The use of intellectual property rights by French firms

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Abstract: In attempting to appropriate their innovations, firms can chose from a range of mechanisms, including patents, trade secrets and lead-times. Yet, little is known about how firms choose different appropriability mechanisms. The aim of this paper is to determine how the use of intellectual property rights (IPs) by French firms is related to their characteristics, activities, competitive strategies and the industry sector in which they operate. Among their characteristics, we test the role of the human resource strategies in keeping employees. Our empirical model is based on the French 2004 Community Innovation Survey (CIS). Our results show that firms have different strategies in the choice of the means of protection according to their basic economic characteristics of firms, their activities and industry environment. They also put in evidence of the role of human resources strategies. Firms that finance R&D training prefer to use non-statutory means.

Keywords: Appropriability, Intellectual property rights, Innovation, Human resources strategies, Multivariate probit.

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1 Introduction

The protection of intellectual property (IP) is an often debated crucial question in economics. Patenting seems to be the most obvious mechanism of protection. However, Scherer et al. (1959) and large-scale industrial surveys carried out over recent decades (Levin et al., 1987; Cohen et al., 1996, 2000) show that firms improve the conditions for appropriating the returns on their innovations through different channels, including of course patenting but also lead time and moving quickly down the learning curve, secrecy, exploiting their reputation and implementing sales and services efforts (Mendonça et al., 2004). The economic literature searches to identify which is the most efficient. It appears that the ranking of these strategies is not steady and notably varies according to the sector of the firm and the nature of the protected innovations. Moreover, few studies have been undertaken to understand the strategies which lead firms to use one of these mechanisms and the potential complementarities which can exist between them, as a firm can use different protection.

In this context, we aim to go further in the understanding of the choice of mechanisms of protection by the firms. We analyse their use by French firms. We suppose that the sector and the nature of innovation, but also the human resources strategies and firms characteristics may influence the choice. The aim of the study is then to use the fourth Community Innovation Survey (CIS4) data to provide empirical estimates of the propensity of choosing one mechanism of protection rather than another.

Our study is original as it includes different explanatory variables which have not been included together in previous studies. Thus, we test the impact of sector, innovation and firms characteristics, including human resources strategies such as training and wages. The results show that some means of protection can be explained by very similar factors while other reveal very different strategies. The strategies are partly correlated. The remainder of the paper is organized in five sections. Section 2 presents a brief overview of the literature on the different appropriability strategies that firms can use. Section 3 explains the estimation methodology. Section 4 outlines the database. Section 5 reports the results and contains a discussion. Finally, section 6 concludes.

2 Why do firms use intellectual properties rights?

2.1 Diversity of mechanisms of protection

Knowledge is a peculiar good because its cost of reproduction is low, in comparison with how costly it is to produce it in the first place. Innovations are thus vulnerable to copying and imitation (Arrow, 1962). In economic terms, knowledge has the attributes of a public good. Without IP mechanisms of protection, private producers of knowledge would not be able to appropriate the value of their investments, and this nonappropriability of benefits would lead to underproduction of new knowledge and innovations. IP protection provides inventors with limited monopoly power, increasing their ability to appropriate the benefits created by their research effort

(Friedman et al., 1991). The firm producing innovations which are protected by patent is able to price its product above the marginal cost of production. Thereby it appropriates profit that would otherwise be passed on to consumers through lower prices. Intellectual property right (IP) laws have been used to provide incentives for inventors, and firms to invest in research.

There are various IP protection methods which allow to apply for different forms of knowledge or different strategies of protection[1]. We can distinguish the IP Rights (IP) from the non-statutory means. Among IP, patents, Copyrights and trademarks are the most common forms. They allow to protect different forms of knowledge. A patent is arguably the strongest form of IP. It confers to the inventor the sole right to exclude others from economically exploiting the innovation (by making it, using it, selling it, and so on) for a limited time[2]. However, the disclosure requirement generates for the patent holder some disutilities that might outweigh the monopoly benefits. First, a patent highlights a presumably profitable technology field. This enables competitors to jump onto a technological trend by conducting further research related to the patented technology. Second, publicly available patent information facilitates reverse engineering of an invention and may thus encourage rival firms to invent around a patent[3].

As for copyrights, they protect original works of authorship. Unlike patents, there is no novelty or usefulness requirement, although there are conditions of originality (the work has not been copied) and authorship.

A trademark is a sign, word, symbol, or device that distinguishes the goods or services of a firm from those of others. No novelty or originality is necessary, but the main requirement is distinctiveness. Trademarks are valid if they are registered. Protection of trademarks does not have a time limit, provided the trademarks are used and renewed periodically.

Due to the disadvantages of the disclosure requirement for legal means of protection, some firms may prefer using non-statutory mechanisms which do not require disclosure. We can quote secrecy, complexity of product, lead-time. Trade secrets cover any information a firm may have -including formulae, devices, methods, techniques, processes, etc.- that confers an advantage over competitors which do not have the information. For trade secret protection to apply, the general requirement is that reasonable efforts be undertaken to maintain secrecy. More specifically, protection is extended against another party's discovery by inappropriate means, but a trade secret offers no protection against independent discovery or reverse engineering. In both the Yale and Carnegie Mellon surveys, secrecy appears to be the most important mechanism for appropriating innovations. Complexity of products and manufacturing processes may also provide a mechanism for firms to appropriate their innovations. Many products rely on integration of wide range of different technologies, components and systems. The integration between these different technologies often requires deep knowledge of component technologies and ability to specify the

[1]Indeed, firms also increasingly use IP-based strategies for other purposes than protection against imitation.

