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DETERMINATION OF OPTIMAL PATENT LENGTH IN FAVOR OF INNOVATION AND GROWTH

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Abstract: *Patent policy aims not only to protect industrial property, but also to create incentives for innovation and thus to encourage companies to invest more in research and development. This policy should not consider excessive protection and should not constitute a barrier to the dissemination of knowledge. Indeed, by privatizing the knowledge of innovations, excessive protection is an obstacle to the dissemination of new ideas and a barrier to entry. This could therefore slow down innovation in the long term. The purpose of this article is to determine the optimal length of the patent in favor of innovation and growth.*

JEL classification: O30, O31, O34.

Key words: innovation, growth, patent length.

INTRODUCTION

Innovation is crucial for the development and deployment of technologies. Economic theory sees patients as policy instruments to foster innovation and promote growth. For example, economist-historian Douglass North has shown that the expansion of innovation and sustained growth is dependent on the existence of a system of intellectual property rights. Since Nordhaus (1969), a major preoccupation of economic theory had been: *how to protect the innovator, without creating excessive rents, the duration and extent of the monopoly conferred by the patent, and without creating obstacles to the diffusion of new technologies and new products?*

The objective of this chapter is to determine the optimal length of the patent in favor of innovation and growth. Indeed, we briefly review the characteristics of the patent as they emerge from the microeconomic or endogenous growth models, in order to analyze the characteristic length of the patent as a means of action for an innovation policy.

The length of the patent or the statutory lifetime is the maximum period during which the patent may remain valid. However, it should be noted that the statutory life of the patent does not necessarily coincide with its actual lifetime. A patent may not continue for the legal term, either for technological reasons (because it is technologically out of date) or for economic reasons (because it is no longer profitable). In most countries, in order to maintain their patents, holders must pay renewal annuities. The effective life of patents can be influenced by the amounts and the profile of these annuities.

By refining patenting by microeconomic models and endogenous growth models, we are pursuing an approach that allows us to clarify the place of patent length as an economic policy instrument to encourage the innovation and improve economic growth. First, we will start with the representation of the optimal duration of the patent in the microeconomic models (first section). Then we will study the place of the length of the patent as it stands from the endogenous growth models based on innovation: horizontal differentiation of innovation, vertical differentiation and both horizontal and vertical differentiation (second section). Finally, concluding everything recommends on the economic aspect of the length of protection by the patent.

1. THE PLACE OF LENGTH IN THE MICROECONOMIC LITERATURE

Can the choice of an optimal level of protection conferred by the patent over the lifetime be a public policy instrument in order to resolve the dilemma between protection and dissemination of inventions? Scherer (1984) considered that the patent was interpreted as a possible instrument of economic policy only through the work of Nordhaus (1969).

1.1. The Nordhaus model (1969)

The problem of this model is the determination of the optimal validity period of patent protection. This refers to the trade-off between the protection afforded to innovators (patentees) and the distortion generated by the patent which serves to ensure the social optimum in a partial equilibrium framework. According to Nordhaus, the optimal lifetime of patents must be finished in order to reduce, on average, monopoly distortions.

Scherer (1972), taking up the work of Nordhaus (1969), showed that long-term protection leads to more intense research and development efforts in that the expected profits would be greater. At the same time, it generates costs in terms of social welfare (dry loss) due to static inefficiency due to monopoly distortions.

The Nordhaus model shows that the optimal protection duration is sensitive to the elasticity of demand (η) and productivity in research (β). Indeed, the higher the elasticity of demand, the greater the dry loss (measured by the gain as a function of demand when the patent falls into the public domain). Because higher prices result in a greater reduction in the quantities requested. When η is important, demand is more sensitive to a rise in prices and therefore a significant proportion of consumers will be excluded from the consumption of product. Indeed, when the elasticity to the demand is high the optimal lifetime of the patent must be shorter.

Optimal life expectancy is a decreasing function of productivity in research (β). When productivity is high it will be possible to achieve the same level of well-being by applying a shorter patents life span.

