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**Patents against imitators:  
an empirical investigation on French data**

Emmanuel COMBE

Etienne PFISTER

2000.01

# Patents against imitators : an empirical investigation on French data<sup>#</sup>

Emmanuel Combe & Etienne Pfister\*

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\* Emmanuel Combe est Professeur à l’Université du Havre et membre du TEAM. Etienne Pfister est doctorant au TEAM

*Abstract:*

This paper is an empirical study of the effectiveness of patents against imitators based on French survey data. We use a multinomial ordered logit and regress patent effectiveness on qualitative and quantitative variables. We find that patent costs are not a significant limitation on patent effectiveness while patent disclosure is. We also find a positive threshold effect for size. Finally, we observe many differences between the determinants of the effectiveness of product and process patents; in particular, the former is more dependant on R&D intensity and first-mover advantage while the latter is more dependent on market share, advertisement intensity and on the presence of an internal department in charge of intellectual property rights.

Keywords: Appropriation survey, innovation, patent, imitation.

*Résumé:*

Cet article est une étude empirique de l'efficacité des brevets contre les imitateurs s'appuyant sur des données d'enquête françaises. Nous régressons l'efficacité du brevet sur différentes variables qualitatives et quantitatives dans un logit multinomial ordonné. Nos résultats indiquent que les différents coûts liés au brevet (dépôt, renouvellement, défense) ne constituent pas un obstacle significatif à son efficacité; la divulgation de l'innovation induite par le brevet semble une limite plus importante. Nous observons également un effet seuil au niveau du rôle de la taille des firmes. Enfin, nous constatons que les déterminants de l'efficacité des brevets sont différents selon que l'innovation est de produit ou de procédé; dans le premiers cas, l'intensité en R&D et les avantages de premier entrant jouent un rôle plus important; dans le second cas, la part de marché, les dépenses de publicité et la présence d'un département juridique interne sont plus significatifs.

Mots-clef: Enquête Appropriation, innovation, brevet, imitation.

Classification JEL : C35 L10 L60 032 034

## I. INTRODUCTION

Patents are defined as institutional tools designed to enhance the appropriation of the returns to an innovation by the innovator. By granting the innovator a supposed monopoly over the right to use and/or to sell his innovation (in exchange for the disclosure of the innovation which should reduce the risk of costly duplicative R&D efforts as well promote cumulative innovations), the patent prevents other firms, be them competitors or not, from free-riding on the innovation. The profits from innovation are thus increased and so are the incentives to innovate.

The flaw with such theoretical exposition is that patent protection against imitators is rated as imperfect in many empirical studies. Indeed, apart from a few industries, such as pharmaceuticals, where patents are held to be crucial tools of innovation appropriation, patents are often ranked to be among the least effective of all available appropriation strategies (Levin & al. [1987], Cohen & al. [1997], Combe & Pfister [1999]). While theoretical models have many alternative explanations, why patents are deemed imperfect appropriation tools by firms has rarely been studied in an econometric setting.

In this paper we attempt to determine the effect of selected variables on product and process patent effectiveness in the French manufacturing industry. The data used in this study are from two sources: first, a survey made by the Statistical Department of the French Ministry of Industry (SESSI) is used to gather qualitative information on patents and other appropriation tools' effectiveness as well as on patent limitations; then these data are recouped with quantitative information about the responding firms. These latter data include turnover, R&D investment, advertisement intensity and market share and are also extracted from a SESSI database.

Using an appropriate ordered logit specification, our results tend to deny the importance for patent effectiveness of deposit, renewal and enforcement costs of patents. Instead, the disclosure induced by patents is the only significant limitation to patent effectiveness. We also find evidence of a threshold effect for size. When small firms are included in the sample, size exerts a significant positive influence on patent effectiveness; this effect disappears when only large, patenting and R&D investing firms remain in the

sample. Finally, we observe many differences between process and product patent effectiveness: in the former case, advertisement intensity, market share and legal competence are important factors; in the latter case, strategies based on frequent innovation or on first mover advantage are very complementary to patent effectiveness. The rest of the paper is organised as follows. Section 2 presents a brief survey of the previous literature on that subject. Section 3 describes the sample and our variables. Section 4 proceeds with our empirical finding while section 5 concludes.