[2]For most countries this time period is now 20 years from the date of filing.

[3]These drawbacks were reduced in the United States thank to the use of submarine patents but the latter officially do not exist anymore.

interfaces between different sub-systems (Brusoni, Prencipe and Pavitt, 2001). In this way, firms may rely on the fact that producing the product requires considerable specialized capital investment and capabilities in manufacturing that are not easily replicated (Utterback, 1994).

In all these cases of non-statutory means, many firms make extensive efforts to control the communication flows between their workers and the external environment. Non-disclosure, confidentiality and subsequent employment agreements are often used to ensure that trade secrets and specific skills are retained inside the firm (Roebben, 2005; Galia and Legros, 2003). Such practices are likely complementary to various incentive-based reward and remuneration schemes (Holmstrom and Milgrom, 1994) that reduces turnover.

The discussion above suggests that there are a large range of mechanisms of IP protection. No single mechanism is able to provide firms with perfect protection for their innovations. Different mechanisms may be used at the same time for a given innovation (Cohen et al., 2000; Arora, 1997). Moreover different elements of an innovation may be protected by more than one protection tool.

2.2 Choice of a IP means of protection

2.2.1 Traditional factors

Economic literature tries to understand if there is a hierarchy between the different forms of IP protection. The use of patent versus secret seems to be the most studied in the theoretical and empirical literature (Hussinger, 2006; Anton and Yao, 2004; Arundel, 2001, Horstmann et al., 1985). Theoretical models (Harter, 1993; Scotchmer and Green, 1990, Horstmann et al., 1985) focus on the invention level and identify which IP tool is most suitable for a particular innovation. Anton and Yao (2004) show that large inventions are protected primarily through secrecy and small inventions, much less imitated, through patents. Levin et al. (1987) and Arundel (2001) conclude that firms prefer secrecy over patenting to protect their IP and also that firms retrospectively consider secrecy more effective than patenting. Levin et al. (1987) show that patents are not the most important mechanism of IP appropriation. Secrecy and learning advantages as well sales and service efforts are more important. Nevertheless, they detect significant inter-industry variation regarding the use of IP protection instruments because of the different value of patents as a means of appropriating investments in innovation (Harabi, 1995, in Arundel and Kabla (1998)). In the chemical and pharmaceutical industries, patents are most often used and are considered to be more effective than in other industries sector because the cost of copying an innovation is considerably less than the initial cost of invention. Moreover, the nature of innovation seems to account. Indeed, product innovations are better suited to patent protection than process innovations (Arundel and Kabla, 1998). Indeed, firms avoid patenting process innovations because of the difficulty in detecting infringement. Finally, empirical studies indicate that small and medium-sized firms do not use IP in the same way as larger firms. Arundel and Kabla (1998) show that patent propensity rates increase with firm size. Baldwin and Hanel (2003) confirm this result with Canadian data. The preference of small firms for secrecy is presumably due to their lack of financial resources needed to

protect their patents.

2.2.2 Human resources factor

The heterogeneity of the firms' performances is based on the nature and the quality of their specific assets, and particularly immaterial assets such as knowledge. However, knowledge cannot be acquired easily on market as it is partly tacit (Polanyi) and embedded in workers. It must be continuously updated and improved. In this perspective, firms develop human resources management to keep and improve these specific competences as their loss (by the departure of the workers for instance) could create an important deficit. Ballot, Fakhfakh and Taymaz (2001) find that training and R&D stock positively influence the firm's productivity. Laursen and Foss (2000) and Laursen and Mahnke (2000) show that new practices in human resource management such as training, delegation of the decisions at the level of the workers who possess the information, rotation on the posts spreading the knowledge etc. favour innovation. More recently few studies consider that human resources management can influence the strategic choice of the firms and specially the choice of the means of IP protection. Thus, Roebben (2005) shows that strategies undertaken to gain employees loyalty lead to use more secret than patent. When firms have a high rate of engineers' resignation they prefer patent strategy to limit risks of information diffusion.

2.2.3 Complementarity of the means of protection

Most of the studies analyse the choice of patent versus secret. Hanel (2008) proposes to enlarge the study of the different IP. He analyses how the use of IPs is correlated with how the firm innovates and with firms' characteristics and sector effects. He argues that innovation and IP determine each other. So IP variables appear among explanatory variables in the innovation equation and innovation variables in the IP equations. A drawback of this study (Hanel, 2008) is that it does not take into account the correlation between the different IPs strategies[4]. Patents, secrecy and others IPs are not always mutually exclusive appropriation methods. As mentioned above, a firm could use secrecy to protect an invention during a development phase and then rely on patents or other appropriation methods when the invention is on the market (Hussinger, 2006). Secrecy might also be used in order to protect process innovation.

The literature shows that according to the nature and the level of innovation, the sector and their characteristics, firms choose between the different forms of protection. However, only few of them take into account the role of human resources management as a means to improve competencies. Following Roebben, we then suppose that the existence of specific human resources strategies, which try to keep employees in the firms could explained the use of non-statutory means. Moreover, most of the studies focus on the choice of patent versus secrecy. As a consequence, they rarely analyse the potential complementarities of the mechanisms.

[4]The author only uses a series of two-way contingency tables classifying firms by the impact of innovation on profitability and as users and non-users of each IP.

The aim of this paper is then to determine how the use of intellectual property means of protection by French firms is related to their characteristics, activities, human resources strategies, competitive strategies and industry sector in which they operate.