Kolida (2001), in interpreting the sensitivity of T to η and β, showed that the optimal lifetime of the patent has a strong sectoral (or product) component. Indeed, it concluded, from the Nordhaus model, that it is preferable that the term of protection by patents be finished for three reasons:

- ✓ In the context of patent races, innovators compete for the purpose of achieving innovation and thus obtaining the patent; The winner of the race obtains all the gains even if his advance is minimal compared to his competitors.
- ✓ The effect of innovations on supply and demand is uncertain, which justifies the limitation of the duration of the monopoly,
- ✓ The social value of any invention is limited, which makes protection unlimited over time unjustified due to the distortion of competition and the reduction of surplus generated by this protection.

However, many empirical studies show that the effective life of patents is much shorter than their legal duration (Schankerman and Pakes (1986)). According to Kolida (2005), in France the effective life span is eight and a half years on average for a legal duration of twenty years. Thus, the next paragraph emphasizes the modular aspect of the lifetime of the patent, introducing the notion of renewal.

1.2. Modular life of the patent: the role of renewal rule

The model of Pakes and Schankerman (1984) considers an agent holding a patent; To keep it in force it must pay annually a renewal annuity $c(t)$ variable according to the age of the patent. The patentee receives an annual income $r(t)$. The decision rule of this agent is the maximization of the net present value of his profits ($V(T)$) by choosing the age from which he will cease to pay the renewal annuities and the patent falls into the public domain.

$$\underset{T\in\{0,1,2,\ldots,\bar{T}\}}{Max} V(T)=\int_0^T [r(t)-c(t)]e^{-\rho t}dt \qquad (1)$$

With ρ, is the discount rate and $\bar{T}$ the maximum duration of legal protection.

The differentiation of (1) with respect to t, gives the optimal expiration date T^*:

$$r(T^*)=c(T^*) \qquad (2)$$

Provided that $r'(t)<c'(t), \quad \forall t$.

The condition for renewal of the patent in year t is that the annual profit covers at least the cost of renewal, that is to say:

$$r(t)\geq c(t) \qquad (3)$$

Based on the hypothesis of economic behavior of innovators, renewal models propose to estimate the private value of patents on the basis of renewal data provided by industrial property offices. Indeed, if this assumption is valid, the optimal duration of the patent coincides with the date from which the innovator must cease paying the renewal fees. This approach provides a direct measure of the private value of the patent and evaluates the role of the patent system as an incentive for innovation.

The different empirical uses of renewal models have shown that the value of the patent varies according to the cohorts, sectors, countries, owners and origin of the applicant. This implies that the lifetime of the patent also varies according to these different factors. The lifetime of the patent is therefore not exogenous, it is the result of an economic arbitrage between the discounted revenue and the cost of ownership. The length of legal protection is a decreasing function of renewal cost. Indeed, the system of industrial property can influence the length of the patent by the amounts of renewal annuities.

After this analysis of the contribution of microeconomic models to the description of the lifetime of the patent, we will study in the next section the place of the length of the patent in the models of endogenous growth.

2. THE PLACE OF LENGTH IN ENDOGENOUS GROWTH MODELS

2.1. The horizontal dimension of innovation

2.1.1. Infinite life of the patent: the Romer model (1990)

The Romer variety expansion model (1990) is the first endogenous growth model based on innovation. In the context of endogenous growth, in its model, Romer has made endogenous the technical progress that is determined by the research and development activity generated by the private companies motivated by the realization of profits. In the theory of growth, this model has introduced some notions borrowed from other domains such as the domain of the public economy (non-rival goods) and the domain of the industrial economy (imperfect competition, expansion of Range of products).

Following this model, the price of patents evolves in the same direction as the number of researchers and moves in the opposite direction as the interest rate. Indeed, the increase in the number of researchers encourages the demand for capital goods and consequently increases the price of patents. However, the increase in the interest rate affects the price of patents in two ways. On the one hand, this increase increases the total cost of capital goods and reduces their demand and consequently the price of patents. On the other hand, it negatively affects the present value of future patent profits, thereby reducing the price of the patent.

