DISCUSSION PAPER SERIES

DP16255

To License or Commercialize: Behavioral Considerations in Patent Exploitation by Family Firms

Addis Birhanu and Alfonso Gambardella

ORGANIZATIONAL ECONOMICS

CEPR

ISSN 0265-8003

To License or Commercialize: Behavioral Considerations in Patent Exploitation by Family Firms

Addis Birhanu and Alfonso Gambardella

Discussion Paper DP16255
Published 14 June 2021
Submitted 08 June 2021

Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
Tel: +44 (0)20 7183 8801
www.cepr.org

To License or Commercialize: Behavioral Considerations in Patent Exploitation by Family Firms

Abstract

This paper examines the relationship between family ownership and patent use strategy using primary data from a patent survey, and patent and firm-level data from secondary sources. We find that family firms are less likely than non-family firms to license and more than non-family firms to commercialize their patents. This decision is not driven by family firms' lower patent quality or inefficient use of patents. Instead, it is due to family firms' strong preference for patent uses that give them more control over values they can appropriate from their patents. To this end, family firms actively search for opportunities to use their patents internally by deviating from intended patent uses in favor of commercialization and spending more research time to commercialize even unanticipated (serendipitous) patents more than non-family firms. This idiosyncratic preference in patent exploitation may positively contribute to the scaling up of family firms but potentially hinders the development of Market for Technology.

JEL Classification: L21, L22, L24, L25, M21

Keywords: family firms, patents, licensing, markets for technology

Addis Birhanu - birhanu@em-lyon.com
Em-Lyon Business School

Alfonso Gambardella - alfonso.gambardella@unibocconi.it
Bocconi University and CEPR

INTRODUCTION

As a ubiquitous ownership type (La Porta, Lopez-De-Silanes, and Shleifer, 1999), the influence of family ownership on strategic decisions of firms such as growth, diversification, divestiture, internationalization, and performance outcomes such as market value and profit stability has been largely explored (e.g., Bertrand and Schoar, 2006; Feldman, Amit, and Villalonga, 2016; Miller, Breton-Miller, and Lester, 2010; Miroshnychenko *et al.*, 2020; Villalonga and Amit, 2020). Similarly, innovation and patents have long been recognized as key sources of competitive advantage of firms, and several studies have examined how and the conditions under which firms can appropriate returns from their innovations and patents (e.g., Arora and Ceccagnoli, 2006; Arora and Gambardella, 2010; Teece, 2006).

A few studies examined the influence of family ownership on firm innovation in general, and on patenting in particular (Chirico *et al.*, 2020; Duran *et al.*, 2016). Those few studies demonstrate that family firms produce more patents with less R&D (Duran *et al.*, 2016; Lodh, Nandy, and Chen, 2014) and that the value of patents produced by family firms are not less than those generated by non-family firms (Asaba and Wada, 2019). Moreover, they show that family firms are more reluctant to acquire external technology via outsourcing R&D services (Kotlar *et al.*, 2013), and to patent their inventions (Chirico *et al.*, 2020).

To date, we have a limited understanding of how choices are made by family firms to exploit patents internally and/or externally. While the innovation literature offers economic considerations such as competition, access to complementary assets, and profit-dissipation effects of licensing as the key drivers (e.g. Arora and Ceccagnoli, 2006; Fosfuri, 2006) there is a paucity in the family firm literature on this issue. As such, behavioral explanations that emanate from

governance characteristics like family ownership on patent uses are rather under-examined (Chirico *et al.*, 2020; James, Leiblein, and Lu, 2013).

The lack of research that brings these two streams of literature: family ownership and patent use strategies can be attributed to two factors. First, the two streams of research remain independent and seem to talk less to each other. Second, at the practical level, there is a lack of data on the possible uses of patents at a granular level unless one conducts a survey, expensive and time-consuming to gather at a large scale. We believe that as important as family businesses are around the world and innovation and patents for the competitiveness of firms, examining how family ownership influences the use of patents is important for several reasons. First, non-economic factors play a paramount role in a range of strategic decisions made by family firms. Bringing this insight would help to better explain why decisions related to innovation and patent uses vary across firms in light of differences in firm ownership type. Second, systematic difference in exploiting technology externally or internally by ownership type may affect the development of Market for Technology, a key institution that enhances the rate and direction of inventions by giving the right incentive for specialization and efficient allocation of resources (Arora and Gambardella, 2010; Gans, Hsu, and Stern, 2008; Hegde and Luo, 2018). Third, it also provides insights into how ownership structure influences patent uses and its implication on the growth and scale-up of firms.

We aim to contribute to this gap in the literature by examining the difference between family and non-family firms in the use of their patents within the firm (patent commercialization) versus in the Market for Technology (patent licensing). As well, we explain the underlying behavioral drivers of this difference in patent use by a) identifying and empirically testing actions

family firms distinctively pursue to maintain their taste for a specific kind of patent uses and b) ruling out alternative explanations.

We use a unique patent survey data collected from inventors in 20 European countries, Japan, and the US (Patval2). We combine this survey data with patent characteristics data from PATSTAT, and ownership and other firm characteristic data from Orbis. We tested our hypotheses with a sample of 471 firms and 2759 patents.

Our results suggest that family firms are more reluctant to license their patents than non-family firms and they commercialize their patents more than non-family firms. Further analyses show that the choice to license less by family firms is not due to their low patent quality but it is a behavioral choice. They prefer to exploit their patents without having to rely on licensees' capability for financial returns of their inventions and without having to risk their influence and competitiveness in their technology/product market. To this end, family firms actively pursue opportunities to exploit their patents internally by deviating substantively from planned patent use in favor of commercialization and spending more research time to commercialize even unanticipated (serendipitous) patents.

The paper makes several contributions to innovation and family firm literature. First, it shows that in family firms, the decision to exploit patents is not only driven by economic considerations as is established in the innovation literature (Arora and Ceccagnoli, 2006; Ziedonis, 2004). It is also driven by whether the chosen approach protects their interest to maintain control over the financial and technological returns of their patents. Second, their preference to use their patents internally than externally has implications on scaling up and growth of family firms. This is an interesting contribution because it has been established in the literature that family firms' interest to maintain control of strategic resources has limited their growth potential by reducing

their involvement in M&A, and internationalization (Arregle *et al.*, 2017; Caprio, Croci, and Del Giudice, 2011). Here we show how the same behavior– the preference for control –could positively contribute to scaling up and growth of family firms. Third, this paper contributes to innovation literature by providing a behavioral explanation that goes into the decision to exploit patents internally or externally and sheds light on how the idiosyncratic choice of family firms to internally exploit their patents could affect the development of Market for Technology.

The remaining part of the paper is organized as follows. We briefly provide a theoretical background on the types of patent uses and move on to developing hypotheses. Then in the data and method section, we describe our data and variables and explain our empirical strategy. In the result and discussion section, hypotheses are tested and additional results are presented a) to empirically probe into the distinct actions family firms take to maintain their preferred patent use and b) to rule out alternative explanations. This is followed by a contribution and conclusion section.

THEORETICAL BACKGROUND

Types of patent Uses

Innovation and its outputs like patents are the founding blocks of gaining competitive advantages (Grant, 1996; Teece, 2007). They are the bases for keeping capabilities dynamic via ensuring sustained experimentation, improving absorptive capacity, and granting monopolistic rent (Leone and Reichstein, 2012; Moreira, Klueter, and Tasselli, 2020; Teece, 2007; Ziedonis, 2004). Patents allow owners to gain monopolistic rent by protecting them from direct imitation (Gans, Hsu, and Stern, 2008). Firms use patents to pursue their profit interest directly or indirectly. Directly, they benefit from commercializing new products or processes by embedding the technology, or licensing patents in the Market for Technology. Indirectly, firms use their patents to prevent rivals

from inventing around (offensive blocking), and to protect themselves from infringement suits (defensive blocking) (Cohen, Nelson, and Walsh, 2000; Torrisi *et al.*, 2016). Though both licensing and commercializing new products using the technology are commercial use of patents, in this paper, we refer to the first type of use as Licensing and the second as Commercialization.

The literature proposes that firms' choice of how to use patents depends on the strength of intellectual property protection, complexity of the technology, availability of complementary resources, and extent of competition in the technology domain (Cohen *et al.*, 2000; James *et al.*, 2013; Lanjouw *et al.*, 2000). The use of patents in complex product industries such as semiconductors, biotechnology, and digital platforms is different from their use in industries with discrete products such as pharmaceuticals (Hall and Ziedonis, 2007; Teece 2006). Patenting in complex product industries serves primarily as a tool to defend holdups and infringement suits that might block the use of own technology to product commercialization (Ziedonis, 2004).

Similarly, ownership of complementary assets is an important determinant of the decision to license or commercialize technologies (Teece 2006). Complimentary assets refer to generic or specialized manufacturing, marketing, distribution networks, and aftersales services relevant to the technology-embedded product to be produced, promoted, and distributed. The presence of these assets gives a competitive edge by increasing the quality and reliability of the product and reduce the cost of production (Arora and Ceccagnoli, 2006; Arora and Gambardella, 2010; Teece, 2006).