3 The model

In order to protect their innovations from being copied by competitors, innovators have to choose among different forms of IPs and non-statutory means. Their decision can then be modelled by binary variables. These latter are based on whether or not a firm uses patents, use trade secrets, use trade marks, copyrights, design registration, lead-time advantage over competitors, complexity of product design, copyright, technology advantage. Each variable takes a value of one if the particular property right is used and a value of zero if not. In order to identify the determinants of use of IPs, we use a multivariate probit model (Greene, 2000). The choice of an IP mechanism can influence the choice of another.

The multivariate probit model generalizes the bivariate probit model which is a natural extension of the probit model. It allows more than one equation with correlated disturbances. Then, the disturbances across equations are allowed to be freely correlated. The basic formulation for a bivariate probit model is as follows:

$$y_{i1}^{*} = \alpha_1 + \beta_1' x_{i1} + u_{i1} \tag{1}$$

where $y_{i1} = 1$ if $y_{i1}^{*} > 0$, and 0 otherwise.

$$y_{i2}^{*} = \alpha_2 + \beta_2' x_{i2} + u_{i2} \tag{2}$$

where $y_{i2} = 1$ if $y_{i2}^{*} > 0$, and 0 otherwise, $i = 1, \ldots, n$, $E(u_{i1}) = E(u_{i2}) = 0$, $Var(u_{i1}) = Var(u_{i2}) = 1$, and $Cov(u_{i1}, u_{i2}) = \rho$

In other words, the disturbances (u_{i1}, u_{i2}) have a bivariate normal distribution, i.e. $(u_{i1}, u_{i2}) \sim BVN(0, 0, 1, 1, \rho)$. In this paper, the multivariate probit model includes seven equations estimating the different IPs' strategies of firms. The answers are binary variables.

Each of the IPs strategy is then modelled as a latent variable by a standard probit model. The general specification of the multivariate probit model is as follows:

$$y_{ij}^{*} = \alpha_j + \beta_j' x_{ij} + u_{ij} \tag{3}$$

where $y_{ij} = 1$ if $y_{ij}^{*} > 0$, and 0 otherwise, $i = 1, \ldots, n$, $j = 1, \ldots, 7$, where the observations are indexed by i and the IPs by j. We use the same explanatory variables x_{ij} for each of the seven equations.

The equations disturbances u_{ij} have a multivariate normal distribution with mean vector 0 and covariance matrix with diagonal elements (i.e. variances) equal to 1 (see Greene, 2000).

4 Data and variables

This section presents the databases used and explains the choice of the variables. We use four databases. The Community Innovation Survey (CIS4) conducted in 2004 in France provides information about the means of protection, the types of innovation, the technology push and market pull situation, the existence of cooperation and subsidies, the level of external R&D and the belonging to a group. The R&D database, which comes from the French Ministry of Research, provides information on the stock of firms research expenditures in 2001. The Annual Survey of Firms (EAE) conducted in 2001 provides us with information about the individual characteristics of firms such as size, sector. It enables us to build indicators on market share and the number of competitors. The DADS database gives us information on the strategy chosen to gain employees' loyalty in 2001. We use data from 2001 and 2004 in order to introduce a time lag between R&D and the results of R&D. Merging these databases, we obtain a final sample of 5295 firms which innovate and a sample of 3547 firms which use at least one means of IP protection.

Our dependent variable is the type of IP[5]. The relevant CIS question asks each respondent what IP it use to protect its innovation. The IP include patents, trade secret, design registration, lead-time advantage over competitors, complexity of product design, copyright, technology advantage. The variables are described in table ??.

We consider that the nature of innovation can have an impact on the probability to choose one means of protection (Arundel and Kabla, 1998; Cohen et al., 2000). We distinguish four types: the product (good or service) innovation, the innovation in production or manufacturing processes of goods or services, the innovation in methods of logistics, supply or distribution of raw materials, goods or services and the innovation in activities of support, like activities of maintenance or purchase, of accountancy... This distinction allows us to test the impact of different types of process innovation.

Arundel (2001) considers that several additional factors influence the relative importance of one IP. He shows that firms, whatever their size, consider secrecy as being relatively more important than patents, but small firms find secrecy to be of greater importance than larger firms. One of the reasons is that the cost of patenting constitutes in relative terms a higher expense for small firms than for large ones. Therefore we add in the model the size of firm measured by the number of employees. We also test the role of the market share in the choice of the IP. Indeed, we can suppose that the IP strategy differs when the firm is a leader or a follower. We also consider that the strategy can differ when firm belongs to a group. We introduce a variable which distinguishes independent firms, firms belonging to a French group, firms belonging to a foreign group. Indeed, we suppose that firms belonging to a group have an easy access to the patent administration. Moreover, foreign groups could prefer patenting as they are present on various markets.

Another important characteristic of a firm is its R&D expenditures. These could increase the proportion of inventions that are patentable. A positive effect of R&D

[5]To make the reading easier, we use the expression IP to refer to legal and non-statutory means of protection.

expenditures is attempted. The CIS database allows to distinguish internal from external R&D. We then introduce two variables, assuming that the strategy can differ according to the place where R&D is conducted. Moreover, we introduce a dummy variable to identify firms that receive subsidies from the French government or the European Union. Indeed, firms that obtain State funds could be more sensitive to IP.

