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Patent Spinoffs: How Important Is the Organizational Environment?

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Abstract

We analyze patent spinoffs by looking at the organizational characteristics of the parent organization, i.e. the firm where the patented invention has occurred. We consider organizational dimensions such as the adoption of teamwork, the decisional autonomy of inventors and collaboration with external parties during the inventive process. We elaborate hypotheses on the association between these characteristics and the likelihood of spinoff. We also control for individual characteristics of the new firm?s founders such as age, R&D experience and risk tolerance. Our empirical analysis is based on Patval- EU II, Patval-US and Patval-JP surveys conducted within the 7FP InnoS&T project. These surveys draw on EPO patent inventors residents in the US, EU, Japan and Israel. Our unit of analysis is the patent-employer-inventor combination which is at risk of spawning a new patent-based firm. Probit estimations largely provide support to our hypotheses.

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ABSTRACT

We analyze patent spinoffs by looking at the organizational characteristics of the parent organization, i.e. the firm where the patented invention has occurred. We consider organizational dimensions such as the adoption of teamwork, the decisional autonomy of inventors and collaboration with external parties during the inventive process. We elaborate hypotheses on the association between these characteristics and the likelihood of spinoff. We also control for individual characteristics of the new firm's founders such as age, R&D experience and risk tolerance. Our empirical analysis is based on Patval- EU II, Patval-US and Patval-JP surveys conducted within the 7FP InnoS&T project. These surveys draw on EPO patent inventors residents in the US, EU, Japan and Israel. Our unit of analysis is the patent-employer-inventor combination which is at risk of spawning a new patent-based firm. Probit estimations largely provide support to our hypotheses.

Key-words: entrepreneurship, patents, innovation process

INTRODUCTION

This paper deals with new firms created to exploit entrepreneurial opportunities arising from technological innovations (Beckman et al., 2012). New technology ventures are viewed as the engine of creative destruction and engender economic growth through the creation of a significant share of new jobs (Schumpeter, 1950; Bhidé, 2000; Klepper 2001; Shane and Venkataraman, 2003; Haltiwanger, Jarmin & Miranda, 2010). In US there are over 15 million entrepreneurs involved in new start-ups in different sectors. Of these about half million can be defined as 'technology entrepreneurs'. These are individuals who launch every year about 200,000 new science- and technology-based start-ups (Reynolds, 2000).

We develop theoretical arguments and test hypotheses about the antecedents of new technological ventures spawned by business enterprises. This goal is motivated by the very large proportion of entrepreneurs who enter into entrepreneurship from employment in established firms (Gompers, Lerner & Scharfstein, 2005; Sorensen and Fassiotto, 2011). Moreover, 31.6% to 47.2% of total funds to new technology start-ups in the US come from established firms that spin out new ventures based on inventions falling outside their core business (Auerswald and Branscomb, 2003). Despite the importance of established firms as a source of technological entrepreneurship, the literature on business spinoffs is still underdeveloped (e.g., Agarwal, Echambadi, Franco & Sarkar, 2004; Klepper and Sleeper, 2005; Elfenbein, Hamilton & Zenger, 2010). In particular, research on how the characteristics of the parent organization affect the entrepreneurial decision is limited (Thornton, 1999; Bhidè, 2000; Hellmann, 2007; Sorensen and Fassiotto, 2011).

Instead, a larger number of studies on technology spinoffs focus on startups spawned by universities and other research institutions (e.g., Shane, 2001a, b; Di Gregorio and Shane, 2003; Clarysse, Wright, Lockett, van de Velde & Vohora, 2005). Other studies have directed attention to the importance of population-level factors, such as technological regime or the number of existing organizations in the industry, on the foundation of new organizations (e.g., Shane, 2001b; Hannan and Freeman, 1989). Still other contributions on technological entrepreneurship are centered on individual (dispositional) characteristics such as human capital (Parker, 2011) and skill composition (Lazear, 2004), risk propensity (Simons and Astebro, 2010), taste for autonomy and independence (Elfenbein et al., 2010; Astebro and Thompson, 2011).

Our analysis draws on contributions from two streams of the literature: (a) the theory of entrepreneurial decision as an organizational process (Freeman 1986; Agarwal et al., 2004; Klepper and Sleeper, 2005; Elfenbein et al., 2010; Sorensen and Fassiotto, 2011) and (b) the theory of organizational creativity and innovation (Woodman et al. 1993; Amabile, 1997; Zhang and Bartol, 2010).

There are limited links between these two streams of research despite the fact that entrepreneurship is a creative activity. The first stream of research provides little evidence on which organizational characteristics favor the formation of technology ventures. These studies typically rely on the parent size or age (e.g., Elfenbein et al., 2010) as proxies for organizational characteristics like bureaucratization (Dobrev and Barnett, 2005; Sorensen, 2007) and technological or market know-how (Agarwal et al. 2004; Klepper and Sleeper, 2005) as proxies for the level of learning opportunities offered by an organization to future entrepreneurs.

The second line of research, to our knowledge, has not explored the implications of creativity for the formation of new firms. Instead, this body of studies has mostly focused on the organizational conditions, such as freedom and autonomy that favor creativity and innovation (Zhang and Bartol, 2011).

The missing links between these two streams of the literature and the paucity of micro-data hinder a deeper understanding of the organizational process underlying technological spinoffs.

Our empirical setting focuses on business spinoffs created to exploit a patented invention. The analysis is based on a large-scale survey of EPO patent inventors residing in the US, EU, Japan and Israel. Our unit of analysis is the patent-employer-inventor combination which is at risk of spawning a new patent-based firm.

We contribute to the existing literature by studying the links between entrepreneurial decision and various dimensions of organizational creativity. First, we ask whether the organization of the inventive process as a team work is positively associated with the entrepreneurial process or, on the contrary, raises the opportunity cost of entrepreneurship. Second, we study the association between the likelihood of spinoff and key dimensions of the inventive process, namely the origin of the invention (e.g., unplanned outcome of non-R&D activity or the result of pure creativity), the level of decisional autonomy and the openness of the inventive process to external sources of innovation. Another important organizational characteristic is the availability of complementary assets. Although earlier studies on entrepreneurship have already addressed this dimension (e.g., Shane, 2001b, Eckhardt and Shane 2011), we provide a finer-grained analysis of complementary assets as predictor of spinoff.

