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PATENT LIFE AND SCOPE: WHAT IS THE OPTIMAL COMBINATION?

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Abstract: *The patent system rewards innovators by giving them monopoly power. Two questions naturally arise: how big must monopoly power be? And for how long should it be granted? In other words: what is the optimal level of protection across the duration (length) and extent (width and height) of patents? Indeed, our goal is to study how patent breadth and height, alongside length, can be instruments in order to solve the dilemma between encouraging investment in research and development and ensuring the dissemination of knowledge.*

JEL classification: O30, O31, O34.

Key words: innovation, growth, patent, length, breadth, height.

INTRODUCTION

Today's economists and lawyers share the common view that a strong patent regime is likely to encourage innovation for the benefit of economic growth. However, critics have argued that strong and overly broad patents are a hindrance to the research that would result and therefore hinder rather than promote technological progress. For David Madore (2002) patents reward the time and money invested. They encourage investment in research and development and thus encourage the creation of new innovations. However, by granting the patentee the right to exclude any other agent from its use for a long time (usually 20 years), patents also constitutes a barrier to innovation.

Economically, the patent has value only by the extent of its legal characteristics: length, breadth and height. We focus the analysis on whether economic theory allows us to draw useful conclusions for what might be an optimal patent policy.

The purpose of this work is to answer the main question: ***what is the optimal scope and form of patent rights protection?***

Our methodology is to investigate and analyze how endogenous growth models based on innovation and microeconomic and industrial economics models have addressed the three dimensions of the patent. Focusing on the different arguments about the optimal level of protection, we seek to clarify how the patent can be conceived as a public policy instrument to promote innovation for the benefit of economic growth.

The length, breadth and height of the legal protection of innovations are instruments that can be used by public authorities to encourage innovation and promote growth. Taking into account the characteristic breadth of the patent makes sense only when the model takes into account the phenomenon of imitation. Indeed, the protection of the patent can only be partial: among the 48 innovations studied by Mansfield et al. (1981) more than 60% were imitated.

The length of the patent or the statutory life is the maximum period during which the patent can remain valid. The breadth of the patent determines the level from which the imitation of a product or process will constitute an infringement. It allows delimiting the possibility for a potential competitor to introduce peripheral innovations. We can interpret the breadth in two directions[1].

- The lagging breadth: it limits the imitation by the specification of which lower products that cannot be produced by the competitors. Thus, the patent holder strengthens its market power by eliminating its closest competitors on its product line.
- The leading breadth: it limits future innovations by the specification of superior products that competitors cannot produce. From the point of view of innovations improving the quality of the products, the front breadth is contested because it grants a right of ownership over qualities and products that the patent holder has not invented himself.

By adopting the definitions of Deffains (1997) which group the two dimensions breadth and height under the extended characteristic of the patent. Indeed, the breadth traces the level from

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[1] This definition of breadth is inspired to a great extent by Gilles Kolida, (2003).

which the imitation of a patented product constitutes an infringement, whereas the height or the requirement of patentability is the minimal size which must satisfy the innovation to be judged patentable. It traces the minimum level of patentability that allows a potential competitor to develop a basic invention.

In the microeconomic literature we find several definitions of the scope of patents. For Klemperer (1990) the scope of the patent refers to the space of a differentiated product covered by a single patent. Gallini (1992) defines the extent of a patent in terms of the cost of imitation. In La Manna (1992), height is implicitly represented by a minimum level of patentability which refers to a minimum investment in research and development necessary for an invention to qualify as patentable by the patent office. For Li (2001) the distinction between breadth and height does not matter, in this model, because of the assumed symmetric nature of the patent breadth.

O'Donoghue, Scotchmer, and Thisse (1998) distinguished two types of breadth: lagging breadth, which represents protection from imitation, and leading breadth, which is protected against new ones improved products. Corinne Langinier (2002) pointed out that the first definition (the lagging breadth) refers to the breadth and that the second definition (leading breadth) reflects the characteristic height.

We note that despite the difference between these definitions, the scope of the patent is related to the strength of the rights attached to it which ultimately determines its value.

Economic theory is ambiguous when it comes to assessing whether patent protection and the monopoly power it induces is the best instrument to encourage innovation and technological advances to foster economic growth.

An optimal patent policy is a compromise between the degree of protection of innovations and the need for dissemination of knowledge. By refining patenting by microeconomics models and innovation-based growth models, we are pursuing an approach that allows us to clarify the place of the patent as an economic policy instrument to encourage innovation and improve the growth.

This work aims to study how patent breadth and height, alongside length, can be instruments in the hands of the public authorities in order to solve the dilemma: ***to encourage innovation and guarantee the dissemination of knowledge, while promoting economic growth.***

Thus, this article is the subject of an analysis and discussion of endogenous growth models and microeconomics that are based on the arbitration between length, breadth and height of patent protection.

Indeed, the rest of the document is structured in the following way: the first section deals with the models which deal with the arbitration between length and breadth of the patent. The notion of breadth is defined by various methods according to the vision of each model analyzed; the phenomenon of imitation is at the heart of these different definitions. In the second section we will present the models dealing with the arbitration between length and height. The height has, according to each model, different definitions satisfying the requirement of novelty requirement. In a third section we will present the work related to the arbitration between length, breadth and height. Finally, the last section will be reserved for the conclusion and recommendations on whether to use the patent for public policy purposes for economic growth.

1. ARBITRATION BETWEEN PATENT LENGTH AND BREADTH

1.1. Arbitration in the context of endogenous growth models: the Segerstrom model (1991)

The canonical models of endogenous growth have largely postulated that patent protection was perfect in order to prevent counterfeiting of a new product by competitors, hence the impossibility of imitation. However, the Segerstrom model (1991) considers that economic growth is fueled by both innovation and imitation.

This model has a steady state of equilibrium in which some firms dedicate resources to the discovery of qualitatively improved products and other companies dedicate resources to the reproduction of these products (imitation). Thus, Segerstrom (1991) considered imitation as an alternative to innovation and integrates it into the research sector.

The theory of endogenous growth based on research and development focuses almost exclusively on the development of new products or processes. The canonical models of this theory ignore the obvious back-effect that imitation can have on the incentive to innovate "imitation pushes to innovate again to no longer be in frontal competition with its imitator." [2] The rate of imitation in this literature is generally determined exogenously on the basis of perfect patents (Segerstrom (1991)). Hence, the possibilities of imitation are ignored; Which strongly contradicts the empirical reality[3].

In this article, Segerstrom presents a growth model in which companies can enter innovative or imitative R&D activities. This point of view considers imitation as an alternative to innovation and integrates it in the research and development sector while considering an infinite patent life. In this model, while inventive activities allow the possibility of patenting imitative activities introduce the possibility of counterfeiting.