Within this model, the patent market is in perfect competition. The company in the intermediate goods market, which buys a patent will be in a permanent monopoly position because the lifetime of patents is infinite. The technology is represented by the number of intermediate goods available and thus by the number of the patent.

The hypothesis of infinite lifetime patents has been criticized by Michel and Nyssen (1998). Indeed, these authors have modeled the expiration of the patent by the introduction of an exogenous knowledge diffusion coefficient.

Kolida (2001), analyzing the place of the patent in the Romer model (1990), pointed out that this model uses the Dixit-Stiglitz differentiation model (1977) and describes a continuum of intermediate goods whose size can evolve Thanks to innovation. The final good sector uses a production function that involves a combination of labor and intermediate goods to produce the final good. Since the lifetime of the patent is infinite, the number of monopolies of differentiated goods increases at the same rate as the number of innovations and thus of patents. This reduces the market shares of new firms, that is, the firms that produce the intermediate goods. Indeed, this dynamic effect of market sharing at the rate of the appearance of new patents, itself tied to the emergence of new innovations, reduces the initial breadth of patents. The externality of knowledge at the research sector level ensures the sustainability of growth. The knowledge embodied in all the patents deposited by the subsequent innovators constitutes the stock of knowledge available to future research. Whereas the infinite lifetime of patent protection in the Romer model (1990) is optimal for market distortion; The reduction in breadth weakened the incentive to invest in research and development as new innovations and new patents appear. Indeed, the knowledge diffusion provided by the patent system is the only factor that ensures the sustainability of the growth and make it endogenous. Thus, Kolida pointed out that the whole model dynamic of Romer (1990) is based on the mission of disseminating scientific and technical information provided by the patent office. If this is not perfect, growth is no longer sustainable.

2.1.2. Length of the patent maximizing growth: model of Michel and Nyssen (1998)

The Romer model (1990) does not encourage patenting as an instrument of economic policy. Indeed, the infinite life span of patent protection reduces the flow of technological information, which is the essential characteristic of the effectiveness of research and development activity in this type of endogenous growth model based on 'innovation. Grossman and Helpman (1991) considered the assumption of an infinite patent life as an assumption of independence between knowledge and the lifetime of patents. Thus, such an assumption amounts to considering that the knowledge contained in patents is a pure public good. However, this is not the case, the condition of non-exclusivity of the knowledge contained in the patent is not fully met; This exclusivity is only partial.

The model of Michel and Nyssen (1998) analyzes the macroeconomic effects of the patent system as part of an endogenous growth model with the development of new products. This decentralized model introduces a limited lifetime of the patent as part of a variety model to Grossman and Helpman (1991). The authors assume that patents represent not only commercial protection for innovators, but also a partial right of ownership over knowledge

Michel and Nyssen (1998) have shown that increasing the lifetime of patents increases the profitability of a given research and development project but also reduces the knowledge externalities that play a crucial role in the growth process.

Criticizing the infinite patent life

The canonical models of Aghion and Howitt (1992), Grossman and Helpman (1991a, b), Romer (1990), Segerström et al. (1990) share a common assumption: the lifetime of the patent is infinite. However, this assumption is unrealistic since the maximum legal lifetime is generally 20 years[1]. Michel and Nyssen (1998) noted that it would not be optimal to propose an infinite patent life, because this would create permanent monopolies with a negative effect on growth and well-being. As an industrial policy tool, the length of the patent is always the result of a

[1] - The term of protection offered will not terminate until the expiration of 20 years from the date of filing. Article 33 TRIPS.

trade-off between incentives for investment in innovative research and limiting market distortions induced by monopolies.

These authors consider that the fixing of an infinite lifetime of patents in endogenous growth models is analytically the simplest way to proceed. Indeed, by virtue of the lifetime of the finished patents, two difficulties arise.

