Using the Patent Term Changes in Assessing the Evolution of Patent Valuation from Filing to Maturity

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Abstract

We argue that the patent term change introduced in TRIPS in the US inadvertently offered a metric of self-valuation of patents at the time of filing, affirming the ability of Drugs and Chemical patents to offer greater R&D incentives than other technology fields. As renewals also offer a metric of self-valuation, we find that upon renewal Computer patents are found to offer greater R&D incentives than Drugs and Chemicals. We inquire as to why Computer patents are considered as more valuable in the post grant period, even though they were not considered as valuable upon filing. We advance the idea that patents can increase in value if encompassed in a patent portfolio.

Keywords: patent portfolios, patent renewals, R&D incentives, technology transfer policy, TRIPS.

JEL Classification: O31, O32, O33, O34

1. Introduction

Patents, or *literae patentae* (open grants) as originally known, are public documents that disclose the particulars of an innovation. In terms of a territorial metaphor, one can think of patents as property deeds that demarcate a technological territory. Such demarcation allows for frictionless tech-transfer because licensor and licensee have at hand a chart of the technology. When too many patents accumulate, as is the present case of affairs, the technology's borders can become foggy because numerous neighbouring patentees may own overlapping technologies. So what was once a technology with a clearly attached value to it becomes an uncertain asset, in which case tech-transfer is plagued by higher transaction costs as only courts can demarcate the innovation's borders. Effectively what was assumed as an open grant can become a quasi *literac clausae* (close grant) until such demarcation takes place.

How to avoid such conversion has stirred up a policy debate on how to evade patent overpopulation; see Correa (2014). Since policy makers must have an appreciation of the usefulness of patents as R&D incentives before contemplating policy exercises, and considering that the only evidence comes from surveys, we revisit the issue. Survey data are limited to the extent that agents are revealing their true priors and only their actions can act as revelation mechanisms. In this paper we use a quasi-natural experiment that reveals their priors at the point of filing a patent.

The quasi-natural experiment we use involves the introduction of the Trade Related Aspects of Intellectual Property Rights (TRIPS) agreement in the US. Before TRIPS the USPTO granted patents for 17 years from the grant date of the patent. By implementing TRIPS the USPTO changed its practice, granting patents with a patent length equal to 20 years since the original patent filing date. In order to facilitate this change, the USPTO (unexpectedly) allowed applicants who filed prior to June 8th

1995 a patent length that was equal to the maximum of the two regimes. Since on average a patent spends at least three years in prosecution at the USPTO, applicants that filed before the deadline were given a possible small extension of patent length.

If a patent embodies an industrial application (as patents are obliged to by law – in the US the patentability requirement is for utility), and its per-period value can be mundanely calculated, then any opportunity of extending one's monopoly tenure must be seized. If the patent is filed for reasons unrelated to the certitude of the embodied technology, its uses must be harder to blueprint prior to being issued, and its value uncertain. Assuming otherwise can only imply that the golden stamp of the patent document can attach an *a priori* certified value to a set of irrelevant technical claims; a free lunch no doubt.[1] Thus, in the latter case, the present value of a possible tenure extension (of a few weeks/months) must be harder to pinpoint in advance.

An innovator who is constrained in terms of her patent filing volume (and must prioritise her patenting) should be inclined to file the patents considered as more valuable first. Having to choose between a patent whose value is hard to pinpoint in advance and one of known technical quality, she should rationally opt for the latter. Ergo, the introduction of TRIPS, by inadvertently offering a possible extension of patent term created a metric of patent self-valuation. The metric is simple: *patents encompassing valuable technologies must be given priority and filed before the deadline*.

In view of this metric, we acquire information for all utility patents that were filed around June 8th 1995 for the following technology fields: Chemicals, Computers & Communications, Drugs & Medical, Electrical & Electronics, and Mechanicals. Our data is both at the industry level and the firm level, and it includes continuing

[1] If such a free lunch existed it would rent trade secrets obsolete.

applications that were filed prior to the deadline; these are applications that were originally filed prior to the unexpected regime change. The data indicates that Drugs & Medical patents, and Chemical patents, were significantly more likely to be filed before the deadline than patents in any other field. This result, which does not change at the firm level and when accounting for continuations, accords with survey evidence that finds patents as being more valuable (as incentives to innovate) to the pharmaceutical and chemical industry; see Cohen, Nelson and Walsh (2000).

This finding allows policy makers to examine the R&D incentivising capacity of patents along one dimension i.e. *which industry/firms values patents the most*. As our data includes renewal history, we also try to establish how industries/firms compare in the way they renew their patents. Such a comparison provides a time related dimension i.e. *how the R&D incentivising capacity of patents varies over time*. By examining renewals to maturity the above pattern reverses and patents in Computers & Communications are significantly more likely to be renewed. This summary statistic does not change at the firm level, nor when accounting for continuations.

In short, by following the same group of patents from filing to maturation, we add a time dimension to value of patents as incentives to innovate. At the point of filing the quasi-natural experiment has self-revealed the preferences of the patentees, while renewals have provided a metric of self-valuation upon maturation. In this respect this exercise has revealed that the patent value of Computers & Communications patents increases through time, while that of Drugs & Medical and Chemical patents drops.

Commentators have provided many candidate explanations for this discrepancy, e.g. inability to evaluate at the point of filing, the need for signaling or for reputation effects, and the necessity to comprehensively protect complex products. Starting with the latter, as electronics (contrasting drugs) become outdated within months, it is hard to explain the need to *en masse* renew the technologies of an obsolete product. Signaling and reputation effects must be crossed out because our results remain valid at the firm level, in which case it is illogical to assume that pharmaceutical firms are not in need of additional reputation, nor of a way to signal their value. Equally, inability to assess value is groundless on account of the success of this industry.

We contribute to the above discussion by offering an alternative explanation related to the increasingly commonplace build up of patent portfolios: *patents increase in value if encompassed in a portfolio*. Such portfolios are bundles of patents whose means to an end lays in their strength in numbers.[2] As Lanjouw and Schankerman (2004) note, when a patent is added to a portfolio the cost of defending any patent in the bundle against infringement allegations decreases. To rephrase, a patent is regarded as the additional foot-soldier who aids the firm, arm-in-arm, in defending its technological territory and in fulfilling its strategic goal. This logic suggests that within a portfolio a patent has two uses, the traditional one involving its stand-alone technological value, and a collective one that rests on how well the patent's claims allow the portfolio to jointly fulfil its purpose. Consequently, unless the two uses coincide, the reasons for renewal may not be restricted to the technological merits of an individual patent. In which case, it should not come as a surprise that patents from the Computers & Communications industry, known for its inordinate patent portfolios, are more likely to be renewed than filed.