In Segerstrom (1991) the patent system is not explicitly modeled. However, the relative costs of both types of activity reflect the role and the mass of the patent system and the judicial institution in charge of counterfeiting problems. This model assumes that imitation is easier than innovation for business. However, a more severe patent system leads to prosecution and significant penalties which makes the cost of imitation higher than the cost of innovation. Thus, the patent system makes it possible to remunerate the innovation and then the imitation by a licensing agreement between the innovator and the imitator hence the sharing of the monopoly profits initially realized by the technological leader.

1.2. Arbitration in the context of microeconomic models

[2] P. Aghion, C. Harris, P. Howitt et J. Vickers: « Competition, Imitation and Growth with Step-by-Step Innovation », Review of Economic Studies, 2000.
[3] See Tilton (1971) et Mansfield, Schwartz et Wagner (1981).

Patent length and breadth are instruments that can be used by governments to address the dilemma of encouraging innovators to invest more in research and development and to ensure the dissemination of knowledge while optimizing a social criterion.

1.2.1. The model of Gilbert and Shapiro (1990)

Gilbert and Shapiro (1990) considered that all definitions of breadth should imply that a wider patent can increase the rate of profit of the innovator during the period of legal protection[4]. They provided the arguments to prove that patenting can be a policy instrument for rewarding innovations. It provided the conditions in which the optimal policy of an infinite lifetime patent with a breadth adjustment allows the reward required for innovation. However, these rewards require the creation of market power, which causes a certain loss of well-being. Hence, the origin of the debate on patent policy which is to study the trade-off between the dynamic efficiency and the static inefficiency attached to the patent.

The main question asked by Gilbert and Shapiro is: what is the optimal combination of patent length and breadth that rewards innovation?

There are two instruments available to achieve the optimal reward of innovation: the length and the dumping of the patent.

First, Gilbert and Shapiro interpret breadth as the current rate of profit (π) received by the innovator when the patent is in effect. They consider the environment to be predictable and stationary. The optimal policy of the patent is to choose the length of protection (T) and current profit (π) to maximize social welfare W. Where W is interpreted as the sum of the surplus of consumers and profits π, likely to realize the reward of innovation (V) for the patentee.

In a second step, Gilbert and Shapiro interpret the breadth as the patent holder's ability to raise the price for a single product that uses innovation[5]. According to this definition, the breadth

[4] « But any definition of breadth involves the idea that a broader patent allows the innovator to earn a higher flow rate of profits during the lifetime of the patent » Gilbert et Shapiro (1990)

[5] « We analyze optimal policy here for this particular interpretation of patent breadth: the ability of the patentee to raise the price for the single product that embodies the innovation ». Gilbert et Shapiro (1990).

only affects the price that the patentee may charge. Unlike the Klemperer model (1990) where breadth also affects substitutable products.

In conclusion, Gilbert and Shapiro (1990) have shown that wide patents are expensive in terms of dry loss and that an optimal policy privileges narrow patents and very long patents. For these authors, the breadth of the patent can be an instrument of economic policy to control prices. Thus, a patent policy that takes into account the breadth as much as the length allows to solve the problem of arbitration between incentives to innovate and cost in terms of dry losses due to the monopoly situation.

This work presents a main limitation that the analysis does not include the threat of competition from incentives by the profit made by the original innovator to innovate in the same field and implicitly assume that the patent system is perfect Hence the impossibility of imitation. Also, this model can be considered as a special case of the Klemperer model (1990) when the transport costs are identical. We present the Klemperer model in the following section.

1.2.2. The Klemperer model (1990)

In order to solve the problem of arbitration between incentives to innovate and monopoly dry loss, the Klemperer (1990) model seeks to determine the optimal duration-extended combination under the constraint of a minimum profit level, Incentive to invest in research and development.

This model considers the scope of the patent as the space of a product differentiated horizontally (spatial differentiation), covered by a single patent; Using the space competition approach at the Hotelling (1929) with competition in price. The breadth being considered as the region of the space of the protected products.

Klemperer (1990) seeks to determine patent breadth (w) and patent life (L), which minimize the present value of social costs due to the monopoly ($s(w)$) subject to the present value of the patentee's profits V . The model is not interested in determining the value V . Because once the optimum form of a patent is determined for any given value V , the problem of choosing the value V of which generates the socially acceptable level of R&D is closely related to the standard analysis of the optimal length of a patent when the breadth is not a control variable.

As a simplification, Klemperer assumed that the patentee produces only one asset at the price p. A patent breadth (more precisely, radius) w allows competitors to produce varieties of products with a distance of products from the patentee. Klemperer defined the scope of patents (or breadth as it qualifies) as the distance, on the product spectrum, away from the patentee's product, where competing firms are permitted. Each consumer has a transport cost per unit of distance. The model assumes that all consumers prefer, at identical prices, the product of the patentee. Consumers may differ on two points: first, the cost of travel per unit of distance and, on the other hand, the booking price.

Van Dijk (1994), illustrated a simplified version of the Klemperer model (1990), as shown in Figure 1. The horizontal axis represents the spectrum of the product; The patentee and all consumers are originally 0, while competitors are at point D (at the border of the patent's scope, defined by the breadth). The vertical axis represents the purchase price of the product for a consumer. The graph shows three consumers with the same booking price (p_r) but different travel costs (t_1 , t_2 and t_3). The consumer 1 is indifferent between buying the product from the patentee originally 0 with prices p_B and buying from competitors at point D by incurring a travel cost $t_1 D$. Whereas, with the same price p_B, the consumer buys from the competitors because $p_B > t_2 D$. The consumer 3 buys from the owner of the patent because $p_B < t_3 D$.

In this model, Klemperer compared the maximum welfare situation resulting from a competitive supply of all varieties of the product spectrum and the situation resulting from the institution of a positive extent of the patent (distance OD). This comparison shows the existence of two types of welfare losses. The first type results from the loss of welfare of consumers who bear the costs of traveling to less privileged varieties but offered at a lower price. For example, the consumer 2 assumes the traveling expenses $t_2 D$. The second type of loss comes from the disappearance of the market of certain consumers. This is the case where the reservation price

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of these consumers is lower than the price charged by the patent holder or if the reservation price is less than the cost of travel for the variety offered by the competitor at point D.

Klemperer's idea is to minimize all of these losses by playing on the patent-length combination. The starting point of his analysis is to guarantee a minimum profit margin to the patent holder in order to encourage him to invest in R&D and to generate, therefore, the new product. According to this model, the optimal combination of duration and extent of the patent depends on distributions of travel costs and reservation prices. When all consumers have the same transport costs, the patentee will fix the price so that all consumers will buy the product. In Chart 1, if all consumers have the same unit cost t_1 , the optimal price will be just less than $t_1 D$. Thus, no consumer moves to buy from competitors and, therefore, the first type of losses disappears. The second type of losses will be minimized with a very narrow breadth and a long enough life to guarantee the minimum profit required to incite innovation. Indeed, when consumers are faced with identical travel expenses, narrow patents are the most effective. However, if the booking prices of the consumers are identical, a contrary conclusion emerges. Thus, the infinitely wide protection prevents any competition. The patentee may then, without the need to take account of the competitors, fix a price equal to the price of reservation of the consumers. Hence the loss of dry loss (second type of loss). Indeed, given the identical reserve prices, broad protection is desirable.

