Exploiting complementarities in IPR mechanisms: the joint use of patents, trademarks and designs by SMEs

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Abstract

In this paper we analyze the existence of complementarity vs. substitution between different forms of IPRs (namely patents as opposed to trademarks and registered designs) in the specific case of SMEs. We address this research question by assessing the impact of different combinations of IPRs on firms' economic performance, and using empirical evidence from a sample of SMEs operating in manufacturing industries in Northern Italy. Our results, based on a propensity score matching approach, provide evidence in support of complementarity.

1. INTRODUCTION

What is needed to firms to capture the value from innovation? Since the seminal work of Teece (1986), this question has occupied a prominent position in the research agenda of scholars interested in innovation studies, due to its relevance for managers and policy-makers. Theoretical and empirical works published over the last twenty years have pointed out that the capacity to profit from innovation is affected by three classes of strategic factors (Cohen et al., 2000): 1) the technological trajectories of the innovation; 2) the appropriability regime; and 3) the position of the inventor with respect to complementary assets.

Despite the significant attention devoted to this topic, to date a number of issues remain relatively under-explored. As suggested by Nelson (2006) and Teece (2006:1138), for example, there is a lack of empirical research about the complementarity of the different protection mechanisms in predicting the profitability of innovation. Moreover, little effort has been devoted to assess the specificity of the problem for small and medium enterprises (SMEs). This kind of organization is subject to significant resource constraints which magnify the problem of how much funding allocate to improve the technological domain or to lower price competition through advertising expenditures. Due to limited resources, the issue of focusing on specific protection mechanisms (i.e. patents), in substitution of others (i.e trade secretes or trademarks and designs), thus becomes particularly critical for this type of companies.

Starting from such considerations, in this paper we analyze the relationship existing among different kinds of IPRs as means to appropriate the value of innovation. In particular, we address the following research question: "For SMEs, are patents and designs/trademarks complements or substitutes to

capture the value from innovation?". We compare patents and trademarks/designs since the former typically protect the technical functionalities of a given product, whereas the latter tend to protect the symbols, meanings and appearance associated to it, thus reflecting different dimensions of innovation (Mendoca et al., 2004; Ramello and Silva, 2006; Verganti, 2008).

Given the research question, this work aims to contribute to the existing literature in two distinct ways. First, we provide empirical evidence of the relation (in terms of complementarity vs. substitution) existing between different kinds of IP in predicting the profitability of innovation, in the specific case of SMEs. Second, we extend the economic literature on IPRs, generally focused on patents, highlighting the possible use of trademarks and designs as mechanisms to protect the symbolic value associated to an innovation (Ravasi and Rindova, 2004), and analyze what determines the SMEs' propensity to use of different types of IPRs. Third, we assess the impact on firms' performance of different combinations of IPRs (simultaneous protection of patents and trademarks/designs; simple patent protection; simple trademark/design protection; no IP protection at all). With this respect, we point out that to date just a limited number of studies have focused on trademark or design protection. Morever, in general they favour a one-dimensional approach which considers them as alternative indicators of organizational performance (Amara, Landry, & Traore, 2008; Mendonça, Pereira, & Godinho, 2004; Ramello & Silva, 2006). To our knowledge, no previous study has directly tackle with the implications for firm's performance of the use of various forms of IPR protection, in the specific case of SMEs.

The empirical setting we investigate is represented by a random sample of 453 SMEs that operate in manufacturing sectors in the region Emilia-Romagna, in Northern Italy. This represents an optimal setting to address our research question, essentially for two reasons: first, the sample is representative of the entire industrial pattern of Italy, principally made of small and medium enterprises (Piore & Sabel, 1984; Malerba & Orsenigo, 1990); second, since all firms are located in the same region, we are able to control for institutional differences that influence the infrastructural endowment (Audretsch, 1995).

Firm-level data were gathered through an e-mail survey, replicated in two different years (2003 and 2008). We complemented such information with: a) data on patents granted at the Italian Patent and Trademark Office and at the European Patent Office, collected from UIBM and EPO websites; b) data on registrations of trademarks and designs at the Italian Patent and Trademark Office and at the OAMI, collected from the UIBM and OAMI websites. We were able therefore to identify 4 clusters of companies: companies jointly recurring to patents and trademarks/designs as a way to protect innovation; those focusing only on patents; those focusing only on trademarks/designs; those not recurring at all to such kinds of protection mechanisms.

We used counterfactual causal modelling in conjunction with regression techniques (Rubin, 1973) to analyze the link between economic performance and the first three types of protection strategies (using the last class respectively as "non treated" subjects or reference category). As recently suggested in the literature, the adoption of a mixed-technique strategy can improve the reliability of empirical results, offering the chance to run sensitivity analysis (Morgan & Winship, 2007). Moreover the application of matching techniques is an approach to pre-processing data that ensures the main variable of interest is closer to being independent of the background covariates (Ho, Imai, King, & Stuart, 2007).

The rest of the paper is organized as follows. In the next section we present our theoretical background. In Section 3 we introduce our empirical setting, the data and the methods. Section 4 reports the results of our analyses. In the final section we draw our conclusions from the theoretical and empirical analysis.