## II. PREVIOUS LITERATURE

Studies on the effectiveness of patents in deterring imitators start with the early work of Scherer & al. [1959], which indicated that U.S. patent protection is important only in a few industries such as pharmaceuticals. Taylor & Silberston [1973] draw a similar conclusion from their UK study. And consistently with these early works, Mansfield [1986] showed that the pharmaceutical industry was almost the sole sector where the absence of patent protection would clearly be an important blow to innovative efforts. These studies are based on survey data upon R&D and firm managers. So do more recent works such as Levin and al. [1987], Cohen and al. [1997], Brouwer and Kleinknecht [1998] and Combe and Pfister [1999], that however include many more information on patent imperfection.

In these later studies, the inclusion of alternative appropriation mechanisms in the surveys allows to measure the relative effectiveness of patents<sup>1</sup>. Patents are never considered the best of the proposed appropriation mechanisms: in particular, they often rank behind strategies based on first mover-advantages, secrecy or qualified people retention. They are also rated less effective for process than for product innovation. Although never tested, the most common explanation to this result is that the disclosure

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<sup>1</sup> Levin and al. use “patents to secure royalty income” (as opposed to “patents to prevent duplication”), “secrecy”, “lead-time”, “moving quickly down the learning curve” and “sales and service efforts”. Cohen and al. use “secrecy”, “lead-time”, “complementary sales efforts”, “complementary manufacturing efforts” and “product/process complexity”. In their study on Dutch firms, Brouwer and Kleinknecht use “secrecy”, “time lead on competitors”, “keeping qualified people in the firm”, “process/product complexity”, “copyright and related laws”, “certification and normalisation”. Finally, Combe and Pfister use secrecy, first mover advantage, product/process complexity, secrecy and frequent

of the innovation implied by patents is more detrimental for process innovation (that can remain in the factory) than for product innovations that are commercialised and easily accessible. Finally, patent effectiveness varies greatly across industries; it reaches its maximum in the drug industry and is lowest in textiles and in the printing industry.

These results on the ineffectiveness of patent protection against imitations can be linked with the studies on patent propensities<sup>2</sup> (see Brouwer and Kleinknecht [1998], Duguet and Kabla [1997] or Arundel and Kabla [1998] for recent examples). All of these agree with the important role of secrecy and other means of appropriation, since a fair share of patentable innovations do not get patented<sup>3</sup>. Patent propensity is generally higher for product innovations than for process innovations and varies highly across industries, with the drug industry systematically displaying a high rate. Arundel and Kabla [1998], Cohen and al. [1997] and Mansfield [1986] show that the propensity to patent is positively related to the effectiveness of patents against imitations (as rated by the respondents).

Theoretical models have developed many alternative explanations for patent ineffectiveness against imitators. Scotchmer and Green [1990], Choi [1991] and Harter [1994] insist on the disclosure effect of patents<sup>4</sup>. Alternatively, Lerner [1995] and Lanjouw and Lerner [1996, 1997] give theoretical and empirical evidence of the role of enforcement costs in reducing patent effectiveness. In particular, small firms may find the patents too costly to enforce. This fits well with much survey data (Koen [1991], Berger Consultants [1994], Cohen & al. [1997], Combe & Pfister [1999]) as well as with patent propensity studies that often find a positive link between size and patent propensity (Brouwer and Kleinknecht [1998], Arundel and Kabla [1998]). However, contradictory results are obtained by Duguet and Kabla [1997] and Pfister [1999]: the first study concludes that patent propensity is correlated neither with sales nor deposit and enforcement costs; in the second work, it is shown that the enforcement of trademarks,

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innovations.

<sup>2</sup> Patent propensity is defined here as the percentage of innovations of a firm that gets patented. See Arundel & Kabla [1998] for a development on the other definitions of patent propensities.

<sup>3</sup> Arundel & Kabla find a patent propensity rate of 36 % for product innovations and of 25 % for process innovations. Lerner [1994] finds that trade secrecy disputes represent 43 % of intellectual property litigation (on a sample of 530 firms and over four and half years).

<sup>4</sup> Disclosure of the innovation in the patent is compulsory in most patent systems.

whose process is very similar to that of patents, is independent from size or from financial strength.

