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Individual Inventors and Market Potentials: Evidence from US Patents

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Abstract

This paper examines the commercialization propensities of individual inventors' patents. Exploiting a peculiarity of the US patent system, concerning patent renewal fees in order to obtain small or large entity status, we are able to distinguish patents that become part of a large corporation's patent portfolio. Using an extensive dataset of US patents, both for domestic and foreign individual inventors, we find that patent characteristics, size of research teams, prior experience and past corporate patenting activity are positively associated with increased likelihood of transferring patent rights to large corporations.

Keywords: individual inventor, patents, market transactions, patent renewals, large entity status

JEL classification: O31, O32

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1. Introduction

An "invention" is defined as the activity directed toward the discovery of new useful knowledge about products and processes, as described by Smookler (1957) and it is most frequently protected by the use of patents which grant exclusive rights to the owner of the invention for a limited time in exchange for full disclosure. Users of this type of Intellectual Property (IP) can be corporations, small businesses, nonprofit organizations and even more individual or independent inventors.[1]

Governments, mainly, and nonprofit organizations have developed programs to promote innovation by individuals, as their inventive performance is a perennial issue of policy interest. They provide consulting and evaluation services to inventors who want to transfer their inventions to the marketplace. Asterbo and Gerchak (2001), in a case study of the Canadian Innovation Centre and its Inventor's Assistance Program, found significant social benefits in consulting independent inventors on how they can best manage and/or commercialize their inventions. However, such programs are not always successful. Spear (2006), for example, indicates that the National Research Development Corporation (NRDC) in the UK had low success rates in independent inventors' patent commercialization.[2]

The objective of this paper is to examine commercialization and market potential of individual inventors' patented inventions. In particular, we are interested in how the patent's characteristics, the size of the research team, the prior patenting experience of the inventor, the inventor's previous corporate ties, as well as some state macroeconomic factors are associated with commercialization of inventor owned

[1]According to the United States Patent and Trademark Office (USPTO), an independent inventor is defined as one whose patent at the time of grant is unassigned (i.e., patent rights are held by the inventor) or assigned to an individual:
(http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cbcby_in.html).

[2] NRDC started in 1948 to help inventors in UK transform inventions into innovations. For an in-depth analysis of the program see Crawley (1993) and Lavington (2011).

US patents. Although, it is difficult to observe commercialization, we infer to this concept in this study by exploiting a particular facet of the US patent system, namely switches from Small Entity Status (SES) to Large Entity Status (LES) for renewal fee purposes.

We find that approximately twelve percent of individual inventors' patents have switched to LES. In addition, the patent characteristics, such as citations, claims and application length, are positively associated with the likelihood of a patent to be commercialized to a large corporation. Furthermore, we discover that the size of the inventive team is a positive indicator of commercial potential, a result that coincides with Singh and Fleming (2010) who show that patent quality is on average higher from research teams' than single inventors' efforts. Prior patenting experience is also positively related with commercialization. Moreover, patents, where at least one inventor has prior corporate ties, have higher probability of being commercialized, a result that agrees with findings of Lawson and Sterzi (2013), where they have indicated that such patents are of higher quality, approximated by more forward citations. All of the above mentioned results are similar across the location of the inventor and technology fields.

This study contributes to the literature of commercialization of individual inventors' technological advancements by employing patent-level data contrary to the vast majority of scholarly work that has relied on primarily survey based evidence. For instance, for surveys in the US, see Weick and Eakin (2005) and Wilkins *et al* (2008), in Canada, see Amesse *et al* (1991) and Dagenais *et al* (1991), in Sweden, see Ejermo and Gabrielsson (2007) and Braunerhjelm and Svensson, (2010) and in Italy, see Schettino *et al* (2013) among others. To our knowledge, this is the first study that uses such an extended dataset of individual inventors' patents, combining information from several sources and examining patent's characteristics' in the propensity of transferring patented inventions to the marketplace.

The paper is organized as follows. Section two describes the concept of commercialization by individual inventors and how it is approximated. Section three presents the econometric specification and describes how the data is constructed. Section four outlines the data and empirical results, whereas the final section concludes.

2. Commercialization

There are two different ways for an individual inventor to achieve commercialization. He can either develop the invention to an end user product/service in-house or to license (and/or sell) the invention to a third part, usually to an established firm; see Braunerhjelm and Svensson (2010). The former is considered as an internal (direct) while the latter as an external (non-direct) method of commercialization; see O' Connor and Hewitt-Dundas (2013).

We infer commercialization activity to large corporations from publicly available data, based on the following procedure. In the United States Patent and Trademark Office (USPTO) a patent applicant pays renewal fees in order to maintain the enforceability of a US patent. Individuals, small business and nonprofit organizations are defined as "small entities" in the code of federal register regulation.[3] Patents issued to one of those entities have the right to pay SES fees, which are approximately half the fees of LES. Transfer of right (such as sale and licensing) to a large corporation of a certain patent drives to loss of SES and leads to mandatory

[3] For further information see 37 U.S.C.§1.27 "Definition of small entities and establishing as small entity to permit payment of small entity fees; when a determination of…loss of entitlement to small entity status are required; fraud on the office.".

payment of LES fees for that particular patent. This switch from SES to LES implies commercialization to a large corporation.