Moreover, the presence of competition in the technology domain increases both licensing and commercialization of patents (Torrisi *et al.*, 2016). Licensing decisions are also influenced by the focal firms' market share in the product market and the extent of competition in the technology domain. Firms' decision to license their patents is determined by the net again from royalty fees of

licensing less revenue that dissipate due to product market competition as a result of licensees entry into the market (Fosfuri, 2006).

Against this background, we argue that exploiting patents via licensing and commercialization have important implications on the extent of control firms may have over their patent technologically and financially. For example, licensing limits licensors' control over how their technology is effectively exploited for commercial returns. It forces makes licensors rely on the expertise and capabilities of licensees to meet their revenue goals. It also limits their control over the trajectory of the technology (Leone and Reichstein, 2012; Moreira *et al.*, 2020). Licensees have the opportunity to recombine the licensed invention in ways that licensors do not have anticipated and challenge the latter's position both in the product and technology domain (Gurgula, 2017).

Therefore, in addition to what has been widely examined in the innovation literature, whether to exploit patents internally or externally may vary not only by economic but also by non-economic considerations, the desire to have strong control over their patents and values they can appropriate from them. In this regard, the ownership type of firms, in particular family ownership, could substantially influence the decision of whether to exploit their patents internally or externally.

HYPOTHESES

Patent use Strategy and Family Firms: Commercializing Vs Licensing

Family firms are known to often remain private than going public to avoid stock market scrutiny, forgo growth opportunities for fear of new capital diluting their controlling ownership, and create pyramidal structure and dual-class stock (La Porta *et al.*, 1999; Villalonga and Amit, 2020). Behind

these governance choices, there is a preference of families' to maintain control over strategic decisions and the deployment of strategic resources. This desire stems from higher risk and loss aversion behavior of controlling families due to pecuniary reasons such as the concentration of wealth in a single company or non-pecuniary reasons such as their desire to ensure the continuity of the firm to the next generation and emotional ties and identification of families to their firms (Duran *et al.*, 2016; Wiseman and Gomez-Mejia, 1998). While the pecuniary reasons may lead to similar behaviors by other ownership types when they have concentrated ownership, the non-pecuniary ones-socio-emotional wealth-make family firms to differ from other ownership types (Kalm and Gomez-Mejia, 2016). This preference for control has restricted family firms' degree of internationalization, mergers and acquisitions, and divestitures (Arregle *et al.*, 2017; Feldman, Amit, and Villalonga, 2016; Miller, Breton-Miller, and Lester, 2010).

In the context of how to exploit patents, the preference to have control over strategic decisions (resources) by family firms means that they would favor patent uses that strengthen their control and elude those that go against this taste. Among the potential uses of patents, integrating the technology into a product in-house and trading it in the Market for Technology have distinct implications in terms of maintaining control over intellectual properties.

When patents are traded in the Market for Technology, firms lose control over this property and risk the value they gain from it in several ways.

The first one relates to the uncertainty surrounding marketing patents, i.e., knowing the value of the patent, and handling transactions (Arora and Gambardella, 2010). Since only a small proportion of patents are licensed in general, the likelihood that licensors lose from this transaction due to undervaluation is very low (Gambardella, Harhoff, and Verspagen, 2008; Torrisi *et al.*, 2016). However, because family firms are loss averse (Wiseman and Gomez-Mejia, 1998), they

prefer patent use that avoids loss over those that reduce the likelihood of loss. That is, despite a smaller chance of licensing the most valuable patent, or any patent below its actual value, family firms would shy away from licensing their patents in the first place as it introduces some likelihood of loss.

Second, the uncertainty around the technological success of patents is inherent to innovation regardless of how firms want to exploit them. However, contracting around patents in the Market for Technology brings another risk into the equation: a potential failure of a licensee to abide by the licensing agreement and subsequent litigation costs (Somaya, 2003). This is a typical risk firm experience only if they decide to license.

Third, licensors have limited control over how their technology is effectively exploited for commercial returns after they license their patents. They would have to rely on the expertise and skills of the licensee to meet the revenue goals which are usually proportionally tied with the total revenue the licensee generates from using this technology (Wang, Liang, and Chou, 2013). Fourth, licensees have the opportunity to recombine the licensed patent in ways the licensor might not have anticipated. Such recombination opportunities by the licensee may at times be consequential in eroding the competitiveness and positions of the licensor both in the product and technology fiends (Laursen, Leone, and Torrisi, 2010; Leone and Reichstein, 2012).

On the other hand, commercializing innovations internally saves firms from risks associated with licensing. Besides, it allows firms to have control over the scalability of the production and distribution as well as on the use and future direction of development of the technology (Laursen *et al.*, 2017). It also provides an opportunity to benefit from technology spillovers to other product lines in the firm.

Therefore, the decision to exploit patents internally or externally (licensing) is also a function of how firms perceive and choose to manage the uncertainty related to maintaining (losing) control over their technology and their influence on the technology trajectory. Given the strong preference of family firms to maintain control over strategic resources, we expect family firms to favor commercializing their patents and shy away from licensing. Therefore, we hypothesis the following.

H1a: All else equal, family firms are less likely to license their patents than non-family firms

H1b: All else equal, family firms are more likely to commercialize their patents than non-family firms

DATA AND METHOD

Data

We tested our hypotheses by combining survey data about patent use strategies, patent characteristics data from PATSTAT, and ownership and other firm characteristic data from Orbis. The survey data (Patval2) was collected from a sample of inventors located in 20 European countries, Japan, and the US. Respondents were randomly drawn from inventors listed in the patent applications submitted to the European Patent Office with a priority date of 2003-2005 (Torrisi et al., 2016). Though inventors may not be directly involved in the decision of how to exploit patents, they are well informed about how the patent. Inventors' reward systems are linked with how the patents are exploited and their economic returns as such they are the right information sources for patent uses (Harhoff and Hoisl, 2007; Torrisi *et al.*, 2016). For example, Gambardella, Harhoff, and Verspagen (2008) compared the distribution of responses to the patent value question by inventors and managers in this survey and found similar distributions with a slight overestimation

of patent values by inventors. Knowing about value of the patent means that inventors know a lot about their patents and how they are used by the firms.

We added patent characteristic data from PATSTAT. Then we matched ownership and firm characteristic data from Orbis for all publicly listed companies that are included in the patent survey data.

Measurement

Dependent variable

Licensed patent: This is based on the survey data which asks inventors whether the patent has been licensed/sold or not. It takes a value of 1 if the patent has been licensed or sold and zero otherwise. It captures the actual licensing, not the intention to license.

Commercialized patent: This is also based on the survey data which asks inventors whether the patent has been commercialized internally or not. It takes a value of 1 if the patent has been internally commercialized and zero otherwise. Similar to the licensing measure, it captures the actual commercialization of the patent, not the intention to commercialize.

Explanatory Variables

Family firms: It is a dummy variable that takes a value of 1 if at least 10% of the firm is owned by a family or a private person otherwise zero. It is quite common to use 10% as a cutoff point to identify family ownership especially among listed companies (e.g., La Porta *et al.*, 1999; Villalonga and Amit, 2020). For robustness check we also used a) 5% and 15% family ownership as cutoff points as well as b) another dummy variable which takes a value of one if a family is represented in the management (board) of the firm and/or has an ownership stake otherwise zero.

Control variables: Since our prediction is on family firms' preference in licensing or commercialization of their patents, we included an array of control variables at the patent, firm, technology, and country level.

Patent Level controls: We control for patent characteristics using seven variables. A) By the amount of input that went into the invention: the number of man-months the invention has taken from no R&D time (1) up to 72 man-months or more (9). We created a dummy variable that takes 1 if the invention time is more than or equal to 13 man-months (above the median) or zero otherwise. B) By the economic value of the patent. For this, we used a survey question that asks inventors to rate the economic value of the focal patent by comparing it with other patents in their industry, top 10%, top 25%, and top 50%. We used a dummy variable that takes a value of one if the focal patent's economic value is rated as the top 50% in the industry and zero otherwise. C) Patent XY forward citation which is commonly considered as a measure of patent quality (Chatterji and Fabrizio, 2016). It is also very much correlated to the economic value of patents (Falk and Train, 2017; Kapoor *et al.*, 2015). So, we used the log of total XY patent citation over the last 5 years since the publication of the search report. D) Patent status: a dummy variable that takes a value of 1 if the patent is granted and zero otherwise. E) Patent family size: It is the number of patents granted in various countries to protect a single invention. It signals the patent owner's expectation of opportunities to use the patent in different markets and by implication the value of the patent. F) We also include dummies for Patent Priority year because previous studies show that information disclosure about the invention, patent publication, affects the likelihood of technologies being traded in the market (Gans *et al.*, 2008; Hegde and Luo, 2018). G) Number of claims reported in the patent document (log transformed). The number of claims defines the scope

of patent protection; a wider scope provides a potentially greater economic value compared with a narrow scope (Marco, Sarnoff, and deGrazia, 2019)

Firm-level Controls: At the firm level we include firm size. The effect of firm size on licensing is quite mixed yet important. Some studies show that large firms have a lower tendency to license their technologies (e.g., Motohashi, 2008). To control for the firm size we classified firms into three categories by employment size, small firms with less than 100 employees, medium firms between 100-249 employees, and large firms with more than 249 employees. We also control for firm age (log-transformed). Moreover, we include a variable that captures the availability of complementary assets within the firm to make sure that patent use choices across family and non-family firms are not driven by their access to complementary assets (Ceccagnoli *et al.*, 2010; Teece, 2006; Wu, Wan, and Levinthal, 2014). This is taken from the survey data. It is a dummy variable that takes a value of 1 if respondents agree or completely agree that the organization has complementary resources to make the invention a success and otherwise zero.

