accounting concepts and principles opened new opportunities for the players involved in this business.

[46] This trend is all the stronger since, as we have seen, new players, like the NPEs already mentioned, taking advantage of market imperfections, operate in such a way that they heighten the risks incurred by all innovators.

[47] See, for example, Machlup and Penrose (1950) and Machlup (1958).