# Are Trade Marks and Patents Complementary or Substitute Protections for Innovation?

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**Abstract**

The benefits of product innovations for firms strongly depend on their ability to develop complementary appropriability means, including intellectual property (IP) rights. This paper aims at assessing the interrelated effects of two types of IP rights, namely patents and trade marks, considering them in their core function as legal protection devices. Based on a supermodularity analysis, we show that the complementary relationship between trade marks and patents is not straightforward. Depending on the level of appropriability of advertising expenditure enabled by trade marks, they are found to be either complementary or substitutable to patents. Based on a data set encompassing the IP activity of French publicly traded firms, we find that patents and trade marks are complementary in life science sectors (pharmaceutical products and health services), but substitute in high-tech business sectors (computer, electronic and optical products and electrical equipment).

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[1] *The opinions expressed in this paper are the sole responsibility of the authors and do not necessarily reflect those of the OECD or of the governments of its member countries.*

# 1 Introduction

The benefits of product innovations for firms strongly depend on their ability to develop complementary appropriability means (Teece 1986, Levin *et al.* 1987, Cohen *et al.* 2000). Intellectual property (IP) rights are one major component of firms' appropriability strategies. Patents, which allow the protection of new technologies, are the most obvious IP rights related to innovation and the most extensively studied in the economics literature (see Griliches 1991 for a survey). But patents alone are not a guarantee to benefit from innovation, which also requires the development of market-based assets to ensure the success of the commercialisation of the product (Rogers 1998, Jennewein 2005, Aaker 2007). Among those market-based assets are trade marks. Several papers in the recent literature mention that trade marks can be used in relation to innovative activity (Schmoch 2003, Mendonça *et al.* 2004, Greenhalgh and Rogers 2007). The creation of a new trade mark may enhance the perception of innovative products by consumers, and may constitute a basis for advertising. Moreover, if a product is launched on the market under a certain brand name, consumers are likely to remain loyal to this pioneer brand even after competitors enter the market (Davis 2009). Trade marks and patents then constitute two distinct means to appropriate the benefits of innovation, whose effects are likely to be interrelated.

While there are a number of studies on the complementarity between technological investments and advertising or marketing investments (Hirschey 1982, Snyder and King 2007, Askenazy *et al.* 2010), the relationship between patents and trade marks was rarely investigated. A few papers tested empirically the complementarity between patents and trade marks at the level of the firm but considering them as proxies for technological and marketing investments (von Graevenitz and Sandner 2009, Schwiebacher 2009), so that the complementarity observed between IP rights in fact mirrors the complementarity of their respective underlying investments. Somaya and Graham (2006) also show a complementarity relationship between IP rights, which they explain mainly by economies of scales in organisational resources deployed for IP management. Those studies do not look at the interaction effects of IP rights in their core function as legal protection devices. Yet patent and trade mark protections are likely to reinforce each other. Indeed the monopoly position given by a patent can favour the establishment of a strong trade mark and in return, trade marks can be used to extend the benefits of the patents. Statman and Tyebjee (1981), for example, observe that the expiration of patent for ethical drugs has only a minor effect on their market dominance, because of brand loyalty. In the words of the authors, "the patent period is used to transfer the value of the patent into the trade mark".

Our paper addresses through a formal approach the interaction effects occurring between trade marks and patents as legal devices protecting respectively a certain brand and a certain technology. We build a model encompassing the separate and joint effects on the profits for an innovating firm of using both IP rights, and analyse the conditions in which they can be considered substitute or complementary (for this we rely on the concept of supermodularity which enables us to address complementarities in a discrete-choice model environment, see Milgrom and Roberts 1990, 1995). This implies modelling beforehand the impact of protecting an innovation by a trade mark. Such a theoretical approach does not exist to our knowledge in the literature. The model consists of a duopoly with one firm innovating in product (leader) and one imitating firm (follower). Each firm may incur advertising expenditure, which contribute to building their goodwill stock, in a dynamic framework. Advertising expenditure are not entirely appropriable: the competitor can benefit from advertising spillover effects. The patent function is to give a monopoly power on the product for a limited period. For trade marks function, we stick to the legal definition and consider that trade marks prevent other parties from benefiting from the reputation built by the firm by creating confusion on the origin of the product. The level of advertising spillovers benefiting the competitor is then lower if the firm files a trade mark. Besides, if the firm registers a trade mark, the reputation built during the monopoly period entirely benefits the monopoly firm, so that the competitor does not benefit from any spillover of advertising performed during the patent period. The interaction between patents and trade marks is then characterised by two counterbalancing effects: a substitutability effect, as the trade mark has no impact on the firm's profit during the patent period, and a complementary effect, as the reputation built in the monopoly period has an impact *a posteriori* on the trade mark benefits after the patent has expired. The main prediction of our theoretical model is that the predominance of the complementarity or the substitutability effect is not straightforward and depends on exogenous characteristics of the market. Depending on the level of appropriability of advertising expenditure given by trade marks, the two IP rights can be found to be either substitutes, or complements.

Using a firm-level database encompassing the trade marking and patenting activity of French publicly traded firms, we test the complementary or substitute relationship between patents and trade marks in various sectors. We find that in life science sectors (mainly pharma), where innovations can be duplicated and advertising expenditure are not easily appropriable, the two IP rights tend to be complementary, whereas in high-tech business sectors, they tend to be substitutes, which confirms our theoretical predictions. Those results tend to push the conclusion of Teece (1986) a step further, as not only the benefits from innovation depend on environmental conditions and the ability of firms to use complementary assets, but the complementarity relationship between these assets may itself depend on the context in which the firms operate.

The remainder of this paper is organised as follows. Section 2 lays out the theoretical framework used to describe the effects of trade mark and patent protections at the firm-level, from which we analytically derive some predictions on their complementary or substitutable relationship. Section 3 presents our empirical strategy to test the model predictions and our main empirical findings. Section 4 concludes with the implications of the model.

## 2 Theoretical Model

This section presents a theoretical model to analyse the relationship between patents and trade marks. We first present the characteristics of the theoretical framework, and then derive results on the complementarity or substitutability of the two IP rights.

## 2.1 General framework

### The two-period game

The starting point of the model is a firm innovating in product, which leads to the creation of a new market for the product. The innovating firm can choose to register a patent, a trade mark, or both or neither of them. IP rights related choices are considered binary: the firm can register at most one of each type of IP right. If the innovating firm files a patent, the model has 2 distinct periods: a monopoly period under the patent protection and then a competition period, characterised by a Cournot-type duopoly between the innovating firm (leader) and an imitating firm (follower). We assume the innovation to be instantaneously imitable, so if no patent is filed by the innovating firm, the competition starts immediately in the first period, right after the innovation is introduced.

### Advertising and goodwill

Firms incur advertising expenditure, which enable them to build a goodwill, which positively affects the demand for the product. Following Nerlove and Arrow (1962), we assume that advertising expenditure are cumulative: the goodwill of the firm is supplied at each period with advertising expenditure, and depreciates at rate $\delta$. In a two-period framework, this translates into an equation of evolution of the goodwill stock $G_t$ from first period to second period:

$$G_2 - G_1 = a_2 - \delta G_1, \tag{1}$$

where $a_2$ is the amount of advertising expenditure of the second period and $\delta$ is the depreciation rate of advertising between the two periods. The firms only start advertising expenditure when they enter the market, so in the first period the amount of goodwill is given by $G_1 = a_1$.

