Big secrets: Patent secrecy and patenting strategies

Juliana Pavan Dornelles[1]

Abstract

The enactment of the American Inventors Protect Act (AIPA), in November 29, 2000, gave to U.S. patent applicants the opportunity to opt for having their patent application secret up to grant or publishing 18 months after the earliest filing date. However, this choice poses patentees to a tradeoff: having the patent application secret up to grant requires relinquishing foreign patent protection. Using a sample of patents applied for by publicly traded companies, between 2000 and 2009, we investigate what drives large companies' decision to keep a patent secret up to grant. Particularly, we investigate the effect of preemption or technological crowdedness, strategic use of in-house knowledge stock, and invention radicalness on the decision of opting out of pre-grant publication. Our findings show a negative association between technological crowdedness and pre-grant secrecy, while in-house knowledge stock and radicalness are positively associated with the likelihood of a patent application being secret until grant.

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

INTRODUCTION

The enactment of the American Inventors Protect Act (AIPA), in November 29, 2000, gave to U.S. patent applicants the opportunity to opt to keep their patent application secret up to grant[2] or published 18 months after the earliest filing date[3]. However, this choice poses a trade-off: having the patent application secret up to grant require relinquishing foreign patent protection. In this paper, we investigate what drives large companies to opt out of pre-grant publication. Econometric results show that there is a weak evidence of preemptive patent application publication, 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[4] the more likely it is to opt out of pre-

[1] Universidad Carlos III de Madrid. jpavan@emp.uc3m.es

[2] 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)

[3] 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 available the patent applications in the US at the same time they are published abroad.

[4] In this paper we 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.

grant patent application publication. However, this effect is moderated by technology characteristics.

The decision on whether to keep a patent application secret is made *after* the decision to file a patent. Jell (2011) lists some reasons why companies may choose to file patents including: blocking others, securing freedom to operate, and enhancing reputation. However, in addition to filing a patent, inventors have also to decide whether to keep it secret or disclose the application. Multiple considerations go into that decision and this paper explores some of the factors that influence the choice to opt out of application publication and its costs.

Choosing pre-grant application publication allows patentees to pursue foreign patent protection. Graham and Hedge (2012) report that 51% of U.S. patent applications filed between January 1, 1995 and November 28, 2000, were also applied for in a foreign country. Unsurprisingly, inventors are more likely to seek foreign patent protection for their valuable inventions (Graham and Hedge, 2012). Moreover, earlier publication grants the patent owner once the patent is granted, the right to seek reasonable royalties from the publication date to the grant (Hedge and Luo, 2013). 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 or foreign patent protection.

Besides valuing 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). Therefore, pre-grant publication of a patent application may assist managers in making more informed decisions about R&D investment and to some degree in avoiding hold up (FTC, 2003). Additionally, as AIPA aims to harmonize U.S. patent law with the patent system of other developed economies[5], pre-grant publication may be driven by firms' willingness to conform to international standards. Further, 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

[5] 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)

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[6] way only when the uncertainty regarding the patent is solved favourably[7], 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 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.

The option to keep the patent secret until grant was justified as a mechanism to protect small U.S. inventors who may not have enough resources to protect themselves against competitors' imitation (Ragusa, 1992; Johnson and Popp, 2001; Graham and Hedge, 2012). However, Graham and Hedge (2012) analysing successful U.S. patent applications filed between 1996 and 2005 find that 7.5% of the applications filed during 2001 and 2005 chose pre-grant secrecy. Moreover, small inventors are not more likely to opt out than large ones. In our sample, about 8.15% of the granted patents, during 2001 and 2010, owned by publicly traded firms were opted out of earlier publication.

In a large sample study, we show that strategic concerns are relevant to the decision to keep the patent application secret up to grant, besides invention characteristics. Therefore, we contribute to the literature on patenting strategies, unveiling drivers of large firms' patent pre-grant secrecy. Furthermore, we investigate strategic motives for large firms to opt out of pre-grant publication, waving foreign patent protection.

THEORY AND HYPOTHESES DEVELOPMENT

In this section, we discuss the drivers of patentees' decision of earlier application publication and derive some hypotheses. In particular, we theorize about large entities' incentives to disclose or not the inventions through earlier patent publication and how disclosing or not is linked to companies' patenting strategies.

[6] "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).

[7] 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)

When filing a patent, beyond the traditional motive of protecting the invention against imitation, assignees aim to maximize the profits generated by the patent. Therefore, patentees might derive value by choosing one filing strategy or the other, in our specific case, publishing or not the patent application before patent issuance.

Patents have been used as instruments of firms' strategy. It can be generic strategies or strategic patent management (Somaya, 2012). Nonetheless, the strategic use of patents is closely linked to the motives to patent and, therefore, to filing strategies (Jell, 2011).

Besides the argument that a patent granting the exclusivity right enables innovators to appropriate an innovation's returns, it has been shown in the empirical literature that managers mostly rely on informal innovation appropriability mechanisms, mainly secrecy, instead of formal mechanisms – e.g., 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 engineer the invention. The latter states that the propensity to patent depends on market barriers and on the relevance of the information disclosed.

Scholars have identified a set of motives to patent. 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 firm's research capabilities (Hsu and Ziedonis, 2008; Ganglmair and Oh, 2014), and protecting a firm against infringing others' patents and incurring infringement suits costs (Hall and Ziedonis, 2001).