There are large differences in the effectiveness of IPs by sector of activity. The differences can be partly captured by including sector dummies in the model. The drawback is that it does not provide with any information on which aspect of each sector influences the effectiveness of IPs. An alternative approach is to try to identify the sector factors that influence the effectiveness of appropriation means. Therefore we introduce two sets of three dummies variables for controlling the demand pull effect and the technology push effect. We also introduce the number of competitors. Indeed, the intensity of competition could increase the value of patents (Arundel and Kabla, 1998). As we think that theses variables do not take into account all sector effects, we add binary variables for the belonging to a sector.

Brouwer and Kleinknecht (1999) find that firms that participate in collaborative R&D are more likely to apply for a patent than firms that do not. Alternatively, firms that focus strongly on internal information sources give greater emphasis to secrecy. The CIS contains information about cooperative arrangements with other firms. We include in the regression model a binary variable that equals one if firm has cooperation with other firms.

Following Roebben (2005), we consider that human resources strategy can influence the choice of IP. To test this assumption, we introduce three variables of employees' loyalty mechanisms. The first indicates if the firm implements a major strategy to encourage employees to stay in the firm. The second identifies if the firm offers higher fringe benefits that the average level in the sector. The last one specifies if the firm proposes higher wages than the average level in the sector. Finally, the variable "Training in R&D" indicates if the firm trains its researchers. The continuous variables are in logarithm.

5 Results

The estimation of the multivariate probit model enables us to distinguish different strategies in the use of protection means. The results are presented in table **??**. We begin with a vertical reading of the table and discuss the determinants and rationales of each type of protection. We then discuss the results for each explanatory variable.

5.1 Multivariate probit results

The results suggest that the probability of using trade secret is positively influenced by the development of process innovation inside the firm and the strategy of developing employees' loyalty, notably thanks to higher wages, in comparison with the other firms of the same sector. These results confirm previous results (Roebben, 2005; Arundel, 2001). Concerning the nature of innovation, our results differ from that of Hanel, which shows no impact of the nature of innovation. This difference can

be linked to different strategies and laws to patent in Canada and Europe. Indeed, the scope of patent protection was expanded in 1989 (Hanel, 2006). Moreover, the probability increases with the level of internal and external R&D activities, which confirms Hanel's results on Canadian firms. The positive impact of the existence of relations of cooperation and the obtaining of R&D subsidies is more surprising as we supposed that cooperation would lead to patenting. However, it is true that in some sectors such as Knowledge Intensive Business Services (KIBS), there are few patents and many collaborations. We can suppose that as soon as the collaboration contract is well written, secrecy or other means of protection can be also efficient. In this context, the innovation development is driven by a technology push process. The probability to use secret also increases when firms belong to intermediate goods industry and decreases when they belong to the sectors of service to customers and real estate business.

The probability of using the complexity of design is positively influenced by the development of product innovation and innovation in activities of support, the level of R&D activities, the existence of relations of cooperation and the existence of R&D subsidies. This probability is reduced by the size of the firm. The firms using the complexity of design have a strategy of gaining their employees' loyalty which is not characterized by the fringe benefits but rather by activities of training in R&D. The innovation is driven by technology push and not by market pull process. This strategy is rather used by firms from intermediate goods industry and unused by firms specialized in services to customers.

The probability of using lead-time advantage on competitors is positively affected by the development of product and process innovation, in a context of technology push. Firms which use this strategy conduct R&D activities in cooperation. They are rather small, receive subsidies and have a strategy of retaining their employees, which is notably characterized by activities of training in R&D. They are firms from consumption goods, intermediate goods and car industries.

There are a strong similarity between firms which have a strategy of complexity of design and those which have a strategy of lead-time advantage. We can suppose that these are the same firms which have different strategies according to the nature of the innovation. However, we note a small sector difference. The correlation between the two strategies, indicated by the ρ coefficient is high (57,5%). The presentation of these three strategies based on non-statutory[6] means of protection, shows that there are different forms of strategies but that they are highly correlated.

The probability of patenting is positively influenced by the development of product innovation and the belonging to a French or foreign group. It increases also when firms have large size and share market, cooperate, perform internal and external R&D, and receive subsidies. All these results confirm the previous studies (Arundel, 2001; Hanel, 2008). These firms are from industry and not from services. They offer fringe benefits to their employees. However, we can not conclude that it is a strategy of retaining employees, because it can also be linked to the different advantages proposed by large firms. This suggestion is confirmed by the fact that

[6]We use the term non-statutory protection to differentiate the secrecy, the complexity of design and lead-time advantage on competitors from legal means of protection which benefit from legal framework.

the probability of this strategy is reduced if firms provide training in R&D.

The probability of using the registration of design to protect innovation is positively influenced by the development of product innovation and innovation in methods of logistics, supply or distribution of raw materials, goods or services. It increases with the market share of the firm and if the market is competitive. Firms which choose this strategy have external R&D (and not internal) and belong to the consumer goods industry. They have a strong strategy to retain their employees, which is mainly based on fringe benefits, rather than higher wages.

The probability of using trademark as a means of protection is positively affected by the development of product and innovation in methods of logistics, supply or distribution of raw materials, goods or services, the belonging to a group and a strategy of fringe benefits. The probability increases when firms are large, have an important market share and there are few competitors. These firms perform external R&D activities. The probability of using trademark is negatively influenced by firms which belong to industry and which have process innovation. These results are only partly similar to Hanel (2008) who finds that trademark is more developed in competitive context. However, the criteria of using trademark could be different in Canada and Europe.