Technology class and Country-level Control Variables: Technology characteristics, the strength of intellectual property rights, and competition in the technology domain influence how firms choose to exploit their patents (Gurgula, 2017; James *et al.*, 2013; Moreira *et al.*, 2020). Therefore, we control a) technology competition using a survey question that asks inventors if they were aware of one or more parties competing for the patent. We categorized competition equal to one if one or more parties were competing for the patent, otherwise zero. Then, we include dummies for 22 technology classes to control for technical characteristics such as complex vs discrete technology that influences patent uses. And finally, we included country dummies for applicant firms to parse out country-level effects including the strength of IPR on patent uses (Pitkethly, 2001; Zhao, 2006).

Methods

Our dependent variables, commercialization, and licensing are choice variables. To isolate the existence of a causal link between family ownership and these two types of patent uses, it is necessary to rule out confounding factors. Following previous works (e.g., Feldman *et al.*, 2016; Feldman, Amit, and Villalonga, 2019 Li, Xia, Lin, 2017), we create matched samples of firms with and without family ownership using Coarsened Exact Matching technique.

Coarsened Exact Matching technique (CEM) is preferable to alternative matching procedures such as propensity score matching (PSM) because of its reliability in creating a balance between the treatment and control groups (Iacus, King, and Porro, 2012). By matching family and non-family firms on patent and firm-level characteristics, this method allows us to isolate the differences in covariates between family and non-family firms and help to mitigate the effect of nonrandom selection on commercialization and licensing decisions. We proceeded in two steps: identifying relevant covariates to create a balance between treated and control groups, and matching the two groups by those covariates. To identify important covariates, we predicted the propensity to be a family-owned firm (treated group) on all the patent and firm-level variables that we identified in the variable definition section. The result is presented in Table 1. Of these covariates, we find that patents in the top 50% in the industry, log of patent claims, log of firm age, competition, and whether a patent is granted are significantly related to family ownership. That is, they cause sample imbalance between treated (family firms) and control groups while the other covariates do not. This way, we match family and non-family firms based on these relevant covariates and avoid the risk of losing observations that would occur if we were to match the two types of firms with all the covariates which are not a source of sample imbalance.

After identifying the important covariates, we coarsened the covariates as follows. By default, for the dummy covariates, the matching was exact. Firm age was coarsened into 4 categories set by the CEM-stata routine. This matching was done within 3-technology classes, electronics and instruments, chemical and process engineering, and mechanical and constructions, and within country. In the matching, some treated groups (family firms) end up having more than one control group. Therefore, we used cem_weights to account for this in the regressions. With the coarsened exact matching, our sample reduced from 501 firms and 2,966 observations to 471 firms and 2759 observations. Our hypotheses are tested on the later sample size.

A second methodological issue relates to the fact that the key explanatory variable, family ownership is measured at the firm level whereas the main dependent variables are measured at the patent level. Therefore, we cluster robust standard errors by firm-id to account for the repetition of observations at the firm level for each patent.

Estimation: Since our dependent variables are binary, a) whether a patent was licensed or b) whether it was commercialized, we used a Limited Dependent Variable model, logistics regression to test our hypotheses. We also show the results of linear probability model estimates to interpret the coefficients intuitively.

RESULTS AND DISCUSSION

Table 2 presents the summary statistics. Only 12% of the patents in our dataset are licensed or sold and 67% of patents are commercialized while the remaining 21% are unused. A third of the patents are owned by family firms. Even though the sample is drawn from countries that are presumed to have a more developed Market for Technology, the USA, Japan, and European countries, only a small amount of patents are licensed (sold). Since the companies in our sample are listed firms, the majority of them are large firms, have more than 249 employees.

Before formally testing our hypothesis, we present a simple bar graph of the mean difference in patent licensing and commercialization by family and non-family firms in Figures 1 &2 respectively. From a total of 12 % of patents that are licensed, 14% comes from non-family firms while only 8% comes from family firms. Figure 2 shows that family firms commercialize 72% of their patents whereas non-family firms commercialize 64% of their patents. It shows that family firms license 33% less than the average licensed patents and commercialize 10% more than the average commercialized patent.

Then we formalize our test for H1a & H1b in Table 3. The first two columns test H1a and the other two tests H1b. Notice that columns a and b are logistic and linear probability model estimations of the same regressors respectively both for licensing and commercialization. As columns 1a & 1b show, family firms tend to license 3.4% less than non-family firms, i.e., 28% less than the average licensed patents. Similarly, columns 2a & 2b show that family firms commercialize 6.2% more than non-family firms which is equivalent to 9% more than the average commercialized patents. These proportions are only slightly smaller than what we observed in figures 1 & 2 respectively with little effect of the control variables on the explanatory power of the main variables of interest.

The result also shows that patents in the top 50% in the industry, patent family size, and competition in technology increase patent licensing in general, and large firms tend not to license their patents. Similarly, access to complementary assets increases the likelihood of commercializing. Patent quality (being in the top 50% in the industry) is positively related to commercialization as it is for licensing. Interestingly, other measures of patent quality, patent XY citation, number of claims made in the patent, and whether the patent is granted do not have any effect on both licensing and commercialization. These results remain qualitatively the same when

we change the definition of family ownership by decreasing the ownership cutoff point to 5% or increase it to 15 %. As well, we observe similar results when we measure family ownership using a dummy variable that takes a value of one if a family is represented in the management (board) of the firm and/or has an ownership stake. Results are not included in the paper for brevity but they are available upon request.

These findings go in line with the literature of family firms' distinct behavior regarding maintaining control over strategic resources. They choose to license less and commercialization more patents than non-family firms. Licensing erodes firms' control over the value they can appropriate from their patents both technologically and financially. Technologically, licensees can recombine their technologies with the licensors' technology in ways that potentially threaten the competitive position of the licensor and its influence on the technology trajectory. Financially, licensors have to rely on the capability of the licensee in exploiting the patent. Instead, commercialization grants family firms the possibility to control the financial and technological returns of their patents.

Further Analyses

To substantiate our claim above, we made further analyses. Our approach here is to examine the underlying mechanisms that could explain the family firms' tendency to license less and commercialize. More specifically we want to get as close as possible to *family firms' preference to control their resources* as the main underlying mechanism that explains the results observed above and if they encounter *a trade-off to maintain this preference*. To this end, we empirically a) examine the potential actions family firms carryout to maintain their preference to use their patent internally than in the Market for Technology b) rule out alternative explanations related to potential inefficiency of family firms to license their technology and c) test if family firms encounter a trade-

off in the type of patents they license /commercialize, and d) examine if this result is not due to lack of demand for patents owned by family firms in the technology market.

a) What do family firms do differently from non-family firms to commercialize more patents?

As much as family firms choose to commercialize more and license less, we examine the course of action they take that is different from non-family to succeed in commercializing their patents. We examine this in two ways.

The first is how much family firms deviate from their intended patent use in favor of commercialization more than non-family firms. The intuition is that if commercializing more is a preference of family firms, they should look for opportunities to do so even by deviating from intended patent uses. To test this, we use a set of survey questions and construct two variables: 1) Deviation in favor of commercialization and 2) Deviation in favor of licensing. In the survey, inventors were asked, in separate questions, if internal commercial exploitation/licensing was the primary reason (i.e the response is completely agree or agree) for patenting their inventions. We consider this as a measure of intended patent use. Ex-post, firms may commercialize or license their patents inline or different from their intended patent uses. Deviation in favor of commercialization is the difference between actual patent uses less intended commercialization. It takes three values -1(patent commercialization was intended but the patent was actually licensed), 0 (executed as planned), 1(licensing was intended but the patent was commercialized). We followed the same logic to create a variable for Deviation in favor of licensing.