On patents as a tool to secure freedom to operate (Henkel and Pangerl, 2008; Henkel and Jell, 2009; Jell, 2011), Henkel and Pangerl (2008) interviewed 56 IP experts from Germany large companies asking about *defensive publication* strategies. The authors found out that companies use publications as peer-review journals, firm's reports, and patents in order to secure *prior art*[8] and freedom to operate, and then, hinder competitors from patenting similar technology (Jell, 2011).

[8] *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*. *Novel* 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

Earlier, Gilbert and Newbery (1982) have highlighted a patents' strategic use – incumbents preempting innovators from entering the market through patenting. According to the authors, preemptive patenting is a strategy to assure monopolistic profits. Further, 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 to the leader a competitive advantage.

On preemptive patenting, Gullec et al. (2012) use patent examinations outcomes at the European Patent Office (EPO) to access patents applied for by preemption motive. Gullec and co-authors find evidence of preemptive patent filing – patentees file patents that may not comply with patenting requirements (*novelty and nonobviousness*[9]) but target blocking competitors, ensuring freedom to operate. Also empirically, Ceccagnoli (2008) shows that preemption 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 opting out option, patentees may be willing to have their patent published before grant, deriving value from preempting competitors on inventing a similar invention. Therefore, if the patentee is operating in a crowded technological area (in which there are many competitors inventing) it is more likely that the patent application will be published 18 months after the filing date. Considering 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.*

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, companies may be more likely to opt out when they derive higher value protecting internal knowledge by secrecy than preempting competitors through patent application publication.

---

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).

[9] 35 U.S.C. § 102 and 35 U.S.C. § 103, respectively.

In case the invention to be protected is cumulative and builds on firm's internal knowledge, the firm might have greater incentives to delay the disclosure of the invention, masking its innovative trajectory, by choosing pre-grant secrecy. 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 engineering 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 is related to the internal cumulative innovation. Liu et al. (2008) analyse firm's internal sequential innovation and whether the probability of a patent being renewed relates to a patent being part of a sequential innovation. They investigate patents from pharmaceutical and biotechnology industries, granted between 1990 and 1993, and define sequential innovation the set of 'related patents[10]'. Results show that sequential innovation might be an additional mechanism that increases patent value. Thus, a firm building on its own knowledge may forgo earlier patent application publication in order to dissemble internal knowledge and postpone 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"[11] (Schneider, 2008; Reitzig, 2004). It is the characteristics of the technology to be protected that strongly influence the patent filing strategies. Strategies associated with blocking competitors or protecting a core invention are more important for discrete technologies [12](Schneider, 2008; Ziedonis,

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

[11] 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).

[12] 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.

2004; Arundel and Patel, 2003). On the other hand, complex technology[13] industries are more patenting intensive and more frequently use patents to protect them against infringement suits (Hall and Ziedonis, 2001), a strategy also called "patent flooding[14]" (Henkel and Pangerl, 2008; Jell 2011). Moreover, the need of having higher bargaining power spur inventors to increase patent portfolio relying on internal knowledge (Somaya, 2012).

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

Besides technology characteristics, invention characteristics also might influence firms' choice on opting out of earlier patent application publication. First, 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 secret assures that the invention will be disclosed when the uncertainty regarding the patent grant is vanished.

In addition to the property right uncertainty, patentees bear the uncertainty associated to the patent value and the market for the protected invention (Somaya, 2012). Moreover, 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). Furthermore, Hurmelinna-Laukkanen et al. (p.5, 2013) state that "when the creation to be protected is notably different from earlier ones, lead time, secrecy, or tacitness, for instance, are effective 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 develop the technology while at the same time having it protected in the US.

---

[13] Ibid.

[14] This strategy consists of filing a large number of patent applications "on every conceivable improvement on a broad basic invention patented by a rival company" (Ayres and Parchomovsky, p. 869, 2007).

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

Conversely, 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 users 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 approapriability. 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 application information from all major patent offices, including the USPTO. From January 2, 2001, the USPTO adopted "kind codes" to differentiate between 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. By using Kogan et al. (2011)[15] database, we merged USPTO patents to CRSP *permnos.* Then, we merged *permnos* to *gvkeys* (*Compustat*). These merging procedures yield a final sample[16] of 468,556 patents applied for from November 29, 2000 to December 29, 2009 and granted up to November 04, 2010. The sample period is bounded by the AIPA

[15] Kogan et al. (2011) provide a match for all USPTO granted patents up to 2010 and CRSP *permnos*.
[16] When merging with Compustat data we also dropped patents that had corresponding negative sales values.

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 access the drivers of opting-out of pre-grant patent publication we identify patents that were not published before grant by the USPTO kind codes. The dependent variable is equal to one if the patent's kind code was B1 and zero if it was B2.

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 increase, the costs for a potential entrant increase.

Self-citation Ratio

Testing *hypothesis 2*, first I calculate self-citations by the number of times a given assignee refers to her own patents. As this measure is at the assignee level, I calculate the mean value for each patent to get the patent level measure. Further, I use the ratio of mean self-citations to the backward citations to proxy for the intensity that each patent builds on in-house knowledge. 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 found that backward self-citation ratio combined with secrecy is positively associated to patent filing strategies (filing continuation applications).

Radicalness

Regarding the invention radicalness (*hypothesis 3*), I use the radicalness index provided by the OECD REGPAT Database[17]. Based on the patents cited by the focal patent, this index measures the number of different four-digits IPC 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 diverse knowledge and, therefore, represents a radical innovation.

Additionally, I use the dispersion index proposed by Melero and Palomeras (2015) as a measure of technological uncertainty. 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 four-digits. Following Melero and Palomeras, we assigned the 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 (International Patent Classification)) (Lerner, 1994), number of assignees, if the patent is part of a patent family and the number of non-patent literature citations.