2. **THEORETICAL BACKGROUND**

2.1. Patents, trademarks and industrial designs as mechanisms to protect technical and symbolic value

Intellectual property broadly identifies the legal rights which result from intellectual activity in the industrial, scientific, literary and artistic fields. It is generally divided into two categories: Industrial property, including patents, trademarks, industrial designs, and geographic indications of source; and Copyright, which includes literary and artistic works.

The economic and management literature has widely assessed the effectiveness of Intellectual Property Rights as a mechanism to protect the returns stemming from innovation and the determinants of the choice of adoption (Cohen et al., 2000). The large majority of the literature has focused on the analysis of patents, intended as instruments to protect technical inventions (i.e. Arundel and Kabla, 1998; Bound et al., 1984; Harabi, 1995). More recently, an increasing attention has been given in the literature to alternative IP protection mechanisms, in particular for what concerns the role of trademarks, design registration, secrecy, copyrights (Amara et al., 2008; Graham and Somaya, 2006; Mendoca et al., 2004; Ramello and Silva, 2006). The shift to a more comprehensive analysis of how firms mix various protection mechanisms probably reflects the interest for a more complete view of innovation activities, incorporating not only the technical of functional dimensions of a given product, but also the symbolic meanings associated with it. Recent contributions have emphasized the role of symbolic value - defined as the set social and cultural meanings associated with a product, which enable consumers to use it to communicate about their

identity and social and status group membership -, as a fundamental constituent of the total value created by a firm through production and exchange (Ravasi and Rindova, 2004). Symbolic value creation requires firms to possess and deploy tangible and intangible resources that enable them to create products that consumers value for their meanings, not only for their functions (Lawrence & Phillips, 2002).

Among intangible resources, trademarks and industrial design can play a fundamental role in the process of accumulation, protection and exploitation of symbolic value. In their essence, trademark represents distinctive signs aimed at conveying information in order to facilitate consumer choice and avert opportunistic behavior on the part of producers. Although their primary economic function is that of reducing information asymmetries and avert market failures through adverse selection, they have a secondary function, connected with the impact on consumers of the meaning conveyed by the commercial sign (Ramello and Silva, 2006). This second function is therefore related to the concept of "differential distinctiveness", signaling how a particular trademark differs from the others. This is often referred to the "strength" of a trademark, with reference to its ability to convey a sense of uniqueness in the eyes of consumers.

In a similar vein, industrial design, as a form of IPRs, refers to the right granted in many countries, pursuant to a registration system, to protect the original ornamental and non-functional features of an industrial article or product that result from design activity2. In more general sense, a rather traditional view of industrial design highlights the creative activity of achieving a formal or ornamental appearance for mass-produced product that satisfies both the need to appeal visually to potential consumers and need for the product to perform its intended function efficiently. A broader view accepted by many design theorists, on the other hand, highlights that design deals with the meanings that people give to products, and with the messages and product languages that one can devise to convey that meaning (Verganti, 2008). Under this view, the aesthetic appearance of a product is but one of many ways a product may bring messages to the user. Apart from functionalities and styling, what matters to the user of a product is its emotional and symbolic value (i.e. its meaning) deriving from a system of values, a personality and identity. Designers give meaning to products by using a specific design language, made of signs, symbols and icons. The legal protection of industrial designs registrations thus serves the important function of protecting the distinctive elements associated to the appearance and symbolic meaning of a product, by which manufacturers achieve market success.

2.2. The use of patents, trademarks and design registrations by SMEs

[2] An Industrial Design is distinguished from a trademark primarily because it is constituted by the appearance of a product, which must not necessarily be distinctive (a prime requirement for a trademark).

Previous studies in the field of economics and management of innovation has largely focused on the use of patents, typically in large and high-tech manufacturing firms (Arundel and Kabla, 1998; Bound et al., 1984; Harabi, 1995). The use of other IP protection methods, in particular by SMEs, has received very limited attention in the literature. Significant exceptions are represented by the studies of Greenhalgh and Rogers (2006) and Amara et al. (2008).

In a study based on a large sample of production firms listed in the United Kingdom, Greenhalgh and Rogers (2006) show that trade mark activity tend to be more common than patenting. It is present in around one-third to one-half of firms in supplier-dominated, production intensive, science-based and information-based sectors, and is only slightly lower in the software-related sector. On the other hand, patent activity is higher in science-based (with 41% of the firms holding at least one patent) and production-intensive sectors (38% for scale producers and 31% for specialist producers), whereas software-related firms have the lowest proportion of patenters, reflecting the fact that computer software is not generally patentable under EPO or UK rules. This study, however, refers to large, publicly-listed companies, and does not take into consideration how firm size impacts IP activity.

The study of Amara et al. (2008) based on a survey among 2625 service firms in Canada analyzes the mix of IP mechanisms used by firms to protect their innovations. Approximately 15.7% of service firms in the sample relied on patents, 11.8% on registration of design patterns, and 34.5% on trademarks. Although the authors do not explicitly compare differences between small and large firms in the propensity to use the different mechanisms, their regression analyses point out that firm size is positively and significantly associated with the use of all the three protection methods. Their results thus confirm that firm size is an important determinant of the use of legal protection mechanism[3].