The paper continues as follows. In section two we provide a literature review, the main facts surrounding this quasi-natural experiment and we formulate our main hypothesis. In section three we elaborate on the data that we use in testing our

[2] For example, Nokia and Samsung each hold at least 30,000 patents related to their core technologies.

hypothesis, in section four. In section five we focus on renewals by using the same methodology that we outline in section four. Section six concludes.

2. A review of the main facts and literature

It is recognized that in the absence of some form of protection, technology becomes a public good, diminishing incentives to innovate. Accordingly, society grants, via patents, limited monopolies that can allow the innovator to claim back her R&D cost; see Nordhaus (1969). As a result, countries around the world have founded institutions that deal with granting and monitoring patents. While the strength of patents varies significantly by country, there is a slow but stable increase in patent strength across most countries (Park 2008, Papageorgiadis *et al*. 2014). This trend shows the importance that countries are placing to a comprehensive and sound patent system.

Even though the intuition behind patents is straightforward, the reasons why firms use patents remain elusive. For instance, it is understood that patents act as incentives to innovate for the pharmaceutical and chemical industry only. Specifically, survey evidence from firm managers shows that in all other industries, firms value first mover advantage, trade secrets and technological superiority far more than patents as incentives to innovate; see Cohen, Nelson and Walsh (2000), Graham *et al*. (2009).

In further uncovering the role of patents as incentives to innovate researchers have turned their attention to patent renewals. Since renewing a patent implies a pecuniary cost, firms that choose to renew their patents must consider these patents as value-adding instruments. Therefore, renewals (which take place at 3.5 years, 7.5 years and 11.5 years) can provide us with information about the R&D incentivising capacity of patents that is based on actual decisions, and not on survey evidence. However, what renewal studies lack is a perception of the patent's value at the time of filling. Therefore, a shortfall of renewal studies is that the metric they employ in assessing the value of patents as incentives to innovate is their post filling value.

Somewhat puzzling, and in contrast to the aforementioned survey evidence, renewal studies suggest that pharmaceutical and chemical patents are not the most valuable ones. For instance, Schankerman (1998) using French patent renewal data and employing a renewal options model found that mechanical and electronics patents are more valuable than pharmaceutical and chemical patents. Bessen (2008) found that US patents in computers and communication are more likely to be renewed to full term than pharmaceutical patents. A recent paper by Deng (2011) seems to confirm the above findings as he shows that Electronics patents are more valuable than Pharmaceutical patents evident by their respective renewal decisions.

The difference in methodology allows this paper to earmark the puzzle. At the point of filling, drugs and medical patents are perceived as having a greater value as R&D incentives, while at the point of renewal computers and communication patents are considered as being more valuable. Accordingly, the puzzle is not if computers and communications patents are more valuable or not, the real puzzle is: *why do we see an increase in their post filing value*?

We propose that managerial practice can account for this increase. In terms of managerial practice, Kortum and Lerner (1997) where the first to examine how changes in innovation management affect patenting. They argued that patent-managers realized that patents can have uses beyond the ones involved in licensing/commercialization of the invention. For example, often via the amassing of large portfolios, patents can be employed in holding rivals hostage by controlling valuable technology. This portfolio based strategy has been identified by Cohen, Nelson and Walsh (2000), Jell and Henkel (2010), and Boldrin and Levine (2013).

To elaborate the point, firms use patent portfolios for “patent mining” purposes, for so called “defensive” purposes, and in order to influence standard setting and patent pool negotiations. Patent mining refers to laying a minefield of patents for the unaware patentee to tread on, allowing the portfolio holder to aggressively assert her patent rights. This is a strategy that is frequently followed by the non-practicing entities that are euphemistically known as patent trolls; see Hagiu and Yoffie (2013). Moreover, since the production of complex products often requires unhindered access to the technologies of others, firms use portfolios in facilitating tech-transferring negotiations by avoiding been held hostage by firms who hold key patents. Such a use is termed a defensive one as it allows the firm to defend its product from unwarranted infringement allegations. Furthermore, in terms of standards and patent pools, by purposefully employing a portfolio’s patent mining capacity -or defensive capacity, firms can try to influence the future evolution of a technology.[4]

In terms of the quasi-natural experiment, we make use of a policy change, the introduction of the TRIPS agreement. The TRIPS agreement is an international agreement that sets down minimum standards for many forms of intellectual property (IP). The relevant Act was signed by the president on December 8, 1994 and the patent term change that is central to our argument came in effect in June 8, 1995. Prior to the introduction of TRIPS, in the US the length of the patent privilege was 17 years from the grant date. However, TRIPS necessitated a change in how patent length is calculated. Specifically, the length of a patent became equal to 20 years since the original patent application’s date. In order to accommodate this regime change the

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[4] Jaffe and Lerner (2011), outline the case of RAMBUS Inc, and the way it used its patents as to profit from a forthcoming industry standard.

USPTO decided that patents filed before June 8th 1995 would receive as patent length the maximum of the two regimes. In other words, it gave a grace period to patent applicants of maximum potential patent life conditioned that they would file before June 8th. Patent applicants took this grace period seriously into account. The number of patent applications increased dramatically in May of 1995 and the first days of June leading up to June 8th, plummeting afterwards (Figures 1 and 2).

However the number of patent applications can be misleading and may not represent new filings. This is because it accounts for continuing patent applications. In detail, in the US, there are two main classes of patent applications: original applications and continuing applications. Continuing patent applications are used to revise claims, or to add/subtract subject matter to the original application; see Quillen and Webster (2001), and Quillen, Webster and Eichman (2002). The original patent application date of a continuing application is the application date of the original application which the continuing application claims priority over.

Continuing patent applications create a measurement issue. To start with, both the original application and the continuing application may be awarded a patent. Furthermore, it is understood that such applications are on average more privately valuable than original patent applications; see Liu *et al.* (2008). Thus, by accounting for continuing applications we account for valuable technologies for which the decision to patent was taken irrespectively of the law change.