Finally, we control for individual characteristics by focusing on a subset of spinoffs where the employee either founds or holds a financial stake in a new firm (the spinoff), with or without the strategic commitment of the incumbent (the parent). Our measures of individual characteristics are age, education, R&D experience, risk propensity and familiarity with entrepreneurship. With few exceptions (e.g., Lee, Wong, Foo & Leung, 2011), earlier entrepreneurship studies have not studied individual and organizational characteristics in the same empirical setting.

Our empirical investigation originates a number of interesting results. First, inventions developed by different co-inventors and resulting from a teamwork inventive process are less likely to entail the formation of a new firm. Second, working autonomy, especially the possibility that inventors disclose information through publications and informal exchange, are positively associated with the likelihood of spinoff. Third, inventions arising from non-R&D activities and pure creativity are also positively associated with spinoffs. Finally, collaboration with competitors and other parties is positively associated with the emergence of spinoffs, while the availability of complementary assets for the technical and commercial implementation of the invention in the parent organization reduces the likelihood that employees leave to set a new venture.

The reminder of the paper is organized as follows. Section 2 reviews the existing literature and single out the research hypotheses. Section 3 describes the data and defines variables while Section 4 presents our preliminary findings. Section 5 concludes.

LITERATURE REVIEW AND RESEARCH HYPOTHESES

The literature that explores the relationship between organizational characteristics and entrepreneurial activity (Dobrev and Barnett, 2005; Erikkson and Kuhn, 2006; Sorensen, 2007; Elfenbein et al, (2010) relies primarily on size and age as proxies for unobservable organizational features of the parent. By doing so these works overlook the fact that organizations of comparable size and age can be quite different on several grounds. For instance, size and age are only imprecise proxies for the degree of bureaucratization and delegation of authority (Sorensen, 2007; Sorensen and Fassiotto, 2011). Moreover these variables are highly correlated with other characteristics (e.g., performance) which are often not observable in empirical analysis (Elfenbein et al, 2010). Finally, the effect of organization size and age can be contingent upon individual dispositional characteristics and roles (Dobrev and Barnett, 2005).

Our analysis goes beyond parent size and age to shed some light on key organizational characteristics that have been overlooked thus far. The importance of working environment on the entrepreneurship decision is not obvious. For example, Parker (2011) has found that, compared with intrapreneurs (i.e., entrepreneurs within existing organizations), nascent entrepreneurs respond positively to external stimuli from parents or role models rather than the working environment of their employer organization.

Teamwork and Spinoffs

The association between teamwork and spinoffs is still not well understood. The literature has mostly argued that organizations play a central role in the entrepreneurial process because they represent an arena for learning skills and abilities needed to make the transition to entrepreneurship viable. Organizations can accomplish this task in three ways. First, by broadly defining jobs and roles or relying on teamwork organizations nurture a balanced and varied set of skills in employees which, according to the jack-of-all-trades theory of entrepreneurship, increases the likelihood of entry into entrepreneurship (Lazear, 2004).

Clearly, a division of labor based on the participation of different workers who collaborate for the achievement of a common goal (an invention) increases the likelihood that employees are involved in a wider range of activities and skills. In this respect, teamwork and collaboration among co-workers favor formal and informal socialization processes and may provide employees with skills that are important to become an entrepreneur (Sorensen and Fassiotto, 2011).

However, teamwork and the joint effort of various co-inventors may signal a strong commitment of the organization to the invention and a high expected value of this invention which should reduce the probability of spinoff. Moreover, teamwork and co-workers point out the complexity of inventive activities, requiring multiple skills to achieve an inventive output. Complementarities among co-workers and the organization-specific knowledge developed through interactions among them cannot be easily transferred to a new organization. Tacit knowledge is not only embedded in human capital, but also socially embedded in organizational routines at the team and the firm level (Nelson and Winter, 1982; Teece, 1986;

Kogut and Zander 1992; Hitt, Bierman, Shimizu & Kochhar, 2001). While employees may leave and appropriate the human capital component of an organizations' knowledge, they cannot easily appropriate and transfer organizational routines. Moreover, as noted by Lazear (2005), complexity implies that a larger variety of skills are required to become an entrepreneur and this reduces the supply of entrepreneurs. The socialization process fostered by these complementarities and interactions among co-workers may also hamper creativity and the formation of new ventures if it strengthens the corporate culture and commitment to core norms and values. For instance, Sorensen (2002) suggested that a strong corporate culture encourages exploitation rather than exploration and creativeness.

We can summarize this discussion by referring to two forces shaping the association between teamwork (as opposed to individual work) and spinoffs: (a) social and entrepreneurial capital accumulation effect which increases the likelihood of spinoffs; (b) an idiosyncratic and tacit knowledge effect which reduces the likelihood of spinoffs. Which of these two effects will dominate is an empirical question that we will explore by testing the following contrasting hypotheses:

> *Hypothesis 1a. Inventions generated in a teamwork environment are more likely to be used to spawn a spinoff.*

> *Hypothesis 1b. Inventions generated in a teamwork environment are less likely to be used to spawn a spinoff.*

Complementary Assets and Spinoffs

Earlier studies on entrepreneurship have analyzed the rate of entry of new firms in relation with industry characteristics like the technological regime (Audretsch, 1997; Shane 2001b). For example, Shane (2001b) makes the point that the more important complementary assets in commercialization are in an industry, the less likely an invention will be exploited by a new firm. However, subsequent research on this issue has yielded unclear results. For example, Eckhardt and Shane (2011) did not find any significant association between the importance of complementary assets in an industry and new firm formation. They also suggest that "additional research is necessary to understand under what conditions this relationship exists and how these [complementary] assets should be identified" (p. 425). Our analysis addresses this issue by using the parent organization rather than the industry as unit of analysis.

An obvious reason why complementary assets should reduce the likelihood of spinoff is that these assets signal the level of set up costs that should be borne by the founders of a new firm. Complementary assets then represent a barrier to exit. Moreover, the importance of complementary assets suggests that the organization has entered a stage of institutionalization and, to some degree, routinization of innovative opportunities and activities. Under these conditions, it is unlikely that innovative employees leave to found a new firm. Dobrev and Barnett (2005) have provided evidence in favor of a negative association between organization routinization (measured by size and age) and entrepreneurship. However, Dobrev and Barnett (2005) do not observe complementary assets directly and thus their results may erroneously assign to size and age part of spinoff's variability which is due to heterogeneity in complementary assets' endowment.