Moving from this result, it is possible to advance different explanations to support a lower propensity to use formal IP protection mechanisms by SMEs. A first explanation deals with the lower rates of innovative activity among SMEs as compared to large companies, although the extensive literature on the relationship between firm size and innovation has still not reached conclusive results on this issue (Cohen and Levin, 1989). Focusing more directly on arguments related to IP usage rather than on levels of inventive activity, it should be noted that the registration and maintenance of IPRs, such as patents, trademarks and industrial designs, require the payment of fees, which can represent a significant financial burden for small enterprises[4]. In addition to that, one should also calculate the

[3] In this study, R&D-intensity also results an important antecedents of IP protection choices, being positively related to the likelihood to have a patent or a trademark.

4 For instance, an analysis commissioned in 2004 by the European Patent Office to the consulting firm Roland Berger tried to compute the costs incurred for a typical European patent. Based on a survey conducted among 254 companies, the study showed that the typical European patent obtained by such companies in 2003 involved costs of around 30.500 Euro,

honorary of the IP consultants who are generally involved in the registration process, given that such kind of companies typically do not maintain in-house IP professionals.

Moreover, IP rights are costly to enforce. Consider for instance the type of costs that an innovator has to undertake in case of infringement disputes. On the one hand, there are direct legal costs. In the case of a patent lawsuit in the U.S that goes on trial, for instance, such legal costs can easily reach levels of one to several million US$.[5] In addition to that, there are business costs of litigation that can take several forms, going from the time devoted by managers and researchers to prepare documents and depositions in the court, to the blockage of cooperative relations with suppliers and customers, to the shut-down of production and sales activities during the litigation period. SMEs may not have the financial resources to fund such dispute resolution procedures and face the related risks, therefore preferring to recur to informal protection mechanisms (such as trade secrets).

Finally, an important organization resource to fully exploit IP strategies is represented by the availability of firm-level expertise in the area of IP law and IP management. Given the financial and resource constraints which typically characterize SMEs, it is very difficult that they retain in-house the necessary expertise, either in formalized IP department, or in single IP professional. As to this point, the UK IP Awareness Survey run in September 2006 among more than 1700 firms of all sizes and different sectors by the UK Intellectual Property Office show that SMEs and the mass of Micro-enterprises are in the main effectively unaware of the IP system[6]. The lack of knowledge and awareness of IPRs among SMEs thus represents a critical barrier for the diffusion of such instruments in this particular setting.

Although the explanations for a limited propensity of SMEs to use IPRs are well rooted in the literature, there exists only limited empirical evidence to support such view. To our knowledge, the only studies which have empirically tackled with this issue, with respect to different forms of IPRs by SMEs, are those by Bordoy et al. in Europe (2007) and by Jensen and Webster in Austrialia (2004). The former study is based on data by the Third Community Innovation Survey (CIS-3) to investigate the percentage of SMEs and large firms in Europe that used one of four types of IP in 2000: patents, design registration, trademarks and copyrights. It shows that on average, a higher percentage of large firms than SMEs applied for one or more patents in 2000 in each of 15 EU countries under study. The rate for large firms was on average five times than for SMEs. Similar results are obtained for the remaing three types of IP. More specifically, only 5.8%, of SMEs applied for at least one patent in

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divided between pre-filing expenditures, internal cost of processing, attorney fees, translation of application and claims, official EPO fees, validation.

[5] Such estimates of legal costs of patent lawsuits are provided in Bessen and Maurer, based on a survey of patent lawyers conducted by the American Intellectual Property Law Association (AIPLA) in 2005.

[6] Only 11.2% of micro-enterprises with 0-9 employees contacted in this survey knew that publishing before filing will invalidate a UK patent application (as compared to 33% of firms with more than 250 employees). Moreover, the majority of SMEs and Micro-enterprises in this study to not assign a clear responsibility for IPR issues and are leaving the issue without active management.

the period 1998-2000 in the case of developed countries, only 10.2% and 11.1% of them made use respectively of design and of trademark in the same period. There are significant variations by countries and sectors with this respect[7].

Jensen and Webster (2004) compare the intensity of IP usage (the ratio of IP applications to the number of employees) between large firms and SMEs in a large sample of Australian firms in the period 1994-2001. They find that SMEs have a lower patent application rate, a higher trademark application rate and an equivalent design registration rate to large firms, with marked differences across industries. However, their regression analyses controlling for technology, production and supply characteristics, show no significant differences in the rates for patents and trademark by firm size (whereas for desing registrations they indicated higher rates for large firms).

In summary, we only have limited empirical evidence on the joint use of patents, trademarks and design registrations by SMEs, as mechanisms to protect the technical and symbolic value of innovations. Moreover, further work is needed to analyze in more detail the various factors (both external and internal to the firm) which affect the propensity to adopt different IP mechanism by this type of firms. A third an important issue which is still relatively unaddressed in the literature refers to the complementarities or substitution that characterize the different types of IPRs. In particular, it seems of particular interest analyzing whether patents on one hand (as a means to protect the technical and functional elements of an innovation), and trademarks and designs on the other hand (as means to protect the symbolic elements of an innovation) can be seen as substitutes or complements by SMEs. We will discuss in more depth this issue in the next section of the paper.