It should be noted that this method of identifying commercialization does not imply that all other patents were not profitable for their owners since there may be a group within the set of patents, which never switched to LES, but still were profitable. However, our methodology captures the three main outcomes of individual inventors commercialization goals, which are either license/sell their patented inventions to a large corporation in exchange of large compensations or grow their innovative startups to an Initial Public Offering (IPO) or acquisition by a large corporation (Meyer, 2005). In other words, we capture the individual inventors' patents that made it 'big'.

The truth is that renewal data has been extensively used to infer the private economic value of patents, since the pioneer work of Pakes (1986) and Schankerman and Pakes (1986), whereas Bessen (2008) and Liu *et al* (2008) were the first to examine renewal data of US patents. Furthermore, Bessen (2008) and Rassenfosse & van Pottelsberghe (2012) have also explicitly accounted for whether the patent fees paid correspond to large or small entity status, but their sole motivation was to infer the economic value of patents in money-metric variables and did not focus on switches from SES to LES and what that might indicate.

3. Empirical Specification and Data

3.1. Empirical Specification

The likelihood of a certain patent switching to LES can be described by a probit model defined as follows:

$$\text{Prob}(\text{LES} = 1|X_i) = \Phi(X_i\beta) \qquad (1.1)$$

where the endogenous variable LES takes the value 1, if patent *i*, has paid LES fees during its patent life, and 0 otherwise; Φ is the standard normal cumulative distribution function and X_i is a set of covariates defined as:

$$X_i\beta = \beta_0 + \beta_1 Citations_i + \beta_2 Scope_i + \beta_3 Inventors_i + \beta_4 PastPatExperience_i + \beta_5 PriorTies_i + \beta_6 StateCharacteristics_i + \beta_7 GrantYear_i + \varepsilon_i$$

where $\varepsilon \sim N(0, 1)$. The set of variables $Citations_i$ for patent i includes the variables $ForwCites_i$, which is the number of patent citations patent *i* receives by 2010, the variable $BackCitesPat_i$, which is the number of citations patent *i* makes to the patent literature and the variable $BackCitesSci_i$, which is the number of citations patent *i* makes to the scientific literature. The set of variables $Scope_i$ includes the number of claims, $Claims_i$, the application length, $AppLength_i$ and technology fields dummies $TechnologyDummy_i$. For the last variable, each patent *i* is assigned to a broad technology field according to its primary US Classification per Hall *et al* (2001). As there are 37 broad technology fields, the number of technology field dummies is 36 to avoid the dummy variable trap.

The set of variables $Inventors_i$ capture the collaborations of individuals. $InventorLow_i$ takes the value of 1 when there is only one inventor in patent *i* and 0 otherwise. $InventorMed_i$ takes the value of 1, if there are two inventors in patent *i* and 0 otherwise. $InventorHigh_i$ takes the value of 1, if there are more than two inventors in patent *i* and 0 otherwise. As before, to avoid the dummy variable trap, we exclude $InventorLow_i$.

The past patenting experience of the inventors of a certain patent is denoted as *PastPatExperience*$_i$, which is a set of four dummies. *PastPatsNo*$_i$ takes the value of 1, if all inventors in the patent have no previous patenting experience and 0 otherwise. *PastPatsLow*$_i$ takes the value of 1, if at least one inventor in the patent has previously one patent as an inventor and 0 otherwise. *PastPatsMed*$_i$ takes the value of 1, if at least one inventor in the patent has between 2 and 9 past patents and 0 otherwise. *PastPatsHigh*$_i$ takes the value of 1, if at least one inventor in the patent has 10 or more past patents and 0 otherwise. *PastPatsNo*$_i$ is not included in the estimation.

PriorTies$_i$ is a set of two variables which capture whether the inventor has had any patents under a corporation or a university: *PastCorp*$_i$ takes the value of 1, if at least one inventor of the patent was an inventor in a previous patent that was owned by a corporation and 0 otherwise, whereas *PastUniv*$_i$ takes the value of 1, if at least one inventor of the patent was an inventor in a previous patent that was owned by a university and 0 otherwise.

StateCharacteristics$_i$ is a set of two dummies that control for state characteristics: *StateHigh*$_i$ takes the value of 1, if the lead inventor of patent *i* is located in a state that has produced the year that patent *i* was granted more than a thousand patents and 0 otherwise and *ShareTechState*$_i$ is the share of the technology field that the patent *i* belongs to, at the grant year in the specific state and takes values between 0 and 100. These two dummy variables are similarly constructed at the country level for foreign inventors. *GrantYear*$_i$ is a set of dummies that captures the year that patent *i* was granted. Table 1 includes the definitions of all variables used in the present paper.

3.2. Data Construction

Our first source of data is the Patent Data Project, sponsored by the National Bureau of Economics Research (NBER), hereafter NBER dataset, in which all patents are categorized by assignee type.[4] The sample of interest includes all patents that are assigned to a "US individual" or "Foreign individual" or are unassigned, which means that they are owned by the patent inventors, and are issued between 1990 and 2000. Overall, we obtain 197,407 inventor-owned patents.