Our approach to complementary assets draws on a theory developed by Agarwal *et al*. (2004). In their analysis of knowledge inheritance by spinoffs, Agarwal et al. (2004) argue that spinoffs are likely to depend on 'how well incumbent firms utilize their knowledge' (p. 504). Established organizations often underexploit their technological knowledge because they fail to develop simultaneously market know-how while on other occasions organizations lack the technological knowledge required to pursue new market opportunities. Tushman and Anderson (1986), Henderson and Clark (1990) and Christensen (1993) discuss how organizational inertia results in failure and entry of new competitors. For our purposes, this inertia generates two effects highlighted by Agarwal et al. (2004). First, inertia and inability to respond to technological and market opportunities leads to frustration and a growing gap between employees' aspirations and organizational performance which may eventually result in turnover and spinoffs. Second, by missing important market opportunities because of lacking complementary assets the employer signals the availability of attractive business opportunities that are not preempted by the entry of the parent organization (Eisenhardt, 1989). An important implication of this theory for our purposes here is that spinoffs are less likely to occur when established organizations own a complete set of complementary assets required to make an invention a technical and commercial success. Instead, a partial set of assets reduces the ability to respond to business opportunities and paves the way to spinoffs.

> *Hypothesis 2. Inventions generated by organizations endowed with technological and commercial resources required to turn the invention into a successful innovation are less likely to be used to spawn a spinoff.*

Working Autonomy, Creativity and Spinoffs

Organizations are not always a training ground and a source of knowledge for future entrepreneurs. On the contrary, they can be a source of dissatisfaction and frustration when offer employee with entrepreneurial idea limited opportunities to develop those ideas within the organizational boundaries (Freeman, 1986). Established firms are typically viewed as organizations: *(i)* unwilling or unable to pursue radical technological changes that challenge established ways of doing business; *(ii)* unwilling or unable to evaluate entrepreneurial opportunities that fall outside their core business (Gompers et al., 2005; Cassiman and Ueda, 2006). While large established organizations often match this profile, there are important differences across organizations of comparable size which need to be accounted for. For example, organizations with a rigid division of labor and limited autonomy granted to employees are less likely to pursue internally their employees' entrepreneurial ideas (Hannan and Freeman, 1984; Sorensen and Fassiotto, 2011). This organizational style, typically centered on monitoring and control, gives rise to frustration and leads creative individuals with a preference for autonomy and independence to leave the firm and, possibly, to startup a new venture (Freeman, 1986). Although earlier studies show that more bureaucratic firms spawn less spinoffs (Sorensen, 2007), the effects of the organizational dimensions discussed here on spinoffs are not obvious and deserve finer-grained analysis. Organizations can shape the attractiveness of entrepreneurial opportunities relative to employment by relying on different policies such as monetary and nonmonetary incentives (Hellman, 2007). An important non-pecuniary incentive is working autonomy. Organizations that grant autonomy help employees to make decisions and take responsibility, and therefore may induce employees with a taste for independence and a high risk tolerance to start a new firm. An innovative environment characterized by a high levels of autonomy offers employees the freedom of exploring, recognizing new business opportunities and entering into entrepreneurship (Helfat and Lieberman, 2002; Agarwal et al., 2004; Klepper, 2009). However, autonomy may have different implications for entrepreneurship. Compared to other employees, inventors are supposed to be particularly driven by intrinsic motivations and therefore willing to trade autonomy and a free working environment for monetary incentives. Stern (2004) has found that firms adopting a science-oriented R&D approach allow researchers the freedom to set their research priorities, undertake long term research topics and publish their research output. Sterns' empirical analysis based on multiple job offers to postdoctoral biologists shows a negative relationship between wages and the science-oriented R&D approach. The literature on organizational creativity has also shown that freedom or autonomy in deciding what work to do or how to perform it is a fundamental driver of creativity and innovation (Woodman, Sawyer & Griffin, 1993; Amabile, 1997; Zhang and Bartol, 2010).

However, the implications of autonomy for the likelihood of spinoffs are quite ambiguous. On the one hand, autonomy may foster the accumulation of entrepreneurial human capital, thus favoring entrepreneurship. On other hand, researchers with a strong taste for autonomy are likely to give up the potential higher wages (or higher rewards for ability) offered by entrepreneurship if the organization grants autonomy.

This ambiguity notwithstanding, we believe that the latter effect dominates the former for the following reason. As Lee et al. (2011) have demonstrated, an organizational innovative climate and technical excellence incentives positively affect job satisfaction and this in turn reduces entrepreneurial intention. If we assume that autonomy is a major determinant of job satisfaction for inventors then we may expect that this organizational dimension has a negative impact on the likelihood of spinoffs. These considerations lead to the following testable hypothesis.

> *Hypothesis 3a. Inventions generated in an innovative environment with great working autonomy are less likely to be used to spawn a spinoff.*

Although autonomy may help established organizations prevent employees from exploiting proprietary knowledge in a new venture, in given circumstances creative employees may be allowed, if not encouraged to found a new firm. This is the case of ideas resulting from the curiosity of non-professional, occasional inventors or inventions coming into existence as the unplanned outcome of creative activities unrelated with formal R&D. Such inventions are likely to fall outside the firm’s strategic targets. Although these inventions are likely to occur especially in highly innovative organizations that allow a great level of autonomy and explorative freedom to employers - e.g., 3M or Gore&Associates, they may also result from serendipity in organizations that do not grant much autonomy to their employees. Therefore, the scenario that generates such inventions is not necessarily correlated with the level of autonomy. In any case, turning pure creativity into innovation requires resources and organizational efforts that could not be in line with the firm's strategic goals. And this misalignment is more likely to occur for curiosity-driven inventions and new ideas generated outside a targeted R&D project. These categories of inventions are more likely to be rejected especially by established firms with formal R&D departments, which typically adopt severe project selection procedures (Cassiman and Ueda, 2006). These considerations lead to the following hypothesis

> *Hypothesis 3b. Inventions resulting from informal R&D activity or pure individual creativity are more likely to be used to spawn a spinoff.*

Collaborative Links with Other Organizations and Spinoffs

The importance of external sources of knowledge for the firm's innovativeness and growth has been acknowledged by the innovation management research and the entrepreneurship literature.

In this study we examine the association between spinoffs and formal or informal collaborative links that the employer organization undertook with external partners during the inventive activity. We also distinguish different types of partners (e.g., universities, competitors, etc.) and their implications for spinoffs.