The descriptive statistics in table 2 show that, in general, both family and non-family firms deviate from their planned patent uses. This is much bigger on the licensing front (27%) than on commercialization (11%). Figure 3 compares the deviation of family and non-family firms from

their intended patent use in favor of commercialization. It shows that family firms deviate from their intended patent use in favor of commercialization 8% of the time while non-family firms deviate slightly against commercialization. To make sure that this deviation is not related to a general tendency of family firms to deviate from plans and is not systematic to their preference for commercial exploitation of their patents internally, we make the same comparison for deviation from patent use in favor of licensing, see Figure 4. We see that family firms are not any different from non-family firms when it comes to following their licensing intentions. We made a full regression test of this difference in Table 4 columns 1 & 2 using ordered logistic regressions. Results show that, indeed, family firms deviate from intended patent uses 20.2% more than nonfamily firms in favor of commercialization while this distinction does not exist in licensing decisions. This indicates that family firms are nimble to exploit opportunities to commercialize but not to license their inventions much more than non-family firms.

The second mechanism we examined is if family firms experiment on serendipitous inventions for their commercializability. The intuition is the following. Serendipitous inventions are fortuitous in that firms have never thought of them before and are discovered in "very crude and nascent" conditions (Murayama, Nirei, and Shimizu, 2015). They need resources such as research time to further develop and evaluate the relevance of these inventions. The pursuit of family firms to commercialization their inventions might make them spend more resources than non-family firms on serendipitous inventions particularly when they see a commercialization potential. To test this, we examine if family firms invest more research time on serendipitous patents and in particular on commercialized serendipitous patents. We captured research time by a dummy variable equal to 1 if firms invest more than 13 man-months (above the median) or zero if they invest less than that for serendipitous inventions.

Figure 5 presents this difference in research time spent by family and non-family firms on all serendipitous patents and Figure 6 shows this difference for commercialized serendipitous patents. As Figure 5 shows, family firms tend to spend more time on serendipitous patents in general. However, this difference is pronounced when serendipitous patents are commercialized. For the non-commercialized serendipitous patents, the difference is rather small (see Figure 6). Results with the inclusion of control variables are shown in Table 4 columns 3-5 respectively. Column 3 shows that family firms spend more research time on serendipitous patents regardless of the type of use. This is the case if the serendipitous patent is commercialized (column 4) but we don't observe the same tendency if it is licensed (column 5). This suggests that family firms experiment on serendipitous innovations for their commercializability than non-family firms.

We interpreted these two results, i.e, deviating from planned patent uses in favor of commercialization and spending more research time on serendipitous patents and especially on commercialized serendipitous patents as indications of family firms' agility to search and pursue emerging opportunities to exploit their patents internally more than nonfamily firms.

B) Is the lower propensity of licensing by family firms driven by the inefficient use of their patents?

More commercialization and less licensing by family firms do not make it clear if family firms are less or more efficient in their overall patent uses. For example, for fear of losing control, the proportion of patents that are left idle (neither licensed nor commercialized) by family firms might be more than those of non-family firms. Or even though the proportion of unused patents is the same as non-family firms, the quality of patents that are unused by family firms could be different from (better or worse than) unused patents of nonfamily firms. If either of these is true,

it means that family firms' preference to license less is an indication of their lower capacity to utilize their patents in the market and that they are inefficient in their overall patent exploitation.

To rule out this explanation a) we compare the difference in the proportion of patents that are unused by ownership type, see Figure 7. We also run a full regression where the dependent variable is a dummy that takes 1 if the patent is unused (neither licensed nor commercialized) and zero otherwise. The results are shown in Table 5, columns 1a & 1b. Similar to what we observe in Figure 7, the coefficients of family firms in columns 1a & 1b in Table 5 are negative, meaning that the proportion of patents unused by family firms is slightly less but not significantly different from their non-family counterparts.

Then, to see if unused patents of family and nonfamily firms are different in quality, b) we run a range of regressions with several dependent variables that proxy patent quality: Patent citation (log), Patent family size, Patent in the top 50% in the industry, and whether the patent is granted. Our main independent variable is the interaction term of unused patent & being a family firm. If the patent quality of unused patents of family firms is higher, we expect to observe a positive and significant coefficient of this interaction term in at least some or all the regressions in Table 5, columns 2-6. What the results show is the absence of a significant difference in the patent quality of unused patents of family firms. That is, we do not find any inefficiency both in the proportion and quality of unused patents by family firms. Family firms' tendency not to license as much as the nonfamily firms didn't lead them to put more patents idle.

C) Is there a pecking order in the quality of patents that family firms choose to license and commercialize?

A related question to what we raised above is if family firms are following a pecking order such that they license high-quality patents and whatever is left from licensing they commercialize.

Or it may as well be that they pick high-quality patents to commercialize and attempt to license low-quality patents and that is why they finally manage to license less. To this end, like in point b above, we run a set of regressions in which the dependent variables are measures of patent quality and our main independent variables are the interaction terms of the type of patent use and being a family firm. We show the results in table 6. In columns 1-5, our main explanatory variable is the interaction of commercialized patents and family firms. In columns 6-10, our main explanatory variable is the interaction term of licensed patents and family firms. As you can see, our main explanatory variables are not strongly related to any of the measures of patent quality, meaning that the quality of patents that are commercialized or licensed by family firms are not any different from patents of non-family firms that are put for similar use. Therefore, family firms are not making a tradeoff or setting a pecking order on the quality of patents when they choose to commercialize more or license less.

D) Are family-firm patents less demanded in the Market for Technology?

Our theoretical explanation hinges on the idea that the lower licensing and high commercialization is a choice made by family firms. We rule out explanations related to patent quality and the actions that family firms take to exploit their technology internally than externally. We find results corroborating this claim. However, licensing is an exchange and the outcome is determined not only by the family firms' choice to license but also by the licensees' choice not to enter a licensing agreement with family firms. This argument is generally related to the notion that family firms are disadvantaged in matching markets because they are more informationally opaque, i.e., their resources harder to value by external counterparts (Anderson, Duru, and Reeb, 2009; Chirico *et al.*, 2011).

We examined this claim by dividing our analyses into two subsamples of patent applications that are granted by the patent office and those that are not granted (rejected, under examination, or withdrawn). A patent grant is an important milestone in indicating the value of the patent as it is an approval by the third party regarding the novelty and industrial applicability of the invention (Farre-Mensa, Hegde, and Ljungqvist, 2020; Hsu and Ziedonis, 2013). Therefore, if the lower licensing of family patents is driven by information opaqueness of patent of family firms, we expect the difference between family and non-family firms' propensity to license to decline among the sample of granted patents. Similarly, we expect this difference to be more pronounced in the subsample of patents that are not yet granted. The results are shown in Table 7 (column 1 for patents that are granted and column 2 for patents that are not granted). We observe a stronger negative relationship between family firms and licensing in the sample of granted patents and no effect in the sample of non-granted patents. We interpreted this result as an indication that the information opaqueness of patents by family firms is unlikely to be the reason for less licensing by family firms.

All these analyses suggest that family firm's tendency to use their inventions internally as opposed to externally is strongly driven by their preference to control their intellectual properties both technologically and financially than due to inefficiency reasons. One caveat to this explanation is that we do not know the comparative payoffs of commercialization or licensing by family or non-family firms ex-post. However, ex-ante we do not observe efficiency differences but behavior differences on the side of family firms to exploit their technology internally.

CONTRIBUTIONS AND CONCLUSION

We studied the relationship between family ownership and patent use strategy using patent survey data of publicly listed companies in Europe, the US, and Japan. The results show that family firms

differ substantially from non-family firms in their patent uses. Compared to non-family firms, they exploit more of their patents internally by integrating the technology in new products and less of their patent in the Market for Technology via licensing or selling.

This preference of family firms does not have any effect on the proportion of patents they exploited. Moreover, the quality of patents (measured by patent citation, patent family size, the economic value of the patent, and whether the patent is granted) that are commercialized or licensed by family firms are not any different from those of the non-family firms that are put to the same use. This suggests that family firm's preference to use their patents internally does not make them less efficient in the use of their patents nor does it force them to systematically choose lower (higher) quality patents for internal (external) exploitation. Family firms' preference not to adopt patent uses that reduce control make them to continuously search for commercialization opportunities that might not be planned at the outset. Specifically, our results suggest that family firms have a leeway to deviate from intended patent uses and resource allocations (research time) to satisfy their preference to maintain their technology internally.

We draw four implications from these findings. Our first contribution is to the patent and innovation literature. The role of family ownership on the use of patents does not get as much traction in scholarly work as it does in M&A, internationalization, divestiture, diversification, environmental performance, and political influence (Berrone and Gomez-Mejia, 2009; Birhanu and Wezel, 2020; Feldman *et al.*, 2016). Our finding contributes to this literature by introducing a new antecedent that determines patent licensing and commercialization decisions and that the choice of patent use strategies is not only driven by economic considerations (Arora and Ceccagnoli, 2006; Fosfuri, 2006; Teece 2006) but it is influenced by idiosyncratic preference towards ensuring control over intellectual properties. Family ownership determines whether

patents are exploited within or outside the boundary of the firm. In order to meet these preferences, they explore emerging opportunities that can allow them to exploit their technology internally.

