Patents versus ex-post rewards : a new look

Julien PENIN*

Content

Economic studies that aim at comparing the patent system social efficiency versus an ex-post reward system rest on a traditional view of patents. They make the hypothesis that firms use the patent system only in order to be granted a short-term monopoly rent and therefore that patents lead to strong and steady monopolies. This assumption is convenient because it allows straightforward comparisons between patent and reward systems. But empirical studies do not confirm this vision of patents. Most firms do not consider patents as efficient devices to exploit commercial monopoly positions. Patents are rather perceived as strategic devices to signal firms' competences and to strengthen firms' bargaining power during negotiations prior to knowledge exchange and to R&D cooperation. These changes lead to rethink the framework of the patent-reward debate.
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* BETA, Université Louis Pasteur, 61 avenue de la Forêt Noire, 67085 Strasbourg Cedex et Université du Québec à Montréal, Département des sciences économiques, case postale 8888, Succursale Centre Ville, Montréal, Québec, Canada, H3C 3P8.

e-mail : penin@cournot.u-strasbg.fr

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Introduction

Patents are often regarded as a good consensus allowing both to increase the incentives to invest in knowledge production and to ensure a wide diffusion of the patented knowledge. But, problems inherent to the patent system, mainly the static dead-weight monopoly loss it creates, has led researchers to explore alternative solutions to this system.

Among these alternative solutions this work focuses on ex-post rewards and public patent buy-out[1] (see Polanyi, 1944; Wright, 1983; Kremer, 1998; Llobet, Hopenhayn and Mitchell (2001), Shavell and Ypersele, 2001). Under an ex-post reward system, innovators are paid directly by governments for their contribution to social welfare and their innovations pass immediately into the public domain. Similarly, under a patent buy-out system, governments buy patents to the innovators in order to put them into the public domain and to ensure a free access of the patented knowledge to everybody.

Such systems are appealing since, under certain conditions, they have: "the potential to eliminate monopoly price distortions and incentives for wasteful reverse engineering, while encouraging for original research" (see Kremer, 1998, p. 1138). In other terms, they could preserve the benefits of the patent system while mitigating its main disadvantages.

However, studies that attempted so far to appraise the social efficiency of an ex-post reward system and to compare it with patents used somehow similar approaches. They all rest on a classical patent perspective in the sense that they make the central hypothesis that firms apply for patents for the sole purpose to exploit a commercial monopoly position, the other benefits provided by patents entering only marginally into the decision to patent or not. Therefore, according to the classical view, patents lead to strong commercial monopolies. This hypothesis reduces by far the role of patents but it is convenient because within such a framework it is straightforward to compare the patent and reward systems.

Indeed, if patents are used only in order to ensure firms with a short-term monopoly rent, governments can compute innovations expected monopoly profit and pay this amount to innovators. Instead of granting a patent, the government can directly reward innovators such that incentives to invest in R&D are held constants but the dead-weight monopoly loss provoked by the patent is removed.

Following this traditional approach of the patent system, governments' decision to use the patent or reward system rests only on the quantity and quality of information available to policy makers. If a central planner can gather enough information to appraise, even approximately, the expected monopoly

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[1] Patent buy-out and ex-post reward are close but not exactly the same in practice as we will see in section 2. Nevertheless, in this work we use alternatively these two expressions without making any differences between them because the point we want to enlighten, that the patent system cannot be reduced to a simple amount of money and as such that it cannot be properly replaced by a system that would give only money to innovators, applies similarly to both of them.

profit of each innovation then it is worth replacing patents by an ex-post reward system. However, rooted in an Hayekian tradition, partisans of the patent system argue that a planned solution cannot be successful because governments can never gather enough information to assess the amount of the reward and as such, the patent system, being decentralised, is always better.

This paper aims to widening the discussion concerning the social desirability of patents over rewards and vice versa. Indeed, few industries excepted (mainly chemicals based industries), firms are far from considering patents as efficient devices to appropriate their innovations and therefore to secure monopoly rents (see Mansfield, 1986; Levin, Klevorick, Nelson and Winter, 1987; Mazzoleni and Nelson, 1998; Jaffe, 2000). It follows that in most industries, patents do not lead to commercial monopolies. The central hypothesis that allowed a straightforward comparison between patent and reward systems collapses.

Nowadays, the emerging consensus is that in most industries patents are used to increase firms bargaining power during negotiations prior to knowledge exchange and to R&D cooperation (see Rivette and Kline, 2000; Hall and Ziedonis, 2001; Reitzig, 2003). The property right associated to the patent, even if not perfect, allows the patent holder to bargain an access to other firms' knowledge by entering R&D cooperation or by cross-licensing. Moreover, patents can also manage to signal firms' competences in a given technological field (see Pénin, 2002).

Therefore, a patent ensures its holder with an option for a monopoly position and this option is often not exerted because firms find some agreements. Following this vision, the patent system, because it favours negotiations and knowledge exchange, is an essential element for the collective knowledge production process to perform well. It assists this process not only by providing incentives to invest in knowledge production but also by facilitating the coordination among agents (see Pénin, 2003a).