2.3. Complementarity vs substitution in the use of IPRs by SMEs

Not only the economic and management literature has tended to underplay the importance of non-patent forms of IP, but it has also largely ignored the relationships existing between the different forms. As noted by Graham and Somaya (2006), the prevailing implicit assumption viewed the different types of IPRs as substitutes rather then as complements, largely focusing on the trade-off between patents and trade secrets. The very influential Yale innovation survey (Levin et al., 1989, for instance, reduces legal appropriability mechanisms to two dimensions – patent and non-patents (including secrecy) – which appeared as used as substitutes. Other surveys conducted in Europe either assumed implicitly that a firm had to choose between patenting and secrecy (Harabi, 1995; Arundel, 2001), or found negative correlations in the perceived effectiveness of such instruments (Arundel and Kabla, 1998).

[7] Germany, the United Kingdom and Estonia respectively presents the higher rates for the use of patents, designs and trademarks by SMEs in this survey. In all countries except Portugal the sector combination Medium-High and High-tech manufacturing has the highest percentage of SMEs that have applied for at least one patent.

Once the level of analysis is shifted from the single invention to the whole technology or product, however, it becomes immediate to recognize that numerous separately protectable elements can be simultaneously subject to different forms of IPRs (Graham and Somaya, 2006). The enormously successful I-phone commercialized by Apple, for instance, encompasses several patents (for instance those protecting the innovative Multi-touch technology), trademarks (for instance the one identifying the same Multi-touch technology), as well as copyright for the software code. The explorative interviews conducted by Graham and Somaya (2006) with IP legal counsels or IP managers in 19 U.S. software firms were broadly supportive of complementarity of different types of IPRs in software. Their successive quantitative analyses employing copyright, patent and trademark litigation data from the same industry provide evidence in support of complementarity beween software firms' copyright and trademark use. Moreover, the level of managerial attention to IP strategy and the amount of organization resources used for IP management result as mediating mechanisms that explains complementarity between copyright and trademark use in software.

Recalling the discussion made in section 2.1, we are particularly interested in the relationship of complementarity vs. substitution exsiting between patents on one side, and trademarks/designs on the other side. Whereas the former can be seen as exclusive right granted for an invention, thus protecting the technical and functional features of a product, the latter primarily relate to the symbolic elements of a product, protecting respectively its distinctive signs or its aesthetic nature. Given that recent contributions have highlighted how firms can reach a position of sustainable competitive advantage by radically innovating *both* in terms of new functionalities and in terms of new meanings and languages (Verganti, 2008; Ravasi and Rindova, 2004), it is possible to argue that complementarities in IPR mechanism can be exploited to simultaneously protect both innovation dimensions[8].

Indeed, the only study, to our knowledge, looking into the complementarities among patent, trademark and design registrations provides support for this view. In their analysis of knowledge-intensive business services firms, Amara et al. (2008) found that such firms simultaneously make use of the three different types of IPRs (among others) when protecting their innovation. In this study, results from the Multivariate Probit Models show that patents, trademarks and design registrations are used as sets of complementary protection methods. This study, however, addresses specifically firms operating in three different service industries, it is not certain that its findings can be generalized to manufacturing industries. Moreover, the study does not include firms with less than 15

[8] Several examples of succesful innovative products on both the technological and the symbolic side are available, in additino to the already mentioned example of I-Phone. The Swatch watch, for instance, included several patent-protected innovations related to the quartz technology, but also conveyed an entirely new meaning of fashion wristwatch, thanks to its innovative design based on the intensive use of plastic, colorful style and low price (Glasmeier, 1991).

employees, its results therefore cannot be generalized to small enterprises. Indeed, given the financial and resource constraints characterizing small firms, it is possible to argue that, as compared to large companies, they face more difficulties in jointly using different types of IPRs. The advantages of complementarity can be less straightforward in this case. Finally, in this work, as in all other studies analyzing the joint use of different forms of IPRs, no attempt has been made to investigate how the choice of a given mix of IPRs impacts on firm's performance. Ultimately, in order to more deeply understand the conditions leading to optimal choices of different IP protection strategies, we do believe it is also necessary to analyze their impact on firm's economic outcomes.

Building on such considerations, we aim to contribute to previous literature also by looking into complementarity vs substitution between different forms of IPRs (namely patents vs trademarks and designs) in the specific case of SMEs operating in manufacturing industries. We address this research question by assessing the impact on firms' performance of different combinations of IPRs (simultaneous protection of patents and trademarks/designs; simple patent protection; simple trademark/design protection; no IP protection at all), for a sample of SMEs operating in Northern Italy.

3. RESEARCH SETTING, DATA AND METHODS

3.1 Research setting and data collection

This study was based on a cross-industries sample of SME's in the Emilia-Romagna region, in Northern Italy. According to the European Commission recommendation, we consider as SME's those firms with a head-count of less than 250 and a turnover of not more than 50 millions of euros. Firms were selected in the following 2-digits SIC codes: "Lumber and Wood Products" (24), "Chemicals and Allied Products" (28), "Industrial and Commercial Machinery and Computer Equipment" (35), "Electrical Equipment and Components" (36). Details about sample composition by industry are provided below, in the next section.