Second, it also contributes to the family firm literature. It is established in the family firm literature that family firms desire to have control over firms through different governance approaches such as over representation in the board, creating a pyramidal structure, and minimize equity financing is explained by their desire to control because of their higher risk and loss aversion behavior (Chirico *et al.*, 2020; Villalonga and Amit, 2020; Wiseman and Gomez-Mejia, 1998). Our finding extends this literature by delving into how family firms use their patents (a key output of innovation) and empirically examine the range of possible uses of it: nonuse, commercialization, and licensing and make a clear case that family firms indeed have a clear preference to maintain control of their strategic resources without necessarily making tradeoffs or being inefficient. They leverage management discretion of family ownership to actively pursue alternatives that enable them to exploit their technology in their preferred way.

Third, family firms' preference to maintain control over their firms for financial and non-financial reasons is argued to limit the growth of family firms by limiting their internationalization, going public, and undertaking mergers and acquisitions (Arregle *et al.*, 2017; Caprio *et al.*, 2011; Villalonga and Amit, 2020). Our study shows the presence of a possible growth approach by family firms. That is, our finding indicates that for the same amount of patents, family firms are very likely to scale up than non-family firms because they have a strong preference to exploit their patents internally. This gives some insight on how the same behavioral tendency that deters the growth of family firms through internationalization, and M&A could lead to the growth of family firms internally.

Fourth, our finding also contributes to the literature of Market for Technology (Arora, Fosfuri, and Gambardella, 2004). The development of Market for Technology is argued to enhance the private and public benefits of innovation by giving access to other technologies, creating the opportunity to trade intellectual properties that a firm does not want to commercially exploit, and opening up the possibility to recombining knowledge and hence enhance rate and quality of innovation (Arora and Gambardella, 2010; Chatterji and Fabrizio, 2016). The reluctance of family firms to transact their technology affects the development of Market for Technology by reducing the number of patents available for trading. This might in turn limit specialization in upstream innovation and downstream commercialization especially in countries where family firms account for the significant share of firms in an economy.

As we alluded to earlier in the paper, firm ownership and governance structure on the use of patents and other intellectual properties are under-examined. This study shows the influence of family ownership on internal vs external use of patents and points out how those chosen patent uses are practically pursued. We believe that bringing these two streams of work would enlighten us a lot on how firm governance influences strategic choices related to intellectual property use and management and their implications on firms' competitiveness and growth.

References

Anderson RC, Duru A, Reeb DM. 2009. Founders, heirs, and corporate opacity in the United States☆. *Journal of Financial Economics* **92**(2): 205–222.

Arora A, Ceccagnoli M. 2006. Patent Protection, Complementary Assets, and Firms' Incentives for Technology Licensing. *Management Science* **52**(2): 293–308.

Arora A, Gambardella A. 2010. The Market for Technology. In *Handbook of the Economics of Innovation*. Elsevier, 1: 641–678. Available at: https://ideas.repec.org/h/eee/haechp/v1_641.html.

Arora A, Fosfuri A, Gambardella A. 2004. *Markets for Technology – The Economics of Innovation and Corporate Strategy*, New Ed. MIT Press: Cambridge, Mass.

Arregle J, Duran P, Hitt MA, van Essen M. 2017. Why is Family Firms' Internationalization Unique? A Meta–Analysis. *Entrepreneurship Theory and Practice*. SAGE Publications Inc **41**(5): 801–831.

Asaba S, Wada T. 2019. The Contact-Hitting R&D Strategy of Family Firms in the Japanese Pharmaceutical Industry. *Family Business Review*. SAGE Publications Inc **32**(3): 277–295.

Berrone P, Gomez-Mejia LR. 2009. Environmental Performance and Executive Compensation: An Integrated Agency-Institutional Perspective. *Academy of Management Journal* **52**(1): 103–126.

Bertrand M, Schoar A. 2006. The role of family in family firms. *The Journal of Economic Perspectives* **20**(2): 73–96.

Birhanu AG, Wezel FC. 2020. The competitive advantage of affiliation with business groups in the political environment: Evidence from the Arab Spring. *Strategic Organization* : 147612702095217.

Caprio L, Croci E, Del Giudice A. 2011. Ownership structure, family control, and acquisition decisions. *Journal of Corporate Finance* **17**(5): 1636–1657.

Ceccagnoli M, Graham SJH, Higgins MJ, Lee J. 2010. Productivity and the role of complementary assets in firms' demand for technology innovations. *Industrial and Corporate Change* **19**(3): 839–869.

Chatterji AK, Fabrizio KR. 2016. Does the market for ideas influence the rate and direction of innovative activity? Evidence from the medical device industry. *Strategic Management Journal* **37**(3): 447–465.

Chirico F *et al.* 2020. To patent or not to patent: That is the question. Intellectual property protection in family firms. *Entrepreneurship Theory and Practice*. SAGE Publications Inc **44**(2): 339–367.

Chirico F, Sirmon DG, Sciascia S, Mazzola P. 2011. Resource orchestration in family firms: investigating how entrepreneurial orientation, generational involvement, and participative strategy affect performance. *Strategic Entrepreneurship Journal* **5**(4): 307–326.

Cohen W, Nelson R, Walsh J. 2000. *Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (or Not)*. National Bureau of Economic Research, Cambridge, MA: w7552. Available at: http://www.nber.org/papers/w7552.pdf.

Duran P, Kammerlander N, Essen M van, Zellweger T. 2016. Doing More with Less: Innovation Input and Output in Family Firms. *Academy of Management Journal* **59**(4): 1224–1264.

Falk N, Train K. 2017. Patent Valuation with Forecasts of Forward Citations. *Journal of Business Valuation and Economic Loss Analysis* **12**(1). Available at: http://www.degruyter.com/view/j/jbvela.2017.12.issue-1/jbvela-2016-0002/jbvela-2016-0002.xml.

Farre-Mensa J, Hegde D, Ljungqvist A. 2020. What Is a Patent Worth? Evidence from the U.S. Patent "Lottery". *The Journal of Finance* **75**(2): 639–682.

Feldman ER, Amit R, Villalonga B. 2016. Corporate divestitures and family control: Corporate Divestitures and Family Control. *Strategic Management Journal* **37**(3): 429–446.

Feldman ER, Amit R, Villalonga B. 2019. Family firms and the stock market performance of acquisitions and divestitures. *Strategic Management Journal* **40**(5): 757–780.

Fosfuri A. 2006. The licensing dilemma: understanding the determinants of the rate of technology licensing. *Strategic Management Journal* **27**(12): 1141–1158.

Gambardella A, Harhoff D, Verspagen B. 2008. The value of European patents. *European Management Review* **5**(2): 69–84.

Gans JS, Hsu DH, Stern S. 2008. The Impact of Uncertain Intellectual Property Rights on the Market for Ideas: Evidence from Patent Grant Delays. *Management Science* **54**(5): 982–997.

Grant RM. 1996. Toward a knowledge-based theory of the firm. *Strategic Management Journal* **17**(S2): 109–122.

Gurgula O. 2017. Strategic Accumulation of Patents in the Pharmaceutical Industry and Patent Thickets in Complex Technologies – Two Different Concepts Sharing Similar Features. *IIC - International Review of Intellectual Property and Competition Law* **48**(4): 385–404.

Hall BH, Ziedonis RH. 2007. An Empirical Analysis of Patent Litigation in the Semiconductor Industry. *University of California at Berkeley working paper: .* : 30.

Harhoff D, Hoisl K. 2007. Institutionalized incentives for ingenuity—Patent value and the German Employees' Inventions Act. *Research Policy* **36**(8): 1143–1162.

Hegde D, Luo H. 2018. Patent Publication and the Market for Ideas. *Management Science* **64**(2): 652–672.

Hsu DH, Ziedonis RH. 2013. Resources as dual sources of advantage: Implications for valuing entrepreneurial-firm patents. *Strategic Management Journal* **34**(7): 761–781.

Iacus SM, King G, Porro G. 2012. Causal Inference Without Balance Checking: Coarsened Exact Matching. *Political Analysis* **20**(1): 1--24.

James SD, Leiblein MJ, Lu S. 2013. How Firms Capture Value From Their Innovations. *Journal of Management*. SAGE Publications Inc **39**(5): 1123–1155.

Kalm M, Gomez-Mejia LR. 2016. Ties that bind: Socioemotional wealth preservation in family firms. *Academy of Management Annals* **51**(4): 409–411.

Kapoor R, Karvonen M, Ranaei S, Kässi T. 2015. Patent portfolios of European wind industry: New insights using citation categories. *World Patent Information* **41**: 4–10.

Kotlar J, De Massis A, Frattini F, Bianchi M, Fang H. 2013. Technology Acquisition in Family and Nonfamily Firms: A Longitudinal Analysis of Spanish Manufacturing Firms: Technology Acquisition in Family and Nonfamily Firms. *Journal of Product Innovation Management* **30**(6): 1073–1088.

La Porta R, Lopez-De-Silanes F, Shleifer A. 1999. Corporate Ownership Around the World. *The Journal of Finance* **54**(2): 471–517.