This new vision of the patent system leads to re-think the debate between patent and reward and to orient it on a ground that would take in account the features above mentioned. If patents are used as devices for bargaining and not for directly exploiting a commercial monopoly there is less need to find alternative to the patent system. Even if a central planner can gather good information concerning a given innovation, the implementation of a reward system might not be socially desirable. All the more that consequences on the bargaining outcome, and therefore on the innovation process, of the replacement of patents by rewards are uncertain. For instance, would a reward system not have some negative impacts on the number of cooperative agreements between firms? Would rewards facilitate collective forms of knowledge production as well as patents do? However that may be, it appears clearly that in most industries a patent cannot be reduced merely to a single amount of money and therefore cannot be compared directly with an ex-post reward system.

The paper is structured as follows: we start by reminding the classical foundations of patent policy. Then we introduce the ex-post reward system and we analyse the traditional line of comparison between this system and the patent one. In the third section we present the critics that have affected the patent classical view. We conclude by an attempt to deduce the changes that the new vision of the patent system introduces concerning the patent-reward debate.

1) The theoretical background of patent policy

Current innovation policies, including patents, are based on a vision of knowledge that goes back to the pioneer work of Nelson (1959) and Arrow (1962). Knowledge is assimilated to pure information. It is considered as a non-rival and non-appropriable good and as such its production generates spillovers. New knowledge flows from its creative source to other agents who, despite they did not share the production costs, share the benefits of this new knowledge.

The presence of knowledge spillovers (coupled with the fact that knowledge creation is a risky activity) decreases the incentives to invest in knowledge production. It follows that there is a gap between the investment level in research activities achieved by the market and the ideal amount of investments for the society. As market mechanisms lead to under investments in knowledge production, as compared with an ideal, non-market mechanisms must be implemented in order to increase firms' incentives to invest in knowledge production and to orient the market toward a social optimum.

However, on one side knowledge spillovers lead to under optimal knowledge production level but on the other side, if it would be possible to dismiss these spillovers, by allowing inventors to appropriate perfectly their new knowledge, the situation might not be improved because the repartition of knowledge among individuals would not be optimal. Indeed, when knowledge is considered as pure information it can be transferred with few cost and the optimal allocation of a piece of knowledge among an economy is a universal repartition. Everybody must be allowed to use this knowledge.

A situation in which only one individual uses the new knowledge is not optimal because knowledge is not only an input to produce a finished, marketable, good, it is also an input to produce further knowledge. Knowledge production is a cumulative process (see Scotchmer, 1991). Therefore, the more an agent holds knowledge, the higher his probability to invent and to generate further knowledge. It follows that an economy must allow a wide dissemination of the knowledge among its members in order to be innovative.

There is an obvious opposition between the two views exposed here, between the optimal allocation of knowledge within an economy and the optimal level of knowledge production (see Arrow, 1962). Without spillovers, incentives to produce new knowledge are strong but this knowledge is not well

distributed among the agents and on the other side, when spillovers are strong agents have few incentives to invest in knowledge production.

The dilemma between the optimal level of knowledge production and distribution leads to the conclusion that the true problem is less the presence of knowledge spillovers than the lack of incentives to invest in knowledge production. For instance, Spence (1984) shows that the system performs better with than without spillovers with the incentives appropriately restored. Therefore, non-market mechanisms must be implemented not only in order to increase incentives to produce knowledge but also to preserve knowledge spillovers and to increase the repartition of the new knowledge among the economy.

This statement is at the core of the patent system implementation. Indeed, a patent does not directly give a property right on a new piece of knowledge, but on the marketable artefacts that are issued from this new piece of knowledge. For instance, if someone discovers a new medicine, this inventor may be granted a patent on this medicine and benefits from a monopoly position for the sell of this medicine in every country where the patent holds. But this inventor cannot be granted a property right on the knowledge underlying this new medicine. Therefore, everybody is allowed, and even encouraged, to use this knowledge in order to produce further medicines or other products. With the aim to encourage the cumulative process of knowledge production, the patent system even try to ensure a wide diffusion of the knowledge (codified) underlying the patented innovation. Indeed, when an inventor applies for a patent he must give a description of his invention that allows every person knowing the state-of-the-art to reproduce it. Once the patent is granted, or in some countries even if the patent is not granted, this description is published and everybody has free access to it.

Theoretically the patent system manages both to restore incentives to invest in knowledge production and to ensure the necessary dissemination of the research results. This performance explains why patents are often considered as an ideal consensus between the optimal level of knowledge production and allocation and why the patent system is widely used all around the world.

However, there is a counterpart to this idyllic picture: the patent system, by granting a temporally monopoly position to the patent holder, provokes a static monopoly dead-weight loss as compared with a competitive situation. During the time the patent holds, social welfare is not maximised because the monopoly pricing penalizes consumers: some consumers who value the good above the marginal cost do not consume it at the monopoly price. For this reason it is often argued that the patent system leads to sacrifice the static efficiency of the economy in order to ensure the dynamic efficiency. Today's welfare diminution, due to the monopoly price distortion created by patents, leads to an increase of tomorrow's welfare, because higher incentives to invent mean further innovation in the future.