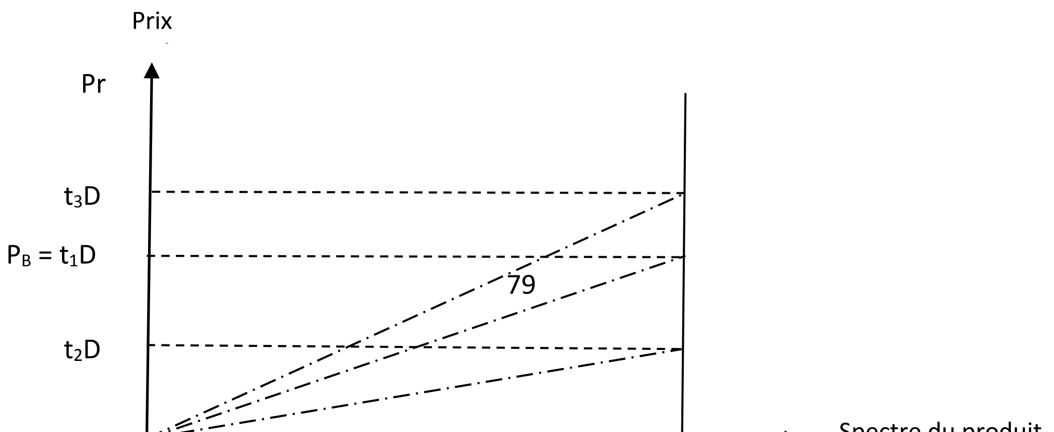

Figure 1: Simplified Klemperer model

The Klemperer model (1990) implicitly assumes that imitation is free of charge (negligible imitation costs). However, imitation is generally expensive. One by, because the technology is not available for free and immediately. On the other hand, the imitator will face the cost if the patentee takes him to court for infringement of patent rights. The extension of the Klemperer model by Gallini (1992) implies the cost of imitation.

1.2.3. Endogenization of imitation costs: the Gallini model (1992)

The model Gallini (1992) with positive imitation costs, defines the scope of a patent by the cost of R&D required to imitate a patented innovation without infringing the patent. It introduces the possibility that firms mimic the patented product by relying on the dissemination of knowledge. Much of the literature on optimal patent term guess imitation of patented products is either too costly and therefore never a threat to the innovator (Nordhaus, 1969; Scherer, 1972), or negligible costs and thus still pose a threat to the innovator (Gilbert and Shapiro, 1990, and Klemperer, 1990). According Gallini, in both cases, the decision to imitate is independent of the duration of patents, and consequently, increased patent term always promotes both research and dissemination of innovation. The intermediate, and most realistic, case is that imitation is costly, but not prohibitive. The Gallini model (1992) focuses on the optimal policy of the patent in the presence of the possibility of costly imitation. It endogenizes imitation costs while considering that the incentive to imitate depends on the lifetime of the patent. Levin et al. (1988) reported that innovators often choose to keep their invention in secret rather than disclose a patent, especially when imitation is likely.

Gallini (1992) began by assuming that a single company (the innovator) invests in R&D to develop a new product or process. If an innovation succeeds, the innovator may decide to patent his invention or keep the secret; The consequences are not the same. If the new process or product is patented, the company is given a monopoly on innovation for a period of years T. After this period the innovation falls into the public domain and will be, at no cost, available to all companies in a competitive market. Potential competitors may either wait for the expiry of the patent to duplicate the product free of charge or develop during the period T an imitation with a cost K. The original innovator and the imitators, in number m, compete and the profits earned by the patent holder and competitors depend only on the number of imitators m.

Alternatively, if the innovator chooses not to patent the new invention, it runs the risk that some competing firms can learn and replicate the innovation.

Length as the only political instrument

First, Gallini (1992) considers only length as a public decision-making instrument to influence research, disclosure and imitation activity. The patent decision and the reactions of the competitors depend directly on the duration of the patent and the costs of imitation K. It seeks to determine the length T^* of the patent, which maximizes the discounted social surplus. The model shows that a long shelf life encourages potential competitors to mimic the new product. In the case where imitation is costly, a variation in patent length indirectly affects breadth by affecting decisions to imitate. Indeed, where patent length is the only patent administration tool, the optimal life of a patent is generally short to discourage imitation. The optimal duration of the patent can not exceed a length from which competitors mimic innovation. At the same time, this duration should not be too short, since in this case the innovator prefers to keep his technology secret and does not file a patent. Thus, the new technology would only be discovered by competing firms with a probability lower than unity.

Length and breadth as two political instruments

We have seen that in the case where length is the sole policy instrument of the patent and where imitation is costly, the variation in the length of the patent indirectly affects the breadth by affecting decisions to imitate. The public authority can use the breadth of the patent as a second instrument alongside the lifetime. In this case, Gallini's (1992) model shows that the social surplus is maximized when patents are wide (to discourage imitation) and the lifetime must be adjusted to obtain the desired patent reward.

The author continued by defining the breadth not by the cost of differentiation totally paid at entry, but by a constant flow which the imitator must pay on each date. In this case, the model prefers a broad patent (the flow to be paid must be high) with a short lifetime in order not to give sufficient time that allows the imitators to arrive on the market.

In conclusion, when endogenizing imitation, the Gallini model (1992) shows that the optimal patent must be large and of short length. These results contrast with those of Gilbert and Shapiro (1990) and, to a certain extent, Klemperer (1990), in which narrow and infinitely long patents are optimal.

1.2.4. Denicolo's model (1996)

Denicolo (1996) examines the issue of the optimal scope of patents by extending the previous literature to the case where many firms compete for patent ownership. He also discusses several examples that suggest the relevance of the nature of competition that prevails in the product market to explain the various findings found in the literature. It introduces competition for innovation in a patent race in which participating firms choose the intensity of their research and development effort based on the length of the patent and the scope of the patent protection. From the point of view of social welfare, the question then arises as to what are the economic forces which, in a particular example, determine the optimal form of the patent? He suggests that, in general, the reduction of the scope of a patent leads to greater competition in the product market after innovation.

2. ARBITRATION BETWEEN LENGTH AND HEIGHT OF PATENT

The height or requirement for patentability is the minimum size that must satisfy innovation to be considered patentable. It lays down the minimum level of patentability which allows a potential competitor to develop a basic invention.