Lanjouw JO *et al.* 2000. *Characteristics of Patent Litigation: A Window on Competition. CEPR.*

Laursen K, Leone MI, Torrisi S. 2010. Technological exploration through licensing: new insights from the licensee's point of view. *Industrial and Corporate Change* **19**(3): 871–897.
Laursen K, Moreira S, Reichstein T, Leone MI. 2017. Evading the Boomerang Effect: Using the Grant-Back Clause to Further Generative Appropriability from Technology Licensing Deals. *Organization Science* **28**(3): 514–530.
Leone MI, Reichstein T. 2012. Licensing-in fosters rapid invention! the effect of the grant-back clause and technological unfamiliarity. *Strategic Management Journal* **33**(8): 965–985.
Lodh S, Nandy M, Chen J. 2014. Innovation and Family Ownership: Empirical Evidence from India. *Corporate Governance: An International Review* **22**(1): 4–23.
Marco AC, Sarnoff JD, deGrazia CAW. 2019. Patent claims and patent scope. *Research Policy* **48**(9): 103790.
Miller D, Breton-Miller IL, Lester RH. 2010. Family ownership and acquisition behavior in publicly-traded companies. *Strategic Management Journal* **31**(2): 201–223.
Miroshnychenko I, De Massis A, Miller D, Barontini R. 2020. Family Business Growth Around the World. *Entrepreneurship Theory and Practice*. SAGE Publications Inc : 1042258720913028.
Moreira S, Klueter TM, Tasselli S. 2020. Competition, Technology Licensing-in, and Innovation. *Organization Science* **31**(4): 1012–1036.
Motohashi K. 2008. Licensing or not licensing? An empirical analysis of the strategic use of patents by Japanese firms. *Research Policy* **37**(9): 1548–1555.
Murayama K, Nirei M, Shimizu H. 2015. Management of science, serendipity, and research performance: Evidence from a survey of scientists in Japan and the U.S. *Research Policy* **44**(4): 862–873.
Pitkethly RH. 2001. Intellectual property strategy in Japanese and UK companies: patent licensing decisions and learning opportunities : 18.
Somaya D. 2003. Strategic determinants of decisions not to settle patent litigation. *Strategic Management Journal* **24**(1): 17–38.
Teece DJ. 2006. Reflections on "Profiting from Innovation". *Research Policy* **35**(8): 1131–1146.
Teece DJ. 2007. Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal* **28**(13): 1319–1350.
Torrisi S *et al.* 2016. Used, blocking and sleeping patents: Empirical evidence from a large-scale inventor survey. *Research Policy* **45**(7): 1374–1385.
Villalonga B, Amit R. 2020. Family ownership. *Oxford Review of Economic Policy* **36**(2): 241–257.
Wang K-CA, Liang W-J, Chou P-S. 2013. Patent licensing under cost asymmetry among firms. *Economic Modelling* **31**: 297–307.
Wiseman RM, Gomez-Mejia LR. 1998. A Behavioral Agency Model of Managerial Risk Taking. *The Academy of Management Review* **23**(1): 133.
Wu B, Wan Z, Levinthal DA. 2014. Complementary assets as pipes and prisms: Innovation incentives and trajectory choices. *Strategic Management Journal* **35**(9): 1257–1278.
Zhao M. 2006. Conducting R&D in Countries with Weak Intellectual Property Rights Protection. *Management Science* **52**(8): 1185–1199.
Ziedonis RH. 2004. Don't Fence Me In: Fragmented Markets for Technology and the Patent Acquisition Strategies of Firms. *Management Science* **50**(6): 804–820.

Table 1: Pre-coarsened matching sample balance test

Dependent variable	Family Firms
Model est.	Logit
Complementary Assets	0.012
	(0.017)
Research Time	-0.002
	(0.004)
Patent is the top 50% in the industry	0.055
	(0.017)
Patent XY citation in the last 5 years (log)	-0.017
	(0.017)
Patent family	0.001
	(0.001)
No. of patent claims (log)	-0.031
	(0.015)
Medium Firm	-0.137
	(0.120)
Large Firm	0.008
	(0.079)
Firm Age (log)	-0.022
	(0.008)
Competition	-0.078
	(0.018)
2004.yr_pr	-0.010
	(0.020)
2005.yr_pr	0.023
	(0.022)
Patent Granted	0.092
	(0.018)
Constant	0.402
	(0.094)
N	2966

Robust standard errors in parentheses.

Table 2: Summary Statistics

Variables	N	Mean	Std. Dev.	10th	50th	90th
Patent licensed	2,426	0.12	0.32	0	0	1
Patent Commercialized	2,523	0.67	0.47	0	1	1
Research time for serendipitous patents	2,757	0.01	0.09	0	0	0
Deviation from planned commercialization	2,460	-0.11	0.59	-1	0	1
Deviation from planned licensing	2,291	-0.27	0.54	-1	0	0
Family firms	2,759	0.32	0.47	0	0	1
Complementary Assets	2,759	0.65	0.48	0	1	1
Research Time	2,759	0.25	0.43	0	0	1
Patent XY citation in the last 5 years (log)	2,759	0.30	0.49	0	0	1.09
Patent family size	2,759	27.45	15.04	7	33	41
Patent in the top 50% in the industry	2,759	0.62	0.49	0	1	1
No. of patent claims (log)	2,759	2.67	0.51	2.08	2.64	3.30
Medium Firm	2,759	0.01	0.08	0	0	0
Large Firm	2,759	0.98	0.14	1	1	1
Competition	2,759	0.32	0.47	0	0	1
Firm Age (log)	2,759	3.94	1.08	2.20	4.40	5.06
Priority_year_2004	2,759	0.38	0.49	0	0	1
Priority_year_2005	2,759	0.31	0.46	0	0	1
Patent Granted	2,759	0.41	0.49	0	0	1