Besides, we assume that advertising expenditure are not totally appropriable by firms (Friedman 1983), and are subject to spillovers. A first interpretation of those spillovers is that the advertising performed by a firm is partly advertising for the product in general and not for its own brand, so that the competitor can partly benefit from it. Another source of spillovers is that firms can play on confusion and then partly benefit from the brand image of their competitor. A share $\overline{s}$ (resp. $s$) of the advertising expenditure incurred by the follower (resp. the leader) benefits the leader (resp. the follower). The total amount of goodwill from which the leader benefits in each period is then $G_t + \overline{s}\overline{G}_t$, where $G_t$ is the goodwill built by the leader, and $\overline{G}_t$ is the goodwill built by its competitor.

### Effect of trade mark

The function of trade marks is to legally prevent other parties from benefiting from the reputation built by the firm by creating confusion on the origin of the product.

We assume that by filing a trade mark, firms increase the level of appropriability of their advertising expenditure. Then if the leader registers a trademark, the rate of advertising spillovers from which the follower benefits from decreases from $s_0$ to $s_{tm}$.

A key assumption of our model is that if the leader files both a trade mark and a patent, advertising expenditure incurred during the patent period benefit only its own reputation: the reputation of the product during the monopoly period coincides with the reputation of the monopoly brand. This means that the follower will benefit from no spillover on the advertising expenditure incurred during the monopoly period. Indeed to benefit from the spillovers, since the respective brand images of the leader and the follower are not confusable, the follower needs first to start to advertise its product so that the customers realise that the products are identical. The advertising spillovers are then only effective in the second period when the follower enters the market. Then from (1), we deduce that the amount of advertising spillovers that the follower benefits from in the second period is:

$$s_{tm}(G_2-(1-\delta)G_1). \tag{2}$$

By contrast if the leader files a patent but no trade mark, the competitor benefits from advertising spillovers in all periods, including the monopoly period, so it will benefit from $s_0G_2$. Indeed without trade mark protection, the competitor can play on confusion on the brand image and immediately benefit from the totality of goodwill spillovers, as customers may mistakenly attribute the goodwill of the pioneer firm to the product sold by the other firm.

Lastly if no patent is filed, the rate of spillovers is always equal, and in each period $t$ the competitor benefits from $s_{tm}G_t$ (resp. $s_0G_t$) if the firm files a trade mark (resp. no trade mark).

### Inverse demand function

Following Dixit (1979), we assume that the inverse demand function facing each firm in the market is negatively related to the total amount of quantities sold. Assuming a quadratic utility function of customers, the relationship between price and quantities is linear (Dixit 1979). We then assume that advertising increases customers' willingness to pay for the product (Brady 2009), so that the goodwill stock has a positive impact on the price for a given quantity sold. The effect of goodwill stock is assumed to have decreasing marginal returns. The inverse demand function facing the leader is given by :

$$P_t=\alpha-\beta\left(Q_t+\overline{Q}_t\right)+\tau\sqrt{G_t+\overline{s}\overline{G}_t}, \tag{3}$$

where $Q_t$ and $\overline{Q}_t$ are the quantities sold by the firm and its competitor in $t$, $G_t$ represents the goodwill stock of the firm, $\overline{s}\overline{G_t}$ is the amount of spillovers, with $\alpha, \beta$ and $\tau$ strictly positive parameters. The inverse demand function facing the follower is symmetrical (except for the amount spillovers, as explained in the previous paragraph).

### Supermodularity analysis

Based on this framework, we compare the inter-temporal profits resulting from the various IP strategies to investigate the complementarity relationship between the various protection means. More specifically, we study the complementarity between trade marks and patents based on the concept of supermodularity (Milgrom and Roberts 1990 and 1995). This framework makes it possible to analyse complementarity in the context of discrete choices (in which pay-offs are not continuous); this is appropriate here since we focus on a single invention so that the firm registers at most one trade mark and one patent. The supermodularity theory states that two inputs which can be used by the firm or not are complements only if using one input while also using the other input has a higher incremental effect on performance than using one input alone (following the intuitive idea that "the whole is more than the sum of its parts").

We test the validity of the following fundamental inequality, where $V$ is the inter-temporal profit gained from innovation and the exponents indicate the presence or not of a trade mark (TM) or a patent (PAT) :

$$V^{TM,PAT}+V^{0,0}>V^{TM,0}+V^{0,PAT} \tag{4}$$

If this inequality is verified, the two types of IP rights are complementary, and if the reverse inequality is shown, they are substitutes[1].

## 2.2 Outcome of the various intellectual property strategies

Based on the above framework, we derive the outcome of the various IP strategies on the profit of the innovating firm, and focus on the supermodularity equation (4) to assess if patents and trade marks are complementary or not.

### 2.2.1 Case of patent protection

If the leader registers a patent, its inter-temporal profit is, from (3):

$$V=\left[\alpha-\beta Q_1+\tau\sqrt{G_1}-c\right]Q_1-a_1+r\left[\alpha-\beta\left(Q_2+\overline{Q_2}\right)+\tau\sqrt{G_2+\bar{s}\overline{G_2}}-c\right]Q_2-ra_2,$$

[1]In the following analysis, we assume that the cost of registering a patent or a trade mark is negligible. This hypothesis may be plausible for trade marks, as a registration in a trade mark office is relatively simple and not expensive (from around 200 Euros for a national trade mark to less than 1000 Euros for a Community trade mark), but it is less likely to apply to patent registration. Indeed patent registration is a relatively complex procedure and requires some human and financial resources. However we can notice that assuming non-negligible costs of IP rights would not change the result on the complementarity analysis. Indeed if we introduce $C_{tm}$ and $C_{pat}$, the respective costs of registering a trade mark and a patent, in equation (4) , we get

$$(V^{TM,PAT}-C_{tm}-C_{pat})+V^{0,0}>(V^{TM,0}-C_{tm})+(V^{0,PAT}-C_{pat}),$$

which is strictly equivalent to (4). Thus for the sake of simplicity we assume null registration costs. The following analysis would still remain valid if IP rights costs were introduced.

where $c$ is the cost of production, assumed linear, and $r$ is the discount rate between the two periods (with $r > 0$, decreasing with the duration of the patent and with the instantaneous discount rate).

From (1), this can rewritten as:

$$V=\left[\alpha-\beta Q_1+\tau\sqrt{G_1}-c\right]Q_1-G_1+r\left[\alpha-\beta\left(Q_2+\overline{Q_2}\right)+\tau\sqrt{G_2+\overline{s}\overline{G_2}}-c\right]Q_2-r(G_2-(1-\delta)G_1) \quad (5)$$

This identity is valid whether or not the firm registers a trade mark. The impact of trade mark registration affects only the goodwill spillovers benefiting the follower.

**If the innovative firm registers a trade mark**

The inter-temporal profit of the follower is, from (2):

$$\overline{V}=\left[\alpha-\beta\left(Q_2+\overline{Q_2}\right)+\tau\sqrt{s_{tm}(G_2-(1-\delta)G_1)+\overline{G_2}}-c\right]\overline{Q_2}-\overline{G_2}, \quad (6)$$

where $s$ is the rate of advertising spillovers obtained from the pioneer firm.

