Why are they hiding? Patent secrecy and patenting strategies

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Abstract

The enactment of the American Inventors Protection Act (AIPA), in November 29, 2000, required U.S. patent applicants to have their patent application published 18 months after filing date but allowed them to opt for keeping it secret if they relinquished foreign patent protection. Using a sample of granted patents applied for by publicly traded companies, between 2000 and 2009, I investigate what drives large companies' decision to keep a patent secret up to grant. Particularly, this paper investigates the effect of technological crowdedness, strategic use of in-house knowledge stock, and invention radicalness on the decision of opting out of pre-grant publication. Results show a negative association between technological crowdedness and pre-grant secrecy, while radicalness and the use of in-house knowledge stock are positively associated with the likelihood of a patent application being secret until grant.

Key words: Patent strategy, pre-grant publication, patent secrecy

INTRODUCTION

A patent provides a mechanism to protect inventors from competitors' imitation of their invention in exchange for a detailed disclosure of the patented invention so that any interested and skilled audience may be able to understand and replicate the knowledge conveyed by the patent document. The temporary exclusivity right bestowed by the patent rights urges inventors to strategically manage their patents to maximize the profits generated by the invention (Jell, 2011) and to sustain a competitive advantage that may be derived from the innovation (Teece, 1986).

The literature on patenting strategies focuses on the motivations driving the strategic uses, filing (Jell, 2011; Van Zeebroeck, 2009) and management of patents (Somaya, 2012). .According to de Rassenfosse et al. (2008) and Jell (2011), in addition to the traditional motive to protect an invention against competitors' imitation, motives to patent include: blocking others, securing freedom to operate, and enhancing reputation. On the strategic management of patents, Somaya (2012) singles out some issues such as "signaling and information disclosure strategies, managing patents as real options, nonmarket strategies, and patent-related managerial capabilities" (Somaya, p.

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1086, 2012). Filing strategies are related to procedural choices made by patentees in filing their patent applications. These choices may accelerate or delay the grant of a patent. Van Zeebroeck (2009) identifies patent filing strategies – the craft of a patent by making it longer and cumbersome to examiners to evaluate the patent, international filings, and the filing of divisional patents.

This paper contributes to the patent filing strategies literature by analyzing patentees' decision, when filing a patent application, to delay the disclosure of the patent document. Enacted on November 29, 2000, the American Inventors Protection Act (AIPA) established the automatic publication of US patent applications 18 months after the earliest filing date[2]. Nonetheless, an inventor may choose to have the patent application secret up to grant[3]. However, this choice poses a trade-off: having the patent application secret up to grant requires relinquishing foreign patent protection.

The option to keep the patent secret until grant was justified as a mechanism to protect small US inventors who may not have enough resources to protect themselves against competitors' imitation (Ragusa, 1992; Johnson and Popp, 2001; Graham and Hedge, 2012), because usually small inventors have limited resources to identify patent infringers and sue them. Graham and Hedge (2012) in their analysis of successful US patent applications filed between 1996 and 2005 find that 7.5% of the applications filed during 2001 and 2005 chose pre-grant secrecy. Interestingly, small inventors are not more likely to opt out than large ones (Graham and Hedge, 2012).

In this paper, I investigate what drives large companies to opt out of pre-grant publication. In my sample of patents applied for by publicly traded firm, about 8.15% of the granted patents, during 2001 and 2010, were opted out of earlier patent application publication. Moreover, patents that were opted out of patent application publication had, on average, 1.7 years more secrecy time than those published pre-grant.

Choosing pre-grant application publication allows patentees to pursue foreign patent protection. Graham and Hedge (2012) report that 51% of US patent applications filed between January 1, 1995 and November 28, 2000, were also applied for in a foreign

[2] Patent applications filed in a foreign jurisdiction were published by the foreign patent office before AIPA enactment; however, AIPA established the patent application publication by the US Patent and Trademark Office (USPTO) making patent applications available in the US at the same time they are published abroad.

[3] AIPA's opt out option requires applicants to certify that the invention disclosed in the application will not be subject of an application in another country or under an international multilateral agreement that requires publication 18 months after the filing date (35 U.S. Code § 122)

country. Unsurprisingly, inventors are more likely to seek foreign patent protection for their valuable inventions (Graham and Hedge, 2012). Moreover, earlier publication allows the patent owner, once the patent is granted, the right to seek reasonable royalties from the publication date to the grant (Hedge and Luo, 2016). Thus, inventors may be willing to have the application disclosed before the grant of the patent right in order to benefit from earlier royalty revenues and foreign patent protection.

In addition to foreign patent protection, patentees derive value from application publication as it signals firms' innovation capabilities (Hsu and Ziedonis, 2007; Ganglmair and Oh, 2014) and may preempt R&D rivals from introducing a substitute innovation and competing with the patenting firm (Ceccagnoli, 2008). Moreover, pre-grant publication of a patent application may assist managers, of competitor firms, in making more informed decisions about R&D investment and avoiding hold up (FTC, 2003). Additionally, as AIPA aims to harmonize US patent law with the patent system of other developed economies[4], pre-grant publication may be driven by (especially multinational) firms' willingness to conform to international standards. Furthermore, pre-grant publication fosters knowledge disclosure, increases business certainty and promotes rational planning (FTC, 2005).

Conversely, AIPA's opt out option provides an opportunity to, to some extent, combine secrecy and the exclusivity right allowing for strategic use of a combination of formal and informal intellectual property (IP) protection (Graham, 2004; Schneider and Veugelers, 2013). Foregoing earlier publication gives patentees more time to develop the invention without having the patent application disclosed. Pre-grant secrecy might give inventors a competitive advantage as competitors have access to the invention in a detailed[5] way only when the uncertainty regarding the patent award is solved favorably[6], hindering imitation and inventing around activities. Indeed, the major argument against patenting is that the knowledge disclosed in the patent document may give valuable information to competitors undermining innovators' profits (Scotchmer

[4] Most of industrialized economies, like Japan and European countries, have adopted the 18 months publication rule long before it was implemented in U.S. (Ragusa, 1992)

[5] "The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention" (35 U.S.C.112).

[6] Uncertainty is not totally mitigated by the patent grant as, after grant, U.S. patents can be challenged by litigation or by a patent re-examination requested to the USPTO (Graham et al., 2002; Lemley and Shapiro, 2005; Gans et al., 2008)

and Green, 1990) and stimulating competitors to design around the patent (FTC, 2003). According to Anton and Yao (2004), disclosing enabling knowledge, included in the patent description, increases the probability of imitation or inventing around the patented invention.

In evaluating publicly traded firms' choice to opt out of earlier patent application publication, the present study shows that not only invention characteristics but also strategic concerns are relevant to the decision to keep the patent application secret up to grant. Furthermore, I propose that companies' filing strategy of keeping the patent application secret up to grant, takes into account the competition the technology faces, the hazard of disclosing firm's internal valuable knowledge, and the invention specific characteristics. Results show that there is a negative association between technological crowdedness and pre-grant secrecy, whereas the more radical an invention the more likely is the patent to be kept secret up to grant. Further, the more an invention builds on companies' in-house knowledge stock[7] the more likely it is to opt out of pre-grant patent application publication.