Figure 1: Patent Licensing by Ownership Type

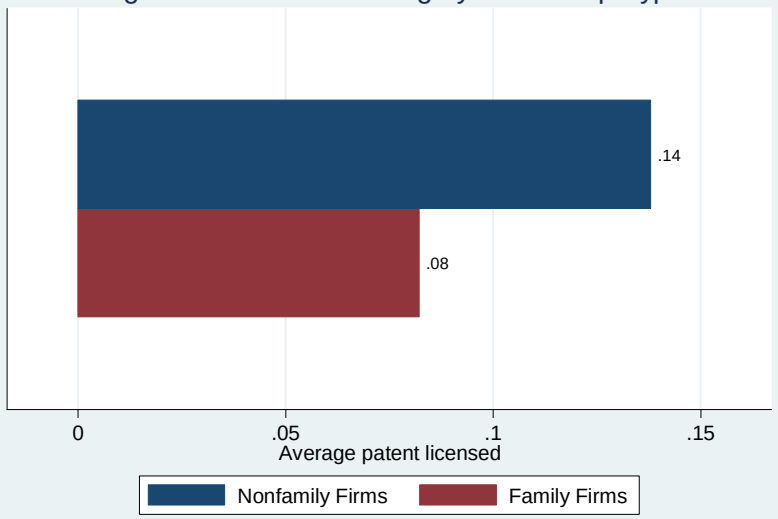

Figure 2: Patent Commercialization by Ownership Type

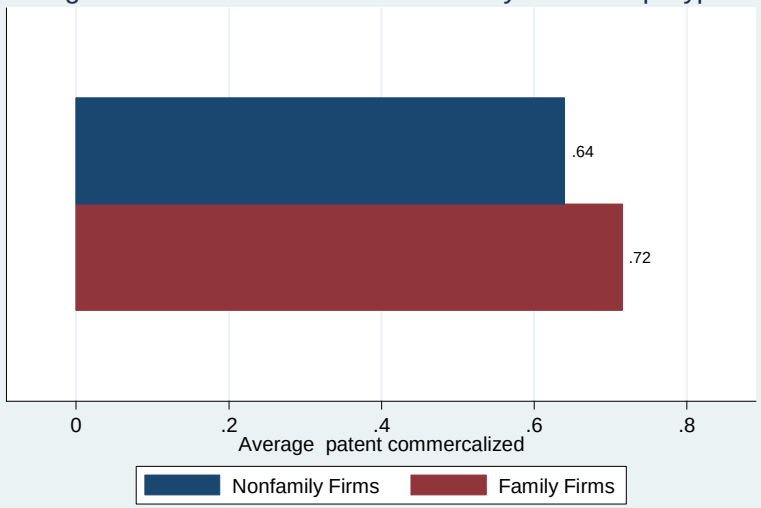

Table 3: Licensing vs commercializing patents by ownership type

Dependent variables	Patent Licensed		Patent Commercialized	
Model	(1a) (logit)	(1b) (Linear Prob.)	(2a) (Logit)	(2b) (Linear Prob.)
Family firms	-0.415	-0.034	0.296	0.062
	(0.200)	(0.016)	(0.144)	(0.030)
Complementary Assets	-0.126	-0.014	0.297	0.064
	(0.187)	(0.018)	(0.129)	(0.028)
Research Time	0.336	0.034	-0.180	-0.039
	(0.210)	(0.022)	(0.147)	(0.032)
Patent XY citation in the last 5 years (log)	0.003	0.004	0.079	0.016
	(0.204)	(0.021)	(0.113)	(0.023)
Patent family size	0.015	0.001	-0.003	-0.001
	(0.007)	(0.001)	(0.005)	(0.001)
The patent in the top 50% in the industry	0.576	0.048	0.316	0.067
	(0.189)	(0.015)	(0.118)	(0.026)
No. of patent claims (log)	0.182	0.020	0.054	0.011
	(0.195)	(0.019)	(0.151)	(0.032)
Medium Firm	0.340	0.050	0.300	0.062
	(1.131)	(0.239)	(0.785)	(0.191)
Large Firm	-1.327	-0.226	0.563	0.127
	(0.514)	(0.108)	(0.484)	(0.117)
Competition	0.333	0.035	-0.078	-0.016
	(0.182)	(0.019)	(0.128)	(0.028)
Firm Age (log)	-0.059	-0.005	0.072	0.015
	(0.080)	(0.007)	(0.064)	(0.014)
Patent Granted	-0.157	-0.012	0.077	0.015
	(0.174)	(0.015)	(0.139)	(0.029)
Constant	-2.862	0.165	-0.002	0.492
	(0.861)	(0.124)	(0.681)	(0.151)
R-squared		0.076		0.053
Observations	2,426	2,426	2,523	2,523

Robust standard errors clustered by company-id in parentheses.
Dummies for 21 technology classes, priority year for patent application, and country dummies are included in all the regressions.

Figure 3: Deviation From Intended Patent Commercialization by Ownership Type

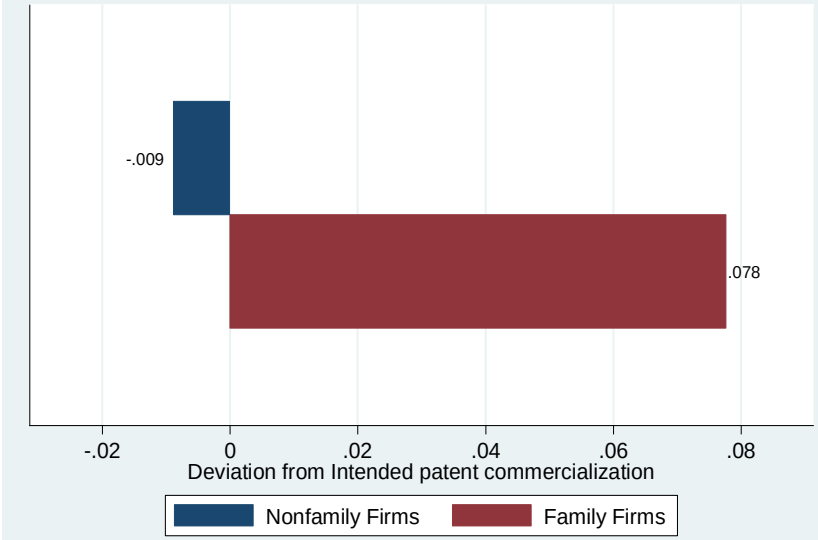

Figure 4: Deviation from Intended Patent Licensing by Ownership Type

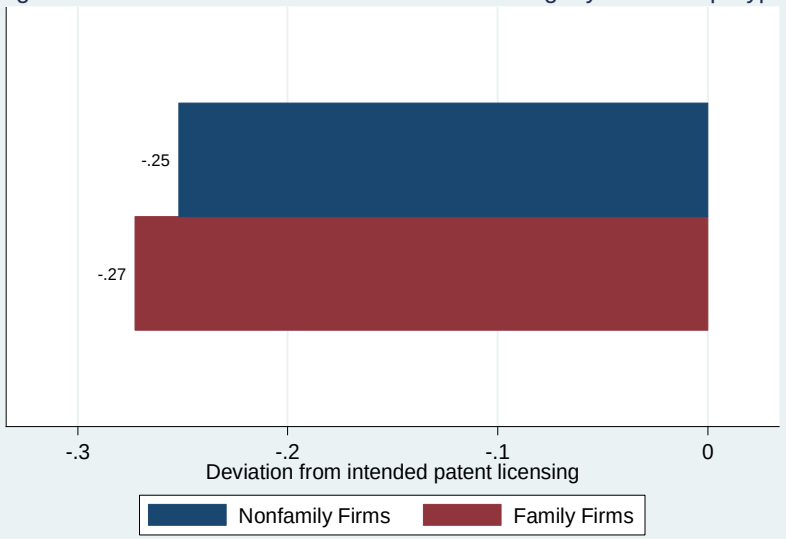

Figure 5: Research_time for Serendepetious Patents

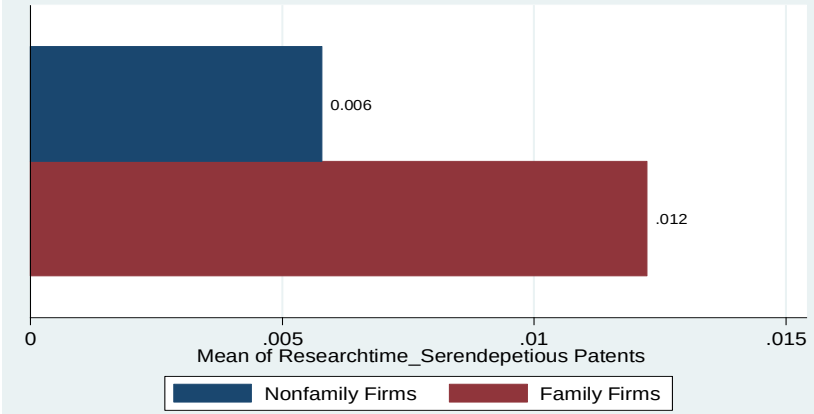

Figure 6: Research_time for Commercialization of Serendepetious Patents

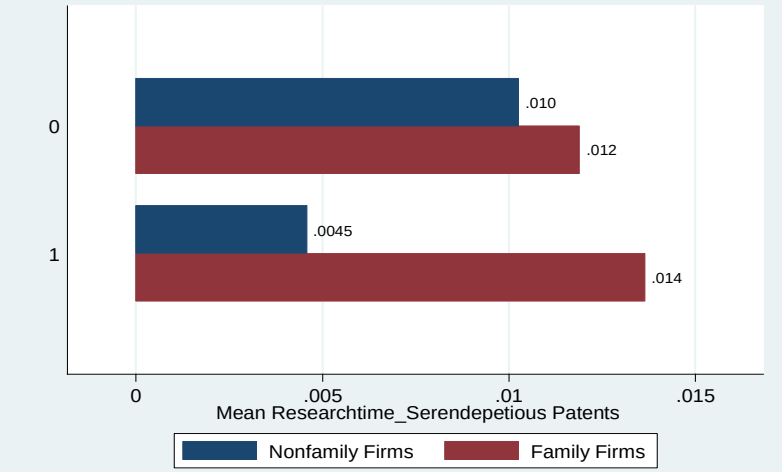

Table 4: Active search for commercialization opportunities by ownership type

Dependent variables	Dev.from planned commercialization	Deviation from planned licensing	Research Time for Serendipitous patents		
	(1)	(2)	(3)	(4)	(5)
Model est.	Ordered logit	Ordered Logit	Linear Prob.	Linear Prob	Linear Prob.
Family firms	0.202	-0.008	0.006	0.011	0.011
	(0.110)	(0.121)	(0.003)	(0.004)	(0.014)
Complementary Assets	-0.046	-0.319	0.001	0.001	0.025
	(0.152)	(0.195)	(0.003)	(0.003)	(0.020)
Research Time	-0.370	0.157	0.041	0.031	0.066
	(0.155)	(0.149)	(0.009)	(0.008)	(0.033)
Patent XY citation in the last 5 years	0.206	0.159	-0.004	-0.005	-0.020
(log)	(0.122)	(0.180)	(0.003)	(0.004)	(0.019)
Patent family size	-0.007	0.008	0.000	-0.000	0.000
	(0.004)	(0.005)	(0.000)	(0.000)	(0.001)
The patent in the top 50% in the	-0.224	-0.360	0.010	0.006	0.010
industry	(0.155)	(0.110)	(0.003)	(0.003)	(0.010)
No. of patent claims (log)	-0.129	-0.082	-0.013	-0.010	-0.029
	(0.122)	(0.120)	(0.004)	(0.004)	(0.015)
Constant			0.011	0.001	0.142
			(0.017)	(0.013)	(0.080)
Constant cut1					
	-1.195	-1.316			
	(0.702)	(0.635)			
Constant cut2	2.073	2.667			
	(0.704)	(0.653)			
Observations	2,460	2,291	2,757	1,678	288
R-squared	0.068	0.052	0.054	0.049	0.291

Robust standard errors clustered by company-id in parentheses. Controls for medium and large firms, competition, firm age, technology classes, priority year for patent application, and country dummies are included in all the regressions.