Survey data also insist on the breadth of patent protection. High scope of patent protection makes imitations illegal, and this may be a sufficient deterrent to imitation. However, more often than not, firms are unsatisfied (or so they say) with the scope of their patents and complain that their innovations can be imitated around too easily (Levin and al. [1987], Cohen and al. [1997], Combe and Pfister [1999]). Alternatively, theoretical models such as Van Dijk [1996] demonstrate how high patent scope can adversely affect the innovator position in technological races. Finally, Horstman and al. [1985] and Crampes and Langinier [1998] show that firms may decide not to patent their innovations in order not to reveal any information on the profits from imitation.

### III. SAMPLE AND VARIABLES

Realised in 1993, the SESSI “appropriation survey” regroups qualitative information on 1797 French firms. It was sent to a representative sample of French manufacturing firms. Leaving out non-innovative firms leads to a sample of 1000 innovative firms. Non-innovative firms were taken out from the sample both because the reliability of their answers was questionable and because we expect them to have only scant knowledge about the patent system and other appropriation strategies. The sample of 1000 firms will then be subsequently diminished because of non-responses to particular sets of questions. Answers to the appropriation survey are analysed in Combe and Pfister [1999].

We first merged our sample of innovative firms from the SESSI survey with the 1993 EAE database (SESSI) and got a sample of 950 firms. Annual 1993 sales in our sample vary from 6 882 000 FF to 183 585 598 000 FF with an average of 1 321 523 220 FF. Employment varies from 20 employees to 118 575, with an average of 1011<sup>5</sup>. The EAE database also enables us to compute the advertisement intensity and the market share at a

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<sup>5</sup> Compared to the American survey data, the average firm in our sample is of a smaller size than that in the Cohen and al [1997] sample (mean sales of \$4,44 billion and mean number of employees of 21 817). It is also smaller than the average firm in the Levin & al [1987] survey, but it is likely to be larger than that in the Brouwer & Kleinknecht [1999] study, which comprises firms with less than 20 employees.



three digit level. Finally, we use the Research database from the Education and Technology Ministry to gather quantitative information on R&D investments.

Our sample includes innovative firms only , but it also comprises firms that never patented an innovation. We thought important to include this type of firm because, justified or not, a major concern for policy-makers since the emergence of the so-called knowledge-based economy has been to increase the effectiveness of patents and especially to entice more firms into using this particular device. It would be a pity to bypass the firms that find patents so ineffective that they never used them. Accordingly, we regress our model on two samples. Sample 1 (average 1993 turnover: 1 084 629 020 FF) includes all data but R&D related information and internal IPP departments for both patenting and non-patenting firms. Sample 2 (average 1993 turnover: 2 432 804 800 FF) only deals with patenting firms and adds R&D related information and internal IPP departments.

We use these data to measure to measure the determinants of process and product patent effectiveness. These are ordered polytomic variables, ranging from 0 (very low effectiveness) to 4 (high effectiveness) and taken from the SESSI Appropriation survey. As such, they reflect subjective judgements and memory of the managers. However, using similar data, Duguet & Kabla [1997] find a strong positive correlation between the measure of patent effectiveness and that of patent propensity, thus demonstrating the relative consistency of the survey answers. We try to alleviate this problem by recouping our qualitative variables with quantitative data and by grouping some of the modalities together in unreported regressions<sup>6</sup>.

Nine explanatory variables and fifteen industry dummies are included in the model. These are listed in Table I with a brief description of each. In the text that follows, we summarise the reasons for including these variables as well as the rationale behind any expected effect.

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<sup>6</sup> That is, instead of using the five modalities separately, we group some of them (0-1; 2-3; 4; or 0; 1-2-3;4; and so on...). Unreported regressions show that the results are only marginally affected.

