UNIVERSITÀ DEGLI STUDI DI PADOVA

Dipartimento di Scienze Economiche ed Aziendali "Marco Fanno"

# PATENTING IN FAMILY FIRMS

ALESSANDRA TOGNAZZO
University of Padova

FEDERICA DESTRO
University of Padova

PAOLO GUBITTA
University of Padova

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# Patenting in Family Firms

Alessandra Tognazzo
Federica Destro
Paolo Gubitta

**Abstract**: In this paper we analyze patenting activities of family businesses, as compared to non-family ones. The main question is whether family businesses patent more or less. Then, we also analyze the composition of the inventor group and patent characteristics. To investigate these issues we analyzed a sample of 234 Italian businesses. We find some evidence that family firms differ in their patenting strategy from non-family ones.

**Keywords**: family business, patenting, innovation.

## 1. Introduction

There is a growing recognition that a better understanding of how family involvement influences performance is essential for progress in the field of family business (Habbershon et al., 2003). One way to reach higher results is to invest in innovation, which stimulates firm growth (Trott, 1998). Patent rights are essential to the protection of this return to invention and are consequently a key inducement to progress and development (Cohen et al., 2000).

Research has shown that innovation investments are important to firm performance in increasingly challenging competitive landscapes (Bettis and Hitt, 1995; Lawless and Anderson, 1996) and help in the acquisition and support of technical knowledge resources, which are key determinants of firm innovativeness (Damanpour, 1991).

Although there is limited research investigating the role of innovation within family firms, some scholars have suggested that family firms could be very innovative and aggressive in their markets (Aronoff, 1998;Craig and Moores, 2006), while others sustain that family involvement increases agency costs due to challenges such as nepotism, free riding, family entrenchment, and intergenerational conflict, thereby negatively affecting performance (e.g., Gomez-Mejia et al., 2001; Miller et al., 2007; Schulze et al., 2003).

This article builds on past research and attempts to investigate patenting activities in family-controlled firms as compared to non-family ones. The main question is whether family businesses patent more or less. Then, we also analyze the composition of the inventor group and patent characteristics.

The paper is organized as follows. First, we reivew the literature about the reasons why family businesses should patent more or less, as compared to non-family ones and we state our hypotheses. Second, we describe the methods used, our analyses and results. Finally, we conclude and discuss future directions and study limitations.

## 2. Literature

### *2.1 Conditions to Patent in Family Firms*

Firms can patent for different reasons according to the sector of activity. First, they aim to directly profit from a patented innovation through either its commercialization or licensing. Second, their goals could include the prevention of rivals from patenting related inventions (i.e., “patent

blocking"), the use of patents in negotiations and the prevention of suits (Cohen et al. 2000). Nonetheless, there are different conditions that facilitate or prevent patenting activities.

The patenting process requires uncertain and significant investments. Therefore, firms that have financial constraints have less possibilities to patent. One way to overcome this problem is to find potential lenders and suppliers of equity, but this brings in the traditional agency problem. The evaluation of innovation returns is difficult especially because of the specificity of the assets commonly involved in research activities, and therefore investors need to face problems of information asymmetry. This problem is quite extensively investigated in the literature about venture capital investments in high technology firms (Hall and Lerner, 2010; Stiglitz and Weiss 1981).

Families can impose on their firms risk aversion or avoidance (Shleifer and Vishny, 1986) through several activities, such as diversifying into unrelated businesses or under-utilizing debt (Anderson and Reeb, 2003).

Yet, founders' and heirs' long-term and continuing commitment to their firms potentially indicates an opposing effect. The media often depict these owners as maintaining long-term horizons that provide powerful incentives to commit substantial financial resources to long-term investment activities (Chen et al., 2008). Also, prior academic research argues that founders and heirs view their firms as an asset to pass on to subsequent generations rather than wealth to be consumed during their lifetimes (e.g., Anderson and Reeb, 2003).

As committed shareholders with a long-term perspective, family business members possess strong incentives to engage in investment activities that ensure the long-term viability and health of the firm (Cassia et al. 2012). Hall (1993) and Del Monte and Papagni (2003) argue that research and development (R&D) spending provides long-term benefits and these benefits often exceed those from capital spending; suggesting that family firms engage in R&D projects to protect the firm's long-term welfare. In other words, the long-term orientation could be a reason to decide to invest in patenting activities.

Many theoretical considerations in the family business field (e.g., Poutzisours, 2001) indicate that family firms are more susceptible to external financing constraints, like for instance, they are reluctant toward venture capital investment. Families might be unwilling to raise new equity since an increase in share capital will dilute their equity stake and gradually undermine their controlling position. According to Shleifer and Vishny (1986), large and undiversified investors will pursue risk reduction strategies, one of which is the use of less debt in the firm's capital

structure. In sum, these arguments suggest that family firms are more susceptible to financing restrictions as all sources of external finance imply possible drawbacks for the main controlling individuals. Patenting activity requires uncertain investments and therefore, these constraints could also lead to inefficient investment decisions in innovation which are primarily based on the availability of internal cash flows. Moreover, smaller firms, which usually are family run, are more dependent upon internal capital and more susceptible to financing restrictions since potential lenders and suppliers of equity have less available information on these firms (Stiglitz and Weiss 1981). For instance, Scellato (2007) shows that smaller Italian companies with reduced innovation activities turn out to be more heavily affected by credit constraints.