The model is solved through backward induction: the firms first determine their optimal levels of goodwill and quantities sold in the second period considering the stock of goodwill of the leader in the first period given, and then the leader maximises its inter-temporal profit on the choice variables of the first period.

*1st step: maximisation of the second period profits on $Q_2, \overline{Q_2}, G_2, \overline{G_2}$ considering $G_1$ given*

The respective programs of the leader and the follower are:

$$\max_{Q_2,G_2}\left(r\left[\alpha-\beta\left(Q_2+\overline{Q_2}\right)+\tau\sqrt{G_2+\overline{s}\overline{G_2}}-c\right]Q_2-r(G_2-(1-\delta)G_1)\right)$$

and

$$\max_{\overline{Q_2},\overline{G_2}}\left(\left[\alpha-\beta\left(Q_2+\overline{Q_2}\right)+\tau\sqrt{s_{tm}(G_2-(1-\delta)G_1)+\overline{G_2}}-c\right]\overline{Q_2}-\overline{G_2}\right).$$

The system of first order conditions yields the following Nash-Cournot equilibrium:

$$\begin{cases} Q_2^* = \overline{Q_2^*} = \frac{2(c-\alpha)}{\tau^2-6b} \\ \overline{G_2^*} = \frac{1-s_{tm}}{(1-\overline{s}s_{tm})}\left(\frac{\tau(c-\alpha)}{\tau^2-6\beta}\right)^2 + \frac{s_{tm}(1-\delta)}{(1-\overline{s}s)}G_1 \\ G_2^* = \frac{1-\overline{s}}{(1-\overline{s}s_{tm})}\left(\frac{\tau(c-\alpha)}{\tau^2-6\beta}\right)^2 - \frac{\overline{s}s_{tm}(1-\delta)}{(1-\overline{s}s_{tm})}G_1 \end{cases} \quad (7)$$

The optimal quantities in second period are equal for the two firms. Assuming the same rate of advertising spillovers, the optimal amount of goodwill stock is higher for the follower, since it does not benefit from advertising expenditure incurred in period 1, so it has to catch up with the leader with higher advertising expenditure in period 2. The difference in reputation is increasing with the level of goodwill achieved by the leader in the first period, and decreasing with the depreciation rate of advertising between the two periods.

From first order condition on $Q_2$ $\left(\alpha-\beta\left(Q_2+\overline{Q_2}\right)+\tau\sqrt{G_2+\overline{s}\overline{G_2}}-c=\beta Q_2\right)$ and the previous expression of $Q_2$ and $G_2$ in (7), (5) becomes:

$$V=\left[\alpha-\beta Q_1+\tau\sqrt{G_1}-c\right]Q_1+\left(\frac{r(1-\delta)}{(1-\overline{s}s_{tm})}-1\right)G_1+r\beta\left[\frac{2(c-\alpha)}{\tau^2-6\beta}\right]^2-r\frac{1-\overline{s}}{(1-\overline{s}s_{tm})}\left(\frac{\tau(c-\alpha)}{\tau^2-6\beta}\right)^2$$

*2nd step: maximisation of the leader inter-temporal profit on $G_1, Q_1$*

The system of first order conditions on $Q_1$, $G_1$ yields:

$$\begin{cases} Q_1^* = \dfrac{2\left(1-\frac{r(1-\delta)}{(1-\overline{s}s_{tm})}\right)(c-\alpha)}{\tau^2-4\beta\left(1-\frac{r(1-\delta)}{(1-\overline{s}s_{tm})}\right)} \\ \sqrt{G_1^*} = \dfrac{\tau(c-\alpha)}{\tau^2-4\beta\left(1-\frac{r(1-\delta)}{(1-\overline{s}s_{tm})}\right)} \end{cases}$$

The model has an interior solution if $4\beta\left(1-\frac{r(1-\delta)}{(1-\overline{s}s_{tm})}\right)>\tau^2$ and $\frac{1-\overline{s}}{(1-\delta)}>\frac{\left(\tau^2-6\beta\right)^2}{\left(\tau^2-4\beta\left(1-\frac{r(1-\delta)}{(1-\overline{s}s_{tm})}\right)\right)^2}$, i.e. $\beta$, the negative impact of quantities on demand is large enough compared to the impact of advertising $\tau$, the depreciation rate of advertising $\delta$ is large enough and the discount rate $r$ between the two periods is small enough.

The final profit of the innovating firm in case it files both a patent and a trade mark is then equal to:

$$V^{TM,PAT}=(c-\alpha)^2\frac{\left(1-\frac{r(1-\delta)}{(1-\overline{s}s_{tm})}\right)}{4\beta\left(1-\frac{r(1-\delta)}{(1-\overline{s}s_{tm})}\right)-\tau^2}+r\beta\left[\frac{2(c-\alpha)}{\tau^2-6\beta}\right]^2-r\frac{1-\overline{s}}{(1-\overline{s}s_{tm})}\left(\frac{\tau(c-\alpha)}{\tau^2-6\beta}\right)^2. \tag{8}$$

**If the innovative firm does not register a trade mark**

The expression of the leader's inter-temporal profit remains unchanged, but the one of the follower is modified. The advertising spillovers which it gets from the leader are now equal to $s_0G_2$ , so its inter-temporal profit is given by:

$$\overline{V}=\left[\alpha-\beta\left(Q_2+\overline{Q_2}\right)+\tau\sqrt{s_0G_2+\overline{G_2}}-c\right]\overline{Q_2}-\overline{G_2}$$

The choice variables in the two periods of the model are here independent. Maximising $V$ on $A_1$, $Q_1$, $A_2$, $Q_2$ and $W$ on $B_2$, $R_2$ yields the following conventional Nash-equilibrium:

$$\begin{cases} Q_2^* = \overline{Q_2^*} = \frac{2(c-\alpha)}{\tau^2-6\beta} \\ \overline{G_2}^* = \frac{1-s_0}{(1-\overline{s}s_0)}\left(\frac{\tau(c-\alpha)}{\tau^2-6\beta}\right)^2 \\ G_2^* = \frac{1-\overline{s}}{(1-\overline{s}s_0)}\left(\frac{\tau(c-\alpha)}{\tau^2-6\beta}\right)^2 \\ Q_1^* = \frac{2(1-r(1-\delta))(c-\alpha)}{(\tau^2-4\beta(1-r(1-\delta)))} \\ G_1^* = \left(\frac{\tau(c-\alpha)}{(\tau^2-4\beta(1-r(1-\delta)))}\right)^2 \end{cases}$$

An interior solution exists on the condition that

$$4\beta(1-r(1-\delta))>\tau^2, \tag{9}$$

i.e. $\beta$, the negative impact of quantities on demand is large enough compared to the impact of advertising $\tau$, the depreciation rate of advertising $\delta$ is large enough and the discount rate $r$ between the two periods is small enough.