THEORY AND HYPOTHESES DEVELOPMENT

This section discusses the drivers of patentees' decision regarding earlier application publication and derives some hypotheses. In particular, I discuss large entities' incentives to disclose or not the inventions through earlier patent publication and how disclosing or not is linked to companies' overall patenting strategies.

When applying for a patent many factors may determine the earliest filing date[8] and, therefore, the publication date. However, this study investigates the motivations to opt out of patent application pre-grant publication, which has to be stated together with the filing of the patent application.

Assuming that firms maximize their profits (Arrow, 1962) then the choice of pre-grant secrecy is made always when it yields higher returns than publishing the patent. Besides motives to keep an invention secret as profit maximizing, minimizing

[7] In this paper, I refer to in-house knowledge stock as the extent that a patent builds on a firm's previous patents, relying on the knowledge generated inside the company.
[8] John F. Martin (August 3, 2015) points out several reasons why patent application publication may occur in less than 18 months or even in more time. http://www.ipwatchdog.com/2015/08/03/the-myth-of-the-18-month-delay-in-publishing-patent-applications/id=60185/ - Access: September 11, 2016.

competition, or further developing the invention (Anderson, 2011), delaying disclosure reveals inventor's believe that domestic (US) protection is enough.

In choosing pre-grant secrecy, patentees may evaluate this choice considering three main aspects of the invention protected by the patent: the competition faced by the invention (technological crowdedness), firm's technology strategy and how much internal knowledge the patent application publication discloses, and the invention specific characteristics (radicalness).

Technological crowdedness

Appropriating returns from an invention depends on the inventor's ability to exclude others from making, using or selling the invention (Arrow, 1962). In case the invention is bound to be incorporated in firm's process or product, excluding competitors is an upmost requirement in order to achieve profits maximization. Therefore, the willingness to patent depends on the effectiveness of the patent as an instrument to exclude and to appropriate returns from the innovation (Cohen et al., 2000).

Even though a patent exclusivity right enables innovation returns appropriation, it has been shown in the empirical literature that managers mostly rely on informal innovation appropriability mechanisms such as secrecy, instead of on formal mechanisms such as patents (Cohen et al., 2000; Levin et al., 1987; Arundel, 2001). Zaby (2010) and Heger and Zaby (2013) stress that the invention disclosure required by the patent implies heterogeneous costs for the patenting firms. The former argues that an inventor's propensity to patent depends on the extent of her technological lead, being more likely to rely on secrecy the more the inventor can appropriate monopoly rents without patent protection, i.e., the more difficult it is for a rival to imitate or reverse engineering the invention. The latter states that the propensity to patent depends on market barriers and on the relevance of the information disclosed.

Patents, by requiring the disclosure of the invention, represent a huge threat to innovating firms and may shrink innovators' competitive advantage and technological lead (Zaby, 2010). Opting-out of pre-grant patent application the patentee is dalaying the disclosure of the invention, what in a higly competitive technological space may give to the patentee similar benefits as secrecy. However, in case disclosure represent an important threat it is reasonable to expect that the inventor is going to opt for secrecy instead of delaying disclosure.

On the other hand, the literature has identified a set of motives to patent beyond the traditional motive of protecting an invention against competitors' imitation. These motives include: blocking competitors from using an invention (Cohen et al., 2000), securing freedom to operate (Henkel and Jell, 2009), gaining time to find a licensee or to evaluate an invention's potential (Henkel and Jell, 2010), signaling the firm's research capabilities (Hsu and Ziedonis, 2008; Ganglmair and Oh, 2014), and protecting a firm against infringing others' patents and incurring infringement suit costs (Hall and Ziedonis, 2001).

On patents as a tool to secure *freedom to operate*[9] (Henkel and Pangerl, 2008; Henkel and Jell, 2009; Jell, 2011), Henkel and Pangerl (2008) interviewed 56 IP experts from Germany's large companies asking about *defensive publication* strategies. The authors find that companies use publications such as peer-review journals, firm's reports, and patents in order to establish *prior art*[10] and secure *freedom to operate*, and then, hinder competitors from patenting similar technology (Jell, 2011).

Parchomovski (2000) and Litchman et al. (2000) point to strategical disclosure of research results, where in a patent race, firms may disclose intermediate results in order to raise the patentability bar for competitors. When such research outcomes become publicly available, they may hinder *novelty* and *nonobviusness*[11] of an otherwise patentable invention.

Gilbert and Newbery (1982) have highlighted a strategic use of patents – incumbents preempt innovators from entering the market through patenting. According to the authors, preemptive patenting is a strategy to assure monopolistic profits. Furthermore, Ganglmair and Oh (2014) claim that by announcing a pending application the innovator (leader) may derive a value of deterrence, i.e., deterring the competitor (follower) from innovating if the threat of infringement is sufficiently strong, giving the leader a competitive advantage.

On preemptive patenting, Gullec et al. (2012) use patent examination outcomes at the European Patent Office (EPO) to access patents applied for in order to preempt

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[9] Jell (2011) defines *freedom to operate* as freedom to make and use the invention in the first place.

[10] *Prior art* refers to the knowledge publicly available at the time the patent is applied for. For an invention to be patented it has to be *novel* and *non-obvious*. *Nove*l means that the invention has not been patented before and under the *non-obviousness* bar, an invention cannot be patented if "the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter pertains" (35 USC § 103a).

[11] 35 U.S.C. § 102 and 35 U.S.C. § 103, respectively.

competitors. They find evidence of preemptive patent filing – patentees file patents that may not comply with patenting requirements (*novelty and nonobviousness*) but aim to block competitors, ensuring freedom to operate. Also empirically, Ceccagnoli (2008), using the Carnegie Mellon survey (CMS) (Cohen et al. 2000), shows that preemptive patenting improves R&D returns appropriability for incumbents, especially when they have greater market share, when there is a threat of market entry, or when the R&D competition is based on incremental innovations.

Considering the AIPA's option to opt out, patentees may be willing to have their patent published before grant, deriving value from preempting competitors from inventing a similar invention. Earlier publication does not mean that the patent will be granted. However, by publishing the patent application it signals, to rivals, patentee's research developments and may stop competitors from investing in the same technological area (Litchman et al., 2000). In addition, pre-grant patent application publication, besides disclosing private information, bears the uncertainty regarding the award of the property right. Furthermore, it may add uncertainty to the marketplace regarding the rights entitled to the patent (Van Zeebroeck, 2011).