From the NBER dataset we obtained directly information concerning the dummy variables *TechnologyDummy* and *GrantYear*. In addition, from the same data set we constructed the variables *ShareTechState*, since the location information for each patent assignee was available as well as the variable *StateHigh*, since we were able to calculate the number of patents for each state or country per year. The variables *ForwCites*, *BackCitesPat*, *BackCitesSci*, *Claims*, and *AppLength* are obtained from Lai *et al* (2011). More importantly, in this dataset, the authors have disambiguated inventor names and have assigned a unique identifier to each inventor. Using this information we are able to acquire information for *PastPatExperience* variables. To construct *PriorTies* we combine information from both NBER and the dataset by Lai *et al* (2011). From the latter, we obtain the inventor's patenting activity and from the former we identify which prior patents were owned by corporations or universities.

Next, we obtain information about recorded maintenance fee events for the above patents from Google Bulk downloads, a dataset maintained weekly by USPTO.[5] The event codes in this dataset enable us to distinguish for these patents whether SES or LES fees have been paid. If LES fees have been paid for a patent, we

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[4] https://sites.google.com/site/patentdataproject/
[5] http://www.google.com/googlebooks/uspto-patents-maintenance-fees.html

consider this observation as an indication for successful technology transfer to a large corporation. Specifically, according to the Code of Federal Regulations (37 CFR §1.27 paragraph a(1)) an individual is entitled in paying SES fees as long as he/she has ".... not assigned, granted, conveyed, or licensed, and is under no obligation under contract or law to assign, grant, convey, or license, any rights in the invention".[6] Note that this regulation applies to each individual patent. Hence, an inventor with more than one patent may pay LES fees for some and SES fees for others depending on their commercial status.

Failure to comply with the above regulations, i.e., not pay LES fees when required, will deem the patent invalid and therefore the rate of compliance is likely to be very high. On the contrary, while there could be inventors that pay LES fees, even though they do not have to do so, this is not very likely, since SES fees are approximately half of the LES fees and therefore inventors have significant incentive to take advantage of this regulation. Even though there are still cases where there may be noise in the data any faulty renewal payments are most likely random and therefore will not bias our results.

4. Empirical Results

4.1. Descriptive Statistics

Before we get into the empirical analysis, it is worthwhile to present some interesting aspects of the dataset. First, as can be seen from Figure 1, the share of inventor owned patents issued per year in the US during the period 1990-2000 remains roughly constant at the range of 15% of the total number of patents. In

[6] We should note that the regulation further states that an inventor "… who has transferred some rights in the invention to one or more parties… can also qualify for small entity status if all the parties who have had rights in the invention transferred to them also qualify for small entity status either as a person, small business concern, or nonprofit organization". In other words if an inventor transfers any rights or licenses the patent another Small Entity, then the owner can still pay SES fees.

addition, the share of inventor owned patents issued per year in the US during the same period that switched to LES for renewal purposes ranges from 11% to 13%, as can be seen from Figure 2. Overall, out of 197,407 individual inventors' patents, 23,871 (12%) switched their status to LES, as Table 2 depicts.

In particular, Table 2 displays the share of patents switching to LES according to six major technological fields. Computer patents have the highest likelihood (25%) of switching to LES followed by Drugs, Chemicals and Electronics. Contrary, Mechanicals and Other technology fields have the lowest likelihoods of switching to LES, even though these technological fields have the highest number of inventor owned patents. Perhaps, one possible explanation for observing this low propensity of switching to LES for Mechanicals is the fact that this technological field relies on consulting as the main tool for technology transfer (see for example Elfenbein 2007).

In addition, Table 2 distinguishes the share of inventor owned patents for each technological field according to the location of the inventors by considering two groups of patents, i.e., first when all inventors are within the US (domestic) and second when all inventors reside outside the US (foreign).[7] Foreign inventors' patents have higher commercialization rates than domestic inventors on average, i.e., 16.8% versus 10.6% respectively. Given this difference, which seems to be significant, we will analyze these two groups separately. Although, it is not intuitive why this difference is observed, perhaps one possible explanation is the fact that some foreign inventors are not aware of the SES and LES renewal schemes.[8] However, this large difference cannot be wholly attributed to faulty payments and probably indicates that

[7] We have already excluded from the analysis 1,316 patents for which at least one inventor is within the US and at least one is located outside the US. Results for this group are qualitatively similar to the results displayed in the paper and therefore excluded from the analysis for brevity.

[8] For instance, the European Patent Office has only a single payment scheme.

foreign inventors' patents are more likely to be commercialized via a large corporation than domestic inventors' patents.

Table 3 presents the summary statistics for the variables of interest decomposing by type of inventor and renewal status. First and foremost we observe that *ForwCites* are higher in the case of patents that switched to LES. This finding is consistent with literature which has used forward citations to approximate patent quality (see Trajtenberg 1990), private economic value (see Harhoff *et al* 1999) and firm's market value (see Hall *et al* 2005). Similar behavior is observed for *BackCitesPat*, *BackCitesSci*, *Claims* and *AppLength*. These variables have also been used to approximate patent quality; even though such metrics have been shown to be noisy (see Harhoff *et al*, 2003 and Bessen, 2008). Note that for all the above patent metrics, differences between commercialized and non-commercialized patents are bigger in the case of domestic than foreign inventors' patents. This observation could support the previous reasoning that a group of foreign inventors may not be aware of the renewal schemes and therefore pay LES fees even though they do not have to.