- ✓ First, the dynamics of the model is described by nonlinear differential equations whose study is far from easy to realize.
- ✓ Secondly, the price vector never reflects the cost structure and consumers' purchases are not effectively divided among the different products. Two types of goods are offered to households: goods that are no longer protected by a patent and are sold at marginal cost (competitive price) and monopoly property protected by a patent (price retaining a margin of profit for the monopoly).

For these authors, patents with infinite lifetimes do not systematically guarantee optimal sharing of purchases, but this problem becomes simpler when production is devoted to monopolies only. This argument becomes even more evident for models based on the variety of products in the Grossman and Helpman line (1991a, ch.3). Indeed, the production of goods differentiated horizontally is devoted only to monopolies while, applying the same margin rate on the marginal cost. Under these conditions, the price structure accurately reflects the cost structure and the positive profits are distributed to households, the presence of monopoly does not lead to any net distortion. The only sub-optimality of the model comes from the public good nature of knowledge. In addition, since the diffusion of knowledge is not affected by variations in the lifetime of patents, it is always optimal to set this duration at infinity.

Michel and Nyssen argue that to reconcile innovation-based endogenous growth literature with reality in terms of patent lifetime, there is a negative effect of the too long patent life on the growth and good -be. They see that this negative effect may come from the process of dissemination of knowledge and not from the existence of permanent monopolies. These authors also consider that the design of patents, used in canonical models, is somewhat too radical because it makes the level of public knowledge independent of the lifetime of patents.

Indeed, the patent is accepted as a contract between the inventor and the government that would oblige the inventor to make his knowledge public in a form that can be understood by a person skilled in the art; On the other hand it obliges the government to guarantee the commercial protection to the inventor.

The information contained in the patent is made public by the patent system, generally 18 months after the filing of the application in the case of Tunisia[2]. This confirms the idea that the whole stock of knowledge is made public in a relatively short time. However, many lawyers consider that the information disseminated by the patent office during the protection period does not cover all of the technological knowledge embodied in the invention. Thus Michel and Nyssen assumed, following the idea of Arrow (1994), that all the knowledge generated by an economy does not propagate instantaneously. Indeed, certain technological information concerning the knowledge developed through private research and development is kept secret for strategic reasons. For example, work organization, learning by doing, know-how are elements that constitute tacit, uncodified knowledge that does not spread as rapidly as technological knowledge in the broad sense

. The key point in the analysis of Michel and Nyssen is the hypothesis that some of the knowledge developed by private research does not spread instantaneously. The complementary part only diffuses when the protection of the patent ceases. Throughout the period of patent protection over a given asset, the producer keeps a certain amount of private knowledge secretly. This is due to: on the one hand, the fact that some of this knowledge can not be codified so as to allow its use by the competitors and, on the other hand, the intentional secrecy.

But when the patent falls into the public domain, anyone can access all the knowledge that enables it to produce the property in question. Therefore, the knowledge that is disseminated to the public depends on the lifetime of the patent. Indeed, it is optimal to shorten the lifetime of patents in order to reduce the share of private knowledge.

Methodology adopted

[2] « La demande de brevet est généralement publiée 18 mois après le dépôt ou la date de priorité; après un examen quant à la forme, avec ou sans rapport de recherche ». INNORPI

In order to study the optimal lifetime of patents, Michel and Nyssen (1998) developed an endogenous product variety growth model based on Judd (1985) and Grossman and Helpman (1991a). These models are very similar in their basic structure. The main difference is that the Judd model is a model of exogenous growth, where research and development does not produce a knowledge externality. Innovation is endogenous, but not sustainable when there is no growth of an exogenous factor such as an increase in the workforce. The absence of knowledge externalities can be interpreted by the fact that the knowledge created by the invention of a given variety is specific to a given product and can not be used to develop a new variety. Also, this knowledge is the private property of the inventor during the period of patent protection. This knowledge becomes public as soon as the patent expired, but it is used only by the competitive producers of the corresponding variety. Thus Judd's model does not take into account the effect of the horizontal diffusion of knowledge. In this context, since the nature of knowledge does not imply any sub-optimality, Judd has shown that when the initial degree of variety is zero, the first best patent policy is to set an infinite protection term. For similar reasons, Grossman and Helpman (1991, c.3) chose an infinite patent life as the second best solution.