If the invention belongs to a technological area where the competition faced is high, publishing the patent application the patentee may derive a higher value by preempting rivals or securing freedom to operate than keeping the invention secret. Therefore, if the patentee is operating in a crowded technological area (in which there are many competitors inventing), she may be willing to publish the patent application before the patent is granted. Following the above argument, the first hypothesis states that:

> *Hypothesis 1: Firms are less likely to opt out of pre-grant publication of a patent application if the technology space is more crowded.*

Firm's internal knowledge

When designing patent filing strategies to maximize invention's returns, inventors might consider the trade-off imposed by AIPA. By forgoing pre-grant publication an assignee also forgoes foreign patenting, i.e., foreign patent protection and the revenues she can get from the exclusivity right or licensing it out in another country. Therefore, it is expected that companies are likely to opt for pre-grant secrecy when earlier publication means earlier disclosure of internal knowledge. Thus, firms deriving higher value from protecting the invention described in the patent document than disclosing and filing abroad are more likely to opt for pre-grant secrecy.

An invention that builds on firm's internal knowledge might cite, as *prior art,* the firm's previous patents. It means that the knowledge that is built upon is already in the public domain. Nonetheless, by opting out of pre-grant patent application publication, the disclosure of the patent document, and therefore the patents cited, are delayed. Pre-grant patent secrecy might be used to protect a core invention or to mask firm's innovative and research trajectory, as in the case of cumulative innovations.

Scholars have mainly addressed cumulative innovation in a context where a competitor builds on a prior invention of a rival firm (Scotchmer, 1991; Harhoff et al., 2003b; Aoki and Spiegel, 2009; Bessen and Maskin, 2009). In this context the first inventor, in case that the following invention greatly relies on the first, can block the development and production of the following invention by having the patent published (Harhoff et al., 2003b). Conversely, Aoki and Spiegel (2009) argue that by disclosing the invention through the patent system inventors may be revealing valuable information, allowing competitors to build on the invention or reverse engineer it. Hence, the likelihood that inventors will patent depends on the probability that they will get the exclusivity right and be able to enforce the patent against competitors.

A less investigated research stream relates to internal cumulative innovation, i.e., firm's own, internal, sequential inventions. Liu et al. (2008) analyze the firm's internal cumulative innovation decisions. They seek to find out whether patents that are part of sequential inventions are more likely to be renewed. Looking at patents from pharmaceutical and biotechnology industries, granted between 1990 and 1993, they define sequential innovation as the set of 'related patents'[12]. Results show that sequential innovation might be an additional mechanism increasing patent value, as related patents are more likely to be renewed. The patent value literature has shown that valuable patents are applied for in foreign countries (e.g., Harhoff et al., 2003a; Putnam, 1996). Therefore, one would expect that an invention building on internal knowledge would be published before grant and internationally protected.

However, Graham (2004) shows that firms inventing upon internal knowledge and valuing secrecy as an appropriability mechanism are more likely to delay the invention

[12] The USPTO define 'related patents' as divisional, continuations, or continuations-in-part, patents that involve similar or related technologies (Liu et al., 2008).

disclosure. Accordingly, a firm building on its own knowledge may forgo earlier patent application publication, hiding internal knowledge and postponing spillovers from the application disclosure.

In addition, firms may build a "bulk" of patents either to protect a core invention, "fencing" by patenting close substitutes, or in order to have a higher stake in cross licensing deals by complementary patents, "thickets" [13] (Schneider, 2008; Reitzig, 2004). Furhter, the need of having higher bargaining power spur inventors to increase the size of the patent portfolio that is relying on internal knowledge (Somaya, 2012). This motivates hypothesis 2:

> *Hypothesis 2. Relying on internal knowledge has a positive effect on the likelihood of a patent to be opted out of pre-grant publication.*

Radicalness and technology uncertainty

Besides firms' strategies and technology characteristics, invention specific characteristics also might influence firms' choice of opting out of earlier patent application publication. Moreover, the decision to keep the invention secret up to the patent grant comes once the decision to patent the invention is made. Keeping the patent application secret assures that the invention will be disclosed when the uncertainty regarding the patent grant is favorably solved.

In addition to the property right uncertainty, patentees bear the uncertainty associated with the patented technology, the patent value, and the market for the protected invention (Somaya, 2012). The further the invention departs from the knowledge and capabilities established inside the firm and in the industry, the greater the uncertainty and the risk, requiring the adoption of new technical skills and routines (Nelson and Winter, 1982; Schoenmakers and Duyster, 2010). Likewise, inventions are said to be radical, as opposed to incremental, when they significantly differ from the state-of-the-art technology. Hence, a radical invention means moving away from established techniques to a new combination of knowledge (Fleiming, 2001). Hurmelinna-Laukkanen et al. (p.5, 2013) argue that "when the creation to be protected is notably different from earlier ones, lead time, secrecy, or tacitness, for instance, are effective

[13] Thickets are characterized by fragmented ownership of patents, especially in complex technologies, forcing patentees to negotiate cross-licenses and to participate in patent pools (Shapiro, 2001; Von Graevenitz et al., 2013).

forms of protection since it takes more time for others to overcome causal ambiguities related to the innovation”. Therefore, the uncertainty borne by radical inventions might prevent firms from pre-grant publication, opting to have more time to further develop the technology before it is disclosed. Accordingly, hypothesis 3a states:

> *Hypothesis 3a. Radicalness has a positive effect on the likelihood of a patent to be opted out of pre-grant publication.*

On the other hand, market uncertainty might prompt inventors to publish a radical invention before grant. To accelerate the adoption and the development of complementary assets, companies with radical inventions may be willing to disclose the invention. Innovating firms may profit from free revealing the invention by accelerating innovation diffusion and user adoption (Harhoff et al., 2003b).

Furthermore, radical inventions are more complex and might be more difficult to imitate (Hurmelinna-Laukkanen et al., 2008); therefore, pre-grant publication may be less of a concern regarding returns appropriability. In addition, earlier publication allows foreign patenting, broadening invention geographical span. Based on this, the following hypothesis presents the opposite prediction to the former one:

> *Hypothesis 3b: Radicalness has a negative effect on the likelihood of a patent to be opted out of pre-grant publication.*

DATA AND MEASURES

Data

The patent data comes from EPO’s Worldwide Patent Statistical Database April 2012 (“PATSTAT”) that contains patent information from all major patent offices, including the USPTO. From January 2, 2001, the USPTO adopted “kind codes” to differentiate between granted patents that were kept secret up to grant and patents that were published before grant, B1 and B2, respectively.

As the focus of this study is publicly traded companies and their choice of publishing or not the patent application, the sample contains patents owned by publicly traded firms. Using Kogan et al. (2016)[14] database, I merged USPTO patents to CRSP *permnos* and then merged *permnos* to *gvkeys* (*Compustat*). These merging procedures yield a final sample[15] of 468,556 granted patents, applied for from November 29, 2000 to December 29, 2009 and granted up to November 02, 2010. The sample period is bounded by the AIPA enactment and database limitations (footnote 14). The merged patents were applied for by 2,645 different companies. In this sample, on average, 8.15% of the patents were opted-out. Figure 1 displays the proportion of opted-out patents along the analyzed period.