2) The patent-reward debate in the literature

Ex-post rewards and patent buy-outs

Before presenting the traditional line of comparison between patents and rewards, let us first introduce and illustrate by historic examples what we mean by ex-post reward or by patent buy-out. These two systems are similar in the sense that they both replace the patent monopoly rent, fixed by the market, by an amount of money determined by the central authority and they both allow to release the invention into the public domain.

An ex-post reward system is a system where the government distributes prizes to successful innovators in order to reward them for their contribution to the social welfare. Under the patent system innovators must earn their remuneration through the exploitation of a monopoly position whereas, under a reward system the government directly rewards them. Moreover, under the patent system the market determines the inventions value whereas under an ex-post reward system it is the central planner who appraises it. The idea to implement an ex-post reward system is not new. Already in 1944, Polanyi M. (1944, p. 65) teaches us that: "In order that inventions may be used freely by all, we must relieve inventors of the necessity of earning their rewards commercially and must grant them instead the right to be rewarded from the public purse".

Nowadays, such a system of rewards is widely used in several domains: for instance, the Nobel prize for academic work and arts, the Pulitzer prize for journalistic excellence, the Hollywood Oscar for actors, etc. These prizes are not merely honorific, they are often accompanied by immediate monetary outcomes and by future outcomes due to the reputation ensured by the prize. The idea here is to adapt such prizes to the industrial world, where they already exist, but on a small and not systematic scale. Here are some historic examples of such industrial prizes:

In 1714 the British government announced his will to deliver a 10 000 pounds prize to the first inventor of a method measuring with reliability the longitude. This incentives led to the invention of the chronometer by Harrison (see Horrobin, 1986)[2]. Similarly, the French Academy of science announced, in 1775, her will to pay a 12000 francs reward to the first to invent an artificial alkali form. Further, the Napoleon's society decided, in 1795, to offer a prize of 12000 francs to the first to invent a method of food preservation that could be used by soldiers. It was awarded in 1810 to Nicolas Appert, the inventor of food canning (see Wright, 1983).

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[2] Wright (1983, p. 704) teaches us that: "Awards of £10000, £15000 and £20000 were offered by the British board of longitude in 1713 for a chronometer which measured longitude to within 60, 40 and 30 minutes, respectively. John Harrison claimed the £20000 reward in 1762, and full payment was completed by 1773 (Encyclopedia Britannica, 1929, vol. 11, p. 220)".

Notice that these examples all illustrate not systematic prizes for which the amount of the reward is computed ex-ante of the invention and that aim to attract resources for invention toward a precise technological domain. As such they are closer to research tournaments or races (see Taylor, 1995) than to ex-post rewards. However, our interest in this work lies in systematic prizes for which the reward is computed ex-post, once the invention has been discovered, and therefore that aim to widely encourage innovation in all economic sectors, in the same way the patent system does.

Instead of implementing such a general and systematic ex-post reward system, governments can also decide to buy systematically patents that have been granted to innovators, in order to put them into the public domain that is, in order to let them used freely by all. This idea of patents buy-outs comes from the purchase of the daguerreotype photography techniques, from the name of its inventor Daguerre, by the French government in 1839. Kremer (1998) explains that: initially Daguerre "offered to sell detailed technical instructions to a single buyer for 200 000 francs or to 100 to 400 subscribers at 1000 francs each" (Kremer, 1998, p. 1144). However Daguerre was not able to find any buyer. Finally, "the French government purchased the patent in exchange for pensions of 6000 francs per year to Daguerre, 4000 francs to his partner, and half that amount to their widows upon their death" (ibid., p. 1144). Then, the French government placed the rights into the public domain (excepted in England) the result being this technology wide adoption all around the world. Instructions were translated into several languages and lots of technological improvements emerged quickly.

Another example of patent buyout is the cotton gin patent that has been sold by his inventor Eli Whitney, who was unable to make money with it, to the state of South Carolina. Kremer mentions that this patent was sold for almost nothing as compared with its social value. A common feature between these two stories is that despite the existence of a patent system both inventors were unable to make money with their invention, although these inventions have since been proved to be socially useful. One of the arguments in favour of an ex-post reward system is therefore that if the market is unable to appraise correctly inventions and to reward decently innovators then, it is the role of the central authority to replace the market and to do it by itself. The counter argument being that governments are often unable to assess innovations social value better than the market.