The inter-temporal profit of the firm in case it files a patent and no trade mark equals:

$$V^{0,PAT} = \beta\left[\frac{2(1-r(1-\delta))(c-\alpha)}{(\tau^2-4\beta(1-r(1-\delta)))}\right]^2+\frac{\tau^2(c-\alpha)^2(r(1-\delta)-1)}{(\tau^2-4\beta(1-r(1-\delta)))^2}+r\beta\left[\frac{2(c-\alpha)}{\tau^2-6\beta}\right]^2-r\frac{1-\overline{s}}{(1-\overline{s}s_0)}\left(\frac{\tau(c-\alpha)}{\tau^2-6\beta}\right)^2.$$

From this expression and from (8), the difference in profit between registering a trade mark and not registering a trade mark, in the case of patent protection is then given by:

$$\begin{aligned} V^{TM,PAT}-V^{0,PAT}= \quad & (c-\alpha)^2\frac{\left(1-\frac{r(1-\delta)}{(1-\overline{s}s_{tm})}\right)}{4\beta\left(1-\frac{r(1-\delta)}{(1-\overline{s}s_{tm})}\right)-\tau^2}-\frac{(c-\alpha)^2(1-r(1-\delta))}{(4\beta(1-r(1-\delta))-\tau^2)} \\ & +r\left(\frac{\tau(c-\alpha)}{\tau^2-6\beta}\right)^2\left[\frac{1-\overline{s}}{(1-\overline{s}s_0)}-\frac{1-\overline{s}}{(1-\overline{s}s_{tm})}\right]. \end{aligned} \tag{10}$$

This difference is positive as long as $s_{tm} < s_0$, i.e. the rate of spillovers benefiting the follower is lower if the leader files a trade mark, which is always true under the assumptions of the model. So assuming negligible registration costs, the trade mark has a positive impact on the firm's profit.

#### 2.2.2 Case without patent protection

If the innovative firm does not protect its innovation with a patent, the competition starts in the first period. Inter-temporal profits are given by:

$$V=\left[\alpha-\beta\left(Q_1+\overline{Q_1}\right)+\tau\sqrt{G_1+\overline{s}\overline{G_1}}-c\right]Q_1-G_1+r\left[\alpha-\beta\left(Q_2+\overline{Q_2}\right)+\tau\sqrt{G_2+\overline{s}\overline{G_2}}-c\right]Q_2-r(G_2-(1-\delta)G_1)$$

$$W=\left[\alpha-\beta\left(Q_1+\overline{Q_1}\right)+\tau\sqrt{sG_1+\overline{G_1}}-c\right]R_1-\overline{G_1}+r\left[\alpha-\beta\left(Q_2+\overline{Q_2}\right)+\tau\sqrt{sG_2+\overline{G_2}}-c\right]\overline{Q_2}-r\left(\overline{G_2}-(1-\delta)\overline{G_1}\right)$$

The choice variables in the two periods are independent. The maximisation programs on $A_2$, $Q_2$, $B_2$, $R_2$ correspond to the case of patent protection and no trade mark. Maximising the profits on $A_1$, $Q_1$ , $B_1$ , $R_1$ yields the following conventional Nash-equilibrium:

$$\begin{cases} Q_1^* = \overline{Q_1}^* = \frac{2(1-r(1-\delta))(c-\alpha)}{(\tau^2-6\beta(1-r(1-\delta)))} \\ \overline{G_1}^* = \frac{\tau^2(c-\alpha)^2(1-s)}{(\tau^2-6\beta(1-r(1-\delta)))^2(1-\overline{s}s)} \\ G_1^* = \frac{\tau^2(c-\alpha)^2(1-\overline{s})}{(\tau^2-6\beta(1-r(1-\delta)))^2(1-\overline{s}s)} \end{cases}$$

An interior solution exists if $\tau^2-6\beta\left(1-r\left(1-\delta\right)\right)<0$ i.e. $\beta$, the negative impact of quantities on demand is large enough compared to the impact of advertising $\tau$, the depreciation rate of advertising $\delta$ is large enough and the discount rate $r$ between the two periods is small enough.

The inter-temporal profit in case no patent is registered is then given by:

$$V=\beta\left[\frac{2(1-r(1-\delta))(c-\alpha)}{(\tau^2-6\beta(1-r(1-\delta)))}\right]^2+\frac{\tau^2(c-\alpha)^2(r(1-\delta)-1)}{(\tau^2-6\beta(1-r(1-\delta)))^2}\frac{1-\bar{s}}{(1-\bar{s}s)}+r\beta\left[\frac{2(c-\alpha)}{\tau^2-6\beta}\right]^2-r\frac{1-\bar{s}}{(1-\bar{s}s)}\left(\frac{\tau(c-\alpha)}{\tau^2-6\beta}\right)^2.$$

The difference in profit between the case where the firm files a trade mark and the case where it files no trade mark, if there is no patent protection is then:

$$V^{TM,0}-V^{0,0}=\tau^2(c-\alpha)^2(1-\bar{s})\left[\frac{(r(1-\delta)-1)}{(\tau^2-6\beta(1-r(1-\delta)))^2}-r\left(\frac{1}{\tau^2-6\beta}\right)^2\right]\left[\frac{1}{(1-\bar{s}s_{tm})}-\frac{1}{(1-\bar{s}s_0)}\right] \tag{11}$$

This expression is positive as long as $s_{tm} < s_0$, which is always true under the model hypotheses. So as in the case where a patent is registered, assuming negligible registration costs, the trade mark has a positive impact on the firm's profit.

### 2.2.3 Complementarity analysis

Based on the previous results, we investigate if the supermodularity equation (4) is verified or not. The supermodularity inequality is verified if the following difference is positive $\left(V^{TM,PAT}-V^{0,PAT}\right)-\left(V^{TM,0}-V^{0,0}\right)$. This amounts to comparing the benefit of filing a trade mark in the case of patent protection and in the case without patent. From (10) and (11), we deduce that:

$$\left(V^{TM,PAT}-V^{0,PAT}\right)-\left(V^{TM,0}-V^{0,0}\right)=$$
$$(c-\alpha)^2\left[\frac{\left(1-\frac{r(1-\delta)}{(1-\bar{s}s_{tm})}\right)}{4\beta\left(1-\frac{r(1-\delta)}{(1-\bar{s}s_{tm})}\right)-\tau^2}-\frac{(1-r(1-\delta))}{(4\beta(1-r(1-\delta))-\tau^2)}-\tau^2(1-\bar{s})\left[\frac{(r(1-\delta)-1)}{(\tau^2-6\beta(1-r(1-\delta)))^2}\right]\left[\frac{1}{(1-\bar{s}s_{tm})}-\frac{1}{(1-\bar{s}s_0)}\right]\right]$$

We have

$$\frac{\partial\left[\left(V^{TM,PAT}-V^{0,PAT}\right)-\left(V^{TM,0}-V^{0,0}\right)\right]}{\partial s_0}=(c-\alpha)^2\tau^2(1-\bar{s})\left[\frac{(r(1-\delta)-1)}{(\tau^2-6\beta(1-r(1-\delta)))^2}\right]\frac{\bar{s}}{(1-\bar{s}s_0)^2}.$$

This expression is negative if $r(1-\delta)-1<0$, which is implied by the condition (9) of the model. So the smaller the increase of advertising appropriation enabled by trade mark, the higher the level of complementarity between trade marks and patents.

Besides for $s_{tm}$ approaching $s_0$, i.e. the effectiveness of trade mark almost null, we have

$$\left(V^{TM,PAT}-V^{0,PAT}\right)-\left(V^{TM,0}-V^{0,0}\right)\sim V^{TM,PAT}-V^{0,PAT}>0.$$

So trade mark and patent are complementary. For $s_{tm}$ approaching 0, i.e. trade marks enable firms to completely appropriate their advertising expenditure, we have

$$\left(V^{TM,PAT}-V^{0,PAT}\right)-\left(V^{TM,0}-V^{0,0}\right)\sim-\left(V^{TM,0}-V^{0,0}\right)<0.$$

So in that case trade mark and patent are substitutable.