Insert Figure 1 about here

Dependent variable

To understand the drivers of opting out of pre-grant patent publication, patents were identified as published and not published before grant by the USPTO kind codes. The dependent variable is equal to one if the patent's kind code is B1 (not published) and zero if it is B2 (published).

Independent variables

Technological crowdedness

To test *hypothesis 1* I follow Hedge et al. (2007) and measured technological crowdedness by counting the number of different assignees of the patents listed as reference (backward citations) and that are not the same as the assignee(s) of the focal patent. It indicates that the inventor is operating in a crowded technological area with a number of "nearby" patents and competitors (Hall et al., 2009). Cockburn and MacGarvie (2006) use the number of cited assignees to proxy for the number of potential licensors. Accordingly, as this number increases, the costs for a potential entrant increase.

[14] Kogan et al. (2016) provide a match for all USPTO granted patents up to 2010 and CRSP *permnos*.
[15] When merging with Compustat data I also dropped patents that had corresponding negative sales values.

Internal knowledge (Self-citation Ratio)

To test *hypothesis 2*, I use the ratio of self-citations to the backward citations to proxy for the degree to which each patent builds on in-house knowledge. Self-cited patents are patents assigned to the same assignee of the focal patent. Graham (2004) uses the backward self-citation ratio as a measure of the technology control a firm has over the technology trajectory in which the focal patent lies in and finds that backward self-citation ratio combined with secrecy (measured by managers' response when secrecy is considered as an effective appropriability mechanism) is positively associated to patent filing strategies (filing continuation applications).

Radicalness

I use two variables to proxy for invention radicalness (*hypothesis 3*). First, I use the radicalness index provided by the OECD REGPAT Database[16]. Based on the patents cited by the focal patent, this index measures the number of different four-digits IPC (International Patent Classification) classes into which the cited patents are classified and to which the focal patent is not classified. It follows Shane (2001)'s definition but the OECD indicator (Squicciarini et al., 2013) is normalized by the total number of classes listed in the backward citations, considering the most disaggregated level available. Thus, the higher the index the more the focal patent builds on distinct knowledge and, therefore, represents a radical innovation. However, the radicalness index represents how radical is an invention to the firm, it does not imply that this technological novelty is on the invention level (Verhoeven et al., 2016).

Additionally, as a proxy for novelty in the invention level, I use the dispersion index proposed by Melero and Palomeras (2015) and create a variable *NEW COMBINATIONS.* This variable is a binary variable equal one when there was no previus IPC classes combination to calculate the index. The dispersion index measures the variance of the importance of past innovations in a given technological domain by the number of citations received (forward citations). The index is defined as follows

$$Dispersion\ index(DI) = \frac{\sigma^2}{\mu}$$

where σ^2 represents the variance and μ the mean of the standardized forward citations (Hall et al. 2001) received by previous patents assigned to the same combination of IPC 8-digits, the most disaggregated level. Following Melero and Palomeras, I assigned the

[16] OECD, REGPAT database, February 2015

index calculated using patents applied for during the previous five years before the focal patent was applied for.

Control variables

First, I control for patent characteristics – number of claims, patent scope (number of unique four-digit IPC subclasses) (Lerner, 1994), number of assignees, whether the patent is part of a patent family, whether the assignee is from the US, and indicator variables for discrete and complex technologies[17].

Patent characteristics were found to be positively correlated with patent value (Harhoff et al., 1999, 2003a; Lanjow and Shankerman, 1999) and more valuable patents are internationally protected (Putnam, 1996). Hence, valuable patents might be published before grant as it also allows foreign patent protection. Controlling for patent characteristics, variables that might affect the likelihood of an application to be published before grant are held constant. Additionally, the model includes a dummy variable identifying patents that were not applied for outside US and do not have any related international patent, i.e., singleton patents[18,19].

The claims define the invention to which protection is sought. The claims are the legally protected part of the patent document, over what the patentee can be sued or sue a possible infringer. Therefore, the number and content of claims can be seen as a measure of the breadth of a patent. With respect to patent scope, a patent allocated to more subclasses means that it has a greater technological potential and a greater market value (Lerner, 1994).

To identify the technological field of a patent I use the OECD classification, which is based on Schmoch (2008), and provides an IPC-technology concordance by main technology field.[20] First I identified four main technology groups, semiconductors, computers, biotechnology, and pharmaceutics. Also, I included a *dummy* variable when the patent is classified in more than one technology field, what may broad the use of the

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[17] Von Graevenitz et al. (2011).

[18] Singletons patents are defined as "single patent applications that form patent families on their own because they are not related to any other application" (Martinez, p. 2, 2011)

[19] PATSTAT record data for DOCDB patent family and INPADOC patent family. DOCDB patent families referred to a set of patents that protect the same technical content, defined by European Patent Office's (EPO) examiners. Differently, INPADOC patent families, also called INPADOC extended priority patent families, referred to a broader set of patents direct or indirectly linked by patent application priorities. In our main analysis, I used the DOCDB patent family definition.

[20] I use the technological field classification included in the OECD, REGPAT database, February 2016.

given invenvion. Further, I classified patents by discrete[21] or complex[22] technologies following Von Graevenitz et al. (2011). This classification does not include all technology fields; it means that there are some patents that are neither discrete nor complex.

Furthermore, I use some indicators based on patent characteristics, basic research and originality. Basic research is the ratio of non-patent literature (NPL) to backward citations, reflecting how much the patented invention relied on scientific knowledge. The originality index, first proposed by Trajtenberg et al. (1997), "refers to the breadth of technology fields on which a patent relies" (Squicciarini et al., p. 49, 2013). It is based on the different classes to which backward citations are allocated. Besides building on Hall et al. (2001), the OECD's originality index uses IPC 8-digits classification. The originality index reflects patents building on a wide array of technology classes.

On the firm level, I control for some firm characteristics. Firm size is proxied by the natural logarithm of sales. Firm size may also capture firms' financial constraints as smaller firms have bigger restrictions to access financial markets. I use the pre-tax foreign income (PIFO[23] in Compustat) and assign the value 1 if PIFO is greater than zero or 0 otherwise as a proxy for firms' foreign activities[24]. Having foreign operations makes foreign patenting more relevant and, therefore, can be related to the decision to have the patent application published 18 months after filing and protected in multiple countries. In addition, I control for the industry's competition intensity by the Herfindahl-Hirschman index (HHI)[25]. I also control for the total number of patents applied for by the company in the respective year.

EMPIRICAL RESULTS

Table 1 presents descriptive statistics and table 2 presents the correlation matrix. As already noted in the literature, patent characteristics – claims, patent scope, backward citations, have a very skewed distribution (Scherer and Harhoff, 2000; Harhoff et al., 2003a). In our sample, it can be seen from table 1 that, on average, patents that were

[21] According to Cohen et al. (2000), discrete technologies refer to products that are protected by few patents, whereas, complex technologies require many patents to protect a single product.
[22] Ibid.
[23] Missing values were replaced by zero (Hanlon et al., 2015)
[24] As a robustness check I also include the continuous variable and results were similar.
[25] Calculated using Compustat by three-digit SIC codes.

opted out of pre-grant publication were secret for about 1.7 years more than patents that were published before grant[26].