Indeed, a major challenge for ex-post rewards is that policy makers must compute the ideal (from a social point of view) amount of the reward or the patent buy-out ideal price. And this ideal amount must encompass all the benefits the innovation generates for the society, including all the spillovers either positive or negative. In other words, without taking any equity concept in account, the ideal reward is equal to the social value of the innovation. Only then, policy makers are sure that all the profitable innovations, from a social point of view, and only them, are implemented. Indeed, when the remuneration is more than the social surplus, there is a risk that some innovations with a social cost higher than the

benefit they generate for the society, are implemented. Conversely, when the reward is less than the social surplus, some innovations profitable for the society (with a social cost lower than the social benefit) may not be implemented. Thus it is only when the reward for an innovation equals the social surplus of this innovation that the social and private goals are perfectly balanced. It is easy to guess, by anticipating on what follows, that one of patent buy-outs main problem is that no central planner could ever gather all the information needed to compute this optimal amount.

Patent or reward: what is more desirable for the society?

Presentation of both patent and reward systems clearly show that the main advantage of rewards over patents is that they do not induce a static monopoly distortion. In a world where central planners are omniscient ex-post rewards perform at least as well as patents because they preserve the incentives to invent, they help to diffuse widely the research results and they do not induce monopoly distortions.

Once the reward has been granted or the patent has been bough-out, the innovation is put into the public domain, meaning that it is accessible to everybody without having to pay a licence to the innovator. Thus, ex-post rewards increase the competition for the production and distribution of a given innovation and as such, they lead to price diminution as compared with the patent system. Further, as other firms can use the knowledge, benefits that arise from ex-post rewards also encompass the effects of more learning by using the now free technology.

Moreover, rewards provide higher incentives than patents if only the amount of the prize surpasses the expected monopoly rent, which is what innovators expect under the patent system. Specifically, patents buy-outs are very attractive for small firms because they ensure them with a certain reward and thus, they eliminate the risk associated to the need to earn the reward commercially.

To sum up, a sufficient condition for patent buy-outs or ex-post rewards to perform better than patents is to warrant to innovators a reward at least equals to what they can expect by exploiting a monopoly while allowing a full disclosure and use of the new knowledge. Polanyi (1944, p. 68) summarises this condition: “If the government were to fix the total sum allocated for public rewards at a level which will just suffice to induce inventors and financiers to be as eager to obtain patents as they are today (which would presumably require a sum about equal to the profits derived from their patents today), the general public would be left with a handsome balance”.

However in a world where information is scarce and costly and therefore where the central planner does not know the value of innovations, the conclusion that rewards are socially more desirable than patents does not hold any more. As it is above mentioned, implementing a reward system that dominates the patent one, requires the government to fix the amount of the rewards at least equal to the expected

monopoly profit. Clearly, a central planner will have great difficulties to gather the needed information to compute these rewards because relevant information are mainly private[3]. Therefore a planned solution will hardly lead to better situation than the patent system.

This statement provides patents with a fundamental advantage over rewards. The patent system is decentralised and as such: "patent leaves nothing to anyone discretion; because the reward conferred by it depends upon the invention's being found useful and the greater the usefulness, the greater the reward" (J.S Mill, 1872, cited in Shavell and Ypersele, 2001, p. 527). Patents special advantage arises from the fact that private researchers have far more information concerning their own invention than a central authority. The patent system exploits the private information by letting the market determine the value of an innovation and therefore this system often leads to better results than what a central planner can do.

Following the economic studies that have documented the topic, conclusions on a global and systematic superiority of patents over rewards, or vice versa, are reasonably straightforward: what matters in order to choose between a patent or a reward system is only the structure of information of the economy. Wright (1983, p. 695) explains that: "The rich informal literature on the patent system emphasises the importance of the patent as a decentralised decision making device, implying that information and its distribution are major elements in the rationale for the patent instrument". Llobet *et al.* (2001, p. 2) summarise the conclusion commonly adopted in the literature: "It is well understood that, when information is complete, it is optimal to choose a prize as the reward, since it does not result in any of the distortions that may accompany market power. When the principal charged with rewarding innovators does not have complete information about the benefits of an invention however, it has been shown that it may be optimal to grant a patent". However, this conclusion rests on a strong and controversial hypothesis.

The hypothesis underlying the Patent-reward debate

The patent-reward debate, as it has been treated so far not only in this work but also in almost all the works devoted to it, is anchored into a classical patent perspective. It is based on the hypothesis that

[3] Kremer (1998) proposes to implement an auction mechanism in order to compute the invention private value (the expected monopoly profit). Briefly, and not considering the details, the intuition of Kremer's method is the following: First an inventor inform the government that he wants to sell his patent. Then, public authorities diffuse this information widely and firms interested to buy this patent must reveal a price in order to be granted the monopoly right. The outcome of this auction process should theoretically lead to the invention private value. The government can then use this information in order to compute the invention approximate social value (Kremer suggest to double at least the auction outcome). Therefore, one can see that, although quite interesting and original, Kremer's method illustrates perfectly the difficulties faced by a central planner in order to compute only an approximate value for the reward.

the economic role of patents is only to provide firms with a monopoly for their innovation that ensures them a short-term monopoly rent. According to this view, patents are always supposed to lead to commercial monopolies.