Patents that have switched to LES are more likely to have more than two inventors as *InventorMed* and *InventorHigh* show. For instance 18% of domestic inventors' patents that switch to LES have more than two inventors, while only 3% of patents that do not have more than two inventors. Similar results are also obtained when examining foreign inventors' patents. These observations are consistent with Singh and Fleming (2010) where they found that the more valuable patents are likely to be a product of inventor collaboration. With respect to inventor's previous patenting experience, a variable that has been used as a proxy for inventor skill (see Conti *et al*, 2010), we observe that patents that switch to LES are more likely to have inventors that have had significant patenting experience. In particular, 68% of domestic inventors' patents that switch to LES have at least one inventor that has more than one prior patent, while the perspective percentage of patents that do not switch is only 31%. Similar behavior is observed for foreign inventors' patents. Furthermore, patents that switch to LES are more likely to have inventors that have a previous patent under a corporation or under a university.

Finally, with respect to the US state or the country profile that the lead inventor is located, we examine whether the size and the type of activity are associated with the likelihood of switching to LES. For domestic inventors, we observe 75% of patents that switch to LES have the lead inventor located in a state with more than a thousand patents annually, while 70% of those that do not, whereas the difference is considerably bigger when examining countries for the foreign inventors' patents; 74% versus 61% respectively. Further, for patents that switch to LES the lead inventor is located in a state that on average has 19% of the patents in the same broad technology field as the focal patent; the percentage for patents that do not switch to LES is slightly higher at 21%. Overall, we observe that state characteristics do not seem to be associated significantly with patents that have switched to LES. However, the size of the inventive activity of the country seems to make a difference when examining foreign inventors' patents.

4.2. Probit Results

Having examined descriptively all the aforementioned characteristics, the next step is to study their relationships simultaneously. Table 4 reports the results of probit estimations that declare marginal effects estimated at the means of the variables for domestic inventors' patents, as shown in Columns 1-3, and for foreign inventors' patents, as shown in Columns 4-6. In particular, from Column 1, which includes all domestic inventors' patents, we observe that all patent characteristics, such as *ForwCites*, *BackCites*, *BackCitesSci*, *Claims* and *AppLength*, have a positive and statistically significant relationship with patents switching to LES. These findings are consistent with previous studies that have shown that these metrics can be used as proxies for patent value, see for example Harhoff *et al* (2003) and Bessen (2008).

We also observe from the coefficients of *InventorMed* and *InvetorHigh* that the bigger the group of inventors in a patent the higher the likelihood of a patent switching to LES. That means that, keeping all other variables at their means, a patent with two inventors is 3.3 percentage units more likely to switch to LES than a patent with just one inventor, whereas a patent with more than two inventors is 13.8 percentage units more likely to switch to LES than a patent with just one inventor. This finding is consistent with both Singh and Fleming (2010) and Schettino *et al* (2013) that found that inventors who work in teams produce patents that are of higher quality.

With respect to past patenting experience, patents with inventors with prior experience are more likely to switch to LES, as can be seen from the estimates of the coefficients of *PastPats* variables. Specifically, patents, where at least one inventor has one prior patent, are 3.2 percentage units more likely to switch to LES than patents where no inventor has a prior patent. Similarly, patents that at least one inventor has two or more than two prior patents are 5.4 and 10.4 percentage units respectively to switch to LES than patents where no inventor has a prior patent. This finding is also consistent with the studies of Amesse *et al* (1991) and Harison & Koski (2009) among others. Moreover, patents where the inventor had a patent under a corporation are 6.7 percentage units more likely to switch to LES. This finding shows that prior corporate ties are important and is consistent with Lawson and Sterzi

(2013) where they found that prior corporate ties are associated with patents of higher quality as that approximated by more forward citations. We do not find statistical significance relationship with inventors that had a patent under a university.

Furthermore, patents where their lead inventors are located in highly innovative states are more likely to switch to LES than patents which the lead inventors are located in less innovative states, even though the difference is virtually zero (i.e. 0.6 percentage units difference). With respect to *ShareTechState* we observe that holding all variables at their means, a ten percentage unit increase in *ShareTechState* increases the likelihood of switching to LES by 0.8 percentage units. Overall, the aforementioned state characteristics where the lead inventor is located do not seem to be substantial.

Column 2 of Table 4 excludes patents where their inventors have little to none prior patenting experience. In particular, we only consider patents for which at least one inventor has strictly more than one patent and the results remain similar to Column 1 indicating that the above findings are not driven just by the cases where inventors have little to no prior patenting experience. Column 3 checks for the robustness of the results for outliers by dropping patents where at least one inventor has more than twenty prior past patents. As previously, results remain qualitatively similar.