Yet, some recent empirical research shows that founding family ownership is associated with lower agency costs and therefore it can help diminish information asymmetries with external suppliers of finance. In other words, family businesses are more responsive to their investment opportunities and seem to invest irrespective of cash flow availability. (Andres 2011).

Even if the debate is still open, we state our hypothesis according to the prevalent view, which considers family business as risk adverse and affected by cash flow constraints, therefore:

Hypothesis 1: Family firms patent less than non-family ones.

*2.2. The Inventor Group in Family Businesses*

Family businesses are endowed with a unique bundle of characteristics which influence the innovation process of patenting.

As we have just stated, innovation often requires acquiring expertise also from non-family people. However, even in those family businesses where innovation is sustained, maintaining family control and preserving the family wealth (Berrone et al., 2010; Gomez-Mejia et al., 2011; Gomez-Mejia et al., 2007) and in particular family social capital (Arregle et al. 2007), may be a priority. Indeed, the family social capital, which is the social capital developed among family members, constitutes a potential source of richness for the firm. Therefore, when developing an innovation, the selection process of inventors' team members may be biased by the need to preserve the family welfare, as well. Thereby family firms will tend to include in the inventor group only non-family trusted people (e.g. friends, university colleagues,…) or other family members with specific competence.

Some research works show that in family firms some unique agency costs arising from family involvement such as nepotism and parental altruism can be present. Family members often receive employment, perquisites, and privileges in the family firm regardless of their contributions (Schulze et al., 2003). Also, parental altruism can hamper family firm leaders' ability to control and discipline family members since the leaders may be biased or may fear ramifications to family relationships (Lubatkin, Ling and Schulze, 2007; Schulze et al., 2003). Although these mechanisms could be present in innovative family business as well (Chrisman, Chua, Chang and Kellermanns, 2007; Schulze, Lubatkin, Dino and Buchholtz, 2001; Corbetta and Salvato, 2004), their effect on the selection of the inventor group might be mitigated by the absolute need to possess technical knowledge to be part of the team. Nonetheless, it is likely that even when the group is completely composed by non-family people and none of the family members has a sufficient competence to discuss technical issues, the family will anyways be able to exert power and influence on the group decision making processes (e.g., rationalizing financing, imposing behavioral rules,…). The close and detailed knowledge of the core business resulting from family actors' active and enduring involvement in the firm (i.e., "strategic proximity", Nordqvist, 2005) together with the personalism by which the family project its own vision onto the business (Carney, 2005; Chua et al., 1999) can impose restrictions in the selection of inventors. For instance, more trusted people could be privileged over acquaintances.

At the same time, the inventor group composition might also be influenced by the long-term orientation and commitment (i.e., "strategic persistence", Nordqvist, 2005) which typically characterize these less-conservative family firms. In this sense, the literature on the resource-based view of the firm and on dynamic capabilities argues that certain types of family businesses are especially apt to embrace a number conditions that invite long-term investments and increase the resources available to long-term investment activities (Carney, 2005; Cassia et al. 2012; Chen et al., 2008; Le-Breton Miller and Miller, 2006;). According to this view, family members care for future generations and are strictly bounded to the firm. Founders and heirs view their firms as an asset to pass on to subsequent generations rather than wealth to be consumed during their lifetimes (e.g., Anderson and Reeb, 2003). Farsighted executives are willing to commit to projects that will enhance company performance only years hence (James, 1999). As argued above, their knowledge of the company tends to be deep (Miller & Shamsie, 2001). Such knowledge may be especially rich where time has been spent learning the business at close quarters with relatives

(Lansberg, 1999). Close familiarity with the business on the part of owners and/or top managers has been shown to reduce uncertainty about future cash flows. Owners or executives who profoundly understand a business are more confident in their ability to manage and control it, and less fearful about projects with longer term payoffs (Milliken, 1987). Therefore, when family members are in leadership positions they may encourage investment in long-term projects such as exploration processes and patenting, especially if they have some technical knowledge which can contribute to the innovation.
There is also another aspect that needs to be considered. Since personalism is relevant in these businesses (Carney, 2005; Chua et al., 1999), it is also probable that protecting the invention - especially when developed by a family member - is a mean both to protect and preserve the family reputation, which can constitute a part of their wealth (Berrone et al., 2010; Gomez-Mejia et al., 2011; Gomez-Mejia et al., 2007), and to affirm in the market the family's craft and contribution (Le-Breton Miller and Miller 2006).