Under the assumptions of the model, depending on the of level of reduction of spillovers that trade marks can achieve $(s_0-s_{tm})$, patents and trade marks can be found either complementary or are substitutable. The interpretation of the results is the following. The interaction between patents and trade marks is characterised by two counterbalancing effects. There is on the one hand a substitutability effect: the trade mark benefits the firm only when it faces competition. The patent implying a non-competition period, trade marks are comparatively less advantageous for the pioneer firm when there is also a patent filed. In the extreme, if the protection offered by patents was infinite in time, the benefit of trade mark would be null as the firm would not need to protect its brand from confusion with other firms. On the other hand, we find a complementary effect: the trade mark makes it possible to capture entirely the goodwill built during the monopoly period. The trade mark benefits in the second period will be all the more important if the firm has benefited from a monopoly period, so trade marks in the second period are comparatively more advantageous if the firm had a patent filed in the first period. Depending on the effectiveness of the trade mark, either the first effect or the second effect can be predominant: patents and trade marks are complementary only if the level of appropriation of advertising enabled by trade mark is small enough. For example, in sectors where technology is not well codified and where the characteristics of the product are hardly identified by the customer, advertising is above all advertising for the brand, and trade mark protection has a strong effect on advertising spillovers. In such cases patents and trade marks are likely to be substitutes. In contrast, in sectors such as pharma where the technology is well codified, advertising performed by firms is very likely to benefit the product in general, so trade marks do not increase significantly the appropriability of advertising. In those sectors, according to the result of our model, patents and trade marks tend to be complementary.

This result does not enable us to conclude on the optimal IP rights strategy of the innovative firm - which in the case of null IP registration costs is always the joint use of trade marks and patents. To know what is the optimal strategy, one would have to take into account the respective costs of registering a patent and a trade mark. But the interaction effects shown in the above analysis should in any case be taken into account in firm's choices of optimal IP strategy.

# 3 Empirical investigation

## 3.1 Tested hypotheses and methodology

This section aims at testing empirically the theoretical model presented above. The general purpose is to test the complementarity between the use of trade marks and the use of patents by firms as tools to protect their assets. To this aim we estimate and compare the firms' performance resulting from various IP rights strategies. We use the market value of the firm as a measure of firm performance: assuming efficient stock markets, the firm's market value is equal to the sum of its discounted future profits, which is the target variable in our previous theoretical model. Another measure of performance, such as the present profit margin in time $t$, would be inadequate as the context of the model is dynamic, with inter-temporal effects of IP strategy choices.

We follow the market value approach, which combines accounting data with the valuation on the stock market. This approach has been used in particular to assess returns to innovation (Griliches 1981, Hall *et al.* 2000, Greenhalgh and Rogers 2007, Sandner 2009). The general idea of those models is that investors estimate a firm's value according to the returns that they expect from its assets (either tangible or intangible). The purpose of those models is to disentangle the contribution of tangible and intangible assets, intangible assets being proxied by measures of R&D, the number of patents or the number of trade marks. In our model, by contrast, the intangible assets of the firm are considered as given, and IP rights are considered in their function to appropriate the benefits of those assets. Thus we do not distinguish the various types of assets. We consider

$$V = qA, \tag{12}$$

where $A$ is the amount of firm's total assets (tangible and intangible). Taking natural logarithms on both sides of (12), the previous equation can be rewritten as $\ln(V) = \ln(q) + \ln(A)$. We assume that the coefficient $q$ depends on the IP strategy of the firm: $q_{TM,PAT}$, $q_{TM,0}$, $q_{0,PAT}$, $q_{0,0}$.

Following the supermodularity approach (see Mohnen and Röler 2003 and Guidetti *et al.* 2009 for deeper methodological explanations on empirical tests of supermodularity), our estimation strategy is to regress the log of the market value of the firm on the log of its assets, including the four dummies associated to the potential IP rights strategies in the set of explanatory variables: use of no patent and no trade mark ($1_{0,0}$), of trade marks but no patents ($1_{TM,0}$), of patents but no trade marks ($1_{0,PAT}$), and of both patents and trade marks ($1_{TM,PAT}$). All dummies are included in the regression, which is thus "without constant". This is necessary in order to get all the estimates of coefficients and variance/covariance. The first model specification is:

$$\ln(V) = \beta_1(1_{0,0}) + \beta_2(1_{TM,0}) + \beta_3(1_{0,PAT}) + \beta_4(1_{TM,PAT}) + \gamma \ln(A) \tag{13}$$

Going back to the model equation $\ln(V) = \ln(q) + \ln(A)$, the coefficients $\beta$ correspond to the evaluation of $\ln(q)$ corresponding to the various IP rights strategies, and $\gamma$ allows for non constant returns to scale. From the previous theoretical section, we derive that complementarity holds if $\beta_1 + \beta_4 > \beta_2 + \beta_3$. To investigate this, we apply a one-sided t-test with null hypothesis $H_0 : \beta_1 + \beta_4 - \beta_2 - \beta_3 > 0$.

The previous specification considers the IP strategies as invariant for the firm, which always relies on the same combination of IP rights. In order to relate more precisely the returns of the firm's assets and the IP strategy associated, we add a second specification, focusing on the difference in firm's market value between two points in time ($t = 1$ and $t = 2$). According to the previous framework, we have:

$$\frac{V_2}{V_1} = q\frac{A_2}{A_1}, \tag{14}$$

where $V_t$ is the market value in $t$ , $A_t$ is the amount of firm's total assets in $t$. Here the coefficient $q$ varies depending on the IP rights acquired by the firm between the two periods $t = 1$ and $t = 2$. This means that the growth in market value depends on the IP strategy specifically associated to the assets acquired between the two periods. Taking the logarithms on both sides of (14), the second model specification corresponds to:

$$\ln(V_2)=\ln(V_1)+\beta_1(1_{0,0})+\beta_2(1_{TM,0})+\beta_3(1_{0,PAT})+\beta_4(1_{TM,PAT})+\gamma\ln(A_2)-\gamma\ln(A_1), \tag{15}$$

where the dummy variables correspond to the use of the corresponding IP right between $t=1$ and $t=2$.

The IP rights strategy is likely to be dependent on the life cycle of the firm: firms tend to file more IP rights applications in their early life time (protecting the name of the firm or their core technology). Thus, in the two previous specifications we control for the age of the firm. We besides add controls for the sector.

The various hypotheses tested stemming from the theoretical model are :

$\begin{cases} H_{1a}: \beta_2 > \beta_1 \\ H_{1b}: \beta_3 > \beta_1 \\ H_{1c}: \beta_4 > \beta_1 \end{cases}$ : inter-temporal profits are higher if the firm uses IP right protection.

$\begin{cases} H_{1d}: \beta_4 > \beta_3 \\ H_{1e}: \beta_4 > \beta_2 \end{cases}$ : inter-temporal profits are higher if the firm chooses to use both a patent and a trade mark than only one type of IP right.

Those hypotheses are always verified in the framework of the theoretical model, but their validity actually depends on the costs of IP right registration. Thus they might be invalidated in the empirical results.