Conditional to this assumption it is possible, with the help of formal models, to compute patents expected monopoly profit and therefore it is possible to associate to each patent its monetary counterpart. Thus, if firms consider a patent as being only useful to earn an immediate, short term, monopoly rent, a central planner can replace this patent by its monetary counterpart without decreasing the efficiency of the system on the contrary, as we have seen above. Under such a framework, patents can be reduced to a single amount of money and the only criteria to choose between patents or rewards is whether or not a central planner has access to good information in order to compute the amount of the reward.

But on the other side, if the role of patents within an economy is not only to ensure monopoly positions and therefore if patents do not always lead to strong and steady monopolies, then the comparison between patents and ex-post rewards is not so straightforward. In such a case comparisons between patents and rewards cannot be based only on the information held by a central planner. They must include the other, maybe non-monetary, characteristics of patents into the balance.

To conclude this part, the hypothesis that underlies the patent-reward debate, and that allows the kind of reasoning we have done here, is that patents are used only in order to ensure firms with monopoly positions. The point we advocate in the following is that this core assumption is far from being validated by empirical studies.

3) Evolution of the patent theory

Classical explanations of patents economic role present serious dysfunctions. More specifically, the hypothesis that lies at the core of the patent-reward debate is strongly rejected by empirical studies. Most firms do not regard patents as efficient devices to appropriate inventions and therefore to exploit commercial monopolies. They prefer other strategies to protect their innovations. Patents are rather perceived as efficient devices during negotiations, because they increase firm's bargaining power, and as useful ways to signal firm's own competences to industrial or academic worlds.

Patents are not central to appropriating the returns to R&D in most industries

This part draws heavily from Jaffe's survey (2000). The author reaches the conclusion that, in most industries, patents prime use is not to ensure direct monopoly rents to their holder. This conclusion appears quite robust in the sense that it is based on several empirical studies, concerning different periods,

countries and industries, that all converge to similar results. Let us remind some of the most significant studies.

The pioneer empirical evaluations of patents usefulness for the firms are due to Scherer *et al.* (1959) in the US and to Taylor and Silberston (1973) in the UK. Both studies conclude similarly that, pharmaceutical industry excepted, firms do not consider patents as efficient to ensure a monopoly position on a given market or as a necessary condition to benefit from an innovation. Such conclusions, viewed as quite surprising then, have been confirmed by all the studies from there on to very recently.

Levin *et al.* (1987) use the answers of 650 firms to a questionnaire in order to compare patents efficiency with other methods to protect innovations. They indicate that firms report to value more methods like secrecy, lead time or superior services than patents in order to protect their innovation from imitation. These results hold both for product and process innovations (excepted for secrecy, which is perceived as being less efficient than patents for product innovation). Only firms located in industries that involve chemical based knowledge (pharmaceuticals, organic and inorganic chemicals, petroleum, plastic materials) value strongly the patent system in order to protect their innovations. Mansfield, Schwartz and Wagner (1981) reach similar conclusion. They report (p. 917) that: "Contrary to the assumption of many economic models, a patent frequently does not result in a seventeen year monopoly over the relevant innovation…Excluding drugs, patents protection did not seem essential for the development and introduction of at least three quarter of the patented innovations studied here".

In the nineties, studies led in the USA (see Cohen, Nelson and Walsh, 2000), Japan (see Goto and Nagata, 1996) and Europe (see Arundel and van de Paal, 1995), also confirmed these results. Arundel (2001) uses the 1993 European Community Innovation Survey (CIS) dataset (this dataset concerns 2849 European firms who reported having an R&D activity) and concludes that: "firms in all size classes find secrecy to be a more effective means of appropriation than patents" (p. 621-622). Studies in the nineties also identified new strategies that firms perceived as being more efficient than patents to protect their innovations[4].

Not only questionnaire based studies but econometric studies as well reach the somehow incontestable conclusion that patents are not central to appropriate the benefits of innovations. For instance, Sakakibara and Branstetter (2001) examined the macro effects of the patent laws reinforcement and the patent scope broadening, which occurred in the 1980s' in Japan and in the US. Following the mainstream theory, such an event should increase the number of patents demand as well as long run

[4] Cohen *et al.* (2000) report that in average firms rated the different method of protection in the following manner: 1) Product complexity 2) Secrecy 3) Lead time 4) Complementary sales and services 5) Complementary Manufacturing 6) Patents and other legal devices.

growth. However, the authors' evidences suggest that the responsiveness to changes in patent scope is limited. Jaffe's analyse is the following (2000, p. 531): "despite the significance of the policy changes and the wide availability of the data relating to patenting, robust conclusions regarding the empirical consequences for technological innovation of changes in patent policy are few".

Rarely such a number of empirical reports, over a 40 years period, reached so close conclusions. It seems therefore that one can take as a given that patents are not effective to capture returns from R&D in all but a handful industries. It follows that patents do not lead to commercial monopolies. Let us add to this categorical denying of the classical role of patent, another one, less robust but nevertheless meaningful, concerning the role of patents as direct knowledge carriers: empirical studies does not identify patents as being an efficient device to ensure a wide knowledge diffusion among the economy. To make ours an expression used by Jaffe, Trajtenberg and Fogarty (2000), empirical studies concerning the effectiveness of patents as knowledge carriers, suggest only "a half full cup" because patents allow only the diffusion of codified knowledge.