TABLE I  
LIST OF EXPLANATORY VARIABLES

<i>Variable Name</i>	<i>Definition</i>
<i>SEC</i>	Binary variable that takes a value of unity if secrecy is a very effective strategy to deter imitators (rating=4) and 0 otherwise (SESSI Appropriation survey)
<i>COM</i>	Binary variable that takes a value of unity if product/process complexity is a very effective strategy to deter imitators (rating=4) and 0 otherwise (id.)
<i>FRI</i>	Binary variable that takes a value of unity if strategies based on frequent innovations are very effective to deter imitators (rating=4) and 0 otherwise (id.)
<i>FMA</i>	Binary variable that takes a value of unity if strategies based on first mover advantage are very effective to deter imitators (rating=4) and 0 otherwise (id.)
<i>DCO</i>	Binary variable that takes a value of unity if patent deposit and renewal costs are an important obstacle to patent effectiveness (rating=4) and 0 otherwise (id.)
<i>ECO</i>	Binary variable that takes a value of unity if patent enforcement costs are an important obstacle to patent effectiveness (rating=4) and 0 otherwise (id.)
<i>DIS</i>	Binary variable that takes a value of unity if patent disclosure is an important obstacle to patent effectiveness (rating=4) and 0 otherwise (id.)
<i>DEP</i>	Binary variable that takes the value of 1 if the firm owns a department in charge of intellectual property rights and 0 otherwise (id.)
<i>SAL</i>	Log of mean sales (1990-1992) (SESSI EAE database)
<i>MSH</i>	Average market share (1990-1992) at the four digit level (id.)
<i>ADV</i>	Mean advertisement expenditures/sales ratio (1990-1992) (id.)
<i>RDS</i>	Mean R&D investment/sales ratio (1990-1992) (SESSI EAE database and Research survey)
<i>INI;..., IN15</i>	Industry-specific effects, controlled by dummy variables equal to 1 if the firm belongs to one of the 15 two-digit industries, and 0 otherwise.

Note: detailed statistic description in Combe and Pfister (1999) or available from the authors.  
Data on intellectual property rights departments and on R&D was available only for the subsample of patenting firms.  
Except for *DEP*, binary variables are originally ordered qualitative variable described on 5 modalities (from zero to four). The classification we made is optional and we give in the text more details about the results with alternative specifications.

The effectiveness of alternative appropriation tool (*SEC, COM, FRI, FMA*) captures possible interactions between patent effectiveness and these appropriation strategies. Cohen & al. [1997] find evidence that firms use the different appropriation strategies complement each other. Arora [1997] notices that in the chemical industry, patents and secrecy are simultaneously used : some components of the patented innovation are published in the patent while others are kept secret. More generally, these alternative appropriation tools render imitation more difficult (*COM*) or less profitable (*FRI, FMA*), thus increasing patent efficiency.

Patent limitations are divided into three variables (*DCO, ECO* and *DIS*) to measure the empirical relevance of models based respectively on patent costs or on patent disclosure. So far, empirical evidence has supported the former type of limitation [Lanjouw and Lerner, 1997]. However, deposit and enforcement costs are often proxied by size - a rather rough proxy at best. Moreover, while most studies are based on the American case, Combe & Pfister [1999] find survey evidence that the enforcement of intellectual property rights is particularly costly in the United States and Pfister [1999] finds no correlation between either size or financial strength and the enforcement of trademarks. Finally, Duguet & Kabla [1997] show that patent deposit and enforcement costs do not seem to play any role on the patent propensity of French firms.

The presence inside the firm of a department in charge with intellectual property rights (*DEP*) reflects many potential effects. On one hand, these type of firms are likely to have more legal experience than others; their litigation costs are likely to be lower [Lerner, 1995]. On the other hand, firms that have such a department are more likely to own a department in charge with detecting the imitations, which is crucial in explaining the enforcement of trademarks [Pfister, 1999]. Because of the structure of the survey, only patenting firms were asked to answer this question.

Coming to quantitative variables, we measure the size of the firm by its sales (*SAL*). Following contradictory previous results on the link between sales and patent propensity (see Duguet & Kabla [1997] or Brouwer & Kleinknecht [1998] or Lerner [1994]), our aim here is to bring new evidence on the link between sales and patent effectiveness. Indeed, size can be an essential determinant of patent effectiveness: thanks to their financial capacities, large firms shall be better able to enforce their patents through trials.

In the case of trademark, Pfister [1999] presents evidence that size is major determinant of whether the imitations can be easily detected. Last, large firms may deter imitation more easily thanks to their higher competitiveness. Conversely, the innovations of large firms are disseminated more broadly than those of small firms and thus face a higher risk of imitation.