We constructed our sample starting from a random selection of 6000 SMEs located in the Region Emilia-Romagna from the "ASIA" database, which is an exhaustive archive of Italian firms managed by Unioncamere, the National Union of Chambers of Commerce, Industry, Handicraft and Agriculture in Italy. Since our objective was to estimate a precise causal effect, we decided to limit external source of heterogeneity in firms' performance simply focusing on firms located in the same geographical area. In so doing we were able to control for institutional differences at regional level (Audretsch, 1995), attaining the infrastructural

endowment. For this reason firms were sampled to had their legal address and operating unit in the Emilia-Romagna region

As specified above, the research design has a quasi-experimental nature and it is based on longitudinal data. Data were collected both from primary sources and secondary sources. Information about firms' performance (i.e. profitability, turnover growth, sales from new products and a self-reported multi-item measure), innovative effort (i.e. R&D intensity, investments in marketing, investments in design, intellectual capital), downstream and upstream market relations were gathered by CNA Emilia-Romagna through two e-mail surveys sent to the initial random sample of 6000 SMEs. Surveys were ran with a temporal lag of three years, respectively in 2004 and 2007. A single key informant strategy was used, preferably the founder/entrepreneur or the CEO. Next, most of the suggestions provided by Dillman (2000) to maximize response rates were followed. Firms received a letter stating the purpose and importance of the research project and then a phone call in which they were requested to participate. In total 581 questionnaires were received, representing an overall participation rate of 9.7 percent. Missing data reduced the usable sample to 425 firms.

We complemented firm-level variables by gathering data about IPR's portfolios for each respondents, tracking the combination of patents, designs and trademarks at different points in time. In this case data were collected from secondary sources. Patents information were gathered from the Italian Patents and Trademarks Office (UIBM) and the European Patent Office (EPO) on-line databases. Trademarks and designs information were gathered from the UIBM and the Trademarks and Designs Registration Office of the European Union (OHMI) on-line databases.

We tested for nonresponse bias by comparing key attributes of respondents and nonrespondents. T-tests indicated no significant differences on either firm size or firm age, measured as employees as well turnover. Nor significant difference was detected in terms of respondents/nonrespondents distribution over industries.

3.2. Variables

According to the quasi-experimental nature of the research design we distinguished among three classes of variables: outcome variables; treatment variables; pre-treatment or stratifying variables.

Outcome variables. The causal effect of distinct IPR combinations on firms performance was evaluated recurring to three distinct variables. Two of them are objective measures of firm's performance: the "Return on Assets (ROA)" and "Return on Sales (ROS)" indexes. The third

variable is a self-reported measure of performance, based on four items expressing the "profitability", "liquidity", "sale growth" and "productivity level" of the firms over the last three years. All the items were measured on a Likert scale ranging form 1 "completely unsatisfactory" to 5 "very satisfactory". The scale was computed by averaging the four items, achieving a Cronbach's alpha of .82. The reliability of the scale was confirmed by average item-to-test correlations over .80 for each item. All dependent variables are measured at year 2007, showing therefore a three years lag respect to both treatment variables and pre-treatment firms characteristics, which are measured at year 2004.

Treatment variables. It represents the (nonrandomized) treatment assignment for each firm. It assumes one of the following modalities for each case. "0", when the firm has no patents nor designs or trademarks; "1", when the firm has only patents in its IPR portfolio (but not trademark/designs); "2", when the firm has only designs or trademarks in its IPR portfolio (but not patents); "3", when the firm has both patents and designs or trademarks in its IPR portfolio. The treatment assignment is based on the IPRs portfolio determined at 2004. We take into consideration only active IPRs in order to assign each firm in one of the abovementioned categories.

Pre-treatment or stratifying variables. This class of variables represented the analogue of "control variables set" employed in usual econometric models. In particular we used industry and firm-level attributes to predict the probability for a firm to receive a certain treatment (use a specific combination of IPRs), given the observed nonrandomized exposure to treatment. In other words we identified as similar as possible cases respect to an array of variables influencing the innovative outcome, and, at a second stage, the chance to protect the innovative outcome, with a piece of intellectual property. Since different industries provide different incentives to use IPRs, we considered four dummies[9] capturing industry-effects related to the intellectual property regimes (affecting the use of patents) and demand characteristics (affecting the use of designs and trademarks). At firm-level we control for the innovative effort exerted by organizations, independently measured as "R&D", "marketing" and "human capital training" expenditures on sales. Further, we controlled for the internationalization degree of firms, potentially influencing the need to protect the innovation with formal instrument. The measure we consider is the percentage of total sales realized in foreign markets. Last, we took into account the bias in the propensity to use IPRs due to the nature of downstream and upstream market relations. In particular we stratified firms respect to the number of customers and the number of suppliers they interact with. All stratifying variables have been measured at 2004, as well the IPRs combination.

[9] SIC code 24 set as baseline.