Column 4 examines the above relationships in the context of foreign inventors. The patent characteristics, as before, are positively associated with the propensity of switching to LES. The results with respect to the size of the research team, past patenting experience and prior ties, are by and large similar with the results of the domestic inventors' patents. A different result arises when exploring the patenting activity of the country that the lead inventors is located. Specifically, a patent for which the lead inventor is located in a country that produces more than a thousand patents annually it is five percentage units more likely to switch to LES than a patent for which the lead inventor is not located in such an innovative country. This result is in contrast with the domestic inventors' patents where the state's innovative activity did not have a sizeable relationship with commercialization potential and it implies that while the location of domestic inventors may play little role in commercialization after controlling for other factors, for foreign inventors it is important to be located within a country that is highly innovative. Although, it is difficult, with the data at hand, to identify large corporations that acquire or license the patents, the above finding denotes that for foreign inventors' patents, most likely candidates are firms within the same country as the lead inventor.

To obtain robustness for the previous results we perform similar estimations as in the case of foreign inventors' patents. Column 5 of Table 4 considers only patents where at least one inventor has more than one patent while Column 6 excludes patents for which at least one inventor has more than twenty patents. The results remain similar as before.

Finally, we examine how the aforementioned results vary by technology fields without distinguishing domestic versus foreign inventors, since we did not find any earmarked differences, and the results of this estimation process are reported in Table 5. First of all, *ForwCites* are positively associated with the propensity of switching to LES across all technology fields, as well as other patent characteristics with the exception of *BackCitesSci* which is not significant. Second, with respect to the size of the research team, we observe that a larger group of inventors is associated with higher propensity of switching to LES for all technology fields. The smallest coefficient is observed in Others and the largest in Chemicals and Computers. In terms of past patenting experience, the positive relationship still holds for all technology fields. However, the largest positive relationship is by far in the case of Drugs, indicating that past patenting experience is more necessary in this field to commercialize an individual inventors' patent than all other fields. When examining prior ties, we observe as before that those patents with inventors that had previous patents, under corporate assignees, have higher likelihood of switching to LES regardless of technology field. Patents in the Computers technology field with prior corporate ties have the highest likelihood of switching to LES.

Overall our results show that patent characteristics are important predictors of a patent switching to LES. The size of research team and prior experience are positively associated with the likelihood of commercialization to large corporations. In contrast to prior university patenting experience, prior corporate patenting experience is also a positive and significant indicator of successful transfer of a patent. Results are similar for both domestic and foreign inventors as well as across different technology fields. Finally, only country level, and not state, innovative activity makes a difference when considering the market potential of individual inventor's patent.

5. Conclusions

Individuals have diachronically contributed in many great inventions. Some characteristic examples are: Guglielmo Marconi who invented the radio, Alexander Fleming who discovered the famous antibiotic penicillin and Thomas Edison who invented the long lasting electric light bulb. As Gorman and Carlson (1990) noted, inventors are creative people that succeed in expressing mental ideas tangibly. In fact, the contribution of individual inventors' activity to the overall innovation output has well been documented in the literature. As a result, scholars have examined in depth the pathways and determinants of the commercialization of such independent inventions. Further, policies in many countries have been set to promote individual inventors' patenting and commercialization activity.

This paper considers all individual inventors' US patents between 1990-2000 and examines the factors that are associated with commercialization by large corporations. In particular, it exploits a peculiarity of the US patent system regarding the two different schemes of maintenance fee payments. Patentees are obliged to pay renewal fees at 3.5, 7.5 and 11.5 years after issuance for each patent to stay in force. Individual inventors have the right to pay Small Entity Status fees for a patent they own as long they have not transferred, licensed or conveyed any rights of that particular patent to a corporation that is concerned as a Large Entity. If they do, then they are obligated to pay LES fees for that particular patent. For this reason, we employ this observation to infer commercialization activity to large corporations.

Our results show that for both domestic and foreign inventors' patent characteristics, including forward citations, are positively associated with the likelihood of switching to LES, whereas the likelihood of commercialization also increases by the size of the inventive team. Past patent experience on prior corporate ties are also positively associated with the likelihood of switching to LES. One difference that is observed between domestic and foreign inventors' patents is in the inventive activity of the state/country the inventors are located in. In the case of domestic inventors' patents, the state's inventive activity is not significantly associated with the likelihood of commercialization, whereas in the case of foreign inventors' patents, the inventive activity of a country is positively and significantly associated with the likelihood of switching to LES. This finding most likely indicates possible cooperation of inventors with firms from the same country. Lastly, all the above results are similar across technology fields with subtle but noteworthy differences for past patenting experience and prior corporate ties.

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Figure 1. Total number of patents and inventor-owned patents per year