Similarly, firms with a high market share (*MSH*) may be better able to deter imitation since imitators may simply fear to compete with these firms; market share may also be a crucial determinant in the effectiveness of lead-time strategies; and last, firms with high market share have a higher incentive to sue their infringers since the profit loss that is incurred is higher than for small firms; however, as for size, firms with large market share run the risk of being imitated more often than others because their innovations are better disseminated across the industry and thus get more coverage.

Advertisement expenses (*ADV*) can serve as a barrier to entry, as demonstrated by Bunch and Smiley [1992] and by Thomas [1999] for the ready-to-eat cereal industry. On the other hand, innovations that are strongly advertised may be more imitated because of the high demand these advertisement expenditures generate.

We introduce the average R&D investment /sales ratio (*RDS*). Firms with high R&D intensity may have higher mean score for patent effectiveness because they have experience in dealing with patent mechanisms or because they can credibly threaten to introduce further innovations ; they also have an incentive to create themselves a reputation of toughness in patent enforcement ; conversely, firms with high R&D intensity innovate more and thus may be more imitated than others. Unfortunately, the available data on R&D is limited, so that we could only use them for the sub-sample of patenting firms.

Finally, to capture sector-specific effects, we use fifteen industry dummies (*INDi*) at the two digit level. In particular, we wish to test whether the consistently higher patent effectiveness in the pharmaceutical industry is specifically linked to that industry or to the characteristics (high R&D intensity) of the pharmaceutical firms.

### III. EMPIRICAL FINDINGS

Table II and table III report the maximum likelihood estimates of the parameters of the logit model for product and process patent effectiveness respectively.

TABLE II  
ORDERED LOGIT REGRESSIONS – PRODUCT PATENTS

Variables	Overall sample				Patenting firms only			
	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)
<i>SAL</i>	0.241* (4.847)	0.223* (4.425)	0.228* (4.434)	0.177* (3.203)	0.167* (1.997)	-0.059 (0.556)	-0.074 (0.684)	-0.051 (0.435)
<i>ADV</i>	0.074* (2.048)	0.059 (1.629)	0.062** (1.763)	0.069 (1.614)	0.147* (2.153)	0.159* (2.027)	0.178* (2.217)	0.138 (1.119)
<i>MSH</i>	0.002 (0.304)	0.002 (0.258)	0.001 (0.242)	0.066 (1.041)	0.004 (0.583)	0.007 (0.873)	0.008 (0.981)	0.011 (1.297)
<i>RDS</i>					0.019 (1.433)	0.042* (2.422)	0.040* (2.316)	0.038** (1.946)
<i>SEC</i>		-0.640* (4.277)	-0.459* (2.989)	-0.583* (3.675)		-0.638* (2.258)	-0.491** (1.689)	-0.498 (1.598)
<i>COM</i>		0.666* (3.372)	0.649* (3.261)	0.632* (3.102)		0.253 (0.739)	0.217 (0.633)	0.483 (1.329)
<i>FRI</i>		-0.552** (1.796)	-0.526** (1.692)	-0.281 (0.884)		1.888 (1.596)	1.754 (1.461)	2.414** (1.916)
<i>FMA</i>		0.385* (2.574)	0.409* (2.705)	0.411* (2.684)		0.870* (2.936)	0.983* (3.247)	1.146* (3.515)
<i>DCO</i>			0.338** (1.664)	0.265 (1.277)			-0.056 (0.129)	-0.040 (0.084)
<i>ECO</i>			-0.094 (0.442)	0.002 (0.011)			0.038 (0.086)	0.158 (0.339)
<i>DIS</i>			-0.937* (5.237)	-0.906* (4.920)			-0.974* (2.426)	-1.232* (2.885)
<i>DEP</i>						-0.199 (0.687)	-0.098 (0.331)	-0.440 (1.374)
<i>IND</i>	No	No	No	Yes	No	No	No	Yes
Chi-2	47.32 p<10 <sup>-4</sup>	80.98 p<10 <sup>-4</sup>	110.35 p<10 <sup>-4</sup>	175.80 p<10 <sup>-4</sup>	15.61 p<0.004	31.21 p<3.10 <sup>-4</sup>	37.27 p<2.10 <sup>-4</sup>	74.45 p<10 <sup>-4</sup>
N	877	877	877	877	266	266	266	266

Dependent variable: patent effectiveness, ranging from zero to four.