2.1. Arbitration in the context of endogenous growth models: the model of Li (2000)

In this work, Li (2000) presented a bi-sectoral model of research where long-term growth is determined by the expansion of knowledge created in two types of R&D activities. Technical progress is modeled in two ways: innovations of varieties that lead to the creation of a sector of intermediate goods and qualitative innovations that improve the quality of certain sectors in each period.

In a Grossman and Helpman model (1991), Li (2000) developed its model (variety / quality) to three sectors: finished products, intermediate goods and R&D.

At every moment, some researchers engage in R&D to innovate varieties, and others carry out R&D to improve quality. If the R&D projects of the varieties are successful at the date τ , a completely new product of the ith quality variety $Q_{\tau}^{1/\varepsilon}$ is introduced into the economy (hence the creation of a new sector) and a patent is granted to the innovator, Excludes others from producing the new product. The innovator becomes a local monopoly. But once the new variety is available on the market, its quality can be improved by other companies. If the new variety is improved once, its quality index becomes $\gamma Q_{\tau}^{1/\varepsilon}$. As a result of the literature, the model assumes that firms with patents do not make quality innovations. This poses the problem of cumulative innovation since the inventor of a new intermediate product variety sees all of its profits disappear as soon as the first innovation of quality in this sector. The high-quality intermediate good captures all market shares, making the original quality product $Q_{\tau}^{1/\varepsilon}$ obsolete. At this stage, to counteract this phenomenon, Li (2000) proposed a licensing system whereby the variety innovator and the quality innovator reach an agreement that stipulates that the second innovator (which only improves The initial quality of that property) pays a fixed fraction $0 < \kappa < 1$ of its profits as a royalty to the first generation innovator. κ may be interpreted as the extent of the variety patent, as determined by the Government.

This license agreement, which always remains whatever the level of quality, implies the participation of the following profits:

- the profits made by the innovator of the variety (the "discoverer" of the branch):

$$\pi^{v}_{n_i t} = \begin{cases} \pi_{n_i t} \;\; pour \;\; n_i = 0 \\ \kappa\pi_{n_i t} \;\; pour \;\; n_i \geq 1 \end{cases} \quad (3)$$

- the profits made by the quality innovators (who successively improve the initial quality of this good):

$$\pi^{q}_{n_i t} = \begin{cases} 0 \;\; pour \;\; n_i = 0 \\ (1-\kappa)\pi_{n_i t} \;\; pour \;\; n_i \geq 1 \end{cases} \quad (4)$$

With $\pi_{n_i t}$, denotes the flow of profits from the exploitation of the variety i in t. $(1-\kappa)$ is the royalty rate of the license granted by the first innovator to its successors (as $0 < \kappa < 1$ the fixed fraction of profit that the second innovator pays as a royalty to the first generation innovator).

In this model of Li, the second innovator pays as a royalty to the first-generation innovator a fixed fraction of profit ($0 < \kappa < 1$). That is, $(1-\kappa)$ the royalty rate of the license granted by the first innovator to its successors. Thus, in any period when it appears a quality innovation, from the second generation to the nth, the last innovator of quality must pay a rate κ royalty to the original inventor of the variety. Indeed, with the idea of licensing, the intermediary good innovator can be considered as the holder of a patent, with an infinite breadth downstream, which gives it the right to receive royalty flows from all Innovators who successively improve its product. While innovators who can only improve the quality of an existing good are obliged to issue patents with zero downstream breadth.

2.2. Arbitration in the context of microeconomic models

Since Scotchmer and Green (1990) and Scotchmer (1991), the economic literature dealing with industrial property has largely taken into account the notion of cumulative innovations and its interactions with the scope of the patent.

2.2.1. The Scotchmer and Green model (1990)

According to Scotchmer and Green (1990) the rigor of the novelty (height) requirement in patent law affects the pace of innovation, as it affects the amount of technical information disseminated by firms. This also influences the ex-ante profitability of the research. This work, by addressing the problem of diffusion, examines the effect of a novelty criterion more or less strict from the point of view of social efficiency. He considers two possible roles: "the first to invent", which applies to the United States, and "the first to file," which apply everywhere else.

These two co-authors begin by noting that the requirements of novelty and non-obviousness are difficult to interpret. These are judicially determined standards administered by the patent office and pleaded in federal courts. Inevitably, it is possible to determine whether a new technology is sufficiently different not to infringe a prior patent. They highlighted two reasons for patent protection. The first is that this protection creates incentives to do research. The social purpose of profit protection is served by a strong demand for novelty, which the authors interpret as meaning that small, derivative improvements will undermine a prior patent. Thus, the patent is likely to have a long life before a sufficiently different technology supplants it. The second reason is that patent protection accelerates innovation through the disclosure of information.

Scotchmer and Green (1990) believe that if every small technological breakthrough was divulged, which would be encouraged by a low requirement for novelty, shared technical knowledge would help other innovators in their own research. This accelerates the overall pace of innovation. They therefore noted that the social purpose of disclosure is served by a low requirement of novelty. Thus, one consideration for balancing these two arguments is that companies might not patent or market every small technical advance, even if the novelty requirement is low. Disclosure of technical information confers a positive externality on a company's competitors, which the company might want to avoid. Companies could therefore remove small technical advances, and a low novelty requirement may not have the desired effect of encouraging disclosure. The strategic reluctance of companies to patent or disclose other small improvements could mitigate the erosion of ex-ante profit that could result from a low requirement for novelty and the possibility of competition between their closest substitutes. Indeed, in order to study the impact of a policy by the requirement of novelty (low or high) on the overall pace of innovation, co-authors have developed a dynamic model in which patent and Entry or exit of a race are taken with foresight, whose subsequent decisions of other players will also be rational.

Scotchmer and Green (1990) propose a two-stage innovation process in which two companies operate. They consider that the discovery of an intermediate invention is essential to the discovery of the final invention. In the case of a strict novelty criterion, the first stage of the innovation is not patentable and the information it contains remains secret. Otherwise, if the novelty criterion is weak, intermediate innovation may be the subject of a patent; which encourages its use and dissemination of the information it contains.

The main conclusions that emerge from the model are:

- ✓ Disclosure of technologies is socially useful because future research builds on prior technical knowledge. Disclosure of advances reduces the cost of seeking progress for other researchers.
- ✓ The strategic reluctance of each company to disclose a small improvement can avoid the ex-ante erosion of profits that could result from a low requirement for novelty.
- ✓ The low novelty requirement makes the competitor stay too strong when the dispute settlement rule is the first to be filed, and gives the competitor too much incentive to drop when the dispute settlement rule is the first to be invented.
- ✓ A low novelty requirement allows temporary technology to be patented and has social value, as long as it does not compromise ex-ante profit, so that companies are dissuaded from research.
- ✓ The first-to-invent rule discourages disclosure, relative to the first applicant.
- ✓ When the novelty requirement is low, optimal efficiency will not always be achieved as companies will not disclose all of their technical progress. If companies could be forced to disclose, first-rate effectiveness might not be achieved because disclosure could undermine profit, so companies might not get into the race at all.
- ✓ The application of the novelty criteria must be modulated according to the nature of the innovation and the competitive structure of the market or the innovation.