$H_0: \beta_1 + \beta_4 > \beta_2 + \beta_3$: supermodularity hypothesis.

According to the theoretical model prediction, the result should depend on the market characteristics, and is thus likely to vary depending on sectors.

## 3.2 Data sources and descriptive statistics

### Dataset building

The various tests described in the previous paragraph are performed on a firm-level database encompassing the trade marking and patenting activity of French firms listed on the stock exchange. Several data sources were used and connected, since no integrated database of firm data and IP rights data is readily available.

General information on firms, as well as accounting and financial variables were retrieved from the database ORBIS© (April 2011 version), edited by the Bureau Van Dijk. Since market value is used as the dependent variable in the regression, the sample is restricted to publicly traded firms. The year considered for the estimation is 2007, before the worsening of the late 2000's financial crisis, in order to avoid the exogenous variation of stock market variables.[2] A second reason for avoiding the crisis period is that the model focuses on firms' IP activity, and the latter is generally hampered during recession periods. Restricted to French firms for which financial and accounting data in 2007 are available, the sample contains 786 observations[3].

[2]NB: the market value is considered at the end of 2007, a time at which the sub-prime crisis had already begun, yet with much lower impact on market prices

[3]The theoretical model applies to firms innovating in products, so the sample should ideally

The firm data were matched with data about trade marks and patents applied for at the national and European level over the period 1998-2007. National and Community trade mark applications were provided by the INPI and by the OHIM respectively, and data on national and EPO patents were retrieved from the EPO *PATSTAT* database.

The matching methodology used consists in linking the company name in the firm database to the applicant name listed in the various IP databases, using an automatic computer-based procedure. This procedure first harmonises the names in both firm and IP datasets, to take into account possible mistakes and equivalent denominations firms may use, based on the algorithm developed by Magerman, Van Looy, and Xiaoyan (2006). The matching is then done according to exact identity of the harmonized names. This matching methodology is thus quite careful, favouring the occurrence of false-negatives over false-positives in the results.[4]

### Variables used and descriptive statistics

The dependent variable used in the regressions is the natural logarithm of the firm's market value, $V$. The market value of a firm is defined as the sum of its market capitalisation and the market value of its debt. Following Blundell *et al.* (1999), Hall and Oriani (2006), and Sandner (2009), we calculated the firm's market value as the sum of the nominal value of market capitalisation and outstanding debt. Finally, outstanding debt was calculated as the sum of long term debt and current liabilities as reported in ORBIS©.

In the set of explanatory variables we use the variable "total assets" as directly contained in ORBIS© database, defined as the sum of tangible and intangible assets. Although IP rights are sometimes qualified as "intangible assets", patents and trade marks applied for by the firm are not accounted in the intangible assets. The latter are recorded on balance sheets at cost, so IP rights are only included in intangible assets if they have been acquired from an external source (see International Accounting Standards Board 2007). For IP rights acquired internally, what is recorded is their corresponding investments (R&D or brand equity investment), and not the IP right itself whose financial value is not possible to assess. This avoids the presence of an endogeneity issue in the joint inclusion of IP rights dummies and intangible assets in the set of explanatory variables in the regression.

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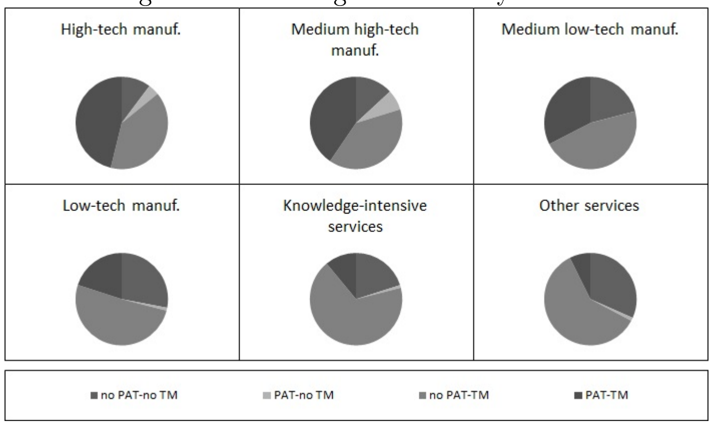
be restricted to innovative firms. Otherwise we cannot know if firms have no IP right activity because they do not innovate (which would have a negative impact on market value compared to other firms) or because they innovate but do not protect their innovations with IP rights. To take this issue into account, we considered matching our dataset to innovation survey data, in order to have information on innovating behaviour. However, because of the small size of innovation survey samples, this would reduce our sample size drastically (from 861 to 170), so this would not allow us to achieve significant results differentiated by sectors. Nevertheless the large majority of publicly traded firms are innovating: based on our sample of listed French firms matched with the French results of the Community Innovation Survey (CIS) 2006-2008, containing in total 170 observations, 113 (66%) have innovated in product or in service during the years 2006-2008, which is a much larger proportion than in the complete CIS sample (26%).

[4] There are alternative methodologies for matching names. It is in particular possible to use rule-based approaches to compare the similarity of names, which makes it possible to match a larger number of observations but favours the occurrence of false positive. For a comprehensive view of the matching methodologies, see Thoma *et al.* 2010.

Figure 1: IP strategies of firms by sectors




*Source: ORBIS©, French publicly traded firms data matched with patent and trade mark and patent databases, authors own calculations.*

The variable "intangible assets" in ORBIS© contains R&D, advertising and organisational expenses (see Giannetti 2003). Thus what the model captures is the respective effects of intangible investments and of the use of IP rights to protect those investments, which is in line with the theoretical framework used in Section 1.

The dummy variables corresponding to IP rights strategy relate to the fact that the firm applied for at least one patent and/or at least one trade mark during the period considered. In the first specification, the period over which the IP right behaviour is tracked is 1998-2007, which we assume describes the general IP right behaviour of the firm. In the second specification, the IP right behaviour is considered only in the years 2006-2007, since the model focuses on the difference in market value before and after this period. Table 1 gives descriptive statistics for the final dataset.

The different IP strategies are not equally represented in the sample. A large majority of firms use IP rights: 78% applied for at least one patent or one trade mark during 1998-2007, and 57% used IP rights in the only two years 2006-2007 (the proportion might be even higher since the matching methodology tends to favour false negatives). The use of trade marks is much more frequent than the use of patents (76% of firms used trade marks, 33% used patents in 1998-2007). The proportion of firms using both types of IP rights in 1998-2007 is 21%, so the complementary states correspond to nearly half of the sample (43%). To have more precisions on this repartition of the various IP rights strategies, we represented in Figure 1 the proportion of firms using the various strategies in the years 1998-2007 by type of sectors, based on the sector aggregation provided by Eurostat .