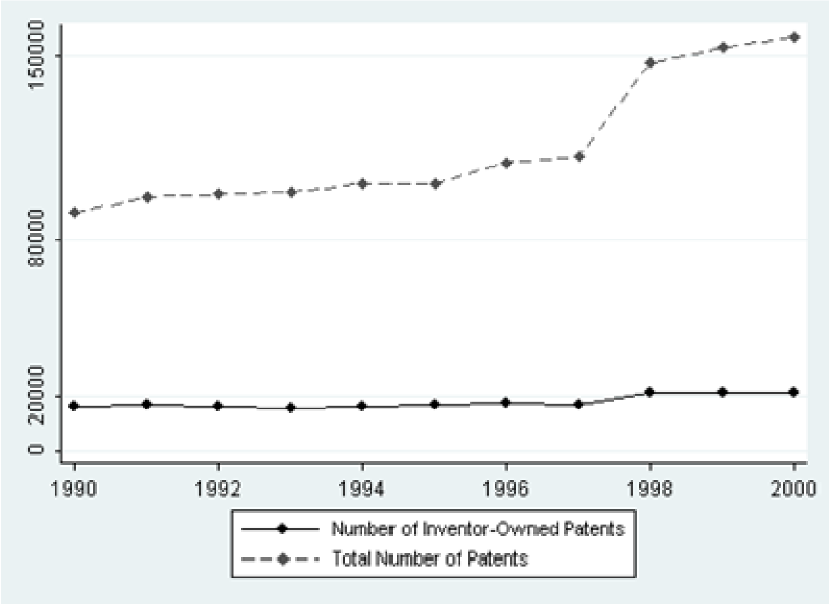

Figure 2. Share of inventor-owned patents that switch to LES for renewal purposes by grant year

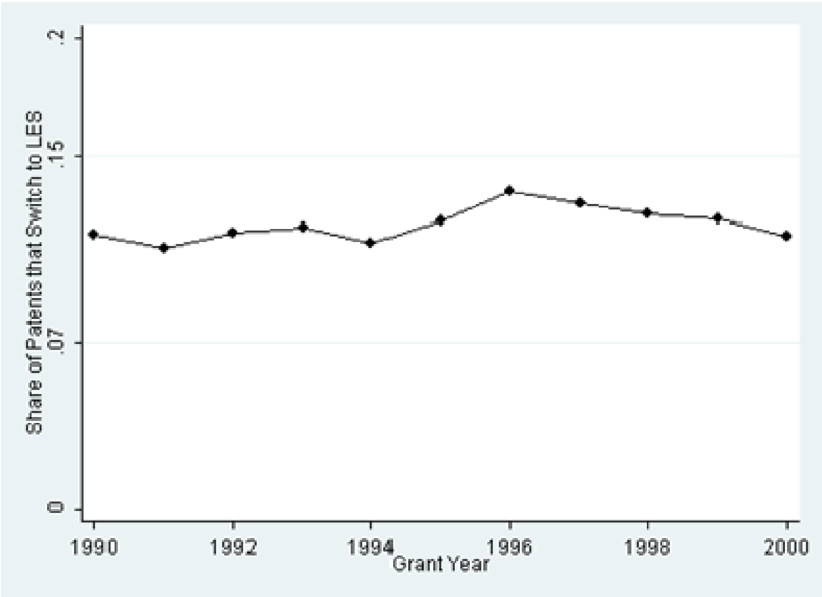

Table 1: Definition of the Variables

VARIABLES	Definition
Citations	A set variable including: *ForwCites, BackCitesPat, BackCitesSci*
ForwCites	The number of patent citations patent *i* receives by 2010
BackCitesPat	The number of patent citations patent *i* makes
BackCitesSci	The number of citations to the scientific literature patent *i* makes
Scope	A set variable including: *Claims, AppLength, TechnologyDummy*
Claims	The number of claims
AppLength	The application length
TechnologyDummy	The technology fields dummies
Inventors	A set variable including: *InventorsLow, InventorsMed, InventorsHigh*
InventorsLow	Dummy variable that takes value 1 when there is only one inventor in patent *i* and 0 otherwise
InventorsMed	Dummy variable that takes value 1 if there aretwo inventor in patent *i* and 0 otherwise
InventorsHigh	Dummy variable that takes value 1 if there are more than two inventors in patent *i* and 0 otherwise
PastPatExperience	A set variable that denotes the past patenting experience of a certain patent's inventors including: *PastPatsNo, PastPatsLow, PastPatsMed, PastPatsHigh*
PastPatsNo	Dummy variable that takes value 1 if all inventors in the patent have no previous patenting experience and 0 otherwise
PastPatsLow	Dummy variable that takes value 1 if at least one inventor in the patent has one past patent and 0 otherwise
PastPatsMed	Dummy variable that takes value 1 if at least one inventor in the patent has between 2 and 9 past patents and 0 otherwise
PastPatsHigh	Dummy variable that takes value 1 if at least one inventor in the patent has 10 or more past patents and 0 otherwise

PriorTies	A set variable including: *PastCorp*, *PastUniv*
PastCorp	Dummy variable that takes value 1 if at least on inventor of the patent was an inventor in a previous patent that was owned by a corporation and 0 otherwise
PastUniv	Dummy variable that takes value 1 if at least one inventor of the patent was an inventor in a previous patent that was owned by a university and 0 otherwise
StateCharacteristics	A set variable that controls for state's/country's characteristics including: *StateHigh*, *ShareTechState*
StateHigh	Dummy variable that takes value 1 if the lead inventor of patent *i* is located in a state/country that has produced the year that patent *i* was granted more than a thousand patents and 0 otherwise
ShareTechState	The share of the technology field that the patent *i* belongs to, at the grant year in the specific state/country and takes values between 0 and 100
GrantYear	A set variable of dummies that captures the year that patent *i* was granted