Practitioners during that period were advising applicants to *"file prior to June the 8th, as many continuations, continuations-in-part or divisional applications as you plan to file in the future"*; see Voet, Berman and Gerardi (1995). As it can be seen from Figure 1 (which shows the number of patent applications filed by corporations from 1994 to 1996, and breaks this number down to original applications and continuing applications) applicants took note. Nonetheless, as Figure 1 shows, while the increase for continuing applications was more pronounced, there was still a sizeable increase for original applications as well. To illustrate the increase of patent applications leading to the June 7th deadline, we plot in Figure 2 the number of patent applications that were filed per day in June 1995. It seems that 10% of all successful patent applications that were filed in 1995 were filed on just one day, namely June the 7th. To further illustrate this dramatic increase, we plot the number of applications for June of 1994 and 1996 in the same figure; for these years no such change is apparent. From the above, it is obvious that patent applicants took the law change into account.

We employ this event to examine for which patents applicants were more responsive, i.e. for which technology fields the motivation to file prior to the change was greater. As we outlined in the introduction, responsiveness to this policy change creates a self-valuating metric of the patent's value and of its ability to incentivize innovation. On account of the above we form the following hypothesis.

Hypothesis: *firms that attach value to the technology should be more likely to take advantage of the policy change*.

Before concluding, while not the focus of the paper, it is noteworthy to mention the recent policy change in the US; the Leahy–Smith America Invents Act where its central provisions came in effect on September 16, 2012 and on March 16, 2013; for a full discussion of the provisions see Armitage (2012). One of the main changes was the shift from first-to-invent to first-inventor-to-file system to align with the majority of patent offices around the world. Scholars have argued that this shift may have negative effects on the incentives to innovate of small firms and inventors as they do not have the resources to quickly file for patent application to claim priority. Further large corporations are better equipped in filing for patent applications within a short time window; for references on the debate and the case of Canada see Lo and Sutthiphisal (2009) and Miyagiwa (2015). We contribute to this discussion by stressing that any effects from this shift will vary significantly across technology fields and any policy recommendation should take the technology dimension into consideration.

3. Data

Our primary source of information comes from the NBER patent data project.[5] A key feature of this dataset is that it classifies patent assignees (owners) displayed in the patent document wrapper in specific categories, e.g. corporations, universities, individuals. Initially, we identified all patents assigned to corporations that were filed for in 1995; through this method we collected 110,455 corporate owned patents filed in 1995 that were issued until 2000.[6] Based on the NBER patent data project, we categorize each patent in a broad technology field: Chemicals (CHEM), Computers and Communications (COMP), Drugs and Medical (DRUG), Electrical and Electronics (ELEC), Mechanical (MECH) and Others (OTHE). This NBER classification relies on the patent's primary US classification in assigning a patent to one of the above fields; see Hall *et al*. (2001).

[5] https://sites.google.com/site/patentdataproject/Home

[6] While there are patents filed in 1995 and granted after 2000, we cannot observe the full maintenance history for these later patents. Indicatively, between 2001 and 2006 there are an additional 2,943 patents issued that were filed in 1995. However, this is just a 2.6% of the entire sample. Including these patents wherever applicable does not alter any of the results.

In addition to the NBER patent data project, we collected renewal information from Google Bulk Downloads[7]. We should note that the USPTO requires patents to be renewed after three and a half years, seven and a half years, and eleven and a half years respectively. Thus, as we accessed the Google Bulk Downloads dataset on March 1st 2013, we have the full renewal history for patents which have been issued up to 2000. Finally, information on whether the patent stems from a continuing application and its original filing date was extracted from the patent document wrapper.

Our main interest is to examine filing behavior for these patents, focusing on the filing behavior around the event date (June 8th). For this reason, we focus on a symmetric 20-week window around June 8th; for robustness we later also consider a smaller window of 10 weeks. Specifically, we consider patents that were filed between April 1st 1995 and August 19th 1995. Overall, 50,996 patents were filed during this period; unless otherwise stated, this latter sample is our sample of analysis. Of these patents, 28,292 (55.5%) patents stem from original patents while 44.5% from continuing applications. The high portion of continuing applications is consistent with findings from Hegde *et al*. (2009), who found that the greatest peak of continuing applications occurred right before the law change. Further, note that 19.2% (9,785) of the sample are CHEM patents, 20.2% (10,327) COMP, 15.4% (7,851) DRUG, 17.7% (9,052) ELEC, 14.6% (7,424) MECH and 12.9% (6,557) OTHE.

Figure 3 shows the percentage of patents that were filed before and after June 8th by technology field by distinguishing whether they were stemming from original or continuing applications. For original applications, we observe that 68% of DRUG patents and 61% of CHEM patents are filed before the event. For comparison, just

[7] http://www.google.com/googlebooks/uspto-patents-maintenance-fees.html

57% of ELEC patents, and 56% of COMP and MECH patents were filed before the event. A similar story emerges when examining continuing applications. Specifically, the incentive to file before the change is higher for DRUG and CHEM patents. Comparing by technology field, we observe that 93% of DRUG patents, 89% of CHEM patents and 84% of COMP patents are filed before the deadline. This increase in filings is not surprising, since the incentive to file a continuing application prior to the law change was higher than original applications as they were standing to gain more patent life if filed before June 8th.

Shifting our attention to renewals, Figure 4 shows the renewal rates of patents filed by technology field within the aforesaid 20-week window by distinguishing between original and continuing applications. Consistent with prior studies and our framework, COMP patents are more likely to be renewed to full maturity than DRUG and CHEM patents. Specifically, 63% of COMP patents and 57% of ELEC patents renewed in all three maintenance fee events, i.e. at 3.5 years, 7.5 years and 11.5 years. By contrast, only 52% of DRUG patents, 48% of CHEM patents, 46% of MECH patents and 45% of OTHE are renewed to full maturity. When examining continuing applications, we first observe that they are more likely to be renewed compared to patents stemming from original applications, a finding consistent with Liu *et al*. (2008). Second, the differences by technology field are consistent with the original patents.