Our analysis captures an important unexplored antecedent of technological entrepreneurship which is openness of innovative activity to external sources of knowledge. While open innovation and its implications for creativity and firm performance have been studied at length by scholars of innovation management (e.g., Cohen and Levinthal, 1990; Chesbrough, 2003; Laursen and Salter, 2006), to our knowledge the implications of open innovation for spinoffs have not been examined yet. We intend to contribute to the literature on open innovation by showing how openness of R&D activities can favor the inventor's ability to explore, recognize and capture outside entrepreneurial opportunities.

Earlier entrepreneurship studies have analyzed the role of ‘weak ties’ to source external knowledge and ‘bridging ties’ to access better market opportunities in the seed stages of new ventures (Hoskisson et al., 2011). Other studies speculates that employees of smaller firms have more access to external networks and therefore are more likely to become entrepreneurs (Gompers et al., 2005; Elfenbein et al., 2010). But, to the best of our knowledge, no earlier work has tested directly the association between external ties and the likelihood of spinoffs.

We draw on the idea that organizations adopting an open innovation approach allow their employees to build professional networks and accumulate social capital (Davidsson and Honig, 2003; Stuart and Sorenson, 2005). By favoring the consolidation of social ties with external parties, workplaces enhance the ability of individuals to identify and grasp value-creating opportunities (Gompers et al., 2005; Elfenbein et al., 2010). At the same time, by leveraging the social capital of their employers, individuals may find it easier to mobilize resources that the launch of a new venture requires (Sorensen and Fassiotto, 2011). Accordingly, we hypothesize:

> *Hypothesis 4. Inventions resulting from collaborative links with external parties are more likely to be used to spawn a spinoff.*

SAMPLE AND VARIABLES

Data and Sample

Data used in this paper are drawn from the Patval- EU II, Patval-US and Patval-JP surveys conducted within the InnoS&T project, which aimed at collecting data on a number of issues related to the invention process leading to EPO patents and their determinants, inventor biographies and motivations for research, patent value, commercialization and related issues (InnoS&T 2011). InnoS&T follows in many regards the PatVal-EU project (see Giuri et al., 2007), although it is global in scope and more focused as regards the research questions. Inventors in 20 European countries, Israel, the USA and Japan are contacted and surveyed, using a harmonized questionnaire across all surveyed regions. Survey data were matched with information from various sources including EPASYS and PATSTAT databases.

The sample comprises 23,044 observations referring to patent applications with priority dates between 2003 and 2005. For the purposes of this paper, we restrict our analysis to patents whose inventor at the time of the invention was either self-employed or an individual employed by a private enterprise. The working sample comprises 11,765 observations.

Measures

Dependent variables.

In order to operationalize the phenomenon under scrutiny in this paper we construct two dichotomous variables. The first variable, SPINOFF, draws on a question asking inventors whether the patent has been used by any of the inventors or applicant to found a new company. Descriptive statistics show that 2.9% of the patents (336 observations) developed by inventors employed in a business enterprise have been used to establish a new firm. The founder can be the inventor (or co-inventors), the patent assignee (which in about 90% of the cases is also the employer), or both. Our second dependent variable is INVENTOR SPINOFF. The survey allows distinguishing different forms of inventor's involvement in the spinoff. He/she may be the founder of the new company or may retain a financial interest in the new company. Even in the latter case, in all probability the inventor has played an active role in the formation of the new firm. 1.8% of all patents (206 observations) in our sample can be classified as inventor spinoffs. We focus on the subsample of inventor spinoffs because we want to control for the influence of individual characteristics such as age, education and risk propensity on the likelihood that an invention is used to form a startup.

Explanatory variables.

The first group of explanatory variables concerns the organization of the inventive activities that lead to the technological breakthrough. In particular, the variable TEAMWORK distinguishes cases in which the inventive activities were arranged as an individual work from cases were the inventive process was organized as teamwork. Alongside, two dummy variables account for the presence of co-inventors employed in the same organization (CO-INVENTORS SAME ORG) and co-inventors who were working for a different organization (CO-INVENTORS OTHER ORG). These variables together tell about whether the inventive process is the outcome of a collective effort or the result of individual creativity.

Although correlated, TEAMWORK and CO-INVENTORS SAME ORG capture different dimensions. TEAMWORK indicates if the invention results from individual or team work, even when team members are not inventors and are employed in other functional areas of the organization or other organizations. Instead, CO-INVENTORS SAME ORG tells whether more than one inventor employed in the same organization are listed in the patent. Descriptive statistics reveal that about 28% of patents with one inventor are the result of team work (6.4% of our sample), which suggests that other contributors may be not co-inventors of the patent. Moreover, about 20% of patents developed by multiple inventors are considered as individual work as opposed to teamwork by the inventor.

The Patval II survey asked inventors to rate their agreement or disagreement - from 1 (= completely disagree) to 5 (=completely agree) with the following statements that describe the organization where the invention was created: (a) the organization had all the complementary resources to make the invention a technical success; (b) the organization had all the resources to turn the invention into something economically valuable (e.g., a new product, process or else). We used this information to construct four dummy variables: NO_COMPL_ASSETS =1 if either assets were absent, COMPL_ASSETS_BOTH =1 if both assets for both technical and economic success were present, COMPL_ASSETS_TECH =1 if there were only assets for technical success and COMPL_ASSETS_ECON = 1 if there were only assets for economic success. These variables, particularly COMPL_ASSETS_ECON

COMPL_ASSETS_BOTH, account for the importance of organizational capabilities needed to make the invention technically and commercially valuable.

Another important explanatory variable is on-the-job autonomy. Patval II survey asked inventors to rate their autonomy or the autonomy of their team – from 0 (= no autonomy) to 5 (= very high) – with respect to the following dimensions: (a) selection of tasks or projects; (b) allocation of working time among different tasks or projects; (c) flexibility of working hours; (d) size of the budget allocated to the task; (e) choice of how to spend this budget; (f) release of information outside the organization (e.g., publications or informal exchanges). We used this piece of information to construct three dummy variables that are meant to capture different dimensions of working autonomy: MANAGEMENT AUTONOMY = 1 if the inventor assigned a value equal or greater than 4 to at least one of the items (a), (b), (c); BUDGET AUTONOMY = 1 if the inventor assigned a value equal or greater than 4 either to item (d) or (e); DISCLOSURE AUTONOMY = 1 if the inventor rated its autonomy equal or greater than 4 on item (f).