Independent variables are described in table I.

a: quantitative variables only, no industry dummies;

b: quantitative variables and alternative appropriation strategies, no industry dummies;

c: quantitative variables, alternative appropriation strategies and patent limitations, no industry dummies;

d: quantitative variables, alternative appropriation strategies, patent limitations and industry dummies.

For the overall sample, significant industry dummies are the pharmaceutical dummy (+) and the textile dummy (-). For the patenting firms' sample, the industry specific effects are stronger, but the drug industry remains a very specific case. The sea, air and train construction industry is used as the reference.

TABLE III  
LOGIT REGRESSIONS – PROCESS PATENTS

<i>Variables</i>	Overall sample				Patenting firms only			
	(a)	(b)	(c)	(d)	(a)	(b)	(c)	(d)
<i>SAL</i>	0.187* (3.712)	0.192* (3.747)	0.186* (3.589)	0.158* (2.834)	0.131 (1.564)	-0.091 (0.874)	-0.102 (0.953)	-0.073 (0.617)
<i>ADV</i>	0.124* (3.380)	0.118* (3.187)	0.117* (3.147)	0.186* (3.966)	0.052 (0.787)	0.043 (0.650)	0.062 (0.923)	0.147 (1.202)
<i>MSH</i>	0.012* (2.106)	0.012* (2.052)	0.012* (2.079)	0.016* (2.678)	0.017* (2.415)	0.020* (2.647)	0.021* (2.744)	0.023* (2.663)
<i>RDS</i>					0.013 (1.213)	0.019 (1.524)	0.019 (1.523)	0.018 (1.227)
<i>SEC</i>		-0.635* (4.494)	-0.586* (4.093)	-0.619* (4.218)		-0.821* (3.227)	-0.751* (2.911)	-0.789* (2.928)
<i>COM</i>		0.361* (2.036)	0.371* (2.085)	0.355** (1.952)		0.242 (0.796)	0.232 (0.759)	0.214 (0.673)
<i>FRI</i>		0.227 (0.538)	0.247 (0.587)	0.361 (0.838)		1.141 (1.536)	1.138 (1.527)	1.334** (0.766)
<i>FMA</i>		0.430* (2.265)	0.449* (2.352)	0.476* (2.453)		0.526 (1.240)	0.568 (1.328)	0.589 (1.332)
<i>DCO</i>			-0.065 (0.276)	-0.082 (0.344)			-0.325 (0.656)	-0.596 (1.151)
<i>ECO</i>			0.101 (0.447)	0.121 (0.531)			0.383 (0.894)	0.583 (1.303)
<i>DIS</i>			-0.419* (2.334)	-0.362* (1.967)			-0.595 (1.565)	-0.385 (0.975)
<i>DEP</i>						0.674* (2.197)	0.738* (2.356)	0.687* (2.061)
<i>IND</i>	No	No	No	Yes	No	No	No	Yes
<i>Chi-2</i>	55.83 p<10 <sup>-4</sup>	80.64 p<10 <sup>-4</sup>	86.37 p<10 <sup>-4</sup>	124.52 p<10 <sup>-4</sup>	20.98 p<3.10 <sup>-4</sup>	32.83 p<10 <sup>-4</sup>	36.27 p<3.10 <sup>-4</sup>	55.61 p<4.10 <sup>-4</sup>
<i>N</i>	778	778	778	778	276	233	233	233

Dependent variable: patent effectiveness, ranging from zero to four.

Independent variables are described in table I.

a: quantitative variables only, no industry dummies;

b: quantitative variables and alternative appropriation strategies, no industry dummies;

c: quantitative variables, alternative appropriation strategies and patent limitations, no industry dummies;

d: quantitative variables, alternative appropriation strategies, patent limitations and industry dummies.

For the overall sample, the significant industry dummies are the drug industry (+) and the soap, perfumes and cleaning industry (-). For the patenting firms' sample, significant industry dummies include the car industry dummy and the mineral products industry. The pharmaceutical industry dummy is no longer significant.

The equations a, b and c do not control for industry effects. Therefore, we use them as a comparison to infer the biases that are likely to arise when these effects are omitted.

The coefficient of size (*SAL*) is positive and significant for both product and process patents effectiveness when the sample comprises patenting and non-patenting firms. It is no longer significant when we omit non-patenting firms. It remains significant though when we include various measures of patent limitations and industry-specific effects. This result tend to prove the existence of a threshold effect in size for patent effectiveness: size exerts a positive influence on patent effectiveness, but only with relatively small firms.