The claim or 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 determine 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). As, according to AIPA's rule, a patent application that opted for pre-grant secrecy

[17] OECD, REGPAT database, February 2015

cannot be applied in any other foreign jurisdiction, we include a dummy for singleton patents[18,19].

The number of non-patent literature (NPL) referred to in a patent document indicates the importance of scientific knowledge for the given invention (Harhoff and Reitzig, 2004). To identify the technological field of a patent we use the OECD classification, which is based on Schmoch (2008), who provides an IPC-technology concordance by main technology field[20] and then I classified patents by discrete or complex technologies following Von Graevenitz et al. (2011).

Furthermore, we use some indicators based on patent characteristics, basic research and originality. Basic research is the ratio of 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 belonging to 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. As a proxy for firms' foreign activities, I use the pre-tax foreign income (PIFO[21] in Compustat) and assigned the value one if PIFO is greater than zero or zero otherwise (FOREIGN). The more foreign operations, the more relevant it is for a firm to be able to apply for a patent outside US and, therefore, to have its patent application published 18 months after filing. At the firm level, I also controlled for R&D intensity as the ratio of R&D expenditure to sales revenue as it might capture firms' R&D capabilities and degree of commitment to research activities. In addition, we control for the industry's competition intensity by the

[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 we used the DOCDB patent family definition.

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

[21] Missing values were replaced by zero (Hanlon et al., 2015)

Herfindahl-Hirschman index (HHI)[22]. Apart from the Compustat data, we control for the total number of patents applied for by year and company.

EMPIRICAL RESULTS

Table 1 present descriptive statistics and table 2 presents the correlation matrix. As already noted in the literature, patent characteristics – claims, patent scope, backward citations, non-patent literature references, 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, opted out of pre-grant publication patents were secret about 1.7 years more than patents that were published before grant[23].

Insert Table 1 and 2 about here

In order to test the hypothesis 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 [24]. 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, equation 1 refers to the baseline model, equation 2 presents the results including the control variables, and in equation 3 I tested the interaction between the main explanatory variables and the two broad technology groups. . All estimations include company fixed effects, application year fixed effects and the standard errors are clustered by company.

Insert Table 3 about here

---

[22] Calculated using Compustat by three-digit SIC codes.
[23] Grant lag (not-published) = 979 days (mean); publication lag (published) = 365 days (mean).
[24] 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.

Results show that we cannot reject hypothesis 1, 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. 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.

We tested hypothesis 3a and 3b by using two variables, radicalness and the dispersion index. Considering both variables, we cannot reject hypothesis 3a, meaning that the more radical is the invention and the more uncertain the technological area the more likely is the patent to be opted out of pre-grant publication..

In equation 3, besides all coefficients being significant and supporting the main results, the size of the coefficients differ in magnitude. For example, a radical invention is more likely to be kept secret up to grant if the patented technology is complex. On the other hand, building on firms' internal knowledge stock has a greater effect on the likelihood of a patent being opted out of pre-grant application publication if the invention is a discrete technology product.

ADDITIONAL ANALYSIS AND ROBUSTNESS TESTS

On average, patents that opt out take less time to issue[25] and, therefore, pre-grant published patents may be underrepresented in our sample as we considered patents granted up to 2010. In order to reduce this possible bias we estimate all the regressions considering patents applied for between 2000 and 2007[26]. Results are consistent with the results presented above.

Second, as opting out of earlier publication requires the inventor to forgo foreign publication, we restrict our sample to singleton patents[27], i.e., patents that do not belong to a patent family. Although one can think that the main reason to publish the patent application is to seek foreign protection, when considering only patents applied in the U.S 84.5% of the patents were published before grant. Furthermore, the estimated results are qualitatively similar to the results for the full sample (table 1 – appendix I).

[25] In our sample, the grant lag of not published patents is 2.68 (1.36 years standard deviation) years whereas for published patents is 3.1 years (1.61 years standard deviation).
[26] Results available upon request.
[27] See *supra* note 17.

However, the variable *self_back*, accounting for the use of internal knowledge in the patented invention becomes insignificant. This result suggest that the use of internal knowledge is a relevant variable for the choice of pre-grant secrecy when compared to patents also filed internationally. Notwithstanding, the interaction between *self_back* and complex technologies (*self_complex*) is not significant while it is marginally significant in the case of discrete technologies (*self_discrete*). In the case of the radicalness index, it becomes insignificant when the technology is discrete but still significant (p-value<0.01) when the technology is complex.

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 2 and 3 (appendix 1) display the results. Overall, when considering the differences on the technology protected by the 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 controls variables this effect becomes not statistically significant.

DISCUSSION AND CONCLUSION

This paper investigates three hypotheses on publicly traded companies' choice of opting out of pre-grant patent application publication – the effect of preemption or technological crowdedness, strategic use of in-house knowledge stock, and invention radicalness on the decision of opting out.

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, company reports, as means of defensive publication. By analyzing firm's choice of publishing or not the patent application before grant we found, support for hypothesis 1a which state 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.

Another patent management strategy relates to firms' internal knowledge. 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). We found support for our second hypothesis, showing that firms are more likely to opt for pre-grant secrecy the more they rely on in-house knowledge. However, this effect is moderated by the technology protected by the patent, i.e., even positive and significant for both technologies – discrete and complex, the effect of using internal knowledge on the decision to not publish a patent application before grant is more pronounced for discrete technologies. This result points to an strategic use of pre-grant secrecy as 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[28]. Delaying the disclosure of a patent that builds on firm's internal knowledge might help the firm to hide its technology trajectory, preserving strategic knowledge embodied in the patent.