Insert Table 1 and 2 about here

In order to test the hypotheses I estimate a linear probability model (LPM) where the dependent variable is a binary variable equal to 0 if the patent application was published before grant and equal 1 if the patent application was not published before grant [27]. A LPM provides a simple and good approximation to the average partial effects (Wooldgridge, p. 563, 2010), moreover, the objective of this study is not to make forecasts but to identify the effect of the explanatory variables on the decision to publish or not a patent application. Table 3 reports the results, model 1 refers to the baseline model and model 2 presents the results including the control variables. The independent variables, crowdedness, internal knowledge (self-citation ratio), and radicalness are in logarithm. All estimations include company fixed effects, application year fixed effects and the standard errors are clustered by company.

Insert Table 3 about here

Results show that hypothesis 1 cannot be rejected, as patents belonging to a crowded technological area are more likely to be published before grant. However, the size of the coefficient suggests that the effect of preemption is only marginally important in driving the choice of having the patent application published before grant. Additionally, I test hypothesis 1 using two alternative measures of technological crowdedness. Calculating crowdedness index considering backward citations within a difference of 10 and 20 years from the focal patent, respectively, results remain qualitatively and statistically

[26] Grant lag (not-published) = 979 days (mean), 819 days (median); publication lag (published) = 365 days (mean), 281 days (median).

[27] I estimate all models using a random sample of 10% of the full sample, accounting for the proportions of the dependent variable, singleton patents, and technology fields, applying a logit specification, Results are robust and consistent with the ones presented here. Results available on request.

similar[28]. Regarding hypothesis 2, estimated results show that the more a patent builds on in-house knowledge stock the more likely it is to be kept secret up to grant. However, results show a weakly support for hypothesis 2 as when adding the controls internal knowledge is not statistically significant anymore.

I test hypothesis 3a and 3b by using two variables, radicalness and the new combination *dummy*.. This variable accounts for first time IPC 8-digits combinations. Therefore, this patents bears the highest uncertainty. Considering both variables, hypothesis 3a cannot be rejected meaning that the more radical is the invention the more likely is the patent to be opted out of pre-grant publication.

In addition, I test differences among the two broad types of technologies, complex and discrete, reported .in the appendix I, table 2. Model 1 shows results for the complex technology patents compare to others technologies, not classified in any of the two main categories. Model 3 displays results for discrete patents compared to other technologies. Results show that the effect of the independent variables on the likelihood of opting out of pre-grant patent application publication do not qualitatively differ between technology categories. The differences between the technology categories appear on the size of the coefficients. However, the effect of all variables have the same direction and are statistical significant.

ADDITIONAL ANALYSIS AND ROBUSTNESS TESTS

On average, patents that were not published before grant took less time to issue[29] and, therefore, pre-grant published patents may be underrepresented in our sample, as it includes patents granted up to 2010. In order to reduce this possible bias, all the regressions were re-estimated considering patents applied for between 2000 and 2007[30]. Results are consistent with the results presented above.

Second, as opting out of earlier publication requires the inventor to forgo foreign publication, I restrict the sample to singleton patents[31], i.e., patents that do not belong to a patent family. Although one can think that the main reason to publish the patent

[28] Results available upon request.
[29] In our sample, the grant lag of not published patents is 2.68 years (1.36 years standard deviation) whereas for published patents is 3.1 years (1.61 years standard deviation).
[30] Results available upon request.
[31] See *supra* note 18.

application is to seek foreign protection, when considering only patents applied in the US 84.5% of the patents were published before grant. Therefore, by restricting the sample to patents only filed in US I am comparing patents that could have been secret, but were published instead, to pre-grant secret patents.

Overall, the estimated results are qualitatively similar to the results for the full sample (table 1 – appendix I). However, the variable *internal knowledge,* accounting for the use of internal knowledge in the patented invention becomes insignificant. This result suggests that, on average, patents only filed in US rely more on firm's internal knowledge than internationally filed patents.

Results regarding technology, complex or discrete, moderation are display in table 2 (appendix I), model 2 and 4. Estimations resambled the ones described in the previous section for the full sample. In the case of the singleton patents subsample, two variables differ when considering the type of technology, while the other results are qualitatively and statistically similar. First, internal knowledge does not have a significant effect on the probability of keeping the patent secret before grant when the technology is complex. Second, when the technology is discrete, radicalness is not significant anymore.

Further, to understand the role of technology characteristics on the decision to opt out of earlier patent publication I estimate baseline and extended models (full sample and singleton patents subsample) including indicator variables for complex and discrete technologies (one at a time). Table 3 and 4 (appendix I) display the results. When considering the differences in the technology protected by a patent, discrete technologies are more likely to be published before grant whereas complex technologies are more likely to be kept secret until grant. Nevertheless, adding the control variables the technology effects become statistically insignificant.

DISCUSSION AND CONCLUSION

This paper investigates three hypotheses on publicly traded companies' choice of dalying patent application publication – the effect of the competition faced by the invention or the technological crowdedness, the effect of reliance on in-house knowledge stock, and the effect of invention characteristics (radicalness).

Theoretical models illustrate the case where a leader and a laggard competing in a patent race may publish interim R&D results in order to raise the patentability bar by disclosing prior art and, therefore, preventing the rival firm from patenting (Baker and Mezzetti, 2005; Bar, 2006). However, these models usually focus on regular publication, e.g. scientific papers and company reports, as means of defensive publication. By analyzing firm's choice of publishing or not the patent application before grant I find, support for hypothesis 1 which states that if an invention belongs to a technological area where there are many others operating, i.e., in a crowded technological space, the patent is more likely to be published before grant. This result is aligned with Henkel and Pangerl (2008) and Jell (2011) where they show that the patent system is used for defensive publishing.

While publishing interim R&D results may prevent rivals from patenting, firms may strategically hide their internal knowledge, for either a defensive or an offensive strategy (Jell, 2011; Somaya 2012; Ziedonis, 2004; Hall and Ziedonis, 2001). Estimations for the baseline model (without the controls) support hypothesis 2, suggesting that firms are more likely to opt for pre-grant secrecy the more they rely on in-house knowledge. However, estimates for the singleton subsample indicates that patents only filed nationally (in US), published or not before grant, do not differ regarding the use of firms' own previous patents. That is, domestic patents tend to cumulatively invest, use more internal knowledge, in a given technology (Lanjow and Shankerman, 2001) comparing to internationally filed patents. Delaying the disclosure of a patent that builds on a firm's internal knowledge might help the firm to hide its technology trajectory, preserving strategic knowledge embodied in the patent.