Hypothesis 2a: When considering innovative businesses, the inventors group size is smaller in family firms as compared to non-family ones.

Hypothesis 2b: In innovative family firms, a family inventor will be present either in the board or in the ownership.

In the development of an innovation, not only the way in which inventors are selected matters. Also the way in which claims in patent applications are written is critical both to obtain a patent and to confer higher protection in the competitive market. Evidence suggests that self-evident advances in science are not that frequent (Dosi, 1982, 1988). Most inventions are likely to be fairly incremental advances on the state of the art (e.g., Harhoff and Wagner, 2005). This suggests that obtaining patent protection and avoiding a wide range of possible imitations of the innovation, are both related to the firms' ability in delineating the sophistication of their invention. One way to capture the enormous heterogeneity in the "value" and "importance" of patents is to use patent citations which are included in patent data (Hall, Jaffe and Trajtenberg 2001).
The characteristics of patents, such as patent breadth and basicness, have demonstrated their importance on the valuations of patents (Hall et al., 2001; Lerner, 1994). In particular, the technological territory claimed and

protected by the patent within which competitors cannot offer rival innovations without infringing the patent, can be measured by the patent breadth, while the ability to find breakthrough innovations can be estimated using a patent basicness, which is related to its novelty and originality.

The process of writing a patent application can be done internally by the firm, either by the inventor team members of by the firm's legal office, or can be outsourced to specialized attorneys or agencies. All these cases could be equally possible in family and non-family firms.

Nevertheless, in all cases, family members will most likely intervene with a stronger voice in the processes influencing the way the application is written as compared to their non-family counterparts, due to their deep market knowledge (Nordqvist, 2005), their strong need to affirm their personality in all business activities (Carney, 2005; Chua et al., 1999), and to their high willingness to protect their business investments which are also part of their familiar wealth (Berrone et al., 2010; Gomez-Mejia et al., 2011; Gomez-Mejia et al., 2007). Such a strong commitment will probably influence also patent protection power, by positively affecting both patent breadth and basicness.

Conversely, since family businesses tend to be characterized by higher (financial and human) resource constraints due to their constant worry to "keep it all in the family" for future generations (Berrone et al., 2010; Gomez-Mejia et al., 2011; Gomez-Mejia et al., 2007) there is a higher risk of "groupthink" and uncreative ideas (Nordqvist 2005).

As a result, some differences should be found between family and non-family businesses, where these attitudes and behaviors should not be systematically present:

Hypothesis 3: Patent characteristics, such as patent breadth and patent basicness, differ between family and non-family firms.

## 3. Methodology

### *3.1 Sample and Data*

The data set we analyzed includes 234 Italian firms. The companies were identified from the business schools associated to ASFOR (Italian Association for Management Development), among the alumni that: 1) have attended an executive course in the last five years, and 2) are members of the top management team of their companies (managing director, chief executive officer, president, or in charge of a function or

business unit). The sample has been selected following a random method from the population of the Alumni of the business schools.
Data on firm characteristics (ownership structure, composition of the board of directors), and sales has been retrieved by AIDA database, while data on patents has been retrieved by the European Patent Register database.

Insert Table 1 about here

The descriptive statistics show that 36% of firms in the sample hold at least one patent, with an average number of 8.42 patents per firm. The distribution is highly skewed, with few firms holding more that one hundred patents. The family firms vary in our sample from 56% to 58% depending on the classification adopted.

Insert Table 2 about here

The correlations between the variables analyzed are provided in Table 2. Correlation is negative between family influence and the number of patents (-0.15), and correlations are also negative between the measures related with the patents' characteristics (breadth -0.10, originality -0.12, science -0.10) and family influence.
Firms' sales instead highly and positively correlate with the number of patents (0.43) and patents' characteristics.

*3.2. Dependent variables*

**Patenting** is measured alternatively by a binary variable coded 1 if the company hold at least one patent (*patent_dummy*) and by the hyperbolic sine transformation (IHS) of the number of patents possessed by the company.

$IHS(y_i) = \log(y_i + (y_i^2 + 1)^{1/2})$

The inverse hyperbolic sine transformation is an alternative to logarithm transformation when the distribution of the variables is skewed and some of variable take on zero or negative values (Burbridge et al., 1988). The high presence of zero in the number of patents distribution suggests that IHS transformation should be preferred to the transformation log(y+1) to avoid alteration of the regression's beta.
The number of inventors (relevant for the second hypothesis) has been calculated as the average number of inventors in a firm's patents reported in the European Patent Register database.