Patents are used primarily in high-tech manufacturing firms, where a non negligible proportion of firms use them and use no trade marks. In low-tech manufacturing, the use of patents is less frequent and almost always associated to the use of trade marks. In service sectors, the use of patents either alone or jointly with

Table 1: Descriptive Statistics for the Final Sample

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| **Valuation and assets variables (bil.euros)** | | | | | |
| Market Value 2007[1] | 786 | 3.239 | 14.501 | 0.0005 | 214.77 |
| Market Capitalisation 2007[1] | 786 | 1.840 | 9.512 | 0 | 148.471 |
| Long Term Debt 2007[1] | 786 | 0.504 | 2.145 | 0 | 32.686 |
| Current Liabilities 2007[1] | 786 | 0.894 | 3.985 | 0.00005 | 48.692 |
| Total Assets 2007[1] | 786 | 2.637 | 11.554 | 0 | 186.149 |
| | | | | | |
| Market Value 2005[2] | 556 | 3.598 | 14.349 | 0.001 | 177.499 |
| Market Capitalisation 2005[2] | 556 | 1.917 | 8.808 | 0 | 130.278 |
| Long Term Debt 2005[2] | 556 | 0.559 | 2.613 | 0 | 42.636 |
| Current Liabilities 2005[2] | 556 | 1.122 | 4.453 | 0 | 44.788 |
| Total Assets 2005[2] | 556 | 3.120 | 12.874 | 0.0004 | 171.136 |
| | | | | | |
| **Age** | | | | | |
| Age of the firm in 2007 | 786 | 38.607 | 42.117 | 0 | 375 |

| **IP strategy distribution** | **1998-2007**[1] | **2006-2007**[2] |
|---|---|---|
| $TM, PAT$ | 168 (21%) | 72 (13%) |
| $TM, 0$ | 433 (55%) | 228 (41%) |
| $0, PAT$ | 16 (2%) | 19 (3%) |
| $0, 0$ | 169 (22%) | 237 (43%) |
| | | |
| **Sector distribution**[3] | | |
| High-Tech Manuf. | 77 (10%)[1] | 48 (9%)[2] |
| Medium-High-Tech Manuf. | 79 (10%)[1] | 58 (10%)[2] |
| Medium-Low-Tech Manuf. | 43 (5%)[1] | 39 (7%)[2] |
| Low-Tech Manuf. | 98 (12%)[1] | 78 (14%)[2] |
| Knowl.-Intensive Services | 251 (32%)[1] | 177 (32%)[2] |
| Less Knowl.-Intensive Services | 171 (22%)[1] | 100 (18%)[2] |
| Other sectors | 67 (9%)[1] | 56 (10%)[2] |

[1] *Sample restricted to firms for which market value in 2007 is known: 786 observations*
[2] *Sample restricted to firms for which market value in 2007 and 2005 is known: 556 observations*
[3] *Sector aggregation based on Nace Rev.2, Eurostat*

trade marks is very rare.

### 3.3 Results

In this section, we estimate the market value equations based on the specifications (13) and (15) presented above. Specification (13) is estimated by :

$$\ln V_t = \beta_1 (1_{0.0}) + \beta_2 (1_{TM,0}) + \beta_3 (1_{0,PAT}) + \beta_4 (1_{TM,PAT}) + \gamma \ln(A_t) + \sigma age + i.sector,$$

in $t = 2007$ where $V$ is the firm's market value, $A$ is the amount of the firm's total assets, and $i.sector$ corresponds to the dummy variables of the sectors (Nace Rev. 2, 2 digit level). The dummy variables of trade mark and/or patent use indicate whether the firm applied for at least one patent or one trade mark at the national or European level between 1998 and 2007.

Specification (15) is estimated by:

$$\ln\left(V_{t_2}\right) = \ln(V_{t_1}) + \beta_1 (1_{0.0}) + \beta_2 (1_{TM,0}) + \beta_3 (1_{0,PAT}) + \beta_4 (1_{TM,PAT}) + \gamma_1 \ln\left(A_{t_2}\right) - \gamma_2 \ln\left(A_{t_1}\right) + \sigma age + i.sector,$$

in $t_2 = 2007$ and $t_1 = 2005$, and where the dummy variables of trade mark and/or patent use indicate if the firm applied for at least one patent or one trade mark at the national or European level between 2006 and 2007.

To investigate if the complementarity hypothesis holds, we apply a one-sided t-test on the obtained coefficients, with null hypothesis: $H_0 : \beta_1 + \beta_4 - \beta_2 - \beta_3 > 0$. The one-sided t-test rejects the null hypothesis at 5% level if the value of the t statistic is lower than $-1.645$ (then substitutability (non strict) holds). If the value of the t statistic is higher than 1.645, then strict complementarity holds at 5% level. At 10% level, the previous thresholds become -1.282, 1.282. Table 2 presents the results of the regressions and tests on the complete sample.

The results of the first specification (presented in column 3) tend to be in line with the theoretical model predictions. The order of the coefficients for IP rights variables are coherent with the expectations: the one-sided t-tests give positive results at the 10% level (and 5% for three of the tests), except $1_{noTM,PAT} > 1_{0,0}$, which gives no significant result. The latter result might come from the existence of IP right registration costs. As mentioned above, the cost of a patent registration is generally quite high, which might explain why the performance of the firm is not significantly higher if the firm registers patents. In the second specification (column 4), the results are less conclusive: the test gives positive results at 10% level only for $1_{TM,PAT} > 1_{0,0}$, and is not significant for the others. This might as well be explained by the non-negligible costs of IP right registration. In both specifications, all coefficients of the regression are significant at the 0.1% level, except the age, which is never significant. The global explanatory power of the model is very high, above 99% in both specifications. This is explained both by the use of without constant specification and by the very high explanatory power of the variable total asset in market value regressions (as can be seen in column 1 of the results).

The complementarity test does not give any significant result on the total sample. This could be expected since the theoretical model indicates that the results are likely to vary across sectors. To investigate this hypothesis, we estimated

Table 2: Market value regression and one-sided t-tests on the total sample

| Variables | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| *Dependent variable : ln (Market Value 2007)* | | | | |
| ln (Total Assets 2007) | 0.805*** | | 0.883*** | 0.879*** |
| | (0.0104) | | (0.010) | (0.022) |
| $1_{0,0}$ (98-07) | | 4.637*** | -5.437*** | |
| | | (0.863) | (0.254) | |
| $1_{0,PAT}$ (98-07) | | 4.710*** | -5.389*** | |
| | | (1.015) | (0.292) | |
| $1_{TM,0}$ (98-07) | | 5.325*** | -5.279*** | |
| | | (0.860) | (0.256) | |
| $1_{TM,PAT}$ (98-07) | | 6.137*** | -5.176*** | |
| | | (0.864) | (0.260) | |
| age | | | -0.0005 | 0.0004 |
| | | | (0.0006) | (0.0004) |
| ln(MV2005) | | | | 0.735*** |
| | | | | (0.029) |
| ln (Total Assets 2005) | | | | -0.631*** |
| | | | | (0.0337) |
| $1_{0,0}$ (06-07) | | | | -1.409*** |
| | | | | (0.229) |
| $1_{0,PAT}$ (06-07) | | | | -1.407*** |
| | | | | (0.239) |
| $1_{TM,0}$ (06-07) | | | | -1.380*** |
| | | | | (0.226) |
| $1_{TM,PAT}$ (06-07) | | | | -1.334*** |
| | | | | (0.231) |
| N | 786 | 786 | 786 | 556 |
| R-sq | 0.985 | 0.874 | 0.991 | 0.998 |
| One-sided Student test: t statistic | | | | |
| $1_{TM,0} > 1_{0,0}$ | | | 2.85 | 0.92 |
| $1_{0,PAT} > 1_{0,0}$ | | | 0.31 | 0.02 |
| $1_{TM,PAT} > 1_{0,0}$ | | | 3.73 | 1.61 |
| $1_{TM,PAT} > 1_{0,PAT}$ | | | 1.40 | 0.85 |
| $1_{TM,PAT} > 1_{TM,0}$ | | | 1.79 | 1.03 |
| Complementarity test: one-sided Student test (t statistics) | | | | |
| $H_0 : 1_{TM,PAT} - 1_{0,PAT} > 1_{TM,0} - 1_{0,0}$ | | | 0.34 | 0.49 |
| | | | - | - |

*OLS estimates. Standard errors in parentheses*
**** p<0.01, ** p<0.05, * p<0.1*
*All regressions also contain controls for sector at the Nace rev.2 2-digit level*

the previous model on sub-samples corresponding to two different sectors, both highly innovative: life science sectors on the one hand (pharmaceutical products and health services) and high-tech business sectors (computer, electronic and optical products and equipment) on the other hand. The results are presented in Table 3.