As quality and complexity must play a role in filing prior to the change (or in renewing), we include certain patent characteristics that approximate quality and complexity as covariates in the econometric specification. In detail, we consider variables whose definitions are displayed in Table A1 and summary statistics in Table A2 of the appendix. Table A2 shows summary statistics for this sample of patents by distinguishing whether patent were filed before or after June 8th and whether they stem from original or continuing applications.

From these variables, *BackCitesPat*, *BackCitesNonPat*, *ForwCites*, and *Claims*are are used in approximating the quality and *Numb4DigitIP*, *Numb3DigitUSClass*, and *AppLength* the complexity of the patent (Lerner 1994, Harhoff *et al*. 2003, and Bessen 2008).

4. Econometric Setup

We first test the hypothesis via our baseline estimation. In this estimation we consider the patent as the observation unit. To provide robustness, we then shift our focus from the patent and consider each firm as the observation unit (Section 4.2). Finally, within this section we outline the results to be able to readily compare with results in the following section; i.e. Section 5. In this latter Section we consider the same estimation methods and design by simply replacing our dependent variable with renewal decisions instead of filing decisions.

4.1. Testing the Hypothesis

We have formulated our Hypothesis as follows: *firms that attach value to the technology should be more likely to take advantage of the policy change*. To test this Hypothesis we examine for which of the 50,996 patents, and in which fields, it was more likely for patent applicants to file before the law came in effect than others. Given the aforementioned substantial incentive for continuing patent applications we separate these two groups of patents.

We consider each patent as a separate observation unit and examine whether patent *i* was filed either before or after the law change. Given this binary decision, the appropriate model should explicitly encompass this aspect. The baseline regression is:

$$(1) \qquad Prob(FileBefore_i = 1/X_i'\beta) = \Phi(X_i'\beta),$$

where:

$$X_i'\beta = a_0 + a_1 CHEM_i + a_2 COMP_i + a_3 DRUG_i + a_4 ELEC_i + a_5 MECH_i + \gamma Z_i + \varepsilon_i.$$

In (1), our discrete variable $FileBefore_i$ takes the value of 1 if patent was filed before June 8th and 0 if filed on or after June 8th. Therefore, as the dependent variable is binary, we pursue estimation of (1) via a probit model. A probit model is superior of a linear model as it is able to restrict the model predictions within the dependent variable's actual values. Another model used widely in such setting is the logit model. Results from a logit model are qualitatively similar to the ones presented here and are available upon request.

We run this regression for patents stemming directly from original applications and a separate regression for patents stemming from continuing patent applications. In the latter case we also include in the $X_i'\beta$ the variable *purgatory* as this variable is only applicable to patents stemming from continuing applications. As *purgatory* captures the difference in months between the continuing patent application's filing date and its original filing date, patents stemming from continuing patent applications for which *purgatory* is high carry a higher incentive to be filed before the law change. The reason is simple, having remained in purgatory for long they stand to lose significant patent life if filed afterwards.[8] Furthermore, Z_i includes the following covariates for patent *i*: *BackCitesPat*, *BackCitesNonPat*, *ForwCites*, *Claims*, *Numb4DigitIPC*, *Numb3DigitUSClass*, *AppLength.* Note that the coefficient a_1 yields the difference in likelihood of filing a CHEM patent versus an OTHE patent; a_2 yields the difference in likelihood of filing a COMP patent versus an OTHE patent; a_3 yields the difference in likelihood of filing a DRUG patent versus an OTHE patent; a_4 yields the difference in likelihood of filing an ELEC patent versus an OTHE patent; a_5 yields the difference in likelihood of filing a MECH patent versus an OTHE patent. Our focus is primarily on the difference in the probabilities of filing a DRUG patent versus a COMP prior the law change. Therefore, we expect $a_3 > a_2$ with the difference being statistically significant. In other words, we expect for DRUG patents to have a significantly higher likelihood to be filed before the law change than COMP patents.

As a last note, from Table A2, patents stemming from original applications filed before the change appear to have slightly more backward patent and non-patent citations than after the change; similarly for forward citations. The two groups are similar with respect to Claims, Number of US Classifications, Number of IPC Classification and *AppLength*. Results are similar when comparing before and after patents for continuing patent applications.

4.2. Robustness Specification

The above analysis focuses on patents and not firm behavior. In other words, we have examined the behavior of an applicant for each patent regardless if patents are

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[8]To illustrate this point, consider two independent continuing patents A and B. The original filing date of patent A is January 1st 1995 while for patent B, January 1st 1990. Assume that both will have an application length of 3 years. If patent A is filed prior the change, it will have 17 years of patent term; if filed after it will have approximately 16.5 years of patent life. The same calculations for patent B result to 17 and 11.5 years respectively. Thus, the incentive to file patent B before the law change is significantly higher than for patent A.

owned by the same firm or not. In this robustness test, we shift our focus to firm behavior by taking into account all patents for each firm. Simply put, in offering further validation for our argument, we examine the filing behavior of firms as to see if their behavior fits the pattern that we have identified.

We focus on patent applicants for whom most of their patents belong to the COMP and DRUG technology fields. In particular, we restrict our attention only on patents of firms that a) have applied for more than five patents within 1995 and b) more than 50% of the firm's patents are either COMP or DRUG patents. We classify a firm as *drug* firm if more than 50% of its patents are DRUG patents; respectively for *comp* firms.[9] To test our hypothesis we estimate the following regression:

$$(2) \qquad Prob\left(FileBefore_i = 1/X_i'\beta\right) = \Phi\left(X_i'\beta\right),$$

where, $X_i'\beta = a_0 + a_1 drug_i + \gamma Z_i + \varepsilon_i$ and Z_i is the same set of covariates as in (1).

From here to find support for our argument we expect $a_1 > 0$. In words, we expect for patents owned by *drug* firms to be more likely to be filed before the law change than patents owned by *comp* firms. As before, we estimate the above regression separately for patents stemming from original applications and patents stemming from continuing applications. In the case of patents stemming from continuing applications we include the variable *purgatory*. This regression is also estimated via a probit model.

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[9]Our sample naturally reduces considerably as we are left with 15,295 patents. 9,052 are classified in 253 *comp* firms and 6,243 in 407 *drug* firms.