The third hypothesis supposes that the patents' indicators differ between family and not family firms.
Previous work using the measures of **patent breadth and basicness** have demonstrated their validity as measure of patent importance in terms of impact on later innovation in a field (Henderson et al., 1998; Hall et al., 2001; Lerner, 1994).
Patent breadth is measured according to Lerner (1994), who employs the number of IPC-classes as a proxy for patent breadth.
Basicness of a patent refers to the fundamental features of innovations such as originality, closeness to science and generality of research outcomes.
Henderson et al. (1998) suggest to calculate the originality of a patent with the Herfindahl index on technological classes of cited patents. We use as a proxy for the technological classes the IPC-classes.

$$ORIGINAL_i == 1 - \sum_{k=1}^{N_i} \left( \frac{NCITED_{ik}}{NCITED_i} \right)^2$$

where NCITED is the number of patents cited by the patent.
The measure tend to be positively correlated with the number of citations made: in fact highly cited patents tend to have higher generality scores, and patents that make lots of citations would display on average higher originality because of a built-in tendency to cover more patent classes where there are more citations (Hall et al., 2001).
We calculate the closeness to science as suggest by Henderson et al. (1998):

$$SCIENCE_i = \frac{NPCITES_i}{NPCITES_i + NCITED_i}$$

where NCITED is the number of patents cited by the patent and NPCITES is the number of non-patent sources cited by the patent. These characteristics discriminate well between less and more basic innovations.

*3.3. Main explanatory independent variables: Family Firm*
There are several possible definitions of the family firm (Westhead and Cowling, 1998). Thereofre, we define a "Family Firm" with three different variables. AIDA databse reports for each company the name and the family name of each board member and of each shareholder with the related ownership share, so that we were able to identify the kinship relations on the basis of their family(-ies) name(s).
First, we identify the family control as the power to appoint the board of directors, both directly and through financial holdings. This definition is in line with previous studies, according to which family control can be

identified as the fractional equity holding by family members (founding or descendants), which allows ownership control over the company (Anderson and Reeb, 2003; Lee, 2006). Specifically, we consider a firm owned by a family (*Fam1*) where the same family owns more than 50 per cent of the shares (Minichilli et al., 2010).
Second, we considered whether a family was present in the board. We defined family managed businesses those firms where two or more board members had the same last name (*Fam2*) (Cassia et al., 2011).
Third, we measured family influence on board (*Fam_inf*) by calculating the percentage of family members on board.

*3.4. Control variables*

Various factors impact on the decision to patent. The most relevant regard the firm industry and the size of the company.
**Industry.** Controlling for high-tech and low-tech industry is particularly important because the use of patents to protect innovation is more widespread in high technology field.
We control for the industry with two different classifications for the manufacturing industries: OECD and Pavitt taxonomies.
The OECD Directorate for Science, Technology and Industry's classification in High-technology, Medium-high-technology, Medium-low-technology and Low-technology industries categorizes manufacturing industries into categories based on R&D intensities.
The Italian National Institute of Statistics in the 2010 report adopted another classification of technology intensity of manufacturing activities elaborated from the Pavitt taxonomies. It defines industry in traditional field, specialized, sectors characterized by high R&D intensity and field with high economy of scale.
The Italian National Institute of Statistics classifies also the high knowledge intensive services and other services.
**Firm size.** Lee and Sung (2005) describe the diverse results present in the empirical literature on the relationship between R&D and firm size. Some studies find a linear and positive relationship, while others suggest that R&D and firm size are independent. The earliest studies of the correlation between firm size and R&D find a positive relationship that is interpreted as support for the Schumpeterian hypothesis. We control for firm size with the hyperbolic sine transformation (IHS) of the firms' sales in 2009 in Euro.
The **firm_year control variable** in the models takes into account the experience maturated by the firms.

*3.5. Models*

To test the first hypothesis, we construct three logit models since the dependent variable *patent_dummy* is coded as a dichotomous variable and the c.d.f. is similar to a logistic distribution.

The second hypothesis instead is tested through tobit models. Tobit models are appropriate when the dependent variable yi of a linear regression is equal to the latent and unobservable variable yi* whenever the latent variable is above zero and zero otherwise. The zeros are left censored observations of the dependent variable.

$$y_i = \begin{cases} y^* & \text{if } y^* > 0 \\ 0 & \text{if } y^* \leq 0 \end{cases}$$

Tobit models are the appropriate models to analyze the sample because the variables are observed only when they assume a value greater than zero (corresponding to the cases in which firms have patented) and zero otherwise.

Indeed, the model cannot be estimated by ordinary least square because of the relevant presence of observations equal to zero (corresponding to all the firm that have zero patents).

The other hypotheses on patents indicators between family and not family firms are tested with the independent samples T test that compares the mean scores of two groups on a given variable.

All statistical calculations are performed with the software package Stata/IC 12.

## 4. Results and Analysis

In order to examine multicollinearity, we calculated the variance inflation factor (VIF). VIFs are between 1.37 and 1.47, which is below the rule-of-thumb cutoff of 5, thus issues of multicollinearity do not seem to prompt concern.