Further, intrinsic technology characteristics also drive patentees' filing strategies. As it is known, the propensity to patent and the value of patents differ by the nature of the technology, complex or discrete technologies. Moreover, appropriability concerns might influence the decision to do not published a patent before grant. Discrete technologies are more effectively protected by patents, whereas complex industries patent intensively in order to have a higher stake in cross-licensing deals (Cohen et al., 2000: Levin et al.,1987). Therefore, as shown by Png (2015), complex technology products may be more likely to opt for pre-grant secrecy taking advantage of the extra secrecy time earned by delaying disclosure.

Patent preemption and defensive or offensive strategies relate to the company strategies, nevertheless, keeping the application secret up to grant may be also related to the invention characteristics. For that reason, besides including patent characteristics, I investigate how being radical, as in Shane (2001), affects the firm's opting out decision. Also, I include a measure of technology uncertainty, as proposed by Melero and Palomeras (2015). In line with hypothesis 3a, I found that the more the patented invention differs from previous inventions, the more radical it is, and the more uncertainty relates to the technology it belongs to, the more likely it is for the patent to be opted out of pre-

[28] In the simple, 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.

grant application publication. Johnson (2014) predicts that inventors are more likely to defensively publish 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".

Given this set up, 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 18 months after the earliest filing date, still about 8.15% of publicly traded companies' patent applications are kept secret up to grant. Hence, this paper contributes to enlarge our understanding of firms' filing strategies to capture value from their inventions. Second, we unveil empirical evidence on preemptive and strategic behavior. Moreover, patent secrecy has been used by companies to guarantee exclusivity over radical inventions while 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 foster diffusion of R&D knowledge, preventing R&D duplication (Aoki and Spiegel, 2009; Baruffaldi and Simeth, 2015). We find that more radical inventions 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 that 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.

REFERENCES

Allison, J. R., Lemley, M. A., Moore, K. A., & Trunkey, R. D. (2003). Valuable patents. **George Mason Law and Economics Research Paper** No. 03-31.

Anton, J. J. & Yao, D. A. (2004). Little patents and big secrets: Managing intellectual property. **The RAND Journal of Economics,** 35(1): 1-22.

Aoki, R., & Spiegel, Y. (2009). Pre-grant patent publication and cumulative innovation. **International Journal of Industrial Organization**, *27*(3): 333-345.

Arundel, A., & Patel, P. (2003). Strategic patenting. In **Background report for the Trend Chart Policy Benchmarking Workshop" New Trends in IPR Policy**. Luxembourg, June 3-4.

Arundel, A. (2001). The relative effectiveness of patents and secrecy for appropriation. **Research policy** 30 (4): 611–624.

Ayres, I., & Parchomovsky, G. (2007). Tradable Patent Rights. **Stanford Law Review**, 863-894.

Baker, S., & Mezzetti, C. (2005). Disclosure as a Strategy in the Patent Race. **Journal of Law and Economics**, 48(1): 173-194.

Bar, T. (2006). Defensive publications in an R&D race. **Journal of Economics & Management Strategy**, 15(1): 229-254.

Baruffaldi, S. H. & Simeth, M. (2015) **Patent disclosure and the diffusion of knowledge**. Paper presented at the 39th DRUID Celebration Conference, Rome, LUISS, Italy. Available at:
http://druid8.sit.aau.dk/druid/acc_papers/9u30tmvrmll6s8gsr07ooc3j4asc.pdf

Bessen, J., & Maskin, E. (2009). Sequential innovation, patents, and imitation. **The RAND Journal of Economics,** 40(4): 611-635.

Blind, K., Cremers, K., & Mueller, E. (2009). The influence of strategic patenting on companies' patent portfolios. **Research Policy**, 38(2): 428-436.

Ceccagnoli, M. (2008). Appropriability, preemption, and firm performance. **Strategic Management Journal**, 29:000-000.

Cockburn, I. M. & MacGarvie, M. (2006). *Entry, exit and patenting in the software industry***. NBER Working Paper** No. 12 563. National Bureau of Economic Research, Cambridge, MA.

Cohen, W. M., R. R. Nelson, & J. P. Walsh (2000). Protecting their intellectual assets: Appropriability conditions and why us manufacturing firms patent (or not). **NBER Working Paper,** No. 7552.

Fleming, L. (2001). Recombinant Uncertainty in technological search. **Management Science**, 47(1): 117-132.

FTC (2003). To promote innovation: the proper balance of competition and patent law and policy. **A report by the Federal Trade Commission**. Available at:https://www.ftc.gov/sites/default/files/documents/reports/promote-innovation-proper-balance-competition-and-patent-law-and-policy/innovationrpt.pdf

FTC (2005). **A Summary Report of Discussions at Town Meetings on Patent Reforms**. Available at www.ftc.gov/opp/intellect/050601summarytownmtg.pdf

Ganglmair, B., & J.-M. Oh (2014). Strategic Secrecy of Pending Patents. **UT Dallas Working Paper**.

Gans, J. S., Hsu, D. H., & 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.

Graham, S. J., & Hedge, D. (2012). Do inventors value secrecy in patenting? Evidence from the American Inventor's Protection Act of 1999. **NYU-Stern School of Business Working Paper.**

Graham, S. J., Hall, B. H, Harhoff,, D., & Mowery, D. C. (2002). Post-issue patent" quality control": A comparative study of us patent re-examinations and European patent oppositions. **NBER Working Paper**, No. 8807.