Patent preemption and defensive or offensive strategies relate to the company strategies. Nevertheless, keeping the application secret up to grant also relates to the invention characteristics. For that reason, in addition to including patent characteristics, I investigate how being radical, as in Shane (2001), affects the firm's opting out decision. In addition, I include a variable which capture new combinations of IPC classes.. In line with hypothesis 3a, I find that the more the patented invention differs from previous firms' inventions, the more radical it is, and being a new combination in the technological space,, the more likely it is for the patent to be opted out of pre-grant application publication. Indeed, the variable accounting for new technologies combination, which means high uncertainty, turns out to have the biggest coefficient in all estimation models. Kim at al. (2016) state that firms may derive higher value by delaying patenting in a context of high uncertainty.

Johnson (2014) predicts that inventors are more likely to publish defensively their inventions for the less technically challenging inventions. Additionally, Ceccagnoli (p. 4, 2008) pointed out that “the more drastic the underlying innovation on which the R&D competition is based the lower the incentives for and the profits with preemptive patenting”.

Inventors report being more able to appropriate returns from the innovation in discrete technologies (Cohen et al., 2000), what in general makes patents from discrete technologies more likely to opt for pre-grant publication[32]. Furthermore, empirical evidence has shown that the propensity to patent and the value of patents differ by the nature of the technology, complex or discrete technologies (Mansfield, 1986). While patents more effectively protect discrete technologies, complex industries patent intensively in order to have a higher stake in cross-licensing deals (Cohen et al., 2000; Levin et al., 1987). Png (2015), analyzing the impact of the Uniform Trade Secrets Act (UTSA) implemented in US, shows that complex industries patented significantly less as trade secret became stronger. Therefore, complex products may be more likely to opt for pre-grant secrecy taking advantage of the extra secrecy time earned by delaying disclosure.

Based on the stated results, this paper makes two main contributions to the literature. First, it is the first paper to evaluate public companies’ motives to opt out of earlier patent application publication, using a large sample of patents. Although, the publication of the majority of the patents occur before the patent is granted, still about 8.15% of publicly traded companies’ patent applications are kept secret up to grant. Hence, this paper contributes to increase our understanding of firms’ filing strategies to capture value from their inventions and on how firms use the patent system. Second, this study unveils empirical evidence on preemptive and strategic behavior. Moreover, companies have used patent pre-grant secrecy to guarantee exclusivity over radical and uncertain inventions by postponing invention disclosure.

Finally, our findings suggest some policy implications. First, AIPA’s earlier publication rule has two main goals: to harmonize US patent rules with the rest of the world (Allison et al., 2003) and to foster knowledge diffusion (Johnson and Popp, 2001). It has been shown that earlier publication fosters diffusion of R&D knowledge,

[32] In this sample, 4.35% of the discrete patents were opted out of pre-grant patent application publication, while 8.83% of the complex patents were kept secret until grant.

preventing R&D duplication (Aoki and Spiegel, 2009; Baruffaldi and Simeth, 2015). Empirical findings show that inventions that are more radical are more likely to be secret up to grant; therefore, in the absence of this option radical inventions would be made available earlier. Second, considering the potentially harmful use of blocking patents (Arundel and Patel, 2003; Blind et al., 2009) may be associated with strategic use of pre-grant patent secrecy, revoking this option would be a step further to assuage this kind of strategy.

Nevertheless, this analysis presents some limitations that point to future research. First, the trade-off imposed by AIPA might be stronger to higher internationalized firms. Therefore, it might be important to control for other variables, in addition to PIFO, to capture firms' international operations – e.g., the number of foreign subsidiaries. Second, it might be that market uncertainty has a more important role in driving pre-grant secrecy decision, and therefore, explicitly controlled for. Finally, in analyzing publicly traded companies this result must be seen with cautions and might not be generalized to private, small firms.

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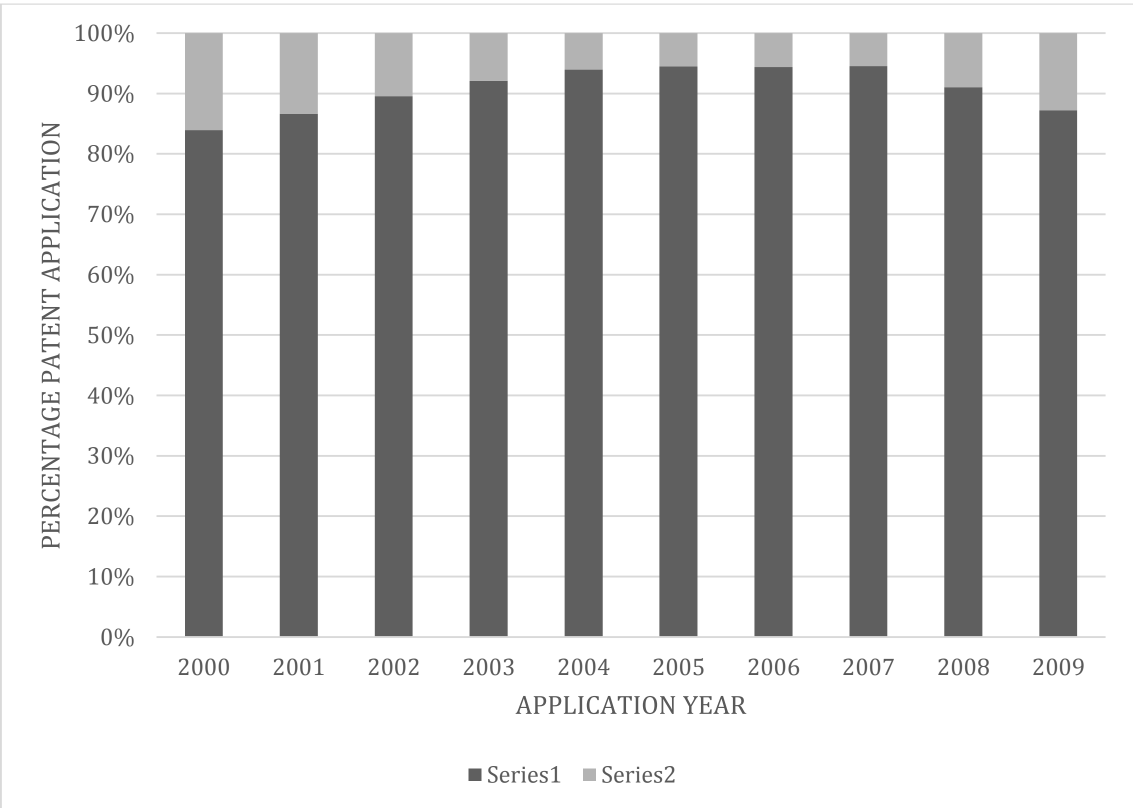

FIGURE 1 - Percentage of patent applications published and not published before grant– Granted patents up to 2010.