The real role of patents: bargaining and signaling

Results displayed in the previous section lead to an evident paradox: firms report to value poorly patents in order to protect their innovations but as a denying of this ascertainment the number of firms that apply for patents has sharply increased since the mid-eighties. The USPTO has been addressed 60 000 patent application in 1983 and more than 120 000 in 1999[5]. Several explanations of this apparent paradox have been proposed:

Kortum and Lerner (1999) identify and test four hypothesis that might help to explain the recent patent application surge: *(i)* The first one they call the "friendly court hypothesis" attributes this surge to new legislations that favour patent holders and make it more profitable to patent innovations; *(ii)* The second is called "fertile technology hypothesis" and attributes the patent application surge to the emergence of new knowledge intensive technologies such as biotech and software that have widened the technological opportunities set; *(iii)* The third assumption to be tested is called "regulatory capture hypothesis" and attributes the surge to incumbent's over patenting strategies aiming to increase the barriers to potential entrants; *(iv)* Last, they attribute this surge to a change in the way firms manage they patent portfolio.

After a thorough check, Kortum and Lerner reject the first three hypothesises and conclude that the recent patent application surge is due to a change in the firm's management of their patent portfolio. It

[5] See www.uspto.gov.

is also the conclusion we adopt in this section: in a knowledge based economy, firms value patents as being important bargaining devices to facilitate R&D cooperation and cross-licensing, and as being an effective way to signal firm's specific competences.

Hall and Ziedonis (1999, p. 4) summarize this point of view: "Instead of being driven by a desire to win strong legal rights to a stand alone price, these firms are driven by broader motives […] Manufacturers amass large patent portfolios of their own, largely to avoid being excluded or held up by other parties […] The classical role of patents seems to be dominated by this broader use of patents as "legal bargaining chips" that enable the firms to avoid being excluded in a particular field of use, to obtain more favourable terms to their licensing agreements, to safe guard against costly patent litigation or to gain access to external technologies or more favourable terms of trade".

Patents are used to prevent suits when the firm is noticed that she is infringing another patent. They allow to bargain cross-licensing agreements and therefore to gain an access to domains that would be forbidden otherwise[6]. It is indeed always risky to engage heavy and costly R&D investments when other firms hold some patents susceptible to prevent the exploitation of the research results. Expecting such situations, firms are induced to gather important patent portfolios that will serve as "legal bargaining chips" when they need to be granted licenses to use new technologies that are protected by other patents.

Agreements are facilitated because to defend a patent in front of a court involves important costs while it remains always a risk concerning the issue of the judgment. Moreover, agreements are also encouraged by the difficulty to prove infringement for the patent holder. And in some countries, legal battles can involve preliminary injunctions that allow a patent holder to close down its competitors operation for some time. When two firms both pretend that the other infringes one of her patent, the danger for both firms represented by a mutual injunctions is a powerful incentive to find an agreement.

Such practices of cross-licensing are also motivated by the fact that the innovation process is a collective and cumulative process (see Gibbons, 1994). Firms are all inter-dependants and therefore if patent holders decide not to grant licenses then the technological progress will come to an end because not a single firm will be able to invent without infringing a patent held by one of her rival[7]. Therefore,

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[6] Von Hippel (1988, p. 53) describes the following situation: "Firm A's corporate patent department will wait to be notified by attorneys from firm B that it is suspected that A's activities are infringing B's patents. Because possibly germane patents and their associated claims are so numerous, it is in practice usually impossible for firm A – or firm B – to evaluate firm B's claims on their merits. Firm A therefore responds - and this the true defensive value of patents in industry – by sending B copies of « a pound or two » of its possible germane patents with the suggestion that, although it is quite sure it is not infringing B, its examination shows that B is in fact probably infringing A. The usual result is cross-licensing, with a modest fee possibly being paid by one side or the other. Who pays, it is important to note, is determined at least as much by the contenders' relative willingness to pay to avoid the expense and bother of a court fight as it is by the merits of the particular case."

[7] Grindley and Teece (1997) illustrate such a situation where the technological progress is stopped due to firms unwillingness to

most of the time firms find agreements and do not have to use their exclusive right.

Patents are not only useful during negotiations that aim to cross-licensing but also during negotiations that aim to determine the terms of a formal cooperation with other firms. They might allow to distort the term of the entente in favour of the firm who holds the most prominent patents. They allow a firm to hinge something on the table and therefore to claim more favourable terms. Moreover, patents are also useful in order to protect the knowledge held by the firm from the pillage of the cooperation partners. Indeed, R&D cooperation is a risky process in the sense that participants must often share some of their most important intellectual assets. R&D cooperation gives an access to the firm most precious knowledge to other participants. Therefore if this knowledge is protected firms will be more willing to start such R&D cooperation. Patent protection decreases risks inherent to R&D cooperation and as such stimulates this cooperation (see Ordover, 1991).