Table 3a illustrated the results of the logit model estimating the factors that affect the likelihood to patent and Table 3b illustrated the results of the tobit model estimating the factors that affect the firm's number of patents. We can observe that there is little difference between the models, in fact the logit models could be considered a particular case of the tobit ones and they convey the same information for the part related to the zero values of the dependent variable.

Insert Tables 3a and 3b
about here

As expected, in all models the high technology industries variables are significant and positive both with the Pavitt taxonomy (*Pavitt_rsspec*) and the OECD classification (*Oecd_high*). The companies operating in these fields (in particular pharmaceuticals and biotechnology) recognize the importance of patenting and usually have an internal department entirely dedicate to the protection of intellectual property rights.
The variables related with medium technology industries are also positive but less significant related with patenting (*Pavitt_escala* and *Oecd_medlow)*. This result is coherent with Doukas and Switzer (1992). The authors provide evidence that the rate of return for R&D is greater for those firms operating in highly concentrated industries.
As expected, firm size (*Sales_2009)* positively affects patenting activities. As explained by Pindado et al. (2010), size increases the market valuation of a firm's R&D spending since size provides economies of scale, easier access to capital markets, and R&D cost spreading. Moreover, Scellato (2007) studying a cross-industries panel of 804 Italian companies report the strong bias of patenting activity towards larger companies in the Italian economy, showing that this bias of patenting activity towards larger firms might be partially explained by the higher cash flow dependence of smaller Italian companies.
The models reported in Table 3a and 3b partially supported our first hypothesis that family firms patent less than non family firms.
The family variable is negative in all models 1-16, but only family influence is slightly significant (model 4: ß = -0.19, $p < .05$, model 8: ß = -0.16, $p < .10$, model 12: ß = -1.31, $p < .05$, model 16: ß = -1.05, $p < .10$), after controlling for the industry variables, the firms' years and the firms' size. Therefore, this supports the prevalent and traditional view in family business literature, which considers these firms as risk adverse and affected by cash flow constraints.

Insert Table 4 about here

Regarding the hypotheses on the inventors' group (H2a and H2b), Table 4 report the independent sample T test. P-value is inferior at the threshold 0.05, indicating that the means of the two groups are significantly

different, confirming that the inventors group size is smaller in family firms.
The high presence of a family inventor in the patents hold by family firms was evident already in the descriptive statistics (0.73, Table 1). A further analysis tabulating the distribution of family inventors between family and non family firms allow us to positively answer to the second hypothesis, thus confirming a significant presence of an inventor with the same surname of the family in the family firms.

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Insert Table 5 and Table 6
about here

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With the third hypothesis we supposed that the family and non family firms were different also in the way of patenting, thus showing a pattern of patents' characteristics diverse.
The results reported in Table 5 don't support our hypothesis. The finding is not surprising; in fact the lack of differences in patents' breadth, originality and science is probably due to the fact that almost all the firms delegate the patenting process to specialized agencies and intermediaries, that provide the patents' and scientific citations in a standard and professionalized way.

## 5. Conclusions

This study represents a first step in exploration of differences between family and non-family businesses in the processes associated with innovation. Starting from a perspective in which family firms represent a distinct social context, with both potential constraints and beneficial aspects, we have examined whether family firms do differ significantly from non-family firms in terms of patenting activity and processes.
Our results partially support our first hypothesis, meaning that family firms tend to patent less than non family firms. This is consistent with the prevalent view in the literature coming both from agency theory and behavioral models, which considers that families are more risk averse and subject to wealth protection constraints (Berrone et al., 2010; Gomez-Mejia et al., 2011; Gomez-Mejia et al., 2007). Our results are coherent with Bugamelli et al., (2012) who find that Italian family firms have a more negative attitude toward R&D as compared to those firms in which the management team is not crucially influenced by a proprietary family.
We have also found that the patenting activity varies according to the sector of activity and the size of the firm. Moreover, we recognized that

industry, size and family influence are interrelated. For example, the small and medium size could reflect the willingness of the family to maintain the company's control.

The second hypotheses are both confirmed. The inventors group size is smaller in family firms. This finding is coherent with the main result obtained in family businesses literature. Family firms tend to open up less to numerous external members (Schulze et al., 2003). Our results also confirm a significant presence of an inventor with the same surname of the family in family firms. Parental altruism (Schulze et al., 2003), personalism (Carney, 2005; Chua et al., 1999), preoccupation for family/firm reputation (Le-Breton Miller and Miller, 2006), strategic proximity and persistence (Nordqvist, 2005) have already been identified by previous research. Here we show that it is likely that they can actually have tangible organizational consequences on human resource processes related to innovation activities.

Finally, we hypothesized that this difference would have influenced also the way of doing research and therefore the characteristics of the patent. However, this was not confirmed by the findings. Probably, two opposite effects offset each other. On one side, the higher familiar commitment and deep knowledge of the business (Nordqvist, 2005) can make family businesses more accurate in monitoring the patenting application process, preventing other competitors from encroaching on their technological "space" with competing products. On the other side, stronger financial constraints (Poutziouris, 2001; Mishra and McConaughy, 1999; McConaughy et al., 2001) and human resource restrictions (Schulze et al., 2003) imposed by familiar control can negatively affect patenting claims.