The probability of using copyright is positively influenced by the development of innovation in activities of support, the belonging to a group, the strategy of retaining employees thanks to higher wages and external R&D activities. It is surprising that it is also influenced by training in R&D whereas these firms are not characterized by R&D activities. That would confirm the importance of developing absorptive capacity (Cohen and Levinthal, 1989) when firms contract out their R&D. Firms which choose this strategy have a high market share, do not belong to industry and evolve in a competitive environment.

These results show that there are different strategies to explain the use of one type of means of protection. However, we note some similarities between legal means of protection (except patenting) on the one hand, and the other means of protection. These similarities are confirmed by the coefficients of correlation of the ρ coefficients. One surprising result is that patenting is not correlated to any non-statutory means of protection. It would mean that firms choose rather between legal and non-statutory protection and then among these two types, they choose the one which is more efficient according to their characteristics and the innovation they produce.

5.2 Results' discussion

5.2.1 The firm's characteristics

The size of the firms positively influences the decision to patent and to use trademark and negatively affects the decision to use complexity of design, lead-time advantage on competitors to protection innovation. That means that the size of the firms has an impact on the type of IP protection. Large firms prefer legal method of protection whereas small firms prefer other less formal types. This distinction could be linked to the cost of the protection. This result confirms previous studies (Cohen et al., 2000).

The results show that the R&D level has an impact on the choice of patenting and of using non-statutory means of protection. That could mean that the other forms of protection are more concerned by non-R&D innovation. This assumption is confirmed by the fact that the existence of R&D cooperations and subsidies influence in the same direction, the choice of the means of protection. Firms which use one legal protection means (except patent) seem to prefer to externalize their R&D. We can note that patenting and the use of trade secret are influenced both by internal and external R&D. The organization of R&D would thus partly explain the different strategies of protection.

The level of market share has an impact on the choice of each means of legal protection. The higher the market share, the more the firm tries to protect itself against imitation. Finally, belonging to a group positively influences the choice of a legal protection means, except the registration of design, confirming Hanel (2006). This result can be linked to the one concerning the size of firms and the market share. Large firms, with high market share and belonging to a group, prefer legal protection. Two reasons can explain these results. First the cost of legal protection could limit its access to small and independent firms. Secondly, large firms could need more legal means to protect themselves against competitors as they could be more confronted with counterfeit. It is important to note that the nationality of the group does not modify the results. However, the impact is generally reinforced when it is a foreign group.

The characteristics of the firms and more specifically the size, the group and the organisation of R&D influence the means of protection used.

5.2.2 The nature of innovation

The nature of innovation has a strong influence on the means of protection used, but it is not very discriminatory for product innovation. This latter could lead to the use of patent, trademark, complexity of design, lead-time advantage on competitors and registration of design. The possibilities of protection are then very large for product innovation. This result differs from previous studies, which consider that production innovation leads to more patenting. This can be linked to the fact that previous studies only compare patent versus secrecy. We note anyway that product innovation has no influence on secrecy. This can be an explanation of the difference between patent and secrecy strategy. The impact of the other innovations seems more specific. The innovation in production or manufacturing processes of goods or services leads only to the use of secrecy and lead-time advantage on competitors. This result can be explained by the nature of innovation which is easier to hide to competitor. These innovations strongly reduce the probability to use trademark. This result is not surprising as process innovation is less sold than other innovations. The innovation in methods of logistics, supply or distribution of raw materials, goods or services positively influences trademark and registration of design. The innovation in activities of support, like activities of maintenance or purchase, or accountancy affects the probability to use complexity of design and copyright. To conclude, the type of process innovations influences the method of protection. Product innovation can lead to almost every means of protection.

5.2.3 Strategy of retaining employees

One of our assumptions was to consider that human resources strategy influences the choice of intellectual property's protection means. To test this assumption we introduce different variables. The results are not as strong as we thought. Indeed, having a strategy that encourages employees to stay in the firm influences every means of protection except patenting. Can we conclude that it is a sign of a specific strategy as soon as innovation cannot be protected by patent? We obtain more significant results when we distinguish different types of action. Fringe benefits influence the use of legal protection, except copyright. But is it the sign of a specific human capital strategy or one aspect of the characteristics of the firm (size and market share)? More interesting is that higher wages positively influence the use of secret and copyright. When knowledge is strategic and protected by secret, firms could try to encourage their employees to stay as the means of protection do not allow legal pursuit against them in case they use or sell the knowledge protected by secret. Finally, training expenditure on R&D activities has a positive impact on copyright, complexity of design, lead-time advantage on competitors. That means that in these cases, firms are ready to invest on-the-job training, considering that employees would stay and that R&D needs to be reinforced. To conclude, we can say that human resource strategy could impact the choice of protection but the action used varies according to the type of protection. Fringe benefits explain legal protection, higher wages are rather linked with secret and copyright, R&D training influence non-statutory protection, except secret.

We confirm the importance of human resource strategy in the choice of means of protection (Roebben, 2005). Human resource strategy to retaining employees could be interpreted as the sign of trust inside firms. However, our results differ a little from those of Roebben (2005). He shows that investment in on-the-job training increases the use of secrecy while wages policy has no significant impact. The difference can be linked to the fact that our variables are not built in the same manner. Indeed, Roebben had the possibility to use expense in training, while we only have information on the organisation of training or not. Moreover, we test the correlation between different types of protection, which is not the case of Roebben (2005).

5.2.4 Market characteristics

Our results show that technology push situations increase the probability to use secrecy and complexity of design, and decrease the probability to use lead-time advantage and trademark. Market-pull innovation has little influence on the strategy of protection. It has only a negative impact on the probability to use complexity of design and lead-time advantage on competitors.