To assess how the scenario that characterizes the inventive process influences the entrepreneurial process we rely on the following two measures: NO R&D INVENTION and CREATIVITY. The first measure is a dummy variable that is equal to 1 if the invention arises from the normal job of a non-professional inventor and may or may not be further developed in an R&D project. The second measure is a dummy variable that takes on the value 1 if the invention arises from the inventor's inspiration/creativity and has not been further developed in an R&D project. It is worth noting that the reference category for the inventive scenario is a dummy variable that equals 1 if the invention was the targeted outcome or a by-product of an R&D project.

To further characterize the process leading to the patented invention we consider the existence of collaborations with external actors during the inventive process. We create 3 dummy variables which are equal to 1 if during the inventive activity the parent organization undertook respectively: *i)* formal or informal collaborations with buyer and suppliers along the value chain, COLL_VERTICAL; *ii)* formal or informal collaborations with competing firms or other business organizations, COLL_HORIZONTAL; iii) formal or informal collaborations with universities, public and private research organizations, COLL_RESEARCH.

Control variables.

We control for various technological, organizational and inventor factors examined in the literature. Our controls include a set of dummy variables distinguishing the size of organizations (number of employees). The baseline category comprises small enterprises employing less than 50 workers which represent 11% of observations in our sample. Besides, we distinguish 6 size classes, including one involving very large organizations (more than 5000 employees) which account for 56% of observations. Beyond firm size we also take into account the age of organization considering 4 dummy variables that distinguish young enterprises (less than 5 years) from more mature organizations. Finally, we control for the scope of the technological portfolio of the parent organization through the variable TECH_DIVERSIFICATION, which is measured as 1 minus the Herfindahl index of concentration of the patent portfolio. In constructing the Herfindahl index we draw on the stock of patent data at the level of 3-digit IPC technological classes. Moreover, we construct the stock in each class relying on a perpetual inventory method that takes as starting point the year 1983 and a depreciation rate of the 15%.

A quite large body of the literature (Shane, 2001a,b; Di Gregorio and Shane, 2003; Stuart and Sorenson, 2003; Sine et al., 2005) has shown that differences in technological opportunities and the institutional environment influence the formation of technological startups. In line with earlier contributions, we control for several characteristics of the patented invention.

First, we control for the importance of earlier patent documents (INFO SOURCE: PATENTS) and scientific publications (INFO SOURCE: SCIENT_PUB) as sources of information during the invention process. We expect that patents relying more on scientific knowledge are likely to favor collaboration with universities and other research centers and therefore can interact with collaborative links in affecting the propensity to spinoff. Second, we control for patent quality measured by the number of received patent citations (QUALITY). Earlier studies have validated this measure by comparing it to other indicators of patent technical and economic value (Harhoff, Narin & Vopel, 1999). Forward citations have also been used in previous studies as a predictor of spinoffs (Shane, 2001a). We also include in our analysis a variable (GENERALITY INDEX) capturing the general-purpose nature of the technology in terms of its potential uses, and a variable (PATENT FAMILY SIZE) expressing the size of the family of patents to which the focal patent accrues. To further control for specific characteristics of the invention, we account for the main technological class of the patent, using 6 macro technology classes.

We take into consideration the presence of competitors for the same patent (PATENT COMPETITION) that could affect the firm’s perception of the value of the patent and shape the willingness to give away its technology to a new firm. Besides, we control for the degree of concentration in the specific 3-digit IPC technological class to which the patent belongs (C10_INDEX). Finally we include controls for the country of the applicant and priority year (i.e., the date of the first patent application for the invention). These variables can also account for unobserved shocks that may affect the propensity to spinoff over time.

Our controls for the characteristics of inventors who have participated in a spinoff include age (INVENTOR AGE), a continuous variables that reports on a logarithmic scale the age of the inventor at the time of the priority year of the patent. Age is a proxy for general experience which has been found to be positively correlated with spinoff in previous studies (Eriksson and Khun, 2006). Another characteristic is R&D experience (INVENTOR RES_EXP) that is computed as the logarithm of the difference between the year of the patented invention and the year when the inventor started to engage in research activities. We interpret this as a measure of specialization which, according to the literature, should be negatively correlated with entrepreneurship (Lazear, 2004 and 2005). TERTIARY_EDUC is a dummy variable that takes the value 1 for inventors whose educational achievement was a bachelor or a higher degree.

Finally, we control for two measures of 'taste' for entrepreneurship - risk propensity and family-owned businesses. The dummy variable FAM_OWNED BUSINESS equals 1 if either any parents or siblings of the inventor ever operated a business of their own until the inventor reached the age of 20. RISK PROPENSITY spans an eleven point scale, from 0 (completely unwilling to take risks) to 10 (completely willing to take risks). Both measures account for the inventor's tolerance to risk (Bhidé, 2000).

RESULTS

Before presenting the results of our econometric analysis, we evaluate the presence of multicollinearity among regressors. Pairwise correlation coefficients[1] are generally below 0.3, except for a few values concerning firm size and age that are around 0.5. This suggests that collinearity does not represent a major concern in our setting. We further explore this issue computing the average variance inflation factor and the condition number: for the specification under Model (7) in Table 2, the two statistics take on a value of 1.67 and 5.84, respectively, thus corroborating the conclusion that collinearity does not affect our regressions.

Because we deal with dichotomous dependent variables, SPINOFF and INVENTOR SPINOFF, we carry out a multivariate regression analysis based on a probit estimator

[1] Data are available on request from the authors.

(Greene, 2000). Table 1 illustrates the results of our probit estimations referring to the occurrence of a business spinoff. The first column shows the average marginal effects obtained when only control variables are factored into the regression model. Columns 2 to 6 progressively add the explanatory variables measuring team work (columns 2), complementary assets (column 3) working autonomy and creativity (column 4 and 5) and collaborative links (column 6). The progressive inclusion of the explanatory variables linked to our hypotheses does not change the significance and the effect of each factor. As a consequence, we will comment on the estimates under Model (6) in Table 1.

Insert Table 1 about here

Hypotheses 1.a,b are about the association between team work and patent-based spinoffs. Results under the specification in Model (6) show that inventions developed in teams are less likely to be associated with the occurrence of a spinoff. Our dummy for TEAMWORK is negative and significant. Consistently, we find that if the patent is developed by more than one co-inventor in the same organization (CO-INVENTORS SAME ORG) the probability of starting a new firm is lower. Instead, the dummy indicating if co-inventors were working in different organizations is not significant.