Table 2: Allocation of Individual Inventors' Patents by Technology Field

	Total Number of Patents	Switch to LES	Switch to LES (%)	Domestic Inventors' Patents	Domestic Switch to LES	Switch to LES (%)	Foreign Inventors' Patents	Foreign Switch to LES	Switch to LES (%)
Chemical	16,934	3,307	19.53	12,039	2,064	17.14	4,895	1,243	25.39
Computers	11,984	3,003	25.06	9,495	2,251	23.71	2,489	752	30.21
Drugs	21,665	4,416	20.38	17,243	3,272	18.98	4,422	1,144	25.87
Electronics	18,854	3,475	18.43	13,227	2,323	17.56	5,627	1,152	20.47
Mechanical	45,470	4,304	9.47	33,683	2,629	7.81	11,787	1,675	14.21
Others	82,500	5,366	6.50	65,000	3,470	5.34	17,500	1,896	10.83
Observations	197,407	23,871	12.09	150,687	16,009	10.62	46,720	7,862	16.83

Table 3: Summary Statistics of Independent Inventors' Patents by LES

	Domestic Inventors' Patents 150,687			Foreign Inventors' Patents 46,720		
	No LES *134,678*	LES *16,009*	p-value	No LES *38,858*	LES *7,862*	p-value
ForwCites	7.65	13.93	0.00	6.13	8.24	0.00
	(0.03)	(0.20)		(0.05)	(0.17)	
BackCitesPat	9.48	13.11	0.00	6.43	6.93	0.00
	(0.02)	(0.13)		(0.03)	(0.08)	
BackCitesSci	0.74	3.08	0.00	0.45	1.50	0.00
	(0.01)	(0.10)		(0.02)	(0.07)	
Claims	12.58	17.56	0.00	9.77	12.93	0.00
	(0.03)	(0.12)		(0.04)	(0.11)	
AppLength	1.72	2.02	0.00	1.72	2.00	0.00
	(0.002)	(0.01)		(0.003)	(0.02)	
InventorsLow	0.81	0.60	0.00	0.84	0.59	0.00
	(0.001)	(0.004)		(0.001)	(0.01)	
InventorsMed	0.15	0.23	0.00	0.12	0.21	0.00
	(0.001)	(0.003)		(0.001)	(0.004)	
InventorsHigh	0.03	0.18	0.00	0.04	0.20	0.00
	(0.0005)	(0.003)		(0.001)	(0.004)	
PastPatsNo	0.56	0.21	0.00	0.59	0.34	0.00
	(0.001)	(0.003)		(0.002)	(0.005)	
PastPatsLow	0.13	0.11	0.00	0.13	0.12	0.02
	(0.001)	(0.002)		(0.001)	(0.004)	
PastPatsMed	0.22	0.38	0.00	0.21	0.31	0.00
	(0.001)	(0.004)		(0.002)	(0.01)	
PastPatsHigh	0.09	0.30	0.00	0.07	0.22	0.00
	(0.001)	(0.004)		(0.001)	(0.005)	
PastCorp	0.18	0.57	0.00	0.15	0.45	0.00
	(0.001)	(0.004)		(0.001)	(0.006)	
PastUniv	0.03	0.09	0.00	0.02	0.06	0.00
	(0.0004)	(0.002)		(0.001)	(0.003)	
StateHigh	0.70	0.75	0.00	0.61	0.74	0.00
	(0.001)	(0.003)		(0.002)	(0.005)	
ShareTechState	0.21	0.19	0.00	0.19	0.19	0.63
	(0.0002)	(0.001)		(0.004)	(0.001)	

Notes: Numbers in parentheses are standard errors

Table 4: Probit Estimations for Domestic and Foreign Inventors' Patents

VARIABLES	Domestic Inventors' Patents: All Patents	Domestic Inventors' Patents: No Low/Med Patents	Domestic Inventors' Patents: No Outliers	Foreign Inventors' Patents: All Patents	Foreign Inventors' Patents: No Low/Med Patents	Foreign Inventors' Patents: No Outliers
ForwCites	0.0009***	0.002***	0.0008***	0.002***	0.003***	0.001***
	(4.85e-05)	(0.0001)	(4.72e-05)	(0.0002)	(0.0004)	(0.0001)
BackCitesPat	0.001***	0.003***	0.001***	0.0009***	0.002***	0.001***
	(8.62e-05)	(0.0002)	(8.12e-05)	(0.0003)	(0.0006)	(0.0003)
BackCitesSci	0.0008***	0.001***	0.0007***	0.001***	0.0007	0.001**
	(0.0002)	(0.0003)	(0.0002)	(0.0005)	(0.0006)	(0.0004)
Claims	0.001***	0.002***	0.001***	0.002***	0.002***	0.002***
	(6.10e-05)	(0.0001)	(6.10e-05)	(0.0002)	(0.0004)	(0.0002)
AppLength	0.0048***	0.0078***	0.004***	0.0180***	0.0162***	0.0183***
	(0.0008)	(0.0018)	(0.0007)	(0.0021)	(0.0044)	(0.0021)
InventorsMed	0.0328***	0.0617***	0.0331***	0.0681***	0.0967***	0.0668***
	(0.0021)	(0.0048)	(0.0020)	(0.0054)	(0.0110)	(0.0054)
InventorsHigh	0.138***	0.239***	0.126***	0.191***	0.257***	0.184***
	(0.0048)	(0.0078)	(0.0049)	(0.0094)	(0.0143)	(0.0097)
PastPatsLow	0.0315***		0.0283***	0.0162***		0.0154***
	(0.0027)		(0.0025)	(0.0055)		(0.0053)
PastPatsMed	0.0542***		0.0481***	0.0287***		0.0276***
	(0.0025)		(0.0024)	(0.0052)		(0.0051)
PastPatsHigh	0.104***	0.0594***	0.0885***	0.100***	0.0875***	0.0731***
	(0.0042)	(0.0040)	(0.0048)	(0.0088)	(0.0087)	(0.0101)
PastCorp	0.0667***	0.0957***	0.0679***	0.115***	0.146***	0.110***
	(0.0025)	(0.0036)	(0.0026)	(0.0064)	(0.0079)	(0.0067)
PastUniv	-0.0023	-0.0112*	0.0015	0.0188*	0.0429***	0.0112
	(0.0031)	(0.0061)	(0.0034)	(0.0104)	(0.0156)	(0.0111)
StateHigh	0.0064***	0.0116***	0.0054***	0.0498***	0.0658***	0.0478***
	(0.0015)	(0.0039)	(0.0014)	(0.0036)	(0.0084)	(0.0035)
ShareTechState	0.0008***	0.002***	0.0006***	0.0002	-0.0002	0.00036*
	(9.29e-05)	(0.0002)	(9.13e-05)	(0.0002)	(0.0004)	(0.0002)
Observations	150,687	52,786	143,223	46,720	15,176	44,625