3.3. Methods

In social sciences data very often do not come from randomized trials but from (nonrandomized) observational studies, as in this case. In a seminal work Rosenbaum & Rubin (1983) proposed propensity score matching as a method to reduce the bias in the estimation of treatment effects with observational datasets. Since in observational studies assignment of cases to the treatment and control groups is not random (Cook & Campbell, 1979), the estimation of the effect of treatment may be biased by the existence of confounding factors. Propensity score matching is a way to "correct" the estimation of treatment effects controlling for the existence of these confounding factors based on the idea that the bias is reduced when the comparison of outcomes is performed using treated and control cases who are as similar as possible. Moreover, matching based on propensity scores can aid to reduce sparseness problems (Rosenbaum & Rubin, 1983), resulting form the finiteness of the sample.
Since matching subjects on an n-dimensional vector of characteristics is typically unfeasible for large n, this method proposes to summarize pre-treatment characteristics of each subject into a single-index variable (the propensity score) that makes the matching feasible.

$$p(X) \equiv \Pr(D=j|X) = E(D|X)$$

where $D = \{0,1,...,J\}$ is the indicator of exposure to treatment and X is the multidimensional vector of pretreatment variables. Rosenbaum and Rubin(1983) show that if the exposure to treatment is random within cells defined by X, it is also random within cells defined by the values of the one-dimensional variable p(X). As a result, supposing a binary treatment and given a population of units denoted by i, if the propensity score p(Xi) is known, then the Average effect of Treatment on the Treated (ATT) can be estimated as follows:

$$\begin{aligned} ATT &\equiv E\{Yi - Y0i|Di = 1\} \\ &= EE\{Y1i - Y0i|Di = 1, p(Xi)\} \\ &= EE\{Y1i|Di = 1, p(Xi)\} - E\{Y0i|Di = 0, p(Xi)\}|Di = 1 \end{aligned}$$

where the outer expectation is over the distribution of$(p(Xi)|Di = 1)$ and Y1i and Y0i are the potential outcomes in the two counterfactual situations of (respectively) treatment and no treatment.

In our case the propensity scores were estimated with a probit model, following the procedures suggested by Rosenbaum (2002) for a many-valued treatment. The pscore STATA plugin (Becker & Ichino, 2002) was then used to estimate the following equation in different sub-sample drawn from the original 425 set of observations:

Pr(D=patens & design/trademarks|X)=p(X)

(X)=(innovative effort, down/up-stream market relations, firm size, internationalization degree, industry effects)

Firms were matched using nearest-neighbors method[10], that constructs the counterfactual for each treatment case using the control cases that are closest to the treatment on p(X). The algorithm was ran with replacement, enabling a control case returns in the pool after a match. We reduced bias in the estimation producing a one-to-one match (Morgan & Winship, 2007). To further improve the quality of matching procedures we excluded those cases out of the region of common support based on propensity scores distribution (cases with very low or very high probability to receive the treatment). Using the appropriate propensity scores derived in the probit models we formed a series of two-groups comparisons (see fig. 1), in order to estimate the ATT as indicated above.

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insert Figure 1 about here

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4. RESULTS

Table 1 provides descriptive statistics and full correlations among the variables used to derive the propensity scores. The average firm had sales levels of about 3 millions of euros. The innovative effort, captured by indicators as R&D, marketing and human capital training expenditures appeared quite modest (less than 2% of sales). On average export sales accounted for more than 10% of the total. Significant positive correlations existed between firms' size and internationalization degree as well as between size and number of market relations. In other words small firms tended to be more "local" and to develop a minor number of down-stream

[10] We used psmatch2 STATA plugin. Leuven, E. & Sianesi, B. 2003. PSMATCH2: Stata module to perform full Mahalanobis and propensity score matching, common support graphing, and covariate imbalance testing.

and up-stream market relations (this is typical case of localized supply chain, very diffuse in the Italian manufacturing sectors).

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Insert Table 1 about here

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Table 2 shows the IPR diffusion among firms, taking into account the stock of active pieces of IP at the year 2004. Significant positive correlations existed between the recourse to patents and designs. Unexpectedly no association resulted among designs and trademarks recourse.

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Insert Table 2 about here

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Figure 2 reports the distribution of firms respect to their IPRs combination. It shows that the large majority of SMEs in our sample do not use any type of IPRs (64.30%). Around 10% of the companies hold at least one patent at the year 2004, but no trademarks or design. Around 12.77% of them, on the contrary, hold at least one trademark or a registered design, but no patents. Finally, around 13% of them hold both patents and trademarks/designs in their IP portfolio. Such numbers are slightly higher of those reported by CIS-3 survey for Italian firms, thus suggesting a good propensity of small firms operating in the region to exploit IPR mechanisms, at least if compared to national standards[11].

Results of probit regression underlying the estimation of propensity scores are illustrated in Table 3. Diagnostics show that treated and nontreated do not significantly differ in terms of stratifying variables after matching (the property of balancedness is satisfied). It follows that treatment assignments is random for firms with similar p(X).