However, according to Bernard Jurion and Pierre Pestieau (2000), the conclusions of Scotchmer and Green are not robust for two main reasons. On the one hand, the model considers that the expected profit of intermediate innovation is lower than that of final innovation. Because the period of exploitation of the first innovation is cut off by the appearance of the second innovation, which reigns without being threatened by any subsequent improvement. Thus, Bernard Jurion and Pierre Pestieau think that without this asymmetry the inventor of intermediate innovation would always choose to obtain a patent and exploit it on the market. This can lead to very different results. In the latter case, each firm also expects to be, average, as often "first inventor" as "second inventor" so that a weak novelty criterion does not necessarily reduce the profitability of the firms involved nor their investments in research and development. On the other hand, the authors assume that the same agents can continue the two phases of the innovation improvement race. Bernard Jurion and Pierre Pestieau believe that sometimes the knowledge required to lead the first and second stages can be very different. In this case, the conditions of each stage of the innovation must be very different.

2.2.2. The Gallini and Scotchmer (2001): cross licenses

Gallini and Scotchmer (2001) ask the question: are there natural market forces that protect inventors so that formal protections or other incentives are not necessary? They compare intellectual property with alternative incentive schemes. They are looking at the issues of optimal design for intellectual property, particularly the issue of the scope of patents in the case of cumulative innovation. Taking into account the specificity of cumulative innovation, in order to find an optimal system of incentives between the different generations of innovators, has been analyzed by Scotchmer (1991, 1996), Scotchmer and Green (1990) and Green and Scotchmer (1995). Scotchmer (1991, 1996) shows that overly broad patents, in the presence of cross-licensing or joint ventures, may be undesirable since they over-favor the leading innovator in bargaining. Green and Scotchmer (1995), in examining the role of patent breadth on the incentives to innovate both upstream and downstream innovators, they show that the division of profits by a licensing agreement between actors can be very important, essential in the case where the first invention is basic. For them it is the existence of a strong patent that encourages companies to accept ex-ante a license agreement based on maximizing joint profits.

For Scotchmer and Green (1990), although their model presents the practical difficulties that can be faced by firms to conclude ex-ante agreements, it does not explore the optimality of a compromise that serves to incite the two innovators in cases where such ex-ante agreements are not possible.

The main conclusions on the effectiveness of intellectual property, which emerge from Gallini and Scotchmer (2001), are as follows:

- ✓ The Intellectual property is probably the best mechanism for selecting invention projects when the value and cost are not observable by the innovator. This is because the private value of intellectual property automatically reflects social value, and companies automatically comparable value to the cost of innovation.
- ✓ Neither IP nor prices can aggregate decentralized information between firms, and none of them will be fully effective in effectively delegating research efforts.

2.2.3. The model of Chang (1995)

Chang (1995) presents a cumulative innovation model to examine the factors that should influence a court's decision when a patient alleges that another inventor has infringed the patent with an improved version of the patented product. It seeks to determine how the courts should establish legal standards for patent infringement to encourage the invention of product improvements or a patented process.

In the model framework of the Scotchmer and Green (1990), Chang (1995) presents a model that includes two periods and two firms. In the first period, company 1 can invent and patent a product. In the second period the company 2 can invent and patent an improved version of the product only in the event that the company 1 invents. Incentives for business invention depend on the patent, antitrust policy implemented by the courts.

This model shows that the patent breadth does not turn out to be a monotonic function of the value of the invention. It suggests that the courts should provide the broadest protection for two distinct categories of basic inventions: not only those that are very useful in relation to possible improvements, but also those that have very little value compared to the improvements expected in the future to follow.

2.2.4. Effect of a change in the scope of claims: the model of Matutes, Regibeau and Rockett (1996)

Matutes, Regibeau and Rockett (1996) defined the scope of patents by the number of different applications protected by the same patent. They focus on protecting fundamental innovations. They first assume that the innovative company has already achieved technological advances as a result of previous research. This technology can be used in the production of a series of products (applications), each of which is patentable per se. The model does not focus on how each of these applications should be protected, but rather how basic technology should be protected by patent law. In the absence of patent protection, an innovator who has made significant technological breakthroughs would be tempted to go deeper into the development of applications, he does not demonstrate his discovery and continues to develop it, before commercializing a product for Avoid the risk of imitating fundamental innovation.

This model allows the patent holder to choose the time spanning the dissemination of information on the basic invention, which is the date of grant of the patent, and the introduction of the first applications. At the same time the model allows the planner to set the parameters of the patent policy and the company reacts to these parameters. The goal of delaying these applications is the profit maximization of the innovative firm. Such a delay in the introduction of the first applications is socially undesirable for two reasons: on the one hand because it refuses to offer products desirable by the market and secondly because it causes the Integrated knowledge in basic innovation.

In this model, the authors seek to examine how this waiting period and the mode of development of later innovations are affected by two patent protection regimes. The first regime, known as length protection, gives the innovative company a period during which it has the exclusive right to introduce basic applications after the innovation is patented. Although competitors may develop applications during the patent protection period, they can not market them until the patent expires. The second scheme, known as height protection, reserves certain applications of basic innovation for the exclusive use of the original inventor. As soon as the patent is granted, competitors can compete for applications outside the scope of the patent.

The authors find that height protection generates a higher level of well-being than length protection. This is explained by the effect that the introduction of the basic invention takes place earlier and hence the period during which competitors can introduce applications is also made earlier. They also find that the combination length and height does not improve anything.

2.2.5. A two-player game: the La Manna model (1992)

La Manna (1992) presented a model that seeks to determine the optimal height and length of the patent. In this work, height is implicitly represented by a minimum level of patentability which refers to a minimum investment in research and development necessary for an invention to be qualified as patentable by the patent office.

Patent design is considered in the La Manna model (1992) as a two-player game (a leader and a follower) in which the patent office sets the rules of the game endogenously. The patent system determines how the patent system is requested and granted. The Patent Office must resolve a dual assignment problem: It therefore designates who is the leader and who is the follower while setting its control variables, ie the lifetime of the patent or the threshold of patentability.

In the La Manna model (1992), the game is represented by the couple, where the innovator plays the role and seeks to optimize and the patent office plays the role and seeks to optimize.