TABLE 1 – Descriptive statistics

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) Mdn	(6) max
DV	468,556	0.0815	0.274	0	0	1
TOTAL	468,556	1,056	1,156	1	1	4,308
HHI	468,556	0.267	0.214	0.0427	0.0427	1
SIZE	462,377	3.942	1.552	0	0	7.650
PATSCOPE	468,556	1.968	1.247	1	1	28
CLAIMS	468,550	18.48	13.17	1	1	418
ORIG	468,514	0.746	0.191	0	0	0.990
RAD	468,554	0.364	0.269	0	0	1
CROWD	468,556	16.96	22.63	0	0	538
SINGLETON	468,556	0.462	0.499	0	0	1
SELF_BACK	468,554	0.0563	0.128	0	0	3
BASICR	468,554	0.284	1.847	0	0	144
DI	468,556	1.780	0.99	0	1.66	28.97
DI_dummy	468,556	0.000	0.03	0	0	1
DOM	468,556	0.610	0.488	0	0	1
NUMASSIGNEES	468,556	1.031	0.209	1	1	14
FOREIGN (PIFO)	468,556	0.310	0.462	0	0	1
COMPLEX	468,556	0.819	0.385	0	0	1
DISCRETE	468,556	0.147	0.355	0	0	1
RAD_DISCRETE	468,554	0.0548	0.166	0	0	1
DI_DISCRETE	468,556	0.218	1.009	0	0	88.87
DI_dummy_DISCRETE	468,556	0.000	0.01	0	0	1
CROWD_DISCRETE	468,556	2.678	11.69	0	0	538
SELF_DISCRETE	468,554	0.00897	0.0586	0	0	3
RAD_COMPLEX	468,554	0.293	0.279	0	0	1
DI_COMPLEX	468,556	1.302	1.514	0	0	36.67
DI_dummy_COMPLEX	468,556	0.000	0.02	0	0	1
CROW_COMPLEX	468,556	13.47	20.72	0	0	461
SELF_COMPLEX	468,554	0.0461	0.117	0	0	2
GRANT_LAG[a]	430,356	1131.22	497.12	130	1054	3596
GRANT_LAG[b]	38,200	978.62	588.35	97	819	3534
PUB_LAG[a]	404,339	364.65	212.51	2	281	2157

[a] Published patents (B2). Number of days.
[b] Not-published patents (B1). Number of days.

TABLE 2 – Correlation Matrix

	VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)
(1)	DV	1																												
(2)	CROWD_COMPLEX	-0.02	1																											
(3)	DI_COMPLEX	0.02	0.23	1																										
(4)	DI_dummy_COMPLEX	0.03	0	-0.03	1																									
(5)	RAD_COMPLEX	0.09	0.21	0.31	0.02	1																								
(6)	SELF_COMPLEX	**0**	-0.05	0.17	**0**	0.02	1																							
(7)	SELF_DISCRETE	-0.01	-0.1	-0.22	0	-0.16	-0.06	1																						
(8)	CROWD_DISCRETE	-0.04	-0.15	-0.32	0	-0.24	-0.09	0.1	1																					
(9)	DI_DISCRETE	-0.03	-0.21	-0.47	-0.01	-0.35	-0.13	0.33	0.43	1																				
(10)	DI_dummy_DISCRETE	0.01	-0.01	-0.02	**0**	-0.01	0	0.01	0.01	0	1																			
(11)	RAD_DISCRETE	-0.04	-0.21	-0.47	-0.01	-0.35	-0.13	0.24	0.5	0.57	0.03	1																		
(12)	COMPLEX	0.05	0.31	0.66	0.01	0.49	0.19	-0.33	-0.49	-0.7	-0.02	-0.7	1																	
(13)	DISCRETE	-0.06	-0.27	-0.59	-0.01	-0.44	-0.16	0.37	0.55	0.79	0.03	0.79	-0.88	1																
(14)	RADICALNESS	0.07	0.05	-0.05	0.02	0.76	-0.08	-0.03	0.05	-0.03	0.01	0.24	-0.05	0.01	1															
(15)	DI	-0.01	-0.01	0.47	-0.04	-0.09	0.02	0.1	0.09	0.52	-0.02	0.08	-0.15	0.19	-0.05	1														
(16)	DI_dummy	0.03	-0.01	-0.04	0.8	0.01	0	**0**	**0**	-0.01	0.43	0.01	-0.01	**0**	0.02	-0.05	1													
(17)	CROWD	-0.04	0.82	0	0	0.03	-0.1	-0.05	0.37	0.01	**0**	0.05	-0.05	0.02	0.08	0.03	0	1												
(18)	SELF_BACK	-0.01	-0.09	0.05	0	-0.06	0.88	0.4	-0.04	0.03	**0**	-0.01	**0**	0.01	-0.09	0.07	0	-0.12	1											
(19)	FOREIGN (PIFO)	0.01	-0.04	**0**	**0**	-0.03	0.01	0.03	**0**	0.03	**0**	**0**	-0.01	0.02	-0.04	0.02	0	-0.04	0.02	1										
(20)	NUMASSIGNEES	-0.03	0.08	-0.02	**0**	-0.03	-0.02	-0.01	0.08	0.06	**0**	0.02	-0.03	0.04	-0.02	0.03	**0**	0.11	-0.03	0.03	1									
(21)	DOM	0.17	0.17	-0.08	0.01	0.06	-0.07	-0.02	0.11	0.06	0.01	0.07	-0.08	0.06	0.12	**0**	0.01	0.24	-0.07	-0.22	-0.08	1								
(22)	SINGLETONE	0.22	0.09	0.01	0.01	0.06	-0.01	-0.01	0.03	0.04	**0**	**0**	0	0	0.07	0.05	0.01	0.1	-0.01	-0.03	-0.04	0.38	1							
(23)	BASICR	0	-0.04	-0.07	**0**	-0.06	-0.02	0.01	0.02	0.17	**0**	0.08	-0.11	0.13	-0.01	0.09	**0**	-0.03	-0.01	0.04	0.01	0.06	0.05	1						
(24)	ORIG	-0.05	0.14	-0.08	0	0.32	-0.09	-0.01	0.13	0.08	**0**	0.18	-0.13	0.13	0.46	0.01	0	0.2	-0.09	0	0	0.08	0.01	**0**	1					
(25)	CLAIMS	0.07	0.14	0.01	0	0.04	-0.03	-0.02	0.06	-0.01	**0**	-0.01	0.01	-0.01	0.04	0	**0**	0.17	-0.04	-0.01	-0.03	0.21	0.09	0	0.06	1				
(26)	PATSCOPE	-0.14	-0.01	-0.14	-0.01	-0.14	-0.06	0.05	0.15	0.19	-0.01	0.11	-0.2	0.22	-0.09	0.05	-0.02	0.07	-0.03	0.05	0.04	-0.08	-0.1	0.1	0.29	-0.01	1			
(27)	SIZE	-0.17	-0.12	0.06	-0.01	0.01	0.1	-0.01	-0.11	-0.13	0	-0.08	0.13	-0.11	-0.05	-0.08	-0.01	-0.19	0.08	-0.17	0.06	-0.31	-0.19	-0.08	-0.05	-0.18	-0.02	1		
(28)	HHI	-0.07	-0.05	0	0	**0**	0.05	0.02	-0.04	-0.05	**0**	-0.01	0.01	-0.04	0	-0.03	0	-0.05	0.06	0.01	0.06	-0.19	-0.13	-0.06	0	-0.09	0.04	0.34	1	
(29)	TOTAL	-0.15	-0.06	0.15	-0.01	-0.01	0.14	-0.03	-0.14	-0.16	-0.01	-0.14	0.21	-0.18	-0.12	-0.03	-0.01	-0.15	0.11	-0.05	0.06	-0.28	-0.07	-0.05	-0.07	-0.13	-0.03	0.63	0.27	1

*Dependent variable (DV): 0 if patent published; 1 if patent not published. *Note:* All correlations are significant at 5% except the ones in bold. Obs.:498,556.