At the opposite end Grossman and Helpman consider that the knowledge created by research and development activities is both non-rival and non-excludable, and can be used in any production line. This means that in the Grossman and Helpman model the patent is only a right that protects production against competition and imitation, but does not exclude the use of knowledge by other agents. This assumption, which guarantees innovation and sustained growth, (as long as disclosure of information is specified to ensure consistent returns in the research and development sector), explains why the infinite patent lifetime Has no effect on the dissemination of knowledge.

The model of Michel and Nyssen is closer to Grossman and Helpman model than to Judd's model in the sense that it is an endogenous growth model whose knowledge diffusion process ensures constant return in the activity Research and development.

Major Model Contributions

The work of Michel and Nyssen contains three major contributions to the literature of endogenous growth based on innovation.

- ✓ First, it introduces a new hypothesis that results from a better analysis of the role of knowledge as an input to the R&D process.
- ✓ Secondly, it provides a complete characterization of the innovation study as part of a general equilibrium model with endogenous growth with finite-life patents. This characterization makes it possible to distinguish situations where the optimal lifetime of patents is finite and those where it is infinite.
- ✓ Third, it shows that, in general, the optimal lifetime of patents does not maximize both growth and innovation.

In addition, this model is a generalization of the growth model of the Grossman and Helpman varieties to assess the effects of restrictions on knowledge dissemination.

In conclusion, Michel and Nyssen's model shows that when the instantaneous diffusion of knowledge embedded in patent-protected innovation is weak, growth is maximized by a finite lifetime of patents; While this lifetime is infinite if the diffusion is strong. Moreover, in the first case, the optimal lifetime of patents is finite and shorter than that which maximizes growth. This is due to the fact that in the case where the instantaneous diffusion of knowledge is weak, the State can compensate for the lack of public knowledge by choosing a patent lifetime (the optimal lifetime) shorter than that which Is able to maximize the profit of innovators. Thus, the manipulation of the lifetime of patents constituted, in a second analysis, a means of acting on the appropriateness of knowledge to promote growth.

2.2. The vertical dimension of innovation

The work of Grossman and Helpman (1991) and Aghion and Howitt (1992) gave rise to a category of models that incorporate a qualitative representation of innovation. This category of models known as "creative destruction" has its origins in the work on patent racing.

2.2.1. The Grossman and Helpman model (1991)

Grossman and Helpman (1991 ch. 4) developed a product improvement model. The economy is represented by a fixed vector of different products, each good is produced by a specialized sector. Each product is requested because it responds to a specific need of consumers, and is indexed by a quality level and follows a stochastic progression on a quality scale. Progress is not uniform across sectors, so that an equilibrium distribution of qualities evolves over time. But the overall growth rate is constant. Within this model, an innovation makes it possible to improve the quality of the goods already existing, hence the name "models of quality scales". The same quantity of the new good gives consumers a greater satisfaction than that provided by the good of the previous generation.

This model considers the size of innovations as exogenous, rather as a technological parameter. It assumes that innovation activity is stochastic, patents have an infinite life span in the sense that they end under the effect of future innovations.

The Grossman and Helpman model (1991) considers the size of innovation as exogenous, while the conclusions emerge from this work depend on the value of the quality increment of this innovation. When the size of innovation is relatively small or very large, there will be an over-allocation of research in relation to the optimal solution. Thus the aim of a patent system would be the orientation of innovators towards qualitative improvements in the middle area around the optimal solution.

The authors also assume that firms themselves determine the level of quality increment of their innovation. Indeed, in this case the aim of the patent system would be to publicly attest to the height of the jump made by the companies so that they can obtain the profits associated with making larger innovations.