Graham, S. J. (2004). **Hiding in the Patent's Shadow: Firms' Uses of Secrecy to Capture Value from New Discoveries**. Available at: https://smartech.gatech.edu/xmlui/handle/1853/10725

Gilbert, R. J., & Newbery, D. M. (1982). Preemptive patenting and the persistence of monopoly. **The American Economic Review**, 514-526.

Guellec, D., Martinez, C., & Zuniga, P. (2012). Pre-emptive patenting: securing market exclusion and freedom of operation. **Economics of Innovation and New Technology**, 21(1):1-29.

Hall, B. H., Lotti, F., & Mairesse, J. (2009): Innovation and productivity in SMEs: empirical evidence for Italy. **Small Business Economics**, 33:13-33.

Hall, B. H., Jaffe, A. B. & Trajtenberg, M. (2001). The NBER patent citation data file: Lessons, insights and methodological tools. **NBER Working Paper,** No. 8498.

Hall, B. H. & Ziedonis, R. H. (2001). The patent paradox revisited: an empirical study of patenting in the U.S. semiconductor industry, 1979-1995. **RAND Journal of Economics**, 32: 101–128.

Hanlon, M., Lester, R., & Verdi, R. (2015). The effect of repatriation tax costs on U.S. multinational investment. **Journal of Financial Economics**, 116: 179-196.

Harhoff, D. & Reitzig, M. (2004). Determinants of opposition against EPO patent grants – the case of biotechnology and pharmaceuticals. **International Journal of Industrial Organization**, 22(4): 443-480.

Harhoff, D., Scherer, F. M., & Vopel, K (2003a). Citations, family size, opposition and the value of patent rights. **Research Policy**, 32 (8): 1343–1363

Harhoff, D., Henkel, J., & Von Hippel, E. (2003b). Profiting from voluntary information spillovers: How users benefit by freely revealing their innovations. **MIT Sloan School Working Paper** 4749-09.

Hedge, D., & Luo, H. (2013). Licensing and patent disclosure. **Mimeo New York University**.

Hegde, D., Mowery, D. C., & Graham, S. (2007). Pioneers, submariners, or thicket-builders: which firms use continuations in patenting? **NBER Working Paper**, No. 13153

Heger, D., & Zaby, A. K. (2013). The heterogeneous costs of disclosure and the propensity to patent. **Oxford Economic Papers**, 65(3): 630-652.

Henkel, J. & Jell, F. (2009). Alternative motives to file for patents: Profiting from pendency and publication, **Working Paper Technische Universität München**, Munich.

Henkel, J., & Jell, F. (2010). Patent Pending–Why faster isn't always better. **Available at SSRN 1738912.**

Henkel, J. & Pangerl, S. (2008). **Defensive publishing: An empirical study**. Paper presented at the 25th DRUID Celebration Conference, Copenhagen, CBS, Denmark. Available at: http://www3.druid.dk/wp/20080004.pdf

Hsu, D. H. & Ziedonis, R. H: (2008). **Patents as quality signals for entrepreneurial ventures**. Academy of Management Best Paper Proceedings. Available at http://www.management.wharton.upenn.edu/hsu/inc/doc/papers/david-hsu-signals.pdf

Hurmelinna-Laukkanen, P., Ritala, P., & Sainio, L. M. (2013). Protection of Radical Innovations-Differences In Domestic and International Markets. **Journal of Global Business and Technology**, 9(1), 1-16.

Hurmelinna-Laukkanen, P., Sainio, L. M., & Jauhiainen, T. (2008). Appropriability regime for radical and incremental innovations. **R&D Management**, *38*(3), 278-289.

Jell, F. (2011). **Patent Filing Strategies and Patent Management: An Empirical Study.** Springer Science & Business Media.

Johnson, D. K. & Popp, D. (2001). Forced out of the closet: The impact of the American Inventors Protection Act on the timing of patent disclosure. **NBER Working Paper,** No. 8374.

Johnson, J. P. (2014). Defensive publishing by a leading firm. **Information Economics and Policy**, 28:15-27.

Kogan, L., Papanikolaou, D., Seru, A., & Stoffman, N. (2011) Technology allocation, resource allocation, and growth. **Available at SSRN**: http://ssrn.com/abstract=2193068.

Lemley, M. A., & Shapiro, C. (2005). Probabilistic patents. **Journal of Economic Perspectives:** 75-98.

Lerner, J. (1994) The Importance of Patent Scope: An Empirical Analysis, **The RAND Journal of Economics**, 25(2): 319-333

Levin, R. C., Klevorick, A. K., Nelson, R. R., Winter, S. G., Gilbert, R. & Griliches, Z. (1987). Appropriating the returns from industrial research and development. **Brookings papers on economic activity**: 783–831.

Liu, K., Arthurs, J., Cullen, J., & Alexander, R. (2008). Internal sequential innovations: How does interrelatedness affect patent renewal? **Research Policy**, 37: 946-953.

Long, C. Patent Signals. **University of Chicago Law Review**, 69: 625-679.

Martínez, C. (2010). Patent families: when do different definitions really matter? **Scientometrics**, 86(1): 39-63.

Melero, E. & Palomeras, N. (2015). The Renaissance man is not dead! The role of generalists in teams of inventors. **Research Policy**, 44(1), 154-167.

Nelson, R. & Winter, S. (1982). **An evolutionary theory of economic change**. Belknap Press of Harvard University Press: Cambridge, Ma.