4.3. Results

Table 1 tests our Hypothesis by displaying estimates from Equation (1). All Tables display marginal effects, estimated at the means of the variables. In detail, Column 1 considers patents originating from original applications. In this column, DRUG and CHEM patents are respectively 8.4 and 2.9 percentage units more likely to be filed before compared to OTHE patents. COMP, ELEC and MECH patents on the other hand are equally likely to be filed before as OTHE patents. Further, the difference between DRUG and these other technological fields is statistically significant at the one percent level. CHEM patents also have significantly higher likelihood than COMP, ELEC, MECH and OTHE patents.

Column 2 considers the patents originating from continuing applications. Here, all patents are more likely to be filed before than OTHE patents. However, DRUG patents still have the highest difference (7.5%) compared to COMP (2.2%). This difference between the DRUG and COMP coefficients is significant. The second highest difference from OTHE patents is again for CHEM patents. As before the difference between CHEM and COMP patents is statistically significant at the 1% level. The above results, indicating that DRUG and CHEM patents are more likely to be filed before the deadline, categorize these two fields as ones that use patents to protect valuable technologies.

To provide robustness of our results we consider a smaller window around June 8th. We consider a 10-week symmetric window ranging between May 1st 1995 and July 21st 1995. Accordingly, in terms of this 10-week window, and in a fashion similar to the above discussion, Column 3 considers patents stemming from original applications, while column 4 from continuing patent applications. The differences between DRUG or CHEM and in the rest of the fields for patents from original applications are even bigger, while for continuing applications the differences are qualitatively similar but they have reduced in absolute size. This latter finding confirms that the incentive for continuing applications to be filed before the law change is greater.

Table 2 considers firms that have more than 5 patents applied for during 1995 and more than 50% of their patent portfolio is compiled by DRUG or COMP patents. We examine their behavior for the 20-week window in columns 1 and 2. Column 1 considers patents stemming from original applications while Column 2 from continuing applications. Examining patents originating from original applications, a patent that belongs to a *drug* firm is 15.6 percentage units more likely to be filed before than a patent belonging to a *comp* firm. When examining patents stemming from continuing applications (Column 2) this difference is at 6.8 percentage units. These findings are consistent with the above, offering further confirmation to our Hypothesis. Columns 3 and 4 consider the smaller 10-week window and yield similar results as Columns 1 and 2.

5. Looking at Renewals

The above section has created a datum point that reveals how patentees (on average) value their patents at the time of filing. We now aim to create a second datum point that can allow for comparisons to be made. Specifically, by looking at renewals we examine how patentees (on average) value their patents in the post grant period; this is our second datum point. As we argue, the valuation of patents seems to change in the post grand period.

Accordingly, in this section we examine for which fields patents are more likely to be renewed to full maturity. We again consider the same 50,996 patents, distinguish whether they are stemming from original or continuing applications and we estimate the following probit regression for each group separately:

$$(3) \qquad Prob(FullMaturity_i = 1/X_i'\beta) = \Phi(X_i'\beta).$$

where (as before):

$X_i'\beta = a_0 + a_1 CHEM_i + a_2 COMP_i + a_3 DRUG_i + a_4 ELEC_i + a_5 MECH_i + \gamma Z_i + \varepsilon_i$ and Z_i is the same set of covariates as in (1).

FullMaturity takes the value of 1 if patent *i* is renewed at all maintenance event nodes (i.e. 3.5, 7.5 and 11.5 years after grant) and zero otherwise. The rest of the variables are defined as above. Coefficient a_1 yields the difference in likelihood of a CHEM patent renewed to full maturity versus an OTHE patent; a_2 yields the difference in likelihood of a COMP patent renewed to full maturity versus an OTHE patent; a_3 yields the difference in likelihood of a DRUG patent renewed to full maturity versus an OTHE patent; a_4 yields the difference in likelihood a MECH patent renewed to full maturity versus an OTHE patent; a_5 yields the difference in likelihood of a MECH patent renewed to full maturity versus an OTHE patent. As above, we are primarily interested in the difference between DRUG and COMP patents but now we expect $a_2 > a_3$, with the difference being statistically significant. In other words, we expect for COMP patents to be renewed to full maturity more frequently than DRUG patents.

In terms of a robustness check we examine the renewal behavior at the firm level for COMP and DRUG patents. In doing so, we follow the exact methodology that we have outlined in section 4.2.

5.1. Results

We now consider the renewal behavior from the firm's standpoint. As before we focus only on *drug* and *comp* firms. Table 4 displays the results. When considering patents stemming from original applications (Column 1), we observe that patents from *drug* firms are 9.5 percentage units less likely to be renewed to full term than patents that are assigned to *comp* firms. In terms of patents stemming from continuing applications (Column 2), as expected, the difference is still significant but notably smaller (i.e. a little over than three percentage units). Columns 3 and 4 consider patents within the smaller 10-week window and results are qualitatively similar as in Columns 1 and 2.

Overall, we see a reversal in the pattern. Specifically, while COMP and ELEC patents are more likely to be renewed to maturity, they are less likely to be filed prior to the deadline (compared to DRUG and CHEM). This reversal is predicted by our theoretical argument. Specifically, we argued that if a patent is included in a patent portfolio its value can increase. Therefore, even though a patent may have been judged to be of little stand alone value at the point of filling, upon renewal its value may have increased, in which case it is renewed.

6. Conclusions

Before tackling patent proliferation, policy makers must first acquire the facts that will allow them to differentiate between technology fields. To do so they need clarifications along two dimensions: technology-space and time. They need an understanding as to the industries that value patents as R&D incentives the most, and how does this valuation change over time. This is the purpose of this paper.

We employ a quasi-natural experiment, the introduction of TRIPS in the US, which allows patentees to self-valuate their technologies at the point of filling. By following a single group of patents from filing to maturation we find that this self-valuation changes through time. At the point of filing drugs and medical patents, along with chemicals, are recognized as being more valuable as R&D incentives. At renewal, its computer and communications patents that are recognized as more valuable. We argue that this inconsistency may be the indirect result of patent proliferation and that it can be explained by the use of patent portfolios, because they have the capacity to attach to a patent value that is unrelated to its industrial application.

The evident policy proposal stemming from our study is that policy makers that aim to tackle patent proliferation should not focus their attention to individual patents. Instead, they should target policies towards patent portfolios, because they provide the means of endowing patents with the extra weight that makes filing and renewing irrelevant patents worthwhile.

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Figure 1. Number of patents that were filed in 1995 by corporations.