2.2.2. The model of Aghion and Howitt (1992)

This work by Aghion and Howitt (1992) analyzes the phenomenon of creative destruction in the context of a simple growth model based on the link between innovation and market structure. These authors adopt a model of the innovation process according to the patent race literature, Tirole (1988) and Reinganum (1989).

Through this conception, the authors have introduced the obsolescence factor into growth theory. Indeed, the best products make the old products obsolete and it is the increase in quality that becomes a factor of growth. In other words, a "schumpeterian" innovation replaces the previous discovery and puts an end to the former monopoly rents. This model implies, following Schumpeter, that individual innovations are important enough to affect the economy as a whole.

This model considers three sectors in the economy: the labor sector, the end consumer goods sector and the intermediate goods sector. There are three categories of work: unskilled labor, which can be used only in the production of the consumer good. Skilled labor, which can be used either in research or in the intermediate goods sector. The specialized workforce, which can be used only in the research and development sector. Each individual has a flow of one work unit. Thanks to the phenomenon of creative destruction, each new variety of good intermediate replaces the old variety; Which will improve the technological parameter.

Aghion and Howitt have observed that it is always possible to produce the consumer good using an old technology, with an old intermediate good corresponding to this technology.

When an innovator succeeds in obtaining an invention, he obtains a patent that provides him with a monopoly on the intermediary good sector. While the patent has an infinite lifetime, the monopoly only lasts until the next innovation, when the intermediate product is replaced by the next product. The object of intermediate goods monopolist is to maximize the present value of expected profits during the current interval. The only uncertainty concerns the duration of the interval.

Each innovation consists of a new intermediate product that can be used to produce the final good more efficiently. Research companies are motivated by the prospect of monopoly rents that can be captured when a successful innovation is patented.

If the size of the innovations is high, the first two effects will dominate. On the other hand, if the monopoly power conferred by the patent is important and the innovations are not too great, the third effect will prevail and therefore the decentralized growth will be excessive.

Aghion and Howitt conclude that the analysis of the effectiveness of the incentive to innovation is not based solely on the endogenous market structure. Indeed, the dimension of competition policy is complemented by another more regulatory dimension, namely the nature of patent policy.

2.3. The horizontal and vertical differentiation of products: the Caballero and Jaffe model (1993)

The work of Caballero and Jaffe in 1993 aimed at establishing a framework for integrating the microeconomics of creative destruction and knowledge externalities into a growth model in order to determine their effects on economic growth. Thus, these authors developed a model in the spirit of Grossman and Helpman (1991) and Aghion and Howitt (1992) which gives a simple relationship for the effect of new products on the value of existing products. The new products are always of superior quality to the old ones.

In this model of innovation and growth, the extension of the range of intermediate products is accompanied by an obsolescence effect. This work is an important theoretical and empirical contribution in establishing the place of the patent as a policy tool for innovation and growth.

Kolida (2001) pointed out that the Caballero and Jaffe (1993) model adopts a much richer formalization of the research process than all other endogenous growth models based on innovation with a single R&D sector. Indeed, these authors have modeled the quality of new ideas as well as the power of externalities, based on a more sophisticated observation and analysis of the patent and innovations.

At a given date (t), the economy consists of a continuum of goods, size N_t, monopolistic competition indexed by their quality, $q \in]-\infty; N_t]$ as for a quality scale model. The most recent products are always the best; Which means that the research process advances the technological frontier at the same time as it increases the number of patents N_t . There is, at the same time, an increase in varieties and an improvement in quality.

Schumpeter's creative destruction phenomenon finds its place in this model because of the implicit classification of the quality of innovations. As a consequence of the emergence of new varieties with a higher technological content, producers who have a constant marginal cost have their profits deminerated. Here we find that the market share of the former goods is gradually decreasing under the effect that demand will be given priority over new goods which are systematically of superior quality to the former goods. Then the rate of decline in the market share of the old goods (and as a result of profit) depends positively on the degree of substitutability between goods and the rate at which new goods are introduced.