The probit regression model has not only an instrumental role. In this case it has a substantive interest, offering original arguments to judge the SME's propensity to IPRs recourse. The

[11] The CIS-3 survey reports the following percentages of Italian small *innovative* firms reporting the use a specific protection mechanism over the period 1998-2000: 10% of them applied for a patent; 7% reported the use of a design registration; 14% of them reported the use of a trademark.

internationalization degree of the firm has a positive influence on the probability to use designs and trademarks, no matter if firms hold patents. The number of suppliers has a positive influence on the odds to jointly use patents and designs/trademarks respect to firms with trademarks only or firms not recurring at all to IPRs. As expected, firms that jointly invest in different innovative antecedents (R&D, marketing, human capital) have more chance to use patents and designs/trademarks respect to firms with no IPRs.

****

Insert Table 3 about here

****

Based on the propensity scores, firms were matched to estimate the causal effect of owning both patents and designs/trademarks respect to alternative strategies: a) adopting an orthogonal strategy, detaining respectively only patents or designs/trademarks, or b) discharging IPRs as a formal instrument to protect investments. For each treated we computed the difference in the outcome variable with respect to its matched case. Then we averaged this quantity for the treated (ATT).

We first notice, that the causal effect of recurring to both forms of IPRs (patents and trademarks/designs) is positive when we consider as control group firms with no IPRs at all. Firms recurring to both types of IPRs to protect not only the technical features, but also the symbolic aspects of their products, tend to be associated with higher performance levels as compared to firms not recurring to IPRs at all. The effect is also positive when we consider firms with only patents as control group. It seems therefore that firms able to deploy and protect intangible downstream assets, such a strong brand name or the symbolic value conferred by a unique industrial design, perform better than firms focusing on the protection of technical/functional aspects. The result is robust respect to various performance measures. On the other hand, when we adopt as a control group firms with designs/trademarks only, the causal effect is ambiguous. It is positive only when we use the self reported measure of performance.

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Insert Table 4 about here

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5. CONCLUSIONS

In this paper we have analyzed how SMEs recur to different forms of IPRs (namely, patents, trademarks and design registrations) and if this impacts on their economic performance. We have provided original empirical evidence from a sample of SMEs from manufacturing sectors in the region Emilia-Romagna, in Northern Italy, to address the issue of complementarity vs substitution in the use of patents (as a way to protect the technical and functional dimensions of a product) and trademarks/designs (as a way to protect the external form, symbols and meanings associated to a product). Our results, based on the propensity score matching approach, provide support in favor of complementarity. We showed that 13% of the SMEs in our sample hold both patents and trademarks/designs. Around 10% of the companies hold at least one patent at the year 2004 (but no trademarks or designs), whereas around 13% of them hold at least one trademark or a registered design (but no patents). The majority of the companies, however, does not recur to formal IP. Such numbers are in line with results by CIS-3 and CIS-4 surveys in the case of Italy, and show that there is ample space for policy intervention to raise the awareness and rate of usage of IPRs among SMEs. Our findings provide further support in this direction, showing that firms that jointly recur to patenting and registration of trademarks and/or designs are associated with higher economic performance (both self-reported and measured by ROS) than matched firms which do not use IPRs. We do believe that the investigation of the use and exploitation of the different forms of IPRs represent a promising area for future research. Further questions deserve more thorough inquiry. For instance, it is necessary to understand in more detail which are the external conditions influencing the optimal mix of IPR mechanisms by firms. Moreover, it should be investigated in more depth the organizational capabilities and processes required to fully exploit the different types of IPRs in an integrated way. Our study just represents a first step in this direction.

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TABLES AND FIGURES

Tab. 1: descriptive statistics and correlations among firm's attributes

Variable	Mean	St. dev	1	2	3	4	5	6	7	8	9	10
1. Size[a]	14.51	0.85	1.00									
2. SIC_28†	0.13	-	-0.01	1.00								
3. SIC_35	0.67	-	0.02	-0.56***	1.00							
4. SIC_36	0.14	-	0.03	-0.16	-0.58***	1.00						
5. Number of customers	232.26	400.74	0.38***	0.05	-0.01	-0.01	1.00					
6. Number of suppliers	102.69	132.86	0.36***	-0.11**	0.14**	-0.02	0.39***	1.00				
7. R&D exp•	0.45	1.81	0.06	0.02	-0.06	0.09	-0.02	0.01	1.00			
8. Human cap. train. exp.•	0.08	0.45	-0.01	-0.04	0.02	0.02	0.17***	0.14***	0.03	1.00		
9. Marketing exp.•	1.16	1.64	-0.03	-0.04	0.01	0.05	-0.00	0.04	0.08	-0.02	1.00	
10. Internat. degree	11.26	21.65	0.31***	-0.05	0.09	-0.02	0.19***	0.20***	0.11	0.14***	-0.04	1.00

n=425

[a]Logaritmic transformation of Sales

•Percentage on sales

† SIC 24 set as baseline

* p<0.05, ** p<0.01, *** p<0.001

Tab. 2: Descriptives and Cramer's V among IPR classes

	Mean	St. dev.	1	2	3
1. Patents	0.15	0.36	1.00		
2. Designs	0.06	0.25	0.24***	1.00	
3. Trademarks	0.11	0.32	0.05	0.08	1.00

n=425

* p<0.05, ** p<0.01, *** p<0.001

Tab. 3: Propensity scores estimation (Probit model)