Png, I. P. L. (2015) Secrecy and Patents: Evidence from the Uniform Trade Secrets Act. **Available at SSRN**: http://ssrn.com/abstract=2617266

Ragusa, P. A. (1992). Eighteen months to publication: Should the United States join Europe and Japan by promptly publishing patent applications. **Geo. Wash. J. Int'l L. & Econ**., *26*, 143.

Reitzig, M. (2004). The private values of 'thickets' and 'fences': towards an updated picture of the use of patents across industries. **Economics of Innovation and New Technology**, 13(5): 457-476.

Scherer, F. M., & Harhoff, D. (2000). Technology policy for a world of skew-distributed outcomes. **Research Policy**, 29(4), 559-566.

Schoenmakers, W., & Duysters, G. (2010). The technological origins of radical inventions. **Research Policy**, 39(8):1051-1059.

Schmoch, U. (2008). Concept of a Technology Classification for Country Comparisons, **Final Report to the World Intellectual Property Organisation (WIPO**), revised August 2011, WIPO, www.wipo.int/export/sites/www/ipstats/en/statistics/patents/pdf/wipo_ipc_technology.pdf

Schneider, C. (2008). Fences and competition in patent races. **International Journal of Industrial Organization**, *26*(6): 1348-1364.

Schneider, C. & Veugelers, R. (2013). Which IP strategies do young highly innovative firms choose? **Available at SSRN 2382516.**

Scotchmer, S., & Green, J. (1990). Novelty and disclosure in patent law. **The RAND Journal of Economics,** 131-146.

Scotchmer, S. (1991). Standing on the shoulders of giants: cumulative research and the patent law. **The Journal of Economic Perspectives**, 29-41.

Shane, S. (2001). Technological Opportunities and New Firm Creation**, Management Science**, 47 (2): 205–220

Shapiro, C. (2001). Navigating the patent thicket: Cross licenses, patent pools, and standard setting. In **Innovation Policy and the Economy**, *Volume 1* (pp. 119-150). MIT press.

Somaya, D. (2012). Patent strategy and management an integrative review and research agenda. **Journal of Management**, *38*(4):1084-1114.

Squicciarini, M., H. Dernis and C. Criscuolo (2013) Measuring Patent Quality: Indicators of Technological and Economic Value. **OECD Science, Technology and Industry Working Papers**, 2013/03, OECD Publishing. http://dx.doi.org/10.1787/5k4522wkw1r8-en

Trajtenberg, M, Jaffe, A., & R. Henderson (1997). University versus Corporate Patents: A Window on the Basicness of Inventions, **Economics of Innovation and New Technology**, 5(1): 19-50

Von Graevenitz, G., Wagner, S. & Harhoff, D. (2011). How to measure patent thickets—A novel approach. **Economics Letters** 111(1): 6-9.

Von Graevenitz, G., Wagner, S., & Harhoff, D. (2013). Incidence and growth of patent thickets: the impact of technological opportunities and complexity. **The Journal of Industrial Economics**, 61(3), 521-563.

Zaby, A. K. (2010). Losing the lead: the patenting decision in the light of the disclosure requirement. **Economics of Innovation and New Technology**, 19(2):147-164.

Ziedonis, R. H. (2004). Don't fence me in: Fragmented markets for technology and the patent acquisition strategies of firms. **Management Science**, 50(6): 804-820.

Wooldridge, J. M. (2010). **Econometric analysis of cross section and panel data**. MIT press.