The magnitude of the effects of both TEAMWORK and CO-INVENTORS SAMEORG is substantial considering that we are controlling for a large number of observable firm, technology and patent characteristics. Teamwork and the presence of co-inventors reduce the probability of spinoffs by 0.8% and 0.6%, respectively. Our results therefore support hypothesis 1.b, which predicts a negative association between teamwork and startups.

But why should inventions generated in teams or by multiple co-inventors generate less start-ups? On the one side, it is less likely that a group of people committed in the organization, leave the employer organization to create an independent start-up, whether or not the patent applicant participates in the new venture. On the other side, inventions resulting from individual work probably fall outside the employer's core activities and are then more likely to be used by an independent new venture. Our estimations suggest that the negative effect on the likelihood of spinoff due to organization's commitment (proxied by the participation of different inventors and teamwork) and the difficulty to transfer organization-specific, tacit knowledge to a new organization exceeds the positive effect due to the accumulation of social and entrepreneurial capital originating from the interactions with different co-workers.

We find evidence in favor of our hypothesis 2. The presence of both technical and economic complementary resources to make the invention technically and commercially valuable (COMPL_ASSETS_BOTH) reduces the probability of spinoff by 1.4%. This implies that patents whose owners lack complementary assets are more likely to be developed in a new firm. Moreover, there are no significant differences between COMPL_ASSETS_TECH and the baseline of no complementary assets, indicating that the probability of spinoffs is not affected by whether technical assets are available.

Our hypothesis 3*a* concerns the association between working autonomy and new firm formation. We do not find support for this hypothesis when considering the entire sample of spinoffs. Autonomy in the management of tasks and budget autonomy (MANAGEMENT AUTONOMY and BUDGET AUTONOMY) are not significant. Instead, the marginal effect of autonomy in the use and dissemination of information related to the invention (DISCLOSURE AUTONOMY) is always positive and significant. The magnitude of this effect is also substantial. A change from 0 to 1 of DISCLOSURE AUTONOMY is associated with about a 1.6% increase in the probability of startup. These results may reflect two opposite effects that workplace autonomy may have on start-ups. On the one hand, working autonomy allows inventors accumulate experience in project management that may be useful and critical for starting a new business. However, a work environment characterized by limited decisional autonomy is probably not desirable for inventors, who might than leave the organization to achieve a greater autonomy. Contrary to our expectations, our findings suggest that the positive entrepreneurial human capital effect overcomes the negative effect due to the value of autonomy and freedom to explore. Nevertheless, we will show below that when focusing on inventor spinoffs, we obtain some evidence consistent with our hypothesis.

Consistent with hypothesis 3*b*, we observe that technological inventions that emerge as an unplanned outcome of creative activities unrelated with formal R&D are more likely to be exploited through the formation of a new firm. In particular, we find that inventions originating from the normal job of individuals (which is not inventing) increase the likelihood of a spinoff by 0.9%. Even larger is the effect of individual creativity. Technological opportunities whose origin can be traced back to pure inspiration raise the chance of observing a spinoff by 1.8%.

Our fourth hypothesis concerns the collaboration with external actors during the inventive process, a measure of an open innovation approach. We find that COLL_HORIZONTAL (collaborations with competitors and other firms) increases the probability of spinoff by 1% while COLL_RESEARCH (collaborations with universities and private research) increases the probability of spinoff by 1.8%. Finally, COLL_VERTICAL (collaboration with suppliers or customers) is not significant. These findings on collaboration provide support to hypothesis 4. Combined with the positive impact of information autonomy, our evidence suggests that an organizational environment open to both in-flows and out-flows of information positively affects entrepreneurship.

Our controls include parent firm, patent and technology level variables. The results confirm previous findings about the negative impact of the employer's organization size on the probability of spawning start-ups. Compared with the baseline size category (less than 50 employees), all size dummies are negative and significant. Their effect remains significant after the inclusion of the key explanatory variables, but the magnitude of the effect decreases substantially. For example the negative marginal effect of FIRM SIZE: >5000 employees decreases from 6.3% (column 1) to 4.1%, when all regressors are included in the estimated equation (column 6). The size dummies then take some of the effect of organizational characteristics like team work, working autonomy, and collaborative links and complementary assets that are omitted in the baseline model. Although the marginal effect of size dummies remains substantially larger than other key regressors, our findings point out that the qualitative characteristics of the organizational environment where the invention has been generated produce significant effects above and beyond organizational size.

We do not generally find that spinoffs are more likely to originate from young employer organizations (baseline dummy: 1-4 years). As Table 1 shows, young organizations are more likely to spawn a spinoff only compared with firms 11-20 years old, whereas the difference with other age categories are not significant.

The effect of TECH_DIVERSIFICATION is also negative and significant. The estimated elasticity implies that a one per cent increase in technological diversification is associated with a 1.52 per cent decrease in the probability of spin-off. This suggests that larger, diversified firms are more able to explore and exploit their knowledge in-house than smaller and specialized firms.

Since it is possible that DISCLOSURE AUTONOMY and COLL_RESEARCH capture some broader association between science-based inventions and entrepreneurship, we include INFO SOURCE: SCIENT_PUB to control for domains in which scientific literature is important. The average marginal effect associated with this variable (0.02%) is positive and significant at the 10% level, but it does not reduce the marginal effects of DISCLOSURE AUTONOMY and COLL_RESEARCH. In line with previous findings (Shane, 2001a), we also find that technologies of higher economic value (QUALITY), are associated with a higher probability of observing the formation of a new firm.

In order to examine the importance of individual characteristics we estimate a separate equation for the subsample of inventor spinoffs. This analysis is important to evaluate whether accounting for the inventor's characteristics affects our key findings. Table 2 reports the average marginal effects for inventor spin-off (INVENTOR SPINOFF), i.e., cases in which the inventor is among the founders or the owners of the new firm. The first four columns report the main regressors and controls. Columns 5 to 7 introduce inventor-specific variables. Precisely, column 5 introduces inventor's age and education, column 6 adds the inventor's research experience and column 7 introduces a measure of familiarity with entrepreneurship and a proxy for risk propensity.