	Model		
	(1) Patents & Designs/Trademarks Vs Patents Only	(2) Patents & Designs/Trademarks Vs Designs/Trademakrs Only	Patents & Designs/Trademarks Vs. No IPRs
Industry effects			
SIC_28	-0.318	-0.0369	0.158
	(1.039)	(0.791)	(0.564)
SIC_35	-0.299	0.224	0.205
	(0.971)	(0.707)	(0.512)
SIC_36	-0.690	0.385	0.135
	(1.040)	(0.775)	(0.566)
Firms size			
Sales (ln)	0.263	0.0714	0.0596
	(0.211)	(0.194)	(0.101)
Market relations			
Number of customers	0.00136	-0.000212	0.000238
	(0.000824)	(0.000289)	(0.000283)
Number of suppliers	0.00210	0.00192*	0.00169*
	(0.00165)	(0.000977)	(0.000721)
Innovative effort			
R&D exp.	0.00618	0.0126	0.00252
	(0.0101)	(0.00961)	(0.00253)
Marketing exp.	0.00288	0.00328	0.0122**
	(0.00593)	(0.00320)	(0.00455)
Human capital train exp.	0.0149	-0.00547	0.0321
	(0.0695)	(0.0503)	(0.0467)
Internationalization degree			
Export sales	0.0136*	0.00560	0.0155***
	(0.00681)	(0.00503)	(0.00404)
2-way interaction terms			
R&D. * Marketing exp.	0.000416	-0.0000422	-0.0000217
	(0.000523)	(0.0000849)	(0.0000451)
Human capital. * Marketing exp.	0.00575	0.00158	0.000297
	(0.00489)	(0.00437)	(0.000364)
Human capital. * Marketing exp.	0.00472	0.0000178	0.00480*
	(0.00405)	(0.000788)	(0.00224)
3-way interaction			
Human cap.* R&D. * Marketing exp.	0.000210	-0.0000125	-0.0000309*
	(0.000270)	(0.0000423)	(0.0000148)
_cons	-4.302	-1.898	-3.000
	(3.184)	(2.819)	(2.044)
Treated	Patents & Designs/Trademarks	Patents & Designs/Trademarks	Patents & Designs/Trademarks
Control	Patents only	Designs/Trademarks only	Untreated
n	98	110	327
pseudo R-sq	0.329	0.167	0.284
Log lik.	-44.54	-62.92	-106.1
Chi-squared	43.64***	25.25***	84.01***

# of blocks	6	6	6
Balancing property	satisfied	satisfied	satisfied

Dep. var. is “treatment 3”: joint use of patents & designs/trademarks

Standard errors in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Tab. 4: Average treatment on the treated estimation

Control Group	# treat.	# contr.	outcome	ATT	Std. Err.	t
Untreated	56	291	ec_fin	0.669	0.200	3.347
(No IPRs)	56	291	ROA	1.303	2.448	0.532
	56	291	ROS	2.077	1.134	1.832
Patents only	56	43	ec_fin	0.074	0.305	0.242
	56	43	ROA	4.021	2.335	1.723
	56	43	ROS	2.163	2.027	1.067
Designs/Trade	56	63	ec_fin	0.212	0.333	0.636
marks only	56	63	ROA	-2.815	2.758	-1.021
	56	63	ROS	-1.433	1.945	-0.737

Treated Group: Firms with “Patents & Designs/Trademarks”
[a] Analytical -bootstrapped- s.e.

Figures

Fig. 1: ATT estimation with a series of two-groups comparison strategy

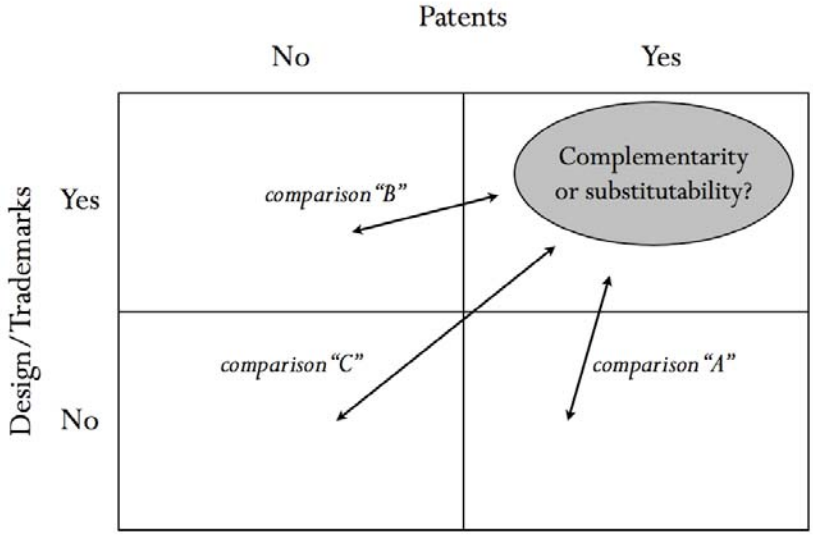

Fig. 2: Firms distribution respect to IPRs combination