These results shed light on the possible effects of the deep and pervasive involvement of the family in the strategic activities of the firm. We believe that focusing only on firm financial performance can be misleading because the consequences of familiar commitment and influence on firm results might be mitigated by external factors (e.g., firm sector or firm size). Therefore, it would be important for scholars to focus on the impact of internal dynamics on relevant strategic processes, such as innovation. Gaining knowledge about these internal results can help consultants, family therapists and those who operate in patenting offices and agencies in their activity, by providing them a clearer framework of the consequences of what actually happens inside organizational boundaries.

We recognize that this is a preliminary result, with the main limitation regarding the specificity of our sample; we acknowledge that considering only Italian firms limits the generalizability of the research. Therefore, our observations must be interpreted cautiously, but they can have important

implications for family businesses and also for policy makers and institutions. Patents can play an important role in "signaling" the value of a firm's technology and inventiveness, both externally to the market and internally to employees. The potential and utility of these tools should be taught by educational institutions and considered by policy makers, especially in family business contexts. Our research can provide a fruitful avenue for future investigation. Further research should focus on strategic processes, such as innovation, diversification and internationalization of family businesses, investigating not only firm results differences, but also internal organizational activities for instance on human resource processes or knowledge sharing, which can lead to different higher level outcomes. Also, similar investigations should be conducted in countries other than Italy in order to increase the external validity of our results.

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## Tables

**Table 1 -** Definition of study variables and descriptive statistics.

| Variable | Description | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| **PATENTS VARIABLES** | | | | | |
| **Pat_dum** | Dummy=1 for firms with at least one patent | 0.36 | 0.48 | 0 | 1 |
| **Num_Pat** | Number of total patents hold by a firm | 8.42 | 40.80 | 0 | 343 |
| **Pat_Breadth** | Maximum number of four-digit IPC classes into which a patent is classified. | 11.42 | 17.36 | 0 | 84 |
| **Pat_Original** | Herfindahl index on four-digit IPC-classes of cited patents. | 0.30 | 0.26 | 0 | 0.75 |
| **Pat_Science** | Average measure of scientific base outside the patents system of a firm's patents. | 0.09 | 0.19 | 0 | 0.83 |
| **Pat_Inventors** | Average number of inventors in a firm's patents. | 1.83 | 1.03 | 1 | 4.95 |
| **Fam_Inventor** | Presence of an inventor with the same surname of the family in the family firms | 0.73 | 0.45 | 0 | 1 |
| **FAMILY VARIABLES** | | | | | |
| **Fam1** | Dummy=1 if more than 50%+1 of ownership belongs to family members (people with the same surname). | 0.58 | 0.49 | 0 | 1 |
| **Fam2** | Dummy=1 if more the two board members are family members (people with the same surname). | 0.56 | 0.50 | 0 | 1 |
| **Fam_inf** | Percentage of family members on board. | 0.41 | 0.39 | 0 | 1 |
| **CONTROLS** | | | | | |
| **Pavitt_rsspec** | Dummy=1 for companies operating in the following industries: Machinery and equipment, Electrical machinery and apparatus, Railroad and boat building and equipment, Medical, precision and optical instruments; pharmaceuticals. | | | | |
| **Pavitt_tradiz** | Dummy=1 for companies operating in the following industries: food products, textiles, clothes and leather, wood and wood products, building materials and ceramic, basic metals and fabricated metal products, lighting products, furniture and other manufacturing (jewels, sport and music instruments, toys, glasses). | 0.28 | 0.45 | 0 | 1 |
| **Pavit_escala** | Dummy=1 for companies operating in all the manufacturing activities not listed above | 0.21 | 0.40 | 0 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| **Oecd_high** | Dummy=1 for companies operating in the following industries:Pharmaceuticals; Office, accounting and computing machinery; Radio, TV and communications equipment; Medical, precision and optical instruments; Electrical machinery and apparatus; Motor vehicles, trailers and semi-trailers; Chemicals; Railroad equipment and transport equipment; Machinery and equipment. | 0.29 | 0.45 | 0 | 1 |
| **Oecd_medlow** | Dummy=1 for companies operating in the following industries: Building and repairing of ships and boats; Rubber and plastics products; Coke, refined petroleum products and nuclear fuel; Other non-metallic mineral products; Basic metals and fabricated metal products. | 0.18 | 0.39 | 0 | 1 |
| **Oecd_low** | Dummy=1 for companies operating in the following industries: Manufacturing; Recycling; Wood pulp, paper, paper products, printing and publishing; Food products, beverages and tobacco; Textiles, textile products, leather and footwear. | 0.16 | 0.37 | 0 | 1 |
| **Serv_highknow** | Dummy=1 for companies offering high knowledge intensive services: telecommunications, informatics and connected activities, research and development, air and water transport services, business services, financial activities | 0.17 | 0.38 | 0 | 1 |
| **Serv_other** | Dummy=1 for companies offering the following services: retail, car fixing, hotels and restaurants, ground transportation and connected activities, travel agency. | 0.19 | 0.39 | 0 | 1 |
| **Firms_years** | Number of years from firm's foundation. | 22.08 | 13.63 | 1 | 86 |
| **Sales_2009** | Firms' sales in 2009 in thousands Euro. | 35896 | 87955 | 16.67 | 872239 |