Insert Table 2 about here

The results in columns 4 indicate that the marginal effects of teamwork, complementary assets, inventor autonomy and external collaborations during the inventive process, maintain their signs and significance. Furthermore, the three final columns of Table 2 show that our findings are robust even when controlling for individual characteristics. It is worth noting that, differently from what observed before, the analysis on inventor spinoffs lends some support to our research hypothesis 3*a*. Indeed, we find that allowing employees the freedom to select their tasks and allocate their working time (MANAGEMENT AUTONOMY) decreases the probability that the inventor will leave to establish a new venture by about one percentage point.

The effects associated with parent company characteristics (FIRM SIZE, FIRM AGE, and TECH_DIVERSIFICATION) do not change qualitatively when individual characteristics are accounted for while country dummies overall become insignificant. Patent characteristics have also the same sign. In particular, technologies of higher quality are more likely to be exploited outside the boundaries of the firm. The differences in the size and significance of coefficients are clearly due to the addition of individual characteristics which take some of the effect of other regressors.

The analysis of inventor-level variables yields interesting results. In line with previous studies (e.g., Parker, 2011) older inventors (INVENTOR AGE) are more likely to participate in the formation of a spin-off. However, the length of the inventors' research experience is negatively associated with the probability of spin-offs. This finding indicates that while experience in general is useful to enter into entrepreneurship, R&D-specific experience apparently reveals a specialized working professional profile which, according to the 'jack-for-all-trade' theory of entrepreneurship (Lazear, 2004), determines a lower propensity to start a new firm.

Results also confirm the expectation that familiarity with entrepreneurship and risk tolerance are positively related to inventors' spinoffs. Both variables FAM_OWNED BUSINESS and RISK PROPENSITY, even if included separately in our estimations, are positive and significant, and their size is not negligible. A 1% increase in risk propensity is associated with 1.87% increase in the probability of spinoff. Finally, the level of education of the inventor is not significant.

We carried out several robustness checks of our results.[2] As far as the estimation models are concerned, we also run rare event logit estimations to account for the fact that our dependent variable is characterized by a small share of positive events (i.e., large number of zeroes in our dependent variables). Results are very similar to those obtained with probit estimations.

Our probit estimations include unused patents, i.e. patents that have neither been used by the assignee nor have been used to start a new firm. Since unused patents may reflect systematic unobservable characteristics that are different from other patents, in unreported regressions

[2] Results are available on request from the authors.

we repeated our analysis restricting the sample to used patents. The results are qualitatively very similar to the evidence discussed in the paper.

IMPLICATIONS AND CONCLUSIONS

This paper provides novel findings on the role of organizational characteristics of business firms on the creation of patent-based start-ups. The convergence between organizational literature and entrepreneurship studies is only recent (Sorensen and Fasiotto, 2011) and there is a lack of theory and empirical analysis on the impact of organizational dimensions like team work or working autonomy on the probability that employees leave their organization to start a new firm. Indeed, most studies use size and age as proxies for organizational factors. Our paper, contributes to better understanding the different drivers of spinoffs by digging deeper into the parent organizational setting. More precisely, our probit estimations suggest that patents developed by different co-inventors and resulting from a teamwork inventive process are less likely to be used by a spinoff. Also complementary assets for the technical and commercial implementation of the invention are negatively associated with spinoffs. Instead, working autonomy, especially the inventors' freedom to disclose information through publications and informal exchange, has a positive association with the likelihood of spinoffs. Inventions arising from non-R&D activity and pure individual creativity are more likely to be used to establish a new firm. Collaboration with competitors and other parties is also positively associated with spinoffs thus pointing out the importance of an open innovation environment in the formation of spinoff.

Some controls deserve a final comment. In particular, in line with previous studies (Gompers et al. 2005) we find that more technologically diversified firms are less likely to spawn either an inventor or a corporate spinoff.

These findings hold also when controlling for individual characteristics. Individual controls enter our regressions with the expected positive sign, especially the inventor's age, risk tolerance and familiarity with entrepreneurship. Instead, R&D experience enters with a negative sign, suggesting that specialization does not favor entry into entrepreneurship.

Besides a better understanding of the origin of technological spinoffs, our findings may also help established firms to make a more efficient use of their knowledge and elaborate effective policies. On the one hand, it is important for established firms to know which organizational conditions and incentive mechanisms prevent inventor spinoffs – for instance by allowing more autonomy or offering other rewards which increase the opportunity costs of entry into entrepreneurship. On the other hand, the empirical evidence discussed in this paper is useful for established firms to know how to develop an organizational environment that favors creativity and 'intrapreneurship'. In addition, our findings on individual characteristics may help an established firm identify which individuals are more likely to exploit the opportunities that the firm is not willing to pursue.

We should warn that this is a preliminary exploration of a new dataset and this implies limitations that we will address in future research. One limitation that we will address in future research is about the mechanisms that link autonomy to creativity. A deeper understanding of these mechanisms may help explain the unexpected findings related on hypothesis 3*a*. Moreover, our data do not allow accounting for the role of the distance between the parent and the spinoff businesses. Future research might also explore the mechanisms that explain the choice between corporate vs. inventor spin-offs conditional upon the decision of spawning a new firm.

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Table 1. Probit estimations of SPINOFF – average marginal effects