Figure 7: Unused Patent by Ownership Type

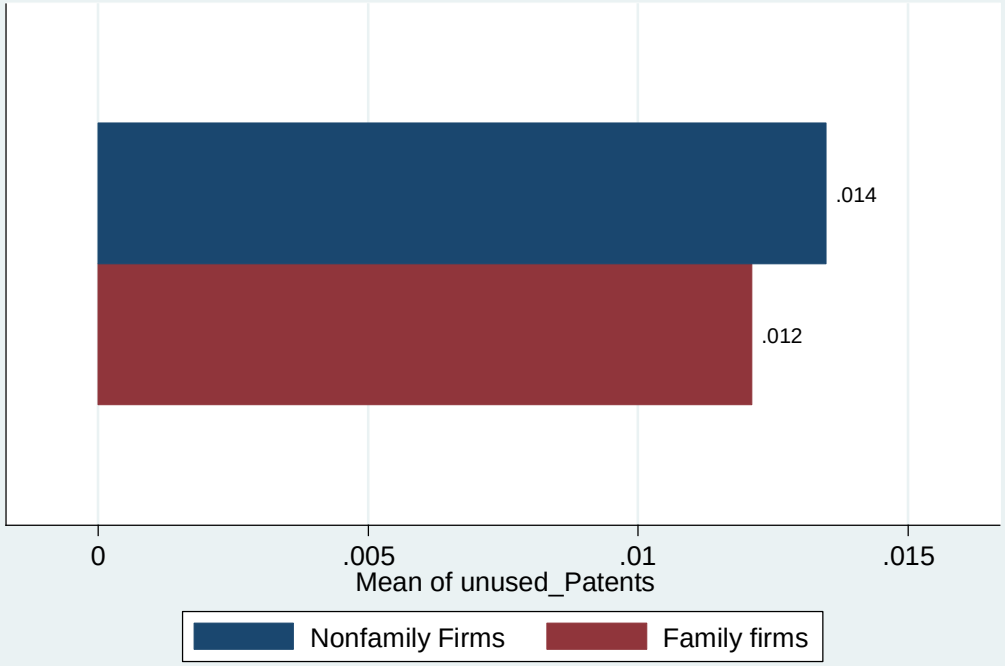

Table 5: Unused patents and their quality by ownership type

Dependent Variables	Patents neither commercialized nor licensed		Patent citation (log)	Size of the patent family	Patent in the top 50% in the industry	Patent Granted	No. of patent claims (log)
Model est.	(1a) Logit	(1b) Linear Pro.	(2)OLS	(3)OLS	(4)Logit	(5) Logit	(6)OLS
Patent XY citation in the last 5 years (log)	-0.205 (0.131)	-0.030 (0.019)		2.866 (0.740)	0.313 (0.131)	-0.147 (0.107)	0.109 (0.023)
Patent family size	-0.005 (0.007)	-0.001 (0.001)	0.003 (0.001)		0.005 (0.004)	0.020 (0.005)	0.002 (0.001)
The patent in the top 50% in the industry	-0.673 (0.164)	-0.105 (0.028)	0.058 (0.024)	0.903 (0.702)		-0.088 (0.127)	0.002 (0.023)
Patent Granted	-0.038 (0.158)	-0.005 (0.025)	-0.030 (0.021)	3.264 (0.856)	-0.074 (0.128)		-0.069 (0.024)
No. of patent claims (log)	-0.136 (0.151)	-0.019 (0.024)	0.099 (0.019)	1.165 (0.905)	0.011 (0.105)	-0.312 (0.110)	
Patents neither commercialized nor licensed			-0.030 (0.028)	-0.577 (1.507)	-0.697 (0.223)	-0.084 (0.207)	-0.048 (0.043)
Family firms	-0.119 (0.153)	-0.018 (0.023)	0.018 (0.030)	0.270 (1.492)	0.086 (0.124)	0.250 (0.123)	0.021 (0.036)
Patents neither commercialized nor licensed #Family			-0.032 (0.053)	-1.084 (2.088)	0.167 (0.291)	0.186 (0.306)	0.071 (0.061)
Constant	-1.146 (0.920)	0.311 (0.106)	0.095 (0.199)	21.794 (4.082)	2.139 (0.674)	-0.523 (0.646)	2.581 (0.149)
R-squared		0.066	0.089	0.243			0.179
Observations	2,448	2,461	2,461	2,461	2,461	2,461	2,461

Robust standard errors clustered by company-id in parentheses. Controls for medium and large firms, competition, firm age, technology classes, priority year for patent application, and country dummies are included in all the regressions.

Table 6: A comparison of the quality of licensed and commercialized patents by ownership type

Dependent Variables	Patent citation (log)	Size of the patent family	Patent in the top 50%	Patent Granted	No. of patent claims (log)	Patent citation (log)	Size of the patent family	Patent in the top 50%	Patent Granted	No. of patent claims (log)
Model est.	(1) OLS	(2) OLS	(3) Logit	(4) Logit	(5) OLS	(6) OLS	(7) OLS	(8) Logit	(9) Logit	(10) OLS
Patent XY citation in the last 5 years (log)		2.598 (0.750)	0.316 (0.133)	-0.165 (0.104)	0.110 (0.022)		2.909 (0.686)	0.325 (0.132)	-0.117 (0.117)	0.115 (0.023)
Patent family size	0.003 (0.001)		0.006 (0.004)	0.021 (0.006)	0.002 (0.001)	0.004 (0.001)		0.006 (0.004)	0.020 (0.006)	0.001 (0.001)
The patent in the top 50% in the industry	0.059 (0.025)	1.001 (0.659)		-0.133 (0.131)	0.006 (0.024)	0.061 (0.024)	1.058 (0.711)		-0.079 (0.131)	0.000 (0.023)
Patent Granted	-0.034 (0.020)	3.369 (0.909)	-0.118 (0.132)		-0.069 (0.025)	-0.024 (0.024)	3.206 (0.913)	-0.062 (0.132)		-0.062 (0.024)
No. of patent claims (log)	0.100 (0.019)	1.161 (0.963)	0.025 (0.108)	-0.311 (0.112)		0.104 (0.020)	0.885 (0.794)	0.005 (0.103)	-0.276 (0.110)	
Patent commercialized	0.009 (0.027)	-0.669 (1.150)	0.331 (0.154)	0.105 (0.177)	0.019 (0.042)					
Patent licensed						0.000 (0.059)	2.169 (1.364)	0.570 (0.230)	-0.097 (0.211)	0.076 (0.056)
Family Firms	-0.006 (0.040)	-0.516 (1.610)	0.150 (0.198)	0.356 (0.239)	0.058 (0.054)	0.007 (0.029)	0.085 (1.362)	0.156 (0.118)	0.319 (0.128)	0.047 (0.034)
Patent commercialized #Family	0.023 (0.047)	0.768 (1.688)	-0.060 (0.234)	-0.089 (0.253)	-0.025 (0.060)					
Patent licensed # Family						0.030 (0.081)	0.546 (1.822)	0.023 (0.397)	-0.253 (0.362)	-0.107 (0.077)
Constant	0.079 (0.196)	22.218 (4.452)	1.946 (0.697)	-0.554 (0.639)	2.570 (0.148)	0.092 (0.204)	21.451 (4.034)	1.868 (0.676)	-0.694 (0.650)	2.553 (0.145)
R-squared	0.084	0.242			0.188	0.091	0.246			0.179
Observations	2,523	2,523	2,523	2,523	2,523	2,426	2,426	2,426	2,426	2,426

Robust standard errors clustered by company-id in parentheses. Controls for medium and large firms, competition, firm age, technology classes, priority year for patent application, and country dummies are included in all the regressions.

Table 7: Licensing by family firms in the subsample of granted and non-granted patents.

Dependent variables	Patent Licensed	
Model est.	(1a) Logit	(1b) Logit
	Granted patents	patents not granted
Family firms	-0.519	-0.338
	(0.300)	(0.273)
Complementary Assets	-0.440	0.143
	(0.396)	(0.255)
Research Time	0.088	0.487
	(0.365)	(0.273)
Patent XY citation in the last 5 years (log)	0.310	-0.187
	(0.327)	(0.216)
Patent family size	0.033	0.006
	(0.012)	(0.009)
The patent in the top 50% in the industry	0.576	0.508
	(0.272)	(0.269)
No. of patent claims (log)	0.105	0.214
	(0.374)	(0.215)
Medium Firm	3.983	-3.091
	(2.485)	(1.202)
Large Firm	-0.599	-1.569
	(1.333)	(0.555)
Competition	-0.099	0.662
	(0.357)	(0.209)
Firm Age (log)	-0.105	-0.050
	(0.128)	(0.112)
Constant	-2.845	-2.370
	(1.909)	(0.990)
Observations	962	1,429

Robust standard errors clustered by company-id in parentheses. Controls for technology classes, priority year for patent application, and country dummies are included in all the regressions.