The number of competitors in the industry does not have any impact on the probability to use non-statutory protection means or patent. It positively influences the probability to use registration of design or copyright and negatively impacts the probability to use trademark. The structure of the market partly influences the choice of a means of protection.

Finally, we consider that sector-based specificities play an important role in the

choice of the type of protection. Indeed, the sector variables have a strong impact on the choice of protection. Thus, firms from intermediate goods industry have a higher probability to use secrecy and complexity of design. Firms specialized in services to consumers have a negative impact on the probability to use secrecy, complexity of design, lead-time advantage on competitors. Industrial firms have a higher probability to patent than service firms which do not use it. Firms from consumer goods industry have a strong influence on the probability to use registration of design. Finally, industrial firms negatively influence the probability to use trademark or copyright to protect innovation. We can wonder if these results can be explained by the nature of the activities and of the knowledge created in each sector, or by their different cultures. Further researches in this direction are needed.

6 Conclusion

The aim of this article was to go further in the knowledge of the choice of IP protection means by the firms. We were able to test seven means of protection. We use multivariate probit model in order to take into account the correlation between the equations, as firms can use different methods of protection. Our estimations test different types of variables to explain the strategy of IP protection, which had not been done before, according to our knowledge of the literature. Indeed, we test the impact of the nature of the innovation, firm's characteristics but also of the human resources strategy.

The main results of our study is that the choice of IP protection method can be explained by the nature of innovation, the strategy of gaining employees' loyalty, the size and market share of the firm, its R&D activities, its belonging to a group and its sector. The table **??** sums up each strategy and allow to identify the differences between the protection means. It appears that big firms with high market share, belonging to a group, use more legal IP protection. The organisation of R&D activities influences the type of IP protection. Non-statutory means of protection are particularly used for process innovation and when the innovation is pushed by technology (and not by market). There could have a will not to disclose information and thus keep advantage on competitors. Hence, the choice of a protection means is not neutral and results from a complex strategy.

Our study shows that the choice of IP protection depends on different factors In this context, public policy should take them into account to encourage all IP protection instead of focusing mainly on patenting. However, further research is needed to take into account other human resource strategies such as bonus or the level of the diploma. Moreover, it would be very interesting to have panel data to analyse the evolution of the firm IP strategy.

Table 1: Variables and data

Explained variables		
Secrecy	1 if the firm uses secrecy	CIS4
Complexity of design		
Lead-time advantage on competitors		
Patent		
Registration of design		
Trademark		
Copyright		
Firm's characteristics		
Internal R&D	Logarithm of the stock of intern R&D expenses	R&D survey 1986-2001
Size	Logarithm of the number of employees	EAE 2001
Part group	1 if the firm is part of a domestic group, 2 if the firm is part of a foreign group, 0 otherwise.	CIS4
Market shares	Logarithm of the share of the company's total sales on total sales of the industry.	EAE 2001
External R&D	Logarithm of the external R&D expenses	CIS4
Cooperation	1 if the firm has R&D cooperation	CIS4
Subsidies	1 if the firm receives R&D subsidies	CIS4
Nature of the innovation		
Product innovation	1 if the firm declares to have introduced a product (good or service) innovation, 0 otherwise	CIS4
Process innovation	1 if the firm declares to have introduced an innovation in production or manufacturing processes of goods or services, 0 otherwise	
Logistics innovation	1 if the firm declares to have introduced an innovation in methods of logistics, supply or distribution of	

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Table 1: Variables and data

	raw materials, goods or services, 0 otherwise	
Support innovation	1 if the firm declares to have introduced an innovation in activities of support, like activities of maintenance or purchase, of accountancy, 0 otherwise	
Strategy of fostering the employees' loyalty		
- Human resources strategy	1 if the firm implements a major strategy to encourage employees to stay in the firm	CIS4
- Fringe benefits	1 if the firm proposes higher fringes benefits than the average level in the sector (NAF36)	DADS
- Wages	1 if the firm proposes higher wages than the average level in the sector (NAF36)	DADS
Training in R&D	1 if the firm has internal or external training for its personnel, specifically for the development and/or introduction of innovations	CIS4
Market's characteristics		
Number of competitors	Logarithm of the number of competitors in the sector (NAF114)	EAE
Technology push	Situation of technology push is null = 0 Situation of technology push is weak = 1 Situation of technology push is moderate = 2 Situation of technology push is strong = 3	CIS4
Market pull	Situation of market pull is null = 0 Situation of market pull is weak = 1 Situation of market pull is moderate = 2 Situation of market pull is strong = 3	CIS4
Sector		
Consumer goods	1 if the firm belongs to the consumer goods sector	EAE

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Table 1: Variables and data

Car industry
machinery and equipment
Intermediate goods
Energy
Transport
Finance
Real estate business
Services to firms
Services to customers

Table 2: Summary statistics

Variable	Percentage
Product innovation	54.46
Process innovation	50.34
Logistic innovation	27.91
Support innovation	26.08
Fringe benefits	33.36
Wage	55.88
Human resources strategy	24.04
Market pull 0	27.15
Market pull 1	3.61
Market pull 2	16.24
Market pull 3	53.00
Technology pull 0	34.33
Technology pull 1	13.37
Technology pull 2	28.09
Technology pull 3	24.21
Cooperation	36.95
Independent firm	31.03
Domestic group	45.20
Foreign group	23.77
Subsidies	26.81
Training in R&D	49.71
Consumer goods	14.82
Car industry	4.05
Machinery and equipment	13.66
Intermediate goods	28.98
Energy	1.97
Transport	0.50
Finance	0.44
Real estate business	2.58
Services to firms	27.84
Services to customers	5.16

Source : Ministère de la Recherche, SESSI, DARES and INSEE.