We find that the results of the supermodularity test vary across sectors. In the life science sector, as could be expected, the test tends to be in favour of the complementarity hypothesis (at the 10% level in the first specification and 5% level in the second specification). Indeed, in the pharmaceutical sectors, innovation generally consists in launching new drugs based on new molecules, and competitors are able to launch perfect substitutes on the market. In this situation, advertising is for a large part advertising for the product in general, so that it is not easily appropriable by the firm even if the latter registers a trademark. In this type of sectors, the theoretical model predicts that it is in the firms' interest to use patents jointly with trade marks in order to acquire the reputation during the monopoly period and continue to benefit from it after the expiration of the patent.

In the high-tech business sectors, by contrast, the supermodularity test tends to be in favour of substitutability in the second specification (the first specification yields no significant result). This might be explained by the fact that in those sectors, relying on cutting-edge technology, product innovations are not easily duplicable, so that advertising spillovers, with or without trademark, are relatively low. In that case, as predicted by the theoretical model, the complementary effect is lower.

# 4 Conclusion

In the paper by Amara *et al.* (2008), which shows complementarities between the use of various IP protection mechanisms for firms in KIBS sectors the authors call for future research on the factors that could explain the complementarities observed. One of those factors is the interaction of the legal mechanisms themselves. The main contribution of this paper is to assess the interrelated effects of IP rights considering them in their core function as legal protection devices instead of as proxies of other underlying assets. We tackle this question both through a formal theoretical model and through an empirical analysis. We compare the outcome of innovating firms adopting various IP right strategies: patent or not and/or trade mark or not, and then assess the complementarity or substitutability relationship between the two IP rights based on the supermodularity approach.

The main finding of our model is that the complementarity or substitutability relationship between trade marks and patents is not straightforward. We find that the interaction between the two IP rights is characterized by two counterbalancing effects: a temporal substitutability effect – as the patent period reduces the time during which the firm faces competition and needs trade marks to protect its reputation against other firms - and a complementarity effect – as the trade mark enables the firm to extend the reputational benefits of the monopoly period beyond the expiration of the patent. We show that the predominance of one or the other effect depends on exogenous parameters, especially the level of appro-

Table 3: Market value regression and one-sided t-tests on life science and high-tech business sectors

| Variables | (1) Life science | (2) Life science | (3) High-tech | (4) High-tech |
|---|---|---|---|---|
| *Dependent variable : ln (Market Value 2007)* | | | | |
| ln (Total Assets 2007) | 0.898*** | 0.908*** | 0.931*** | 0.960*** |
| | (0.039) | (0.210) | (0.037) | (0.037) |
| $1_{0,0}$ (98-07) | -4.994*** | | -5.830*** | |
| | (0.490) | | (0.428) | |
| $1_{0,PAT}$ (98-07) | -5.522*** | | -5.276*** | |
| | (0.638) | | (0.480) | |
| $1_{TM,0}$ (98-07) | -5.103*** | | -5.584*** | |
| | (0.480) | | (0.407) | |
| $1_{TM,PAT}$ (98-07) | -4.719*** | | -5.319*** | |
| | (0.490) | | (0.432) | |
| age | -0.001 | 0.005 | -0.005** | 0.0002 |
| | (0.002) | (0.005) | (0.002) | (0.0009) |
| ln(MV2005) | | 1.334** | | 0.665*** |
| | | (0.465) | | (0.066) |
| ln (Total Assets 2005) | | -1.235** | | -0.638*** |
| | | (0.492) | | (0.071) |
| $1_{0,0}$ (06-07) | | 2.300 | | -2.199*** |
| | | (2.624) | | (0.443) |
| $1_{0,PAT}$ (06-07) | | 1.212 | | -1.881*** |
| | | (2.480) | | (0.447) |
| $1_{TM,0}$ (06-07) | | 1.751 | | -2.046*** |
| | | (2.522) | | (0.407) |
| $1_{TM,PAT}$ (06-07) | | 1.883 | | -2.012*** |
| | | (2.394) | | (0.418) |
| N | 33 | 18 | 45 | 30 |
| R-sq | 0.995 | 0.998 | 0.993 | 0.999 |
| One-sided Student test: t statistic | | | | |
| $1_{TM,0} > 1_{0,0}$ | -0.30 | -1.67 | 1.05 | 1.67 |
| $1_{0,PAT} > 1_{0,0}$ | -0.92 | -2.08 | 1.78 | 3.12 |
| $1_{TM,PAT} > 1_{0,0}$ | 0.75 | -1.04 | 2.31 | 2.08 |
| $1_{TM,PAT} > 1_{0,PAT}$ | 1.67 | 1.37 | -0.16 | -1.20 |
| $1_{TM,PAT} > 1_{TM,0}$ | 2.14 | 0.47 | 1.49 | 0.35 |
| Complementarity test: one-sided Student test (t statistics): $H_0 : 1_{TM,PAT} - 1_{0,PAT} > 1_{TM,0} - 1_{0,0}$ | | | | |
| | 1.52 | 2.22 | -0.81 | -2.09 |
| | *Complem.* | *Complem.* | - | *Substit.* |
| | *(0.1 level)* | *(0.05 level)* | | *(0.05 level)* |

*OLS estimates. Standard errors in parentheses*
**** p<0.01, ** p<0.05, * p<0.1*

priability of advertising expenditure enabled by trade marks. If the latter is high, then trade marks are likely to be substitutes, so the benefits of registering a trade mark will be all the more important if the firm cannot register a patent. On the contrary, if the effectiveness of trade marks is low, for example in sectors such as pharma where technology is highly codified, then trade marks and patents are complementary. The optimal IP rights strategy of firms may then vary from one context to another, from one firm to another. Following the conclusion of Teece (1986) that the profit gained from innovation depends on the possibility of the firm to use complementary assets, our model goes a step further and states that the relationship between the various assets is itself dependent on the context in which the firms operate.

The implications of this model are twofold. First, there are implications for IP right management within firms. We show that beyond the question of the eligibility of the innovation to the various types of IP rights, the profitability of a diversified IP strategy depends on context elements, which need to be taken into account to determine the benefits and costs of the various combinations. Failure to identify complementarity (resp. substitutability) between some protection mechanisms may lead to underexploitation (resp. overexploitation) of synergies and underprotection (resp. overprotection) of innovations. Secondly the model has implications for economic analyses. Whenever investigating firms' IP right activity, for example as a proxy for other intangible assets, one should bear in mind the existence of context-dependent interaction effects between the various types of protection.

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