The innovator

The present value of the innovator's profit is given by:

$$\pi(\sigma,T)=\int_0^T e^{-rt}G(\sigma)dt-R(\sigma)=(\frac{1-e^{-rT}}{r})G(\sigma)-R(\sigma) \qquad (1)$$

With:

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- T The lifetime of the patent (the length of the patent),

- σ The novelty requirement (the height of the patent),

- $G(\sigma)$ The gross profit,

- $R(\sigma)$ The R&D expenditure function to have a patentable innovation,

- r The discount rate (social and private)

The Patent Office

The program of the Patent Office is to maximize the present value of the sum of consumer surplus ($C(\sigma)$) and the gross profit of the innovator ($G(\sigma)$) net of R&D cost ($R(\sigma)$):

$$W(\sigma,T)=\int_0^T e^{-rt}\left[C(\sigma)+G(\sigma)\right]dt+\int_T^\infty e^{-rt}\left[C(\sigma)+G(\sigma)+WL(\sigma)\right]dt-R(\sigma)$$

That is to say:

$$W(\sigma,T)=\left[C(\sigma)+G(\sigma)\right]\frac{1}{r}+WL(\sigma)\frac{e^{-rT}}{r}-R(\sigma) \qquad (2)$$

With $WL(\sigma)$ is the loss of well-being due to the existence of monopoly.

We note that after the expiry of the patent, the new technology will be freely available and the production of new good continues under pure and perfect competition.

Is $\tau=1-e^{-rT}$,when T varies between 0 et ∞, τ varies between 0 et 1. Indeed, the constraint of the lifetime of the patent is: $\tau\leq 1$.

The balance

This model considers six different configurations of the game in which the patent office allows the innovator to control one of the decision variables. Indeed, the nature of equilibrium varies according to the choice made by the Patent Office between the six types of games, which distinguish in three categories:

$$\{(F\sigma, F\tau), (L\sigma, F\tau)\}, \{(F\tau, F\sigma), (L\tau, F\sigma), (F\tau, L\sigma)\} et \{(F\sigma, L\tau)\}$$

The place of the patent

In the La Manna model (1992), the innovator has the possibility of setting the level of an action variable, ie the height or breadth of the patent, while the other variable is Controlled by the Patent Office. The main findings of this analysis are as follows:

- If the patent office gives the innovator the option of choosing the height without first knowing the length of the patent; In equilibrium there will be no innovation (no innovation, zero length).

- If the patent office chooses the height and the innovator chooses the length; At equilibrium the height is finite and the length is infinite. This height will be the same as the innovator is the leader or the patent office is the leader.

- The property is not always maximum when the patent office plays the role of leader and optimizes over the lifetime of the patent.

In conclusion, La Manna (1992) has argued that the choice of a patentability standard can affect the size of the innovation targeted by the company when it invests in R&D. The volume of investment in R&D may increase with a higher standard of patentability. This standard is called novelty requirement; The more important the latter is the more companies strive to achieve more important innovations, thus improving well-being.

2.2.6. Minimum inventive jump in a patent race: the Hunt model (1999)

Article 27 of the TRIPS Agreement provides for three conditions for patentability: the invention must be new, involve an inventive step and be industrially applicable. The first condition refers to the requirement of novelty, it is the essential condition of patentability. It stipulates that the invention must bring an absolute novelty both in time and space. The Hunt model (1999) aims to show that the requirement of novelty can be used as an instrument of economic policy.

In this model the time is continuous and the horizon is infinite. The discoveries are realized in different points in time. The time interval between two discoveries is called a patent race. During each patent race, companies compete to be the first to discover an invention. The race ends when a discovery occurs and the next race starts immediately after the discovery. The actual duration of patent races is variable, because the process that generates the discoveries is random.

The model considers a sector of the economy in which there exist (n + 1) firms indexed by i. At the start of the kth patent race in a sector, firms simultaneously choose their rated R&D intensity (h_k^i) and maintain their search effort until a discovery occurs and the current race ends. The cost of this research ($pC(h_k^i)$) is a strictly increasing function and twice continuously differentiable in relation to the intensity of R&D. The relative price of R&D input being p . All companies have the same R&D technology. The R&D intensity of a firm affects its discovery rate, but does not determine the exact date the discovery occurs. The model assumes that the rate of arrival of ideas for a firm i is λh_k^i , this rate follows a Poisson process. With λ represents an industry-specific productivity parameter. A firm that has made an invention does not participate in the next race.

A discovery corresponds to an improvement in the quality of the product whose amplitude is $u_k \in \left[0, \bar{u}\right]$ where $\bar{u} < \infty$. This amplitude is random, unknown up to the moment of the invention and subsequently made public. For each invention, the amplitude u is derived from a probability distribution $f(u)$ whose density is and the distribution function $F(u)$.

The model assumes that once the discovery has been made, the other companies can perform reverse engineering at zero cost so that the inventory can only benefit from its discovery when it is protected by a patent. For simplicity, the model assumes that the statutory life of the patent is infinite. Not all inventions are protected; Because the patent office requires a minimum value of improvement for which it issues a patent. Either $s \in [0, \bar{u}]$, represents the standard of non-obviousness or novelty requirement. Indeed, an invention whose scope is less than does not obtain protection and enters immediately into the public domain.

Either $\theta(s) = 1 - F(s)$ the probability of obtaining a patent given this novelty requirement (s). Patent claims are defined as the improvement itself. The model makes assumptions about the condition of use of previous improvements. Indeed, a company must obtain licenses on previous inventions from all their inventors. However, the other extreme case is that the company can use all the previous discoveries without obtaining any license. The model assumes an intermediate case: if the invention satisfies the non-obviousness condition, the inventor can use all previous unlicensed discoveries. However, if the condition is not respected, the previous discoveries remain proprietary.

One of the consequences of this specification is that there is always, at most, a protected invention. Whenever another patentable discovery takes place, the inventor of the last patented invention loses its exclusive rights. Thus, while the legal term of patent protection is infinite, the economic life of a patent ceases when an invention is granted a patent.

The model has revealed the existence and properties of a symmetric stationary equilibrium for the game described above. During each patent race, competing companies choose a level of R&D activity that balances spending from the current period to the gains expected in future races. Hunt defined the expected earnings as the weighted average of the success or failure values during the race, updated to reflect the expected duration of the current race. The probability of winning the race and the length of the race; Are dependent on the choice of R & D intensity.

If the government decides to reinforce the novelty requirement (increase), how will the firms react to this measure? We know that at equilibrium, companies equal the marginal cost of an additional R & D effort to the expected gain associated with being the first innovator. If the increase in the novelty requirement causes an increase in gain associated with being the first innovator, the firms increase their research activities. Otherwise, companies reduce their activities. In the case of an increase in the novelty requirement, the expected gain associated with being the first innovator is affected in several ways. By distinguishing two effects: the static effect and the dynamic effect.