Table 3: IPs by sector

Sector	Secrecy	Complexity of design	Lead-time advantage	Patent	Registration of design	Trademark	Copyright
Consumer goods	26.68	24.48	29.25	30.15	33.25	53.48	16.49
Car industry	33.02	27.36	41.98	46.23	30.19	30.19	7.72
Machinery and equipment	34.69	32.73	45.03	51.89	29.51	39.30	9.65
Intermediate goods	35.14	28.54	39.72	42.52	27.69	36.45	6.46
Energy	28.16	18.45	32.04	33.98	11.65	38.83	16.50
Transport	15.38	11.54	23.08	11.54	7.69	57.69	7.69
Finance	30.43	26.09	39.13	4.35	4.35	47.83	8.70
Real estate business	6.67	8.15	14.07	1.48	10.37	22.96	7.41
Services to firms	17.71	18.60	25.46	14.82	10.71	36.38	15.58
Services to customers	10.00	7.41	9.63	6.30	14.44	41.48	20.74

Source : Ministère de la Recherche, SESSI, DARES and INSEE.

Table 4: Descriptives statistics

Variable	Mean	Std err.	Min	Q_1	Q_2	Q_3	Max
R&D stock	64562.60	647521.60	0	0	0	402.32	2.34E07
Market share	2.68	7.69	0	0.106	0.419	1.779	100
Size	486.99	3564.37	0	44	105	344	125176
External R&D	602.15	8080.829	0	0	0	0	381046
Number of competitors	656.48	860.12	1	96	230	886	3860

*: Thousands of 2003 Euros.

Min: minimum, Q_1: first quartile, Q_2: median, Q_3: third quartile, Max: maximum.

Source : Ministère de la Recherche, SESSI, DARES and INSEE.

Table 5: Multivariate results

Variables	Secrecy	Complexity of design	Lead-time advantage	Patent	Registration of design	Trademark	Copyright	
Product innovation		0.000	0.163	0.122	0.200	0.151	0.267	0.054
		(0.061)	(0.062)	(0.060)	(0.065)	(0.063)	(0.061)	(0.073)
Process innovation		0.161	0.060	0.192	0.091	−0.017	−0.296	−0.031
		(0.052)	(0.052)	(0.051)	(0.055)	(0.053)	(0.052)	(0.064)
Logistic innovation		−0.034	0.009	0.031	0.089	0.196	0.174	−0.026
		(0.055)	(0.054)	(0.054)	(0.059)	(0.055)	(0.055)	(0.064)
Support innovation		0.083	0.114	0.042	−0.012	0.032	0.076	0.137
		(0.055)	(0.055)	(0.055)	(0.060)	(0.057)	(0.056)	(0.064)
Fringe benefits		−0.057	−0.122	−0.030	0.105	0.147	0.275	−0.022
		(0.048)	(0.048)	(0.047)	(0.051)	(0.048)	(0.048)	(0.057)
Wage		0.092	0.033	0.038	0.033	−0.143	−0.054	0.168
		(0.050)	(0.050)	(0.049)	(0.054)	(0.051)	(0.049)	(0.060)
Human resources strategy		0.152	0.150	0.115	−0.051	0.225	0.093	0.216
		(0.053)	(0.053)	(0.053)	(0.058)	(0.054)	(0.054)	(0.060)
R&D stock		0.014	0.020	0.017	0.044	−0.008	−0.004	−0.007
		(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)
Market share		0.006	0.005	0.011	0.023	0.041	0.031	0.036
		(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.012)
Size		−0.009	−0.094	−0.038	0.080	−0.001	0.048	0.005
		(0.023)	(0.023)	(0.022)	(0.024)	(0.023)	(0.022)	(0.025)
Market pull 0		ref.	ref.	ref.	ref.	ref.	ref.	ref.
Market pull 1		−0.113	−0.194	−0.466	0.219	−0.136	−0.127	0.065
		(0.153)	(0.153)	(0.151)	(0.158)	(0.153)	(0.149)	(0.177)
Market pull 2		−0.189	−0.406	−0.415	−0.120	−0.128	−0.045	−0.125
		(0.111)	(0.114)	(0.110)	(0.116)	(0.110)	(0.108)	(0.132)
Market pull 3		−0.094	−0.277	−0.306	−0.036	−0.179	−0.125	0.000
		(0.104)	(0.106)	(0.104)	(0.110)	(0.105)	(0.102)	(0.124)
Technology pull 0		ref.	ref.	ref.	ref.	ref.	ref.	ref.
Technology pull 1		0.130	0.120	0.337	0.012	0.032	−0.163	−0.315
		(0.094)	(0.097)	(0.094)	(0.098)	(0.094)	(0.092)	(0.117)
Technology pull 2		0.171	0.205	0.501	0.032	0.036	−0.174	−0.112
		(0.086)	(0.089)	(0.086)	(0.090)	(0.087)	(0.084)	(0.102)
Technology pull 3		0.187	0.383	0.739	0.129	−0.056	−0.128	−0.002
		(0.088)	(0.090)	(0.088)	(0.092)	(0.089)	(0.086)	(0.102)
Cooperation		0.233	0.170	0.214	0.094	−0.009	0.077	0.054
		(0.052)	(0.052)	(0.051)	(0.055)	(0.054)	(0.052)	(0.063)
Independent firm		ref.	ref.	ref.	ref.	ref.	ref.	ref.
Domestic group		0.028	0.040	−0.056	0.393	0.029	0.223	0.211
		(0.059)	(0.059)	(0.058)	(0.064)	(0.059)	(0.058)	(0.072)
Foreign group		0.092	0.034	−0.082	0.652	−0.064	0.160	0.268
		(0.069)	(0.069)	(0.068)	(0.074)	(0.070)	(0.068)	(0.084)
External R&D		0.040	0.012	−0.004	0.069	0.020	0.037	0.029
		(0.010)	(0.010)	(0.010)	(0.012)	(0.010)	(0.011)	(0.012)
Number of competitor		−0.038	−0.032	0.011	0.040	0.060	−0.064	0.076
		(0.029)	(0.029)	(0.029)	(0.031)	(0.030)	(0.029)	(0.035)
Subsidies		0.222	0.100	0.177	0.251	0.070	0.058	−0.033
		(0.054)	(0.054)	(0.053)	(0.058)	(0.055)	(0.055)	(0.068)
Training in R&D		0.013	0.174	0.127	−0.112	0.038	0.021	0.184
		(0.053)	(0.053)	(0.052)	(0.056)	(0.054)	(0.053)	(0.066)