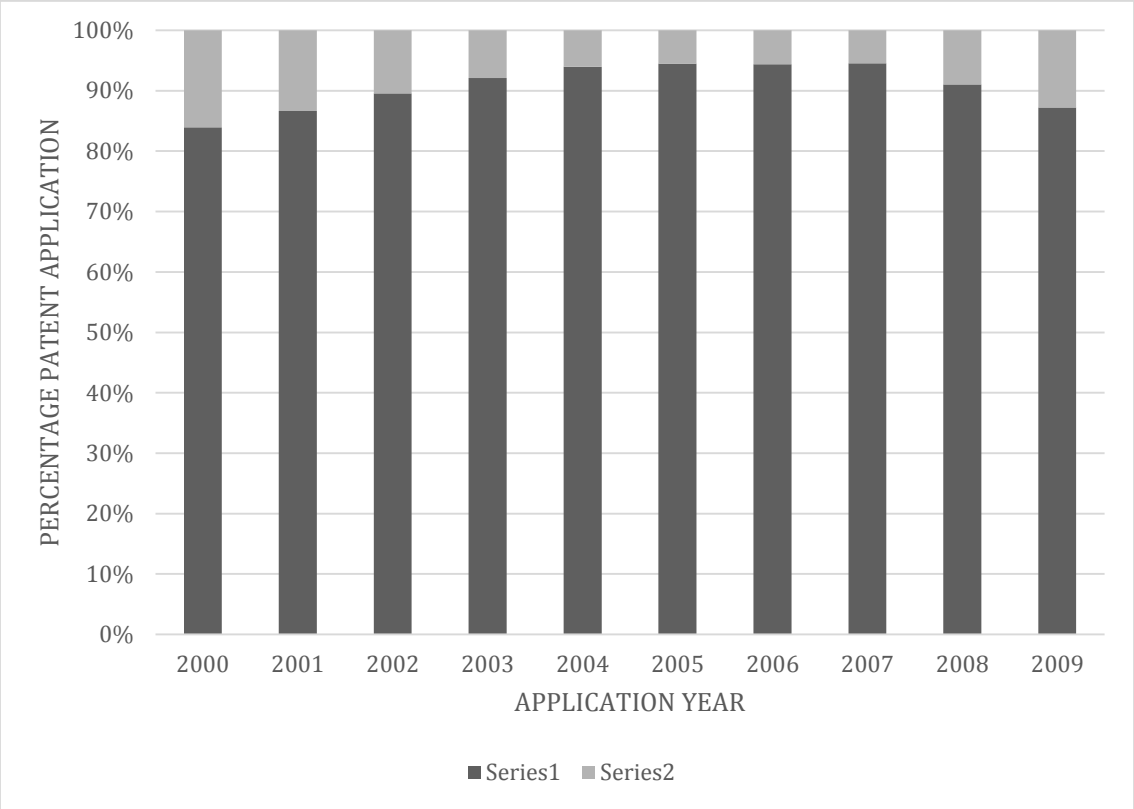

FIGURE 1 - Percentage of patent applications published and not published before grant– Granted patents up to 2010.

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
NPL	468,556	4.001	12.01	0	0	163
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	1.561	1.650	0	0	88.87
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
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
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 (B1)
[b] Not-published patents (B2)

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)
(1)	DV	1																										
(2)	CORWD_COMPLEX	-0.02	1																									
(3)	DI_COMPLEX	0.07	0.13	1																								
(4)	RAD_COMPLEX	0.09	0.21	0.11	1																							
(5)	SELF_COMPLEX	**0**	-0.05	0.1	0.02	1																						
(6)	SELF_DISCRETE	-0.01	-0.1	-0.13	-0.16	-0.06	1																					
(7)	CROWD_DISCRETE	-0.04	-0.15	-0.2	-0.24	-0.09	0.1	1																				
(8)	DI_DISCRETE	-0.02	-0.14	-0.19	-0.23	-0.09	0.23	0.27	1																			
(9)	RAD_DISCRETE	-0.04	-0.21	-0.28	-0.35	-0.13	0.24	0.5	0.35	1																		
(10)	COMPLEX	0.05	0.31	0.4	0.49	0.19	-0.33	-0.49	-0.46	-0.7	1																	
(11)	DISCRETE	-0.06	-0.27	-0.36	-0.44	-0.16	0.37	0.55	0.52	0.79	-0.88	1																
(12)	RADICALNESS	0.07	0.05	-0.11	0.76	-0.08	-0.03	0.05	-0.03	0.24	-0.05	0.01	1															
(13)	DI	0.05	0.02	0.78	-0.06	0.03	0.01	-0.02	0.44	-0.06	0.04	-0.02	-0.11	1														
(14)	CROWD	-0.04	0.82	-0.01	0.03	-0.1	-0.05	0.37	**0**	0.05	-0.05	0.02	0.08	**0**	1													
(15)	SELF_BACK	-0.01	-0.09	0.02	-0.06	0.88	0.4	-0.04	0.02	-0.01	0	0.01	-0.09	0.03	-0.12	1												
(16)	FOREIGN (PIFO)	0.01	-0.04	0.02	-0.03	0.01	0.03	**0**	0.03	**0**	-0.01	0.02	-0.04	0.03	-0.04	0.02	1											
(17)	NUMASSIGNEES	-0.03	0.08	-0.02	-0.03	-0.02	-0.01	0.08	0.02	0.02	-0.03	0.04	-0.02	**0**	0.11	-0.03	0.03	1										
(18)	DOM	0.17	0.17	0.02	0.06	-0.07	-0.02	0.11	0.04	0.07	-0.08	0.06	0.12	0.05	0.24	-0.07	-0.22	-0.08	1									
(19)	SINGLETONE	0.22	0.09	0.08	0.06	-0.01	-0.01	0.03	0.03	**0**	0	0	0.07	0.1	0.1	-0.01	-0.03	-0.04	0.38	1								
(20)	BASICR	0	-0.04	-0.04	-0.06	-0.02	0.01	0.02	0.09	0.08	-0.11	0.13	-0.01	0.01	-0.03	-0.01	0.04	0.01	0.06	0.05	1							
(21)	ORIG	-0.05	0.14	-0.14	0.32	-0.09	-0.01	0.13	0.04	0.18	-0.13	0.13	0.46	-0.1	0.2	-0.09	0	0	0.08	0.01	**0**	1						
(22)	CLAIMS	0.07	0.14	0.02	0.04	-0.03	-0.02	0.06	-0.01	-0.01	0.01	-0.01	0.04	0.02	0.17	-0.04	-0.01	-0.03	0.21	0.09	0	0.06	1					
(23)	NPL	-0.03	0.3	-0.05	-0.06	-0.05	0.02	0.29	0.16	0.14	-0.17	0.19	0.01	0.05	0.44	-0.04	0.04	0.02	0.16	0.11	0.35	0.14	0.12	1				
(24)	PATSCOPE	-0.14	-0.01	-0.33	-0.14	-0.06	0.05	0.15	0.06	0.11	-0.2	0.22	-0.09	-0.28	0.07	-0.03	0.05	0.04	-0.08	-0.1	0.1	0.29	-0.01	0.14	1			
(25)	SIZE	-0.17	-0.12	0.01	0.01	0.1	-0.01	-0.11	-0.09	-0.08	0.13	-0.11	-0.05	-0.05	-0.19	0.08	-0.17	0.06	-0.31	-0.19	-0.08	-0.05	-0.18	-0.21	-0.02	1		
(26)	HHI	-0.07	-0.05	-0.05	**0**	0.05	0.02	-0.04	-0.05	-0.01	0.01	-0.04	0	-0.07	-0.05	0.06	0.01	0.06	-0.19	-0.13	-0.06	0	-0.09	-0.11	0.04	0.34	1	
(27)	TOTAL	-0.15	-0.06	0.12	-0.01	0.14	-0.03	-0.14	-0.12	-0.14	0.21	-0.18	-0.12	0.02	-0.15	0.11	-0.05	0.06	-0.28	-0.07	-0.05	-0.07	-0.13	-0.12	-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	(3) LPM
CROWD	-0.000695***	-0.000623***	
	(0.000077)	(0.000064)	
SELF_BACK	0.045136**	0.035587*	
	(0.015870)	(0.015796)	
RAD	0.044507***	0.051743***	
	(0.006396)	(0.006668)	
DI	0.004460***	0.001168+	
	(0.000760)	(0.000633)	
CROWD_COMPLEX			-0.000757***
			(0.000095)
DI_COMPLEX			0.004291***
			(0.000827)
RAD_COMPLEX			0.047721***
			(0.006801)
SELF_COMPLEX			0.037957*
			(0.015887)
SELF_DISCRETE			0.071770**
			(0.023648)
CROWD_DISCRETE			-0.000441***
			(0.000059)
DI_DISCRETE			0.003898*
			(0.001570)
RAD_DISCRETE			0.016641**
			(0.006166)
CONTROLS		Included	
APP YEAR FE	Included	Included	Included
FIRM FE	Included	Included	Included
Constant	0.022590+	0.031556	0.027211*
	(0.011706)	(0.023015)	(0.011668)
Observations	468,554	468,510	468,554
R-squared	0.328584	0.341101	0.328551