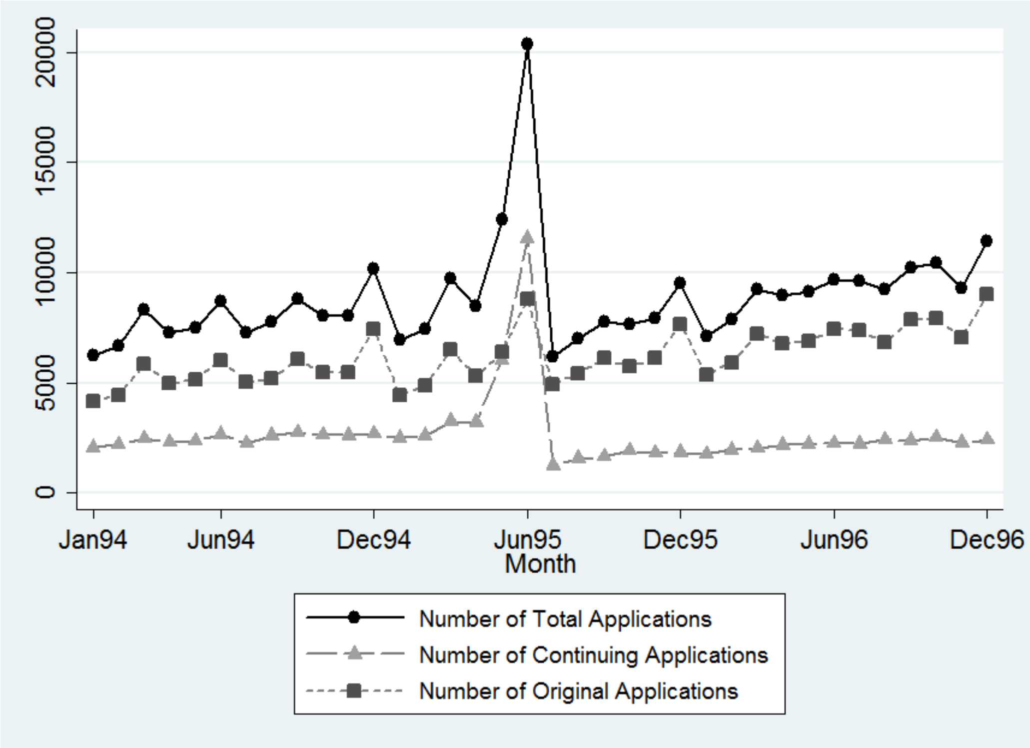

Figure 2. Patent applications filed per day in June 1995.

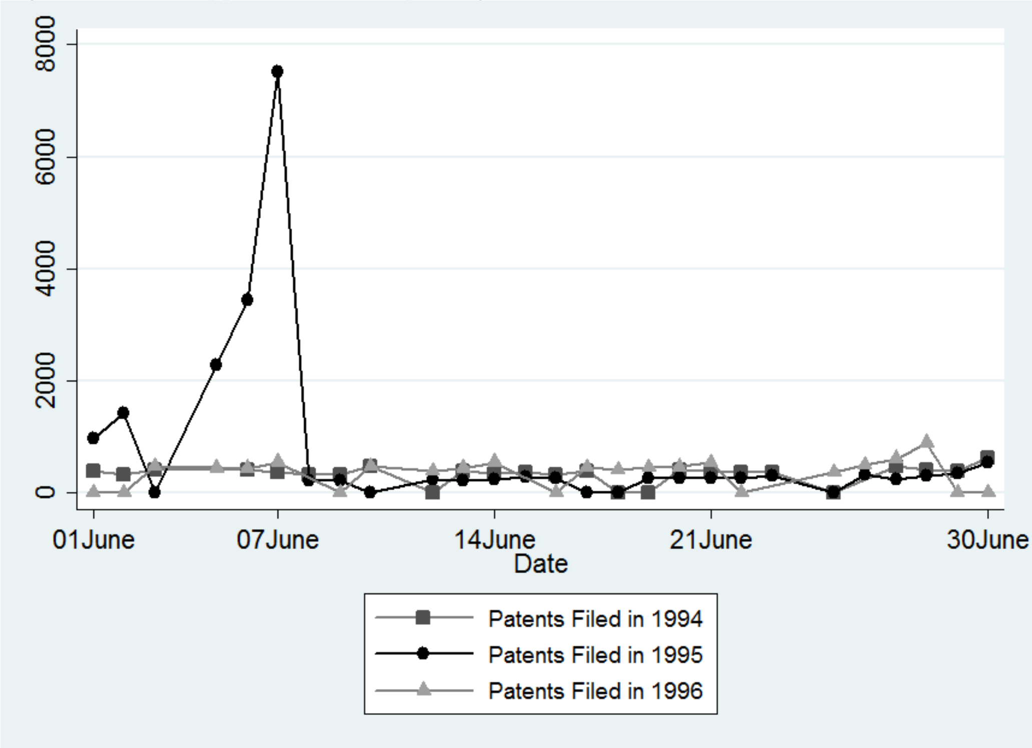

Figure 3. Percentage of original and continuing patent applications filed before and after June 8th.