TABLE 3 – Drivers of opting-out. Dependent variable: Published (0) or not-published (1)

VARIABLES	(1) LPM	(2) LPM
CROWDEDNESS	-0.019***	-0.018***
	(0.002)	(0.002)
RADICALNESS	0.054***	0.061***
	(0.009)	(0.009)
NEW COMBINATIONS	0.220***	0.194***
	(0.029)	(0.028)
INTERNAL KNOWLEDGE	0.038*	0.027
	(0.018)	(0.018)
Controls		Included
Company FE	Included	Included
Application Year FE	Included	Included
Constant	0.068***	0.030
	(0.013)	(0.040)
Observations	468,554	462,334
R-squared	0.329	0.343

Robust standard errors in parentheses. Standard errors are cluster by company in all models. *** p<0.001, ** p<0.01, * p<0.05.

APPENDIX I

TABLE 1 – Drivers of opting-out. Singletons. Dependent variable: Published (0) or not-published (1)

VARIABLES	(1) LPM	(2) LPM
CROWDEDNESS	-0.024***	-0.019***
	(0.003)	(0.002)
RADICALNESS	0.079***	0.092***
	(0.012)	(0.013)
NEW COMBINATIONS	0.214***	0.193***
	(0.033)	(0.032)
INTERNAL KNOWLEDGE	0.010	0.007
	(0.021)	(0.020)
Controls		Included
Company FE	Included	Included
Application Year FE	Included	Included
Constant	0.076***	0.056
	(0.014)	(0.070)
Observations	216,289	213,008
R-squared	0.417	0.427

Robust standard errors in parentheses. Standard errors are cluster by company in all models. *** p<0.001, ** p<0.01, * p<0.05, [a] p<0.1.

TABLE 2 – Drivers of opting-out. Dependent variable: Published (0) or not-published (1). Full sample and singleton subsample.

VARIABLES	(1) FULL	(2) SINGLE	(3) FULL	(4) SINGLE
CROWD (COMPLEX)	-0.018***	-0.025***		
	(0.002)	(0.003)		
NEW COMBINATION (COMPLEX)	0.250***	0.221***		
	(0.036)	(0.038)		
RADICALNESS (COMPLEX)	0.067***	0.093***		
	(0.010)	(0.013)		
INTERNAL KNOWLDGE (COMPLEX)	0.036+	0.007		
	(0.019)	(0.022)		
CROWD (DISCRETE)			-0.009***	-0.010***
			(0.001)	(0.002)
NEW COMBINATION (DISCRETE)			0.283***	0.288***
			(0.053)	(0.075)
RADICALNESS (DISCRETE)			0.029*	0.030
			(0.012)	(0.020)
INTERNAL KNOWLDGE (DISCRETE)			0.090**	0.070+
			(0.030)	(0.039)
COMPANY FE	Included	Included	Included	Included
APPLICATION YEAR FE	Included	Included	Included	Included
CONSTANT	0.055**	0.134***	0.071***	0.095***
	(0.018)	(0.022)	(0.012)	(0.019)
OBSERVATIONS	399,454	184,099	84,833	39,482
R-SQUARED	0.346	0.431	0.200	0.280

Robust standard errors in parentheses. Standard errors are cluster by company in all models. *** p<0.001, ** p<0.01, * p<0.05, [a] p<0.1.

TABLE 3 – Drivers of opting-out. Dependent variable: Published (0) or not-published (1). Full Sample

VARIABLES	(1) LPM	(2) LPM	(3) LPM	(4) LPM
CROWDEDNESS	-0.019***	-0.018***	-0.019***	-0.018***
	(0.002)	(0.002)	(0.002)	(0.002)
RADICALNESS	0.055***	0.061***	0.055***	0.061***
	(0.009)	(0.009)	(0.009)	(0.009)
NEW COMBINATIONS	0.220***	0.194***	0.220***	0.194***
	(0.029)	(0.028)	(0.029)	(0.028)
INTERNAL KNOWLEDGE	0.038*	0.027	0.038*	0.027
	(0.018)	(0.018)	(0.018)	(0.018)
DISCRETE	-0.008*	-0.001		
	(0.003)	(0.003)		
COMPLEX			0.008**	0.003
			(0.003)	(0.003)
CONTROLS		Included		Included
COMPANY FE	Included	Included	Included	Included
APPLICATION YEAR FE	Included	Included	Included	Included
CONSTANT	0.072***	0.031	0.064***	0.029
	(0.013)	(0.039)	(0.012)	(0.040)
OBSERVATIONS	468,554	462,334	468,554	462,334
R-SQUARED	0.329	0.343	0.329	0.343

Robust standard errors in parentheses. Standard errors are cluster by company in all models. *** p<0.001, ** p<0.01, * p<0.05, [a] p<0.1.

TABLE 4 – Drivers of opting-out. Dependent variable: Published (0) or not-published (1). Singleton Patents Subsample.

VARIABLES	(1) LPM	(2) LPM	(3) LPM	(4) LPM
CROWDEDNESS	-0.024***	-0.019***	-0.024***	-0.019***
	(0.003)	(0.002)	(0.003)	(0.002)
RADICALNESS	0.080***	0.092***	0.080***	0.092***
	(0.012)	(0.013)	(0.012)	(0.013)
NEW COMBINATIONS	0.213***	0.193***	0.214***	0.194***
	(0.033)	(0.032)	(0.033)	(0.032)
INTERNAL KNOWLEDGE	0.011	0.007	0.010	0.007
	(0.021)	(0.020)	(0.021)	(0.020)
DISCRETE	-0.020***	-0.007		
	(0.006)	(0.005)		
COMPLEX			0.015**	0.006
			(0.005)	(0.005)
CONTROLS		Included		Included
COMPANY FE	Included	Included	Included	Included
APPLICATION YEAR FE	Included	Included	Included	Included
CONSTANT	0.096***	0.062	0.076***	0.056
	(0.016)	(0.070)	(0.014)	(0.070)
OBSERVATIONS	216,289	213,008	216,289	213,008
R-SQUARED	0.417	0.427	0.417	0.427

Robust standard errors in parentheses. Standard errors are cluster by company in all models. *** p<0.001, ** p<0.01, * p<0.05, [a] p<0.1.