Robust standard errors in parentheses. Standard errors are cluster by industry (three-digit SIC code) 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	(3) LPM
CROWD	-0.000864***	-0.000659***	
	(0.000110)	(0.000092)	
SELF_BACK	0.026727	0.019426	
	(0.017937)	(0.017825)	
RAD	0.063875***	0.077561***	
	(0.008528)	(0.008744)	
DI	0.005490***	0.002153*	
	(0.001150)	(0.000975)	
CROWD_COMPLEX			-0.000961***
			(0.000137)
DI_COMPLEX			0.005376***
			(0.001401)
RAD_COMPLEX			0.067276***
			(0.009154)
SELF_COMPLEX			0.017783
			(0.017791)
SELF_DISCRETE			0.060177+
			(0.031039)
CROWD_DISCRETE			-0.000477***
			(0.000078)
DI_DISCRETE			0.004107*
			(0.001972)
RAD_DISCRETE			0.015252
			(0.009685)
CONTROLS		Included	
APP YEAR FE	Included	Included	Included
FIRM FE	Included	Included	Included
Constant	0.022349+	0.092715*	0.108895***
	(0.013555)	(0.039085)	(0.014618)
Observations	216,289	216,259	216,289
R-squared	0.417225	0.424030	0.422824

Robust standard errors in parentheses. Standard errors are cluster by industry (three-digit SIC code) 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

VARIABLES	(1) LPM	(2) LPM	(3) LPM	(4) LPM
RADICALNESS	0.044892***	0.051942***	0.044622***	0.051774***
	(0.006414)	(0.006670)	(0.006398)	(0.006666)
DI	0.004424***	0.001163+	0.004438***	0.001168+
	(0.000762)	(0.000635)	(0.000762)	(0.000634)
CROWD	-0.000696***	-0.000624***	-0.000696***	-0.000624***
	(0.000077)	(0.000065)	(0.000077)	(0.000065)
SELF_BACK	0.045387**	0.035709*	0.045438**	0.035650*
	(0.015828)	(0.015765)	(0.015824)	(0.015766)
COMPLEX	0.006538*	0.002781		
	(0.003038)	(0.002909)		
DISCRETE			-0.006001+	-0.001126
			(0.003130)	(0.003095)
CONTROLS		Included		Included
APP YEAR FE	Included	Included	Included	Included
FIRM FE	Included	Included	Included	Included
Constant	0.019161+	0.029985	0.025546*	0.032060
	(0.011534)	(0.022940)	(0.011861)	(0.022951)
Observations	468,554	468,510	468,554	468,510
R-squared	0.328629	0.341109	0.328614	0.341102

Robust standard errors in parentheses. Standard errors are cluster by industry (three-digit SIC code) 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). Singleton Patents – Subsample.

VARIABLES	(1) LPM	(2) LPM	(3) LPM	(4) LPM
RADICALNESS	0.064583***	0.077991***	0.064055***	0.077692***
	(0.008536)	(0.008758)	(0.008506)	(0.008733)
DI	0.005426***	0.002138*	0.005433***	0.002145*
	(0.001150)	(0.000978)	(0.001152)	(0.000978)
CROWD	-0.000866***	-0.000662***	-0.000866***	-0.000662***
	(0.000110)	(0.000093)	(0.000110)	(0.000093)
SELF_BACK	0.027035	0.019600	0.027267	0.019693
	(0.017957)	(0.017826)	(0.017939)	(0.017814)
COMPLEX	0.013862**	0.006825		
	(0.005260)	(0.004923)		
DISCRETE			-0.017321**	-0.007748
			(0.005649)	(0.005213)
CONTROLS		Included		Included
APP YEAR FE	Included	Included	Included	Included
FIRM FE	Included	Included	Included	Included
Constant	0.022018	0.092442*	0.039548**	0.100223*
	(0.013525)	(0.039022)	(0.014984)	(0.039603)
Observations	216,289	216,259	216,289	216,259
R-squared	0.417327	0.424055	0.417349	0.424055