**Table 2 -** Correlations of the continuous study variables

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **1. Num_Pat** | - | | | | | | |
| **2. Pat_Breadth** | .56 | - | | | | | |
| **3. Pat_Original** | .20 | .29 | - | | | | |
| **4. Pat_science** | .45 | .45 | -.02 | - | | | |
| **5. Pat_inventors** | .47 | .38 | .26 | .22 | - | | |
| **6. Fam_inf** | -.15 | -.10 | -.12 | -.10 | -.28 | - | |
| **7. Firms_years** | -.06 | .06 | .01 | .06 | -.11 | .16 | - |
| **8. Sales_2009** | .43 | .72 | .05 | .39 | .30 | -.18 | -.01 |

**Table 3a -** The determinants of the patenting activity (logit models).

| | **Model 1** | **Model 2** | **Model 3** | **Model 4** | **Model 5** | **Model 6** | **Model 7** | **Model 8** |
|---|---|---|---|---|---|---|---|---|
| | **Logit [a]** | **Logit [a]** | **Logit [a]** | **Logit [a]** | **Logit [a]** | **Logit [a]** | **Logit [a]** | **Logit [a]** |
| VARIABLES | Pat_dum | Pat_dum | Pat_dum | Pat_dum | Pat_dum | Pat_dum | Pat_dum | Pat_dum |
| Pavitt_rsspec | 0.34** (0.10) | 0.36** (0.10) | 0.34** (0.10) | 0.36** (0.10) | | | | |
| Pavitt_tradiz | 0.11 (0.12) | 0.12 (0.12) | 0.10 (0.12) | 0.14 (0.17) | | | | |
| Pavitt_escala | 0.30* (0.12) | 0.33** (0.12) | 0.33** (0.12) | 0.34** (0.15) | | | | |
| Oecd_high | | | | | 0.39** (0.10) | 0.40** (0.10) | 0.39** (0.10) | 0.40** (0.10) |
| Oecd_medlow | | | | | 0.23† (0.12) | 0.25* (0.12) | 0.23† (0.12) | 0.26* (0.12) |
| Oecd_low | | | | | 0.03 (0.13) | 0.05 (0.12) | 0.02 (0.12) | 0.06 (0.12) |
| Serv_highknow | 0.10 (0.14) | 0.09 (0.14) | 0.09 (0.14) | 0.08 (0.14) | 0.09 (0.14) | 0.08 (0.14) | 0.09 (0.14) | 0.07 (0.14) |
| Firms_years | 0.01 (0.02) | 0.01 (0.02) | 0.01 (0.02) | 0.01 (0.02) | 0.01 (0.02) | 0.01 (0.02) | 0.01 (0.02) | 0.01 (0.02) |
| Sales_2009_ihs | 0.07** (0.02) | 0.06** (0.02) | 0.06** (0.02) | 0.06** (0.02) | 0.06** (0.02) | 0.06** (0.02) | 0.06** (0.02) | 0.05* (0.02) |
| Family Firms | | | | | | | | |
| Fam1 | | -0.11 (0.07) | | | | -0.09 (0.07) | | |
| Fam2 | | | -0.09 (0.07) | | | | -0.06 (0.07) | |
| Fam_inf | | | | -0.19* (0.09) | | | | -0.16† (0.09) |
| LR $\chi^2(7)$ | 32.09** | 34.39** | 33.98** | 36.70** | 38.17** | 39.61** | 39.63** | 41.17** |
| Pseudo $R^2$ | 0.106 | 0.114 | 0.113 | 0.122 | 0.126 | 0.131 | 0.132 | 0.137 |
| Observations | 231 | 231 | 229 | 231 | 231 | 231 | 229 | 231 |

*Note.* Robust standard errors are in parenthesis. [a] Marginal effects coefficients are shown.