VARIABLES	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
TEAM WORK		-0.008**	-0.007**	-0.007**	-0.005	-0.008**
		(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
CO-INVENTORS SAME ORG		-0.011***	-0.010***	-0.009**	-0.007*	-0.006*
		(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
CO-INVENTORS OTHER ORG		0.008	0.008	0.009*	0.010*	0.008
		(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
COMPL_ASSETS_TECH			-0.007	-0.008	-0.007	-0.006
			(0.005)	(0.005)	(0.005)	(0.005)
COMPL_ASSETS_ECON			-0.012**	-0.012**	-0.012**	-0.011**
			(0.005)	(0.005)	(0.005)	(0.005)
COMPL_ASSETS_BOTH			-0.015***	-0.016***	-0.015***	-0.014***
			(0.003)	(0.004)	(0.004)	(0.003)
MANAGEMENT AUTONOMY				-0.005	-0.005	-0.005
				(0.004)	(0.004)	(0.004)
BUDGET AUTONOMY				0.001	0.001	0.001
				(0.003)	(0.003)	(0.003)
DISCLOSURE AUTONOMY				0.018***	0.017***	0.016***
				(0.004)	(0.004)	(0.004)
NO R&D INVENTION					0.008**	0.009**
					(0.004)	(0.004)
CREATIVITY					0.016***	0.018***
					(0.005)	(0.006)
COLL_VERTICAL						-0.001
						(0.003)
COLL_HORIZONTAL						0.010**
						(0.004)
COLL_RESEARCH						0.018***
						(0.004)
INFO SOURCE: SCIENT_PUB	0.003***	0.003***	0.003***	0.002**	0.003***	0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
QUALITY	0.002**	0.002**	0.002**	0.002***	0.002***	0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
TECH_DIVERSIFICATION	-0.046***	-0.044***	-0.043***	-0.042***	-0.041***	-0.039***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
FIRM SIZE: 50-99	-0.045***	-0.036***	-0.031***	-0.027***	-0.026***	-0.024***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
FIRM SIZE: 100-249	-0.048***	-0.037***	-0.031***	-0.027***	-0.026***	-0.024***
	(0.010)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
FIRM SIZE: 250-499	-0.057***	-0.047***	-0.042***	-0.038***	-0.037***	-0.036***
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)	(0.008)
FIRM SIZE: 500-999	-0.063***	-0.052***	-0.048***	-0.043***	-0.043***	-0.042***
	(0.010)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)
FIRM SIZE: 1000-4999	-0.060***	-0.049***	-0.045***	-0.040***	-0.040***	-0.038***
	(0.010)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)
FIRM SIZE: >5000	-0.063***	-0.052***	-0.047***	-0.043***	-0.043***	-0.041***
	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)
FIRM AGE: 5-10 yrs	-0.003	-0.004	-0.003	-0.003	-0.003	-0.002
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
FIRM AGE: 11-20 yrs	-0.011**	-0.012**	-0.010**	-0.010*	-0.010**	-0.009*
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
FIRM AGE: >20 yrs	-0.006	-0.007	-0.006	-0.006	-0.006	-0.004
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Observations	11,765	11,765	11,765	11,765	11,765	11,765
Pseudo R-squared	0.235	0.246	0.253	0.261	0.266	0.277
ll	-1166.759	-1150.358	-1140.023	-1127.124	-1120.712	-1103.707
chi2	654.793	682.938	674.767	697.025	709.397	708.114

*** p<0.01, ** p<0.05, * p<0.1. Standard errors robust to within cluster dependence in parentheses.

Notes. Regressors also include additional control variables for source of knowledge behind the invention process, generality of the patent, family size of the patent, priority year, existence of competitors for the patent, technological classes, degree of concentration in the technological class, countries.

Table 2. Probit estimations of INVENTOR SPINOFF – average marginal effects

VARIABLES	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
TEAM WORK		-0.007***	-0.006**	-0.008***	-0.007***	-0.008***	-0.007***
		(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
CO-INVENTORS SAME		-0.010***	-0.007***	-0.007**	-0.006**	-0.006**	-0.005**
		(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
CO-INVENTORS OTHER		0.000	0.002	0.002	0.002	0.002	0.004
		(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
COMPL_ASSETS_TECH		-0.001	0.000	0.001	0.001	0.001	0.001
		(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
COMPL_ASSETS_ECON		-0.013***	-0.013***	-0.012***	-0.012***	-0.012***	-0.012***
		(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
COMPL_ASSETS_BOTH		-0.008***	-0.008***	-0.007***	-0.007***	-0.007***	-0.007***
		(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
MANAGEMENT			-0.009**	-0.008**	-0.008**	-0.008**	-0.009**
			(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
BUDGET AUTONOMY			0.004	0.004	0.003	0.003	0.002
			(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
DISCLOSURE			0.013***	0.012***	0.012***	0.012***	0.011***
			(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
NO R&D INVENTION			0.007**	0.009***	0.009***	0.008**	0.008**
			(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
CREATIVITY			0.016***	0.017***	0.016***	0.016***	0.014***
			(0.005)	(0.005)	(0.005)	(0.005)	(0.004)
COLL_VERTICAL				-0.004	-0.004	-0.004	-0.004*
				(0.002)	(0.002)	(0.002)	(0.002)
COLL_HORIZONTAL				0.009***	0.009**	0.010***	0.009***
				(0.004)	(0.003)	(0.004)	(0.003)
COLL_RESEARCH				0.012***	0.012***	0.011***	0.010***
				(0.004)	(0.004)	(0.004)	(0.003)
INVENTOR AGE					0.011**	0.019***	0.020***
					(0.006)	(0.006)	(0.006)
TERTIARY_EDUC					0.001	0.003	0.003
					(0.003)	(0.003)	(0.003)
INVENTOR RES_EXP						-0.005***	-0.005***
						(0.001)	(0.001)
DMISSING RES_EXP						-0.007**	-0.007**
						(0.003)	(0.003)
FAM_OWNED BUSINESS							0.004*
							(0.003)
RISK PROPENSITY							0.003***
							(0.001)
TECH_DIVERSIFICATION	-0.033***	-0.029***	-0.027***	-0.026***	-0.026***	-0.024***	-0.024***
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)
FIRM SIZE: 50-99	-0.042***	-0.030***	-0.025***	-0.024***	-0.023***	-0.021***	-0.018***
	(0.009)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)
FIRM SIZE: 100-249	-0.042***	-0.029***	-0.023***	-0.023***	-0.021***	-0.020***	-0.016***
	(0.008)	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
FIRM SIZE: 250-499	-0.048***	-0.034***	-0.030***	-0.030***	-0.028***	-0.027***	-0.023***
	(0.008)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)
FIRM SIZE: 500-999	-0.049***	-0.037***	-0.032***	-0.032***	-0.030***	-0.030***	-0.025***
	(0.008)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
FIRM SIZE: 1000-4999	-0.046***	-0.032***	-0.027***	-0.026***	-0.024***	-0.023***	-0.019***
	(0.009)	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
FIRM SIZE: >5000	-0.050***	-0.037***	-0.032***	-0.031***	-0.029***	-0.029***	-0.024***
	(0.008)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)
Observations	11,007	11,007	11,007	11,007	11,007	11,007	11,007
Pseudo R-squared	0.282	0.308	0.332	0.345	0.347	0.358	0.372
ll	-700.947	-675.070	-651.499	-639.041	-636.968	-626.828	-612.554
chi2	442.331	446.700	477.158	474.475	494.151	511.256	574.978

*** p<0.01, ** p<0.05, * p<0.1. Standard errors robust to within cluster dependence in parentheses.

Notes. Regressors also include additional control variables for source of knowledge behind the invention process, quality and generality of the patent, family size of the patent, priority year, existence of competitors for the patent, technological classes, degree of concentration in the technological class, age of the parent firm and countries.