Firms also value patents because they provide a signal of their competences to other firms or to financial markets. As argued by Mazzoleni and Nelson (1998, p. 278) "the focus here is on the advertising value of patents". A patent means that the invention has been examined and validated by the patent office. Thus, if patents examiners do their job thoroughly (point which is vividly debated today, lots of persons arguing that too many patents are accepted and that the novelty criteria is not respected anymore), a patent signals an innovation that is new and useful. Therefore, a patent warrants that the patent holder holds a given competence, and this reputation might profit to the patent holder through several channels.

For instance, patents have been proved to be highly valued by financial markets or by venture capital providers when they must choose which project to finance (see Hall and Ziedonis, 2001).

Similarly, the reputation ensured by a patent can help to find new partners, industrial or academics. Knowledge being widely disseminated among the world, firms most of the time are not able to locate and to identify potentially useful knowledge. It follows that the signal provided by patents might allow the holder to signal his competences, which might help to start a profitable cooperation with other competent firms (see Pénin, 2002).

It comes out that either in order to trade knowledge through cross-licensing agreements, to facilitate cooperation with other firms or to signal firm's specific competences, the main motive of patenting is triggered by other considerations than by a mere motive of appropriation and exclusion.

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cooperate and to grant licenses. It occurred, they tell us, in the semi conductor industry at the early days of radio in the beginning of the century. Radio is a multi technology product and the problem was the following: "A number of firms had important patent position and could block each other's access to key components. They refused to cross license each other" (Grindley and Teece, 1997, p. 11). The result was a deadlock that lasted till 1919, when pioneers of the electronic industry formed the RCA (Radio Corporation of America) and agreed to sell their patents to RCA. Grindley and Teece argue that the RCA cross licensing agreements became a model for the future and indeed, still today firms in the semi-conductor industry nurture a tradition of knowledge exchange and cross-licensing.

Patents assist the innovation process by reducing the coordination failure

I argued elsewhere that the knowledge production process involves not only an appropriation failure, due to knowledge spillovers, but a coordination failure as well, due to the difficulty to gather all the pieces of knowledge needed to implement a given innovation (see Pénin, 2003a). Further, in a collective and cumulative framework of knowledge production, the coordination failure might be more important than the appropriation failure. However it may be, we argue that patents might allow to solve both failures: the appropriation one because they ensure the innovators with a property right and the coordination one because, for reasons presented above, patents might favor R&D cooperation and knowledge exchange.

Patents are therefore crucial for the collective process of knowledge production to perform well. They allow firms to reveal some information concerning their innovation while keeping the exclusive exploitation right. It is the superposition of the signal and the property right that makes patents so useful to their holders and so precious within the collective process of knowledge production. Without patents firms would be reticent to trade knowledge or to cooperate in R&D and this would be quite damaging for the innovation process.

To come back to the main topic of this work, it appears that patents rarely lead to commercial monopolies. Rather, firms use the patent system in order to prevent suits, to improve their bargaining power or to signal their technological competences. This vision of the patent system must be considered when trying to assess the social desirability of patents as compared with rewards. Comparisons cannot be made by assuming that patents are used for a purpose of appropriation and exclusion and that they lead to strong and steady monopolies.

4) Conclusion : implications for the patent-reward debate

This work aimed to re-orient the patent-reward debate: a patent cannot be reduced to a single amount of money earned from the exploitation of a monopoly position. The patent system is more complex than this over simplified view and the direct corollary of this assertion is that, in most industries, the patent system cannot be properly replaced by a system that would give only money to innovators, like an ex-post reward or patent buyout system.

Our departing point was the ascertainment that the traditional (that we most commonly found in the literature) line of comparison between patents and ex-post rewards rests exclusively on the quantity and quality of information accessible to a central planner. Economic studies almost all converge toward the conclusion that when a central planner can manage to gather good information about the economic

value of innovations then it might be more preferable to implement an ex-post reward system than a patent one. The reply of patent partisans, strongly rooted into the Hayekian tradition, is that a central planner will never be able to gather enough information to replace a decentralised mechanism like the patent system.

This view of the debate is based on the crucial hypothesis that patents are used by firms only in order to be granted an immediate monopoly rent. But this core hypothesis is not validated by empirical studies. Patents are most of the time not used to ensure effective commercial monopolies. Rather, they seem to play a fundamental role of coordination within the knowledge production process by facilitating R&D cooperation and knowledge exchange. Therefore, patents, in most of the industries, do not lead to a static monopoly dead-weight loss. On the contrary, they assist the knowledge production process by reducing the coordination failure that might impede this process. Taking this feature in account, what are the repercussions on the patent-reward debate?

The main determinant, in order to choose between patent and reward systems, is not only the quantity and quality of information held by a central planner but also the way in which firms are using their patent portfolio. What really matters is whether or not patents can be reduced to a single amount of money? If the answer is yes, then, depending on the information available to the central planner a replacement of patents by rewards might be advisable because the traditional line of comparison applies. But if the answer is no then, even if the information available to the central planner is good, it might not be desirable for the society to replace the patent system by a system that would give only money to innovators.