The static effect: this effect is the variation of the probability that the next discovery of a firm is patentable. Thus, as s increases θ decreases; that is, a stricter requirement reduces the likelihood that inventions will be patentable. And consequently, the differential of values between firm in place and competing firm increases with this effect. Conversely, the relaxation of the novelty requirement increases the likelihood that the next discovery of a company will be patentable and thus increases the expected gain of being the first innovator. This should encourage companies to do more R&D.

The dynamic effect: it is the change of the values associated with the situations of firm in place and competitor in the future races to the patent. The study of this effect involves two terms:

• the value associated with the current firm situation; The change in this value following an increase in the novelty requirement is positive.

• the value associated with the situation of a competing firm; The direction of variation of this value due to an increase in the novelty requirement is ambiguous.

The static effect and the dynamic effect of the reinforcement of the novelty requirement act contrary to the incentive for R&D: on the one hand, the reinforcement of the novelty requirement reduces the likelihood that Patented which reduces the expected gain of the research. On the other hand, this increases the expected value of the firm condition in place relative to that of being a competitor which raises the hoped-for gain of the research. This ambiguity raises the question: *which of these two effects dominates?*

The response of firms to a change in the novelty requirement depends on its effect on the expected gain of being the first innovator. If we are faced with an increase in the novelty requirement: the expected gain of being the first innovator is increased by an increase in the average profitability of patented inventions, but is also reduced by the loss of Marginal discoveries that are not patentable. Hunt defines the following expression:

$$\Psi(s) \equiv \left(\frac{\theta\lambda(n+1)h^*}{\rho+\theta\lambda(n+1)h^*} \right) \frac{\left(u^e(s)-s\right)}{\rho} - \left(\frac{\rho}{\rho+\theta\lambda(n+1)h^*} \right) \left(s+pC(h^*)\right)$$

- The static effect takes precedence over the dynamic effect when: $\Psi(s)$ is negative.
- The dynamic effect dominates the static effect when: $\Psi(s)$ is positive.

The relaxation of the novelty requirement will increase R&D activity when the static effect dominates the dynamic effect, ie, when $\Psi(s)<0$. This decreases the R&D activity when $\Psi(s)>0$.

When the public authority increases the novelty requirement, companies meet the following compromise: on the one hand, a company that makes a marginal discovery fails to obtain a patent and continues as a competitor for the next race. It loses the associated profit and the cost of R&D. The present value of the cost flows increases with the expected duration of the next race. When patentable discoveries are rare, these losses are relatively large. But when patentable discoveries occur frequently, the value of these losses is smaller. On the other hand, a strict novelty requirement raises the average benefit of patentable discoveries. The associated gain increases with the frequency of patentable discoveries. The net effect is a weighted average of these cash flow gains and losses, where weights are determined by the industrial scale-up rate of patentable discoveries.

If this weighted average is negative, reducing the level of the novelty requirement will in fact increase the R&D activity of firms and hence the rate of innovation. When this weighted average is positive, R&D activity and the pace of innovation will decrease.

To establish whether the dynamic effect is all the more important as the static effect, Hunt proposes that there is a level of novelty requirement noted $\tilde{s}$, such that in the interval $\left[0,\tilde{s}\right]$, R&D activity is strictly increasing With the requirement of novelty.

Thus, Hunt shows that when the level of novelty requirement is very low, the dynamic effect is stronger than the static effect, so that a reinforcement of the requirement increases the research activity. However, when the level of novelty requirement is high, the static effect dominates the

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dynamic effect. There is only one level of requirement, the two effects of which are exactly equal. The optimal policy is therefore to fix the novelty requirement $\tilde{s}$ and to grant patents only $(1-F(\tilde{s}))$ percent of discoveries.

In conclusion, the Hunt model (1999) shows that a policy using the novelty requirement as an instrument influences the value of patents by determining the average profitability of discoveries and the expected duration of these benefits. It shows that in a well-defined environment there is a unique level of novelty requirement that maximizes the rate of innovation in an industry.

3. Arbitration between length, breadth and height

There are few theoretical analyzes that have dealt with arbitration between the various facets of the patent sets.

3.1. Arbitration in the context of endogenous growth models: the model of Li (2001)

The model of Li (2001) extends the model of Grossman and Helpman (1991, ch. 4) to take into account the results of empirical studies.

There is a continuum of final goods indexed by $j \in [0,1]$, $q_m(j)$ indicates the quality level of each consumer good after being improved m times ($m = 0, 1, 2 ...$) through technological innovation. $q_m(j) = \lambda q_{m-1}(j)$, With $\lambda > 1$ is the size of innovation. Radical innovations are those that possess a λ sufficiently large.

A unit of a variety of property is produced with a unit of labor. Thanks to this technology, companies that produce goods of different quality in the industry compete for prices at the Bertrand. This assumption ensures that only the varieties of the lowest price corrected for quality are consumed. The model assumes that quality improvement follows a stochastic process.

Entrepreneurs fund initial R&D costs by issuing shares, and profits are distributed as dividends to investors if successful R&D. Or $v_{m+1t}(j)$ denotes the market value if the invention of order (m + 1) is realized in industry j. At every moment, entrepreneurs maximize the expected profit of R&D: $v_{m+1t}(j)i_{m+1t}(j)-(1-s)w(t)R_t(j)$ with s is the rate of R&D subsidies for $0<s<1$ and taxes for $s<0$.

In the analysis of this model, it is optimal to subsidize radical innovation, but to tax incremental innovation. At this level, Li (2001) introduced patent policy and the endogenisation of the size of innovation (λ); Thus these results are modified.

Whenever an innovation occurs, a patent is granted on the invented products, prohibiting non-patent holders from producing the same goods. The legal term of the patent is always assumed to be infinite. Another important dimension of patent protection is breadth. In the Li model (2001), the breadth of the patent is considered to be the measure of the quality improvement to which a product is protected against producers of inferior goods. The breadth of the patent is thus defined as the degree of product differentiation (horizontal or vertical) for which a patent is protected from counterfeiting. The distinction between breadth and height does not matter in this model because of the supposed symmetric nature of the patent breadth[6].

While the above analysis implicitly assumes that the government can not change patent breadth, this assumption is relaxed in what follows. Suppose that is the highest quality in an industry. breadth allows the patentee to prohibit the producer of second-quality grade goods from producing quality above $\frac{q_{m-1}}{b}$, where $b>0$ measures the breadth of the patent. $b=\frac{1}{\lambda}$, means that there is no patent protection[7].