The influence of advertisement intensity (*ADV*) is more ambiguous because it is more fragile and dependent on the type of innovation. For product patents, the influence is positive but it is nor robust to the inclusion of industry specific effects or to the inclusion of first mover advantage. It is positive and more robust for process patents; however, it is no longer significant when only patenting firms are included.

The dichotomy between product and process patents is even more striking for the influence of market share (*MSH*). The coefficients are robust and positive for process patents, but largely insignificant for product patents. This result is another explanation of the prevalence of large firms in process innovations: Cohen & Klepper [1996] had identified process innovations with large firms because thanks to their large production volumes, these firms reap higher profits from a given process innovation than small firms. Here, our findings show that market share is also a crucial component of the appropriation of process innovation.

Finally, the dichotomy between process and product innovations is visible through the effects of R&D intensity (*RDS*). The coefficient is positive and significant for product innovations, while non-significant for process innovation. These results are robust to alternative specifications of our model.

Coming to the coefficients of the qualitative variables, we shall note that they come in support of the above dichotomy between product and process patents.

Unsurprisingly, secrecy (*SEC*) appears to be more substitute than complementary to patents, slightly more so for process patents (since process innovations can more easily be kept secret than product innovations)<sup>7</sup>.

Product and process complexity (*COM*) are positively related to patent effectiveness for the overall sample, but not so when non-patenting firms are excluded from the sample. This is all the more surprising that even low ratings in product or process complexity seem to have a positive and significant effect on patent effectiveness.

Strategies based on frequent innovations are complementary (*FRI*) to patent effectiveness for product innovation not for process innovation. It is only significant for large firms, not for the overall sample – it can even be negative, showing that high pace of innovations may diminish patent effectiveness (probably because other firms can more easily invent around the patent). This complements our results for R&D intensity.

Strategies based on first mover advantage (*FMA*) are complementary to patent effectiveness, but the effect is more robust for product innovation than for process innovations: the coefficient is no longer significant when non-patenting firms are excluded.

Finally, we can observe that the existence of a department in charge with intellectual property rights (*DEP*) is complementary to patent effectiveness for process innovations, but it is insignificant for product innovations. The most reasonable explanation for this dichotomy is that imitations are less easily detected and prosecuted when they consist in process imitations.

Coming to patent limitations, our results are straightforward. First, patent costs, whether deposit and renewal costs or enforcement costs (*DCO* and *ECO*), are never significant in explaining patent effectiveness. This contrasts with the view taken by many empirical studies based on American data (see Lanjouw and Lerner [1997]), but it is consistent with the patent propensity study conducted by Duguet & Kabla [1997] on similar data or with the results of Pfister [1999] on French trademarks. We may explain these differences between French and American studies on the costs allocation rule (since

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<sup>7</sup> This effect arises even with low (2) secrecy ratings and gets stronger as the secrecy effectiveness increases.



in France, the losing party endorses all the administrative costs of the legal process while in the US each party endorses its own costs). Combe & Pfister [1999] also provide survey data on higher enforcement costs in the United States than in anywhere else in the world (these higher costs are matched by higher rewards and damages).

Second, our findings highlight the role of patent disclosure as a major limitation of the private effectiveness of patents<sup>8</sup>. Disclosure has often been embedded in theoretical settings, but it has rarely been discussed empirically. This results provides interesting research perspectives for the design of optimal patents. Indeed, while patent length, breadth and height have been extensively looked at, the effects of disclosure on the incentive to innovate and on dynamic efficiency have rarely been integrated in models of optimal patents (Matutes & al., 1996 excepted).

In unreported regressions, we test further the robustness of our results by performing several alternative econometric specification. We replace the mean sales level (*SAL*) with the mean number of employees or with the mean level of internal financial capacities, both taken from the EAE database. This did not alter our results.

We also replaced our R&D intensity variable with the absolute level of R&D investment (log, taken from the “Research” dataset-SESSI); the only significant difference was that R&D was no longer significant in the product patent effectiveness equation. That R&D is not significant contrasts with the results of Duguet & Kabla [1997], who had found a positive relationship between R&D and patent propensity. Here, our results support the view that this positive effect is mainly due to the novelty requirements: firms with high R&D budgets make innovations that are more innovative and thus more patentable. Instead, our results show that what matters is R&D intensity.