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Table 5: Multivariate results

Variables	Secrecy	Complexity of design	Lead-time advantage	Patent	Registration of design	Trademark	Copyright	
Consumer goods		ref.	ref.	ref.	ref.	ref.	ref.	ref.
Car industry		0.141 (0.117)	0.061 (0.117)	0.345 (0.115)	0.516 (0.126)	−0.102 (0.117)	−0.857 (0.120)	−0.737 (0.178)
Machinery and equipment		0.076 (0.080)	0.118 (0.080)	0.328 (0.080)	0.458 (0.086)	−0.209 (0.079)	−0.696 (0.082)	−0.489 (0.097)
Intermediate goods		0.196 (0.069)	0.127 (0.069)	0.249 (0.068)	0.230 (0.071)	−0.241 (0.067)	−0.655 (0.070)	−0.678 (0.084)
Energy		0.047 (0.178)	−0.093 (0.181)	0.229 (0.175)	0.320 (0.194)	−0.792 (0.203)	−0.570 (0.183)	0.149 (0.197)
Transport		−0.118 (0.357)	−0.162 (0.362)	0.215 (0.318)	−0.649 (0.391)	−1.069 (0.415)	0.863 (0.493)	−0.503 (0.414)
Finance		0.286 (0.325)	0.112 (0.329)	0.331 (0.328)	−1.379 (0.565)	−1.655 (0.525)	0.091 (0.351)	−0.586 (0.408)
Real estate business		−0.447 (0.222)	−0.245 (0.213)	−0.073 (0.198)	−1.389 (0.352)	−0.682 (0.203)	−0.285 (0.192)	−0.359 (0.222)
Services to firms		−0.006 (0.096)	0.073 (0.096)	0.144 (0.095)	−0.353 (0.102)	−0.828 (0.097)	0.001 (0.096)	0.002 (0.105)
Services to customers		−0.320 (0.158)	−0.495 (0.165)	−0.577 (0.159)	−0.771 (0.177)	−0.649 (0.149)	0.423 (0.151)	0.262 (0.152)
Intercept		−0.617 (0.216)	−0.263 (0.217)	−0.785 (0.215)	−1.855 (0.232)	−0.685 (0.219)	0.448 (0.217)	−1.763 (0.257)
Number of observations		3547						
Log likelihood		-13522.89						
Wald Chi(224)		2585.30						
Prob > Chi2		0.00						

Standard errors are in brackets.

Table 6: Correlations between IPs strategies

	Secrecy	Complexity of design	Lead-time advantage	Patent	Registration of design	Trademark	Copyright
Secrecy	1						
Complexity of design	0.503 (0.021)	1					
Lead-time advantage	0.370 (0.024)	0.574 (0.020)	1				
Patent	−0.043 (0.028)	−0.079 (0.028)	0.030 (0.028)	1			
Registration of design	−0.037 (0.0271)	−0.029 (0.027)	−0.058 (0.026)	0.279 (0.027)	1		
Trademark	−0.098 (0.026)	−0.158 (0.026)	−0.184 (0.025)	0.125 (0.027)	0.298 (0.025)	1	
Copyright	0.079 (0.032)	0.088 (0.035)	0.405 (0.032)	0.064 (0.064)	0.246 (0.030)	0.251 (0.031)	1

Standard errors are in brackets.

Table 7: Main characteristics of each strategy of IP protection

Secrecy	Complexity of design	Lead-time advantage	Patent	Registration of design	Trademark	Copyright
Process innovation	Product innovation and innovation for support activities	Product and process innovation	Product innovation	Product and logistic innovation	Product and logistic innovation	Support innovation
Human resources strategy	Human resources strategy (training in R&D)	Human resources strategy (training in R&D)		Human resources strategy		Human resources strategy (wage training in R&D)
	Small firms		Group Size Market share	Market share	Market share	Market share
Technology push	Technology push	Technology push				
R&D activities (intern, extern, cooperation, subsidies)	R&D activities (intern, extern, cooperation, subsidies)	R&D activities (intern, extern, cooperation, subsidies)	R&D activities (intern, extern, subsidies)		R&D activities (extern)	R&D activities (extern)
Intermediary goods	Intermediary goods	Industry firms	Industry firms	Competition Consumer goods	No competition Service to customers	Competition