Recall that in this model, only the product of the lowest price adjusted for quality is consumed. For this state of the art, to be consumed, the quality product q_m must have: $\frac{p_m}{q_m}\leq\frac{bp_{m-1}}{q_{m-1}}$ or $p_m\leq b\lambda w$. Under the assumption that $\alpha=0$ the price that maximizes profit is $p_m=b\lambda w$. The associated benefits are given by (5) with $\varepsilon=1$ and $\theta=b\lambda$. It should be noted that an increase

[6] «The former protects a patented product from superior goods, while the latter from inferior goods. The distinction does not matter in our model due to the symmetric nature of patent breadth assumed. » Li (2001)

[7] The Grossman and Helpman model (1991, ch. 4) imposes $b=1$.

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in patent breadth (an increase in b) increases profits. Therefore, growth is favored by the broad patent.

In examining the effect of the introduction of patent policy on industrial policy for λ exogenous. When technology advances too fast, ($i^s < i^*$) due to too strong incentives for private R&D, the social optimum requires the taxation of R&D to reduce the profitability of R&D. With the introduction of patent policy, the social optimum can indeed be achieved by reducing the scope of patents (reduction of b) without taxing R&D. Similarly, where $i^s > i^*$ (low incentive to R&D), the government can achieve the social optimum by expanding the scope of patents, raising the profitability of R&D without R&D subsidies. Thus, patent policy makes industrial policy less important.

In conclusion, Li (2001) showed that it is always optimal to subsidize R&D when the size of the innovation is endogenous and the government can fix the scope of patents.

3.2. Arbitration in microeconomic models: the O'Donoghue, Scotchmer and Thisse model (1998)

In their 1998 model, O'Donoghue, Scotchmer and Thisse introduced the notion of the effective life of the patent; Which is the expected time until a patented product is replaced in the market. They argued that the actual life of the patent depends on the breadth of the patent as well as the duration of the statutory patent. This model is one of the few contributions to the simultaneous study of the three dimensions of the patent.

In this model, the authors distinguished two types of breadth: the lagging breadth, which represents the protection against imitations and the leading breadth, which represents protection against new improved products. Corinne Langinier (2002) pointed out that the first definition (breadth in the rear) refers to breadth and that the second definition (breadth in front) reflects the height characteristic well. O'Donoghue, Scotchmer and Thisse model growth as a sequence of innovations. They asked how patents should be structured to stimulate growth.

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The model assumes that there exists an infinite sequence of innovations described by ($\Delta_1, \Delta_2, ..., \Delta_i, ...$), and the qualities are given by $q_i = q_{i-1} + \Delta_i$, with Δ_i denotes the ith innovation. After the realization of innovation i all qualities ($q \leq q_i$) are technologically feasible. The pace at which companies collectively receive ideas for improvements follows a Poisson process of parameter λ ; Where each idea received by a single random company. It also assumes that there are a large number of companies, so the company is unlikely to be its own successor. In fact, for simplicity, the model assumes that the probability of an enterprise being its own successor is zero. That is, an innovation that can only be improved by another company.

An idea is represented by a couple (Δ, c), where Δ is the improvement of the quality facilitated by the investment and is the cost. If the company does not pay the cost of the investment, the idea will be lost.

The model considers three patent policy instruments: length, breadth, and height.

The statutory life of patents is defined as the number of years, T, until the product can be marketed by competitors. Where a quality q_i is produced by a firm, the height is defined as a number $K > 0$ such that any company producing quality in the interval ($q_i, q_i + K$) (quality superior to the patented quality) is faced with a threat of prosecution for infringement Patent, which means that such quality can not be produced without a license. The rear breadth designates a protected area of qualities below the quality of the innovator (see Figure 2). The model assumes that an innovation is patentable if it does not affect the areas protected by the first patent.

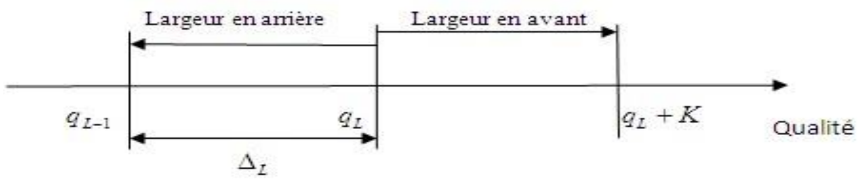

Figure 2: The breadth of a patent

Source : O'Donoghue, Scotchmer et Thisse (1998)

The authors note that the profitability of R&D depends on the actual lifetime of patents, and that the actual life of the patent is determined not only by the legal duration of the patent, but also by the extent (breadth and height). They consider an infinite patent life; While seeking to study the impact of breadth on social welfare. Thus, the actual life of patents depends on the breadth and frequency of ideas for improvement. They show that if the rate of arrival of ideas for improvements is high, a single control over the breadth encourages firms to invest in research and development. Indeed, the use of breadth as the only instrument for an innovation policy is insufficient even with an infinite life span (obviously in the case of a finite lifetime).

In order to overcome this problem of under-investment in research and development, the authors introduce a second instrument, namely height. In this case, if ideas of improvements are frequent, the determination of the height becomes a necessary complement to the determination of the breadth. O'Donoghue, Scotchmer and Thisse have distinguished two types of policy: the first such that the patent has an infinite lifetime and a finite height and the second such that the patent has a finite life and an infinite height. Indeed, the same rate of innovation can be achieved with one or the other of these two policies.

In the first case, where the patent is long and narrow, the effective life ends when a product replaces the protected innovation and the patent expires at an endogenous date determined by the probability of achieving a higher innovation quality. Whereas in the second case, where the patent is short but relatively broad, the effective lifetime may coincide with the statutory lifetime.

The authors have shown that the first policy is more efficient in reducing R&D costs (conditional on the pace of innovation), while the second policy where the patent has a shorter lifetime is more effective in Reduction of market distortions (minimizes the costs associated with the delay in disseminating innovation).

CONCLUSIONS AND DISCUSSION

We discussed how to determine the optimal level of protection across the three dimensions of the patent. While the representation of patent characteristics by microeconomic models is very rich and detailed, innovation-based growth models that have examined with precision how growth can vary with the system of industrial protection are few. The representation of three dimensions of the patent, by these latter models is rather abstract. It should be noted that in most of these models, patents are only indirectly considered.

We have focused our analysis on whether economic theory allows us to draw useful conclusions for what might be an optimal patent policy. Our goal is to extract lessons from modern economic theory on how patent policy can foster the innovation process and affect growth.

Indeed, through the investigation of the economic literature that defends the protection of intellectual property, we find that there is no consensus on the optimal level of protection across the three dimensions of patents. Economic arguments are often highly dependent on the particular characteristics of each model. However, we emphasize that there is, to a large extent, a consensus on a main idea: patent, through the application of these characteristics, can constitute a political instrument in favor of innovation and growth. It is only in recent years that we have been confronted with a body of work that sees the existence of intellectual property rights as unjustifiable. Some of these models even advance the idea of outright suppression of intellectual property rights. It is not strange that this idea can be present in several news articles.

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