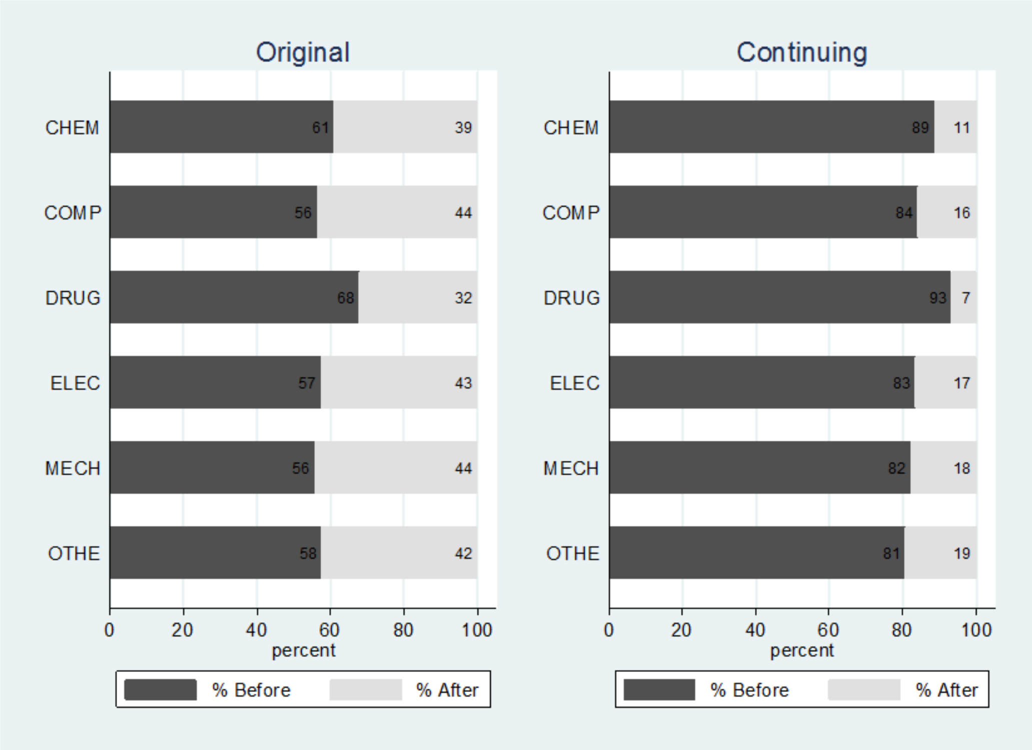

Figure 4. Renewal rates of patents stemming from original and continuing applications.

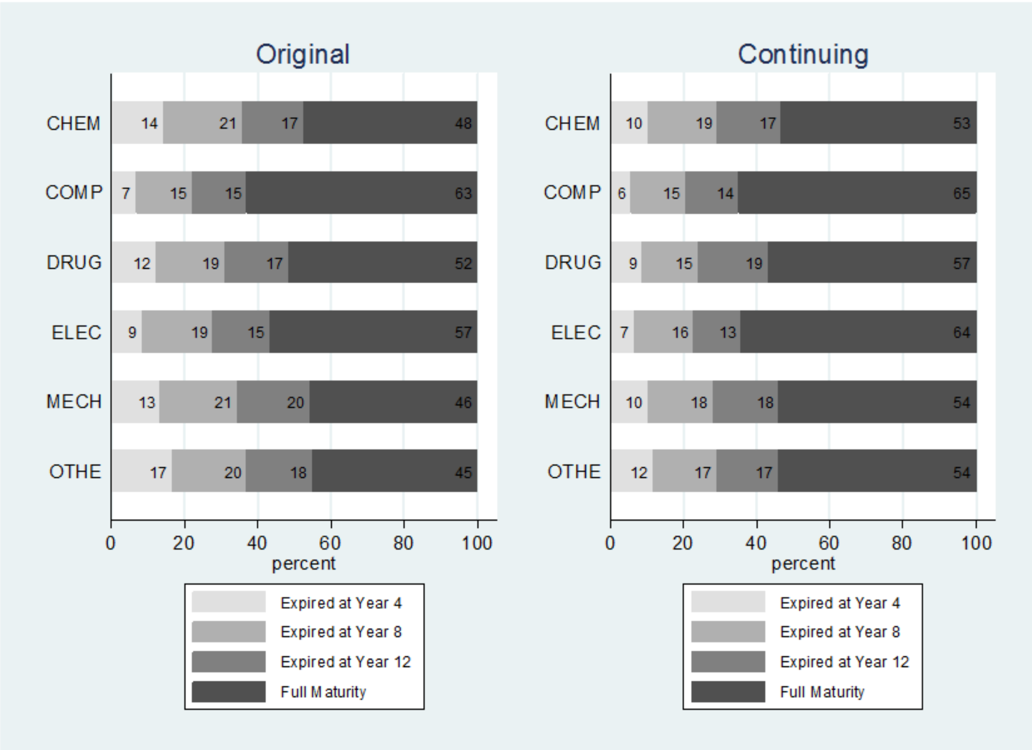

Table 1. Probit estimations of propensity to file before by technology field.

	Dependent Variable: File Before			
VARIABLES	(1)	(2)	(3)	(4)
CHEM	0.0287***	0.0508***	0.0461***	0.0372***
	(0.0106)	(0.00631)	(0.0130)	(0.00561)
COMP	-0.00677	0.0228***	0.00583	0.0200***
	(0.0102)	(0.00699)	(0.0126)	(0.00614)
DRUG	0.0845***	0.0754***	0.105***	0.0593***
	(0.0125)	(0.00664)	(0.0150)	(0.00586)
ELEC	-0.000978	0.0276***	0.0154	0.0200***
	(0.00994)	(0.00697)	(0.0123)	(0.00622)
MECH	-0.0156	0.0167**	-0.00185	0.0160**
	(0.0102)	(0.00769)	(0.0128)	(0.00672)
purgatory		0.0198***		0.0145***
		(0.00126)		(0.00113)
BackCitations	0.000771***	0.000425***	0.000981***	0.000349***
	(0.000257)	(0.000108)	(0.000321)	(0.000105)
BackCitationsNonPat	0.00489***	0.00126***	0.00614***	0.000819***
	(0.000767)	(0.000363)	(0.00118)	(0.000269)
ForwardCitations	0.000215*	-0.000293***	0.000217	-0.000206***
	(0.000116)	(6.52e-05)	(0.000158)	(6.03e-05)
Claims	0.000377	-0.000291**	0.00105***	-0.000212*
	(0.000267)	(0.000144)	(0.000338)	(0.000129)
NumberUSClassifications	0.00387	0.00577***	-0.00148	0.00309*
	(0.00264)	(0.00181)	(0.00325)	(0.00165)
NumberIPCClassifications	0.000760	0.0120***	-0.00245	0.0108***
	(0.00277)	(0.00191)	(0.00341)	(0.00173)
ApplicationLength	-0.0275***	0.00930***	-0.0221***	0.00780***
	(0.00383)	(0.00239)	(0.00476)	(0.00225)
Observations	28,292	22,704	18,120	18,013

Notes: Columns 1 and 3 consider patents stemming from original applications while Columns 2 and 4 patents from continuing applications. Columns 1 and 2 consider a 20-week symmetric window (April 1st 1995-August 19th 1995) and Columns 3 and 4 a 10-week symmetric window(May 1st 1995-July 21st 1995). Robust standard errors in parentheses.