Caballero and Jaffe have developed a model in which growth is based on a horizontal and vertical differentiation of products. Indeed, each new good offers the consumer a different service from those offered by the former goods (horizontal differentiation); At the same time, the quality of this service is superior to those of goods already existing (vertical differentiation). In this model, patent data is used as a representative variable of new ideas and patent quotes to represent knowledge externalities; In order to estimate the parameters of the models. Linking the concept of new ideas with the new patents allows authors to measure the empirical extent of creative destruction. The authors assume that patents are proportional to ideas and quotations are proportional to the ideas used in the creation of new ideas. The speed of advancement of the knowledge boundary ($\dot{N}_t$) is assumed to be proportional to the rate of patentability at the same time. The citation function is an estimate of the probability that a patent in (t) cites a cohort patent (s).

Empirically, the authors show, using the number of patents as proxies of numbers of new ideas, that it is possible to use patent citation information to approximate in a very rich way the diffusion of knowledge, the obsolescence of Ideas and the externality of research. They also show the possibility of verifying whether knowledge seems to have a private component. Practically by checking whether the company cites its own patents more often than patents owned by other companies.

Thanks to patents, the rate of obsolescence of ideas is endogenized, the extent to which the process of research and the creation of new ideas give rise to patent filings. The authors have shown that the patent system can play an important role in the dissemination of knowledge; where the information contained in patents ensures that researchers have rapid access to new knowledge.

CONCLUSIONS AND DISCUSSION

We have seen, in this article, that since the first theoretical work on the patent, the question focuses on the temporal characteristics, that is to say the choice of the optimal life span of the protections. Thus, we have developed the possibilities of using patent length as a political instrument for growth.

We conclude, arguing in favor of the possibility of using one of the characteristics of the patent, its length, as an instrument of economic policy that affects innovation and growth:

• Research firms are motivated by the prospect of monopoly rents that can be captured when a successful innovation is patented.

• The patent system ensures the sustainability of growth and makes it endogenous. Such a system allows the dissemination of knowledge as the holder of a patent is subject to the obligation to publish information on innovation.

• The intensity of research and development efforts depends on the length of patents. Indeed, the long patent offers the innovator more possibilities to make his investments profitable by granting him a longer monopoly right.

• The life of patents is an indispensable instrument for modulating monopoly distortions, since the duration of the monopoly is confused with the length of the patent.

Taking into account these arguments, we conclude that the patent, by its characteristic length, can be judged as an economic policy tool to encourage innovation and promote economic growth. The patent confers on the holder a temporary monopoly right over the exploitation of his invention. This exploitation right may be exercised directly by the inventor himself or transferred to a third party by means of a license. The optimal term of protection is the solution of the arbitration between the protection afforded to innovators (patentees) and the distortion generated by the patent, which serves to ensure the social optimum.

However, the importance given to the length dimension of the patent, by the models discussed at the level of this first work, comes up against an empirical observation. Indeed, numerous empirical studies have shown that the effective life of patents is much lower than their legal duration (Schankerman and Pakes (1986)). According to Kolida (2005), in France the effective life is eight and a half years on average for a statutory period of twenty years. As soon as the revenue expected from the holding of a patent for one additional year becomes less than the costs (renewal fee), the holder abandons his patent. Thus, over time the value of the patent decreases as competitors invent nearby (Deffains (1977)). However, the formulation of this hypothesis requires the introduction of the other dimensions of the patent. Hence, the answer is favorable to the question of the problem: the life of the patent can constitute a political instrument in favor of innovation and growth.

However, O'Donoghue, Scotchmer and Thisse (1998) consider that the prior determination of the optimal lifespan of a patent without taking into account its breadth and height characteristics lead to fallacious results. We will show, at the level of future work, that it is necessary to introduce the other two dimensions of the patent (breadth and height) in order to have the patent as an economic policy instrument for growth and innovation.

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