† $p < .10$
* $p < .05$
** $p < .01$

**Table 3b -** The determinants of the patenting activity (tobit models).

| | **Model 9** | **Model 10** | **Model 11** | **Model 12** | **Model 13** | **Model 14** | **Model 15** | **Model 16** |
|---|---|---|---|---|---|---|---|---|
| | **Tobit** | **Tobit** | **Tobit** | **Tobit** | **Tobit** | **Tobit** | **Tobit** | **Tobit** |
| VARIABLES | Num_Pat | Num_Pat | Num_Pat | Num_Pat | Num_Pat | Num_Pat | Num_Pat | Num_Pat |
| Constant | -8.03** | -7.73** | -7.73** | -6.99** | -7.38** | -7.16** | -7.22** | -6.59** |
| | (1.51) | (1.51) | (1.52) | (1.52) | (1.46) | (1.46) | (1.46) | (1.48) |
| Pavitt_rsspec | 1.95** | 2.09** | 1.95** | 2.08** | | | | |
| | (0.64) | (0.65) | (0.64) | (0.64) | | | | |
| Pavitt_tradiz | 0.28 | 0.40 | 0.24 | 0.50 | | | | |
| | (0.71) | (0.71) | (0.71) | (0.72) | | | | |
| Pavitt_escala | 1.25† | 1.38† | 1.40† | 1.49* | | | | |
| | (0.74) | (0.74) | (0.75) | (0.74) | | | | |
| Oecd_high | | | | | 2.17** | 2.24** | 2.15** | 2.23** |
| | | | | | (0.62) | (0.63) | (0.62) | (0.62) |
| Oecd_medlow | | | | | 0.88 | 0.99 | 0.90 | 1.08 |
| | | | | | (0.68) | (0.69) | (0.69) | (0.69) |
| Oecd_low | | | | | -0.30 | -0.17 | -0.35 | -0.05 |
| | | | | | (0.76) | (0.77) | (0.76) | (0.77) |
| Serv_highknow | 0.62 | 0.60 | 0.56 | 0.53 | 0.56 | 0.54 | 0.52 | 0.49 |
| | (0.79) | (0.79) | (0.79) | (0.78) | (0.76) | (0.77) | (0.76) | (0.76) |
| Firms_years | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) |
| Sales_2009_ihs | 0.62** | 0.62** | 0.61** | 0.55** | 0.57** | 0.56** | 0.56** | 0.51** |
| | (0.13) | (0.13) | (0.13) | (0.13) | (0.13) | (0.13) | (0.13) | (0.13) |
| Family Firms | | | | | | | | |
| Fam1 | | -0.68 | | | | -0.52 | | |
| | | (0.43) | | | | (0.42) | | |
| Fam2 | | | -0.62 | | | | -0.38 | |
| | | | (0.43) | | | | (0.42) | |
| Fam_inf | | | | -1.31* | | | | -1.05† |
| | | | | (0.58) | | | | (0.56) |
| LR $\chi^2(7)$ | 43.77** | 46.30** | 46.17** | 49.20** | 51.52** | 53.04** | 53.41** | 55.05** |
| Pseudo $R^2$ | 0.075 | 0.080 | 0.080 | 0.085 | 0.088 | 0.091 | 0.092 | 0.095 |
| Observations | 231 | 231 | 229 | 231 | 231 | 231 | 229 | 231 |

*Note.* Robust standard errors are in parenthesis.

† $p < .10$

* $p < .05$

** $p < .01$

**Table 4 -** Comparison of the mean number of inventors in family and non family firms

| | Fam1 = 1 | Fam1 = 0 | Independent t-test *p* – Value | Fam2 = 1 | Fam2 = 0 | Independent t-test *p* – Value |
|---|---|---|---|---|---|---|
| Pat_inventors | 1.648 | 2.119 | **0.0390** | 1.562 | 2.133 | **0.0099** |
| No. of observations | 47 | 38 | | 45 | 40 | |

**Table 5 –** Tabulation of the presence of family inventors in family and non family firms

| ***Fam_inventor*** | ***Fam1*** | | |
|---|---|---|---|
| | **0** | **1** | **Total** |
| 0 | 33 | 12 | 45 |
| 1 | 5 | 35 | 40 |
| Total | 38 | 47 | 85 |

| ***Fam_inventor*** | ***Fam2*** | | |
|---|---|---|---|
| | **0** | **1** | **Total** |
| 0 | 33 | 13 | 46 |
| 1 | 7 | 32 | 39 |
| Total | 40 | 45 | 85 |

**Table 6 -** Comparison of the patents' characteristics in family and non family firms

| | ***Fam1* = 1** | ***Fam1* = 0** | **Independent *t*-test *p* – value** | ***Fam2* = 1** | ***Fam2* = 0** | **Independent *t*-test *p* – value** |
|---|---|---|---|---|---|---|
| *Pat_Breadth* | 13.28 | 9.13 | 0.28 | 12.756 | 9.925 | 0.46 |
| *Pat_Original* | 0.29 | 0.31 | 0.68 | 0.255 | 0.355 | **0.08** |
| *Cited_Patents* | 4.52 | 4.65 | 0.77 | 4.432 | 4.744 | 0.49 |
| *Pat_science* | 0.08 | 0.07 | 0.76 | 0.069 | 0.082 | 0.69 |
| No. of observations | 47 | 38 | | 45 | 40 | |