It must be observed that solutions are not uniforms across industries because patents do not serve the same purpose in all sectors. Thus, the choice between patents and rewards must be made industry by industry. One must distinguish sectors where patents are used as devices to exclude competitors and to exploit a monopoly with sectors where they are not. All the more that, following the works done by Levin *et al.* (1987) and other authors mentioned in the third section, industries in which patents lead to strong monopolies and in which they do not are relatively well-known nowadays.

In industries in which patents are not used to exclude competitors but to trade knowledge and to facilitate R&D cooperation, the implementation of an ex-post reward system is far from being straightforward, even if the government can gather almost perfect information concerning the social value of a given innovation. Indeed, in such industries patents perform well at a low social cost.

First, they allow to exchange knowledge because they create a market for knowledge, even if this market is far from being perfect. Second, they facilitate R&D cooperation because they signal where competences are located and they improve firms bargaining power. Third, they provide incentives to invest in R&D. In one word, they assist the collective knowledge production process. Furthermore,

because the monopoly right associated to patents is rarely effective, patents involve only a small dead-weight monopoly loss for the society.

Therefore, in such industries we shall advocate to renounce to the embarrassment provoked by a centrally planned solution and to let the market do the job itself. All the more that a system of ex-post reward would be far from perfect: first, because a central planner will be able to gather only approximate information concerning innovations social value. Second, because the consequences of the replacement of patents by rewards on the collective knowledge production process remain uncertain. And, without being able to assess the impact of rewards on the collective knowledge production process, one cannot conclude on the desirability of rewards over patents.

In such sectors where patents do well at a low cost for the society policies aiming to improve the role of patents in the knowledge production process, and not to replace it by another system, are essentially required. Governments could, for instance, decrease the patent application costs, in order that small firms be also able to apply, they could improve controls concerning patents novelty and usefulness, in order to better the signal sent by patents regarding the competences of their holder, they could ensure strong property right, in order to increase the trust of innovators in the system and therefore to encourage cross-licensing and R&D cooperation[8], etc.

At this step, let us clear an important point: governments must ensure strong property rights but this does not mean that they must tolerate and protect strong and destructive monopolies. We should keep in mind that this advice is formulated in the case of industries for which patents are not used to set up strong commercial monopolies. In such a framework strong property rights shall increase the confidence of the agents and decrease the risks and uncertainties of trading knowledge. It follows that strong legal property rights can help to promote collective forms of knowledge production. But in the same time, governments must display widely their willingness to favour agreements and cooperation rather than defensive patents that aim to block competitors. Governments must, for instance, make it clear that they will not tolerate that patent holders refuse to grant licenses when the offer is widely perceived as fair.

This being said concerning industries in which patents do not lead to commercial monopolies, let us consider industries in which it is well known that patents are used to exploit commercial monopolies.

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[8] Let us give our own definition of a strong patent: Following Foray (2002) we do not consider that patent strength is mainly function of its length and width. Rather, the genuine strength of a patent depends on the expectation of the attitude of the court ex-post. When innovators have faith in the patent system, when they believe that their right, if needed, can be confirmed in front of the tribunal, then the patent is strong. Quoting Foray (2002, p. 86), "one can reinforce the patent system by decreasing the uncertainties relating to the judgment and the conflict and litigation probability, therefore, by increasing the agents faith in the system" (citation originally in French: "en réduisant les incertitudes juridiques et la probabilité de conflits et de litiges en cour, donc en renforcant la confiance des agents envers le système").

In such industries, patents are costly in terms of social welfare and therefore it might be rationale, depending on the information available to the central planner, to replace them by rewards. Indeed, here the classical patent-reward framework applies. It is possible for a central authority to compute a given innovation expected monopoly profit and to pay directly this amount to the innovator instead of granting him a patent. Because firms view patents essentially as a source of direct monetary outcome the replacement of patents by ex-post rewards should not decrease the incentives to invest in knowledge production whereas it should allow the removal of the monopoly dead-weight loss.

Pharmaceuticals provide a good illustration of such industries in which patents lead to effective commercial monopolies and in which the monopoly dead-weight loss is high (see Pénin, 2003b). Indeed, it is well known that a patent on a medicine ensures a strong and effective protection of this medicine and therefore patents provide pharmaceuticals firms with long and fruitful monopolies. But it is also well known that such monopolies lead to situation unbearable from an ethic point of view because lots of ill people, mainly in poor countries, do not have access to essential medicines mainly due to the prices of the treatment. The monopoly dead-weight loss induced by patented medicine is nowhere as high as in the pharmaceutical industry.

Therefore, in the pharmaceutical industry ex-post rewards could replace successfully the patent system. Even knowing that a central planner would not be able to gather the information that would enable him to compute the ideal reward, an ex-post reward or patent buy-out system could manage to maintain the incentives to invest in new medical treatments high, while decreasing the prices of these new treatments. But in almost all the other industries, one must be very cautious before drawing similar conclusions because the patent system appears to work well at an acceptable social cost.

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