In other unreported regressions, we also omitted all the qualitative variables based on alternative appropriation strategies. This did not change our results<sup>9</sup>. In another set, we excluded all quantitative variables but our results stayed robust.

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<sup>8</sup> Only high or very high ratings for disclosure will have a (negative) significant effect on patent effectiveness.

<sup>9</sup> Only in equation (product patent/overall sample), we did observe a significant (at the 10 % level) and positive effect for the deposit and renewal costs variable, a result similar to equation 1c for product patents (see table II) and that can be explained in the following terms: firms that find patent effective are

We also conducted our tests on a sample composed of only the high innovation opportunities industries. Following Pavitt's [1984] classification, we omit the so-called 'supplier-dominated' industries (associated with low innovation opportunity) and focus instead on the 'science based', 'scale intensive' and 'specialised suppliers' industries (those being associated with high innovation opportunity industries)<sup>10</sup>. For product patents, we could notice that for the overall sample advertising intensity was positively and significantly linked to product patent effectiveness even when industry specific effects were accounted for. Another modification was the disappearing of the positive influence of strategies based on frequent innovations. All other results were left unchanged. We also did a more stringent selection of high innovation opportunities industries<sup>11</sup>. Again, for product innovations, we observe that advertising intensity seems more important than for low opportunity industries, while the role and significance of R&D intensity and strategies based on frequent innovation is lowered (in the latter case, it may even get negative). Results for process are only marginally affected: for the overall sample, disclosure and process complexity are no longer significant; results for the patenting firm sample are left unchanged.

Finally, we modified our dependent variable to account for its subjectivity. More precisely, we grouped the intermediate modalities of the patent effectiveness ratings while leaving the extreme modalities intact. With a few exceptions<sup>12</sup>, results were unaltered.

#### IV. CONCLUSION

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more likely than others to deposit patents and to renew them for a long time; hence, these firms may be more sensitive to patent deposit and renewal costs. This possible simultaneity problem is also visible when one looks at the coefficients of the qualitative variables when all their five modalities are accounted for.

<sup>10</sup> The latter group thus includes drugs, soaps and perfumes, household equipment, cars, transportation construction, mechanical equipment, electric and electronics equipment mineral products, chemicals and plastics, steel, electric and electronic components and combustibles.

<sup>11</sup> This selection is based on Brouwer & Kleinknecht [1999]. High opportunity industries include drugs, cars, mechanical equipment, electric and electronic equipment, chemicals and plastics, electric and electronic components.

<sup>12</sup> Advertising intensity was positive and significant for product patent effectiveness (patenting firms only). Complexity was no longer significant for process patent effectiveness (overall sample).

This paper sought to extend our knowledge on patent effectiveness against imitation by using Yale survey data in a logit specification. To this end, we have combined both qualitative and quantitative data to assess the empirical relevance of various firm-level variables. Our results yield several interesting features.

Size (measured by sales, financial strength or number of employees) exerts a positive influence on patent effectiveness when non-patenting firms are included in the sample; it does not when the sample consists only in patenting firms; given that the average firm size is lower in the overall sample, this could mean that there is a threshold effect on the influence of size on patent effectiveness.

This size effect is unrelated to cost-related reasons of patent limitations, such as deposit and renewal costs and/or litigation costs; neither of these turns out to be a significant limitation of patent effectiveness; in other words, reducing patent costs will not result in higher patent effectiveness against imitation and neither will it induce higher R&D investment; instead, the only significant patent limitation is patent disclosure.

Finally, we observe that the effectiveness of product patents is sensibly different from that of process patents. More precisely, secrecy is more of a substitute for process patents than for product patents; conversely, patent disclosure exerts a higher (negative) influence for product patents than for process patents. Advertisement intensity and market share are more important for process patents than for product patents while the opposite holds for first-mover advantage and for strategies based on frequent innovations; one also observes that advertising intensity plays a greater role for product patent effectiveness in the case high innovation opportunities industries than for low opportunity industries. Last, departments in charge with managing the industrial property rights portfolio exert a strong positive role for process patents, not for product patents.

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