Notes: All columns report probit estimates (marginal effects). In all estimations time variables (*GrantYear*) and technology field dummies (*TechnologyDummy*) are included but for brevity not reported here. Heteroskedastic robust standard errors are reported in parentheses.

Table 5: Individual Inventors' Patents by Technology Field

VARIABLES	Chemicals	Computers	Drugs	Electronics	Mechanical	Others
ForwCites	0.002***	0.001***	0.002***	0.0009***	0.001***	0.0009***
	(0.0003)	(0.0002)	(0.0001)	(0.0002)	(0.0001)	(7.74e-05)
BackCitesPat	0.0005	0.001***	0.002***	0.0008**	0.001***	0.0007***
	(0.0003)	(0.0004)	(0.0003)	(0.0004)	(0.0001)	(0.0001)
BackCitesSci	0.002***	0.004***	0.001***	0.001	-0.0001	0.0005
	(0.0006)	(0.0007)	(0.0003)	(0.0008)	(0.0006)	(0.0006)
Claims	0.002***	0.001***	0.002***	0.002***	0.0007***	0.00109***
	(0.0003)	(0.0003)	(0.0002)	(0.0003)	(0.0001)	(7.74e-05)
AppLength	0.0135***	0.0124***	0.0165***	0.0058**	0.0046***	0.0079***
	(0.0029)	(0.0034)	(0.0028)	(0.0022)	(0.0016)	(0.0009)
InventorsMed	0.0917***	0.0975***	0.0306***	0.0755***	0.0333***	0.0229***
	(0.0086)	(0.0111)	(0.0073)	(0.0083)	(0.0041)	(0.0024)
InventorsHigh	0.265***	0.269***	0.177***	0.240***	0.139***	0.105***
	(0.0136)	(0.0166)	(0.0122)	(0.0146)	(0.0101)	(0.0068)
PastPatsLow	0.0135	-0.0054	0.0355***	0.0152	0.0260***	0.0232***
	(0.0107)	(0.0133)	(0.0098)	(0.0098)	(0.0047)	(0.0029)
PastPatsMed	0.0353***	0.0180	0.0768***	0.0122	0.0465***	0.0400***
	(0.0098)	(0.0130)	(0.0084)	(0.0086)	(0.0043)	(0.0028)
PastPatsHigh	0.0727***	0.0769***	0.178***	0.0730***	0.105***	0.0803***
	(0.0134)	(0.0178)	(0.0125)	(0.0120)	(0.0077)	(0.0057)
PastCorp	0.137***	0.188***	0.0883***	0.155***	0.0579***	0.0492***
	(0.0096)	(0.0135)	(0.0082)	(0.0093)	(0.0046)	(0.0033)
PastUniv	-0.0212**	0.0250	-0.0184*	0.0231*	0.0098	0.0090
	(0.0105)	(0.0203)	(0.0095)	(0.0124)	(0.0086)	(0.0063)
StateHigh	0.0236***	0.0181*	-0.0027	0.0306***	0.0212***	-0.0097***
	(0.0064)	(0.0102)	(0.0062)	(0.0059)	(0.0025)	(0.0019)
ShareTechState	0.0028***	0.0023***	0.0024***	-0.00095***	0.0025***	-0.0015***
	(0.0004)	(0.0006)	(0.0005)	(0.0003)	(0.0002)	(0.0001)
Observations	16,934	11,984	21,665	18,854	45,470	82,500

All columns report probit estimates (marginal effects). In all estimations time variables (*GrantYear*) and technology field dummies (*TechnologyDummy*) are included but for brevity not reported here. Heteroskedastically robust standard errors are reported in parentheses.