Table 2.Probit estimations of propensity to file before by technology field. Applicant behavior.

	Dependent Variable: File Before			
VARIABLES	(1)	(2)	(3)	(4)
drug	0.156***	0.0688***	0.176***	0.0515***
	(0.0143)	(0.00712)	(0.0169)	(0.00620)
purgatory		0.0152***		0.00989***
		(0.00151)		(0.00126)
BackCitations	0.000721	0.000593***	0.00126*	0.000484***
	(0.000536)	(0.000156)	(0.000660)	(0.000158)
BackCitationsNonPat	0.00464***	0.000105	0.00522***	4.42e-05
	(0.00119)	(0.000233)	(0.00167)	(0.000154)
ForwardCitations	8.30e-05	-0.000344***	0.000239	-0.000255***
	(0.000170)	(7.13e-05)	(0.000211)	(5.91e-05)
Claims	-0.00103**	-0.000110	-0.000457	-4.13e-05
	(0.000476)	(0.000159)	(0.000625)	(0.000129)
NumberUSClassifications	0.0122**	0.000352	0.0115*	0.00104
	(0.00488)	(0.00219)	(0.00599)	(0.00189)
NumberIPCClassifications	-0.0104*	0.00898***	-0.0173***	0.00606***
	(0.00555)	(0.00253)	(0.00662)	(0.00202)
ApplicationLength	-0.0223***	0.00991***	-0.0176**	0.00723***
	(0.00706)	(0.00292)	(0.00862)	(0.00253)
Observations	6,829	8,466	4,482	7,012

Notes: Columns 1 and 3 consider patents stemming from original applications while Columns 2 and 4 patents from continuing applications. Columns 1 and 2 consider a 20-week symmetric window (April 1st 1995-August 19th 1995) and Columns 3 and 4 a 10-week symmetric window(May 1st 1995-July 21st 1995). Robust standard errors in parentheses.

Table 3.Probit estimations of propensity to renew at the 12th year by technology field.

	Dependent Variable: Renewed at the 12th Year			
VARIABLES	(1)	(2)	(3)	(4)
CHEM	0.0305***	0.000159	0.0291**	0.00572
	(0.0108)	(0.0124)	(0.0135)	(0.0140)
COMP	0.139***	0.0745***	0.128***	0.0719***
	(0.0102)	(0.0128)	(0.0127)	(0.0146)
DRUG	0.0377***	-0.00107	0.0456***	-0.00350
	(0.0132)	(0.0130)	(0.0161)	(0.0146)
ELEC	0.102***	0.0911***	0.115***	0.0926***
	(0.00991)	(0.0131)	(0.0124)	(0.0149)
MECH	0.0106	0.000561	0.00599	0.00474
	(0.0104)	(0.0146)	(0.0132)	(0.0167)
BackCitations	0.000424*	-1.10e-06	0.000507*	-0.000109
	(0.000239)	(0.000130)	(0.000270)	(0.000134)
BackCitationsNonPat	-0.000628	0.000488***	-0.00124*	0.000458***
	(0.000559)	(0.000159)	(0.000648)	(0.000163)
ForwardCitations	0.00357***	0.00369***	0.00385***	0.00384***
	(0.000283)	(0.000240)	(0.000256)	(0.000284)
Claims	0.00231***	0.00157***	0.00207***	0.00128***
	(0.000292)	(0.000250)	(0.000361)	(0.000270)
NumberUSClassifications	-0.00571**	-0.00725***	-0.00236	-0.00613**
	(0.00271)	(0.00279)	(0.00338)	(0.00311)
NumberIPCClassifications	0.00128	0.0121***	0.00712**	0.0138***
	(0.00283)	(0.00260)	(0.00351)	(0.00284)
ApplicationLength	-0.00747*	0.00798**	-0.00686	0.00894**
	(0.00390)	(0.00351)	(0.00486)	(0.00392)
Observations	28,292	22,704	18,120	18,013

Notes: Columns 1 and 3 consider patents stemming from original applications while Columns 2 and 4 patents from continuing applications. Columns 1 and 2 consider a 20-week symmetric window (April 1st 1995-August 19th 1995) and Columns 3 and 4 a 10-week symmetric window (May 1st 1995-July 21st 1995). Robust standard errors in parentheses.

Table 4.Probit estimations of propensity to renew at the 12th year by technology field. Applicant behavior.

	DependentVariable: Renewed at the 12th Year			
VARIABLES	(1)	(2)	(3)	(4)
drug	-0.0952***	-0.0335***	-0.0811***	-0.0266**
	(0.0149)	(0.0122)	(0.0180)	(0.0136)
BackCitations	0.000653	0.00105***	0.000769	0.00105***
	(0.000528)	(0.000261)	(0.000609)	(0.000279)
BackCitationsNonPat	-0.000361	0.000304	-0.000861	0.000280
	(0.000671)	(0.000187)	(0.000782)	(0.000191)
ForwardCitations	0.00383***	0.00374***	0.00402***	0.00379***
	(0.000320)	(0.000423)	(0.000348)	(0.000502)
Claims	0.00343***	0.00101***	0.00371***	0.000760**
	(0.000566)	(0.000356)	(0.000717)	(0.000379)
NumberUSClassifications	-0.0113**	-0.00962**	-0.00929	-0.0106**
	(0.00490)	(0.00454)	(0.00612)	(0.00498)
NumberIPCClassifications	-0.00331	0.0108**	0.00169	0.0147***
	(0.00559)	(0.00430)	(0.00683)	(0.00462)
ApplicationLength	0.00998	0.0136**	0.00540	0.0117*
	(0.00703)	(0.00546)	(0.00868)	(0.00601)
Observations	6,829	8,466	4,482	7,012

Notes: Columns 1 and 3 consider patents stemming from original applications while Columns 2 and 4 patents from continuing applications. Columns 1 and 2 consider a 20-week symmetric window (April 1st 1995-August 19th 1995) and Columns 3 and 4 a 10-week symmetric window (May 1st 1995-July 21st 1995). Robust standard errors in parentheses.

Table A.1. Variable Definitions

Variable Name	Variable Definition
BackCitesPat	The number of patents the focal patent cites
BackCitesNonPat	The number of scientific publications the focal patent cites
ForwCites	The number of patents issued until 2006 that cite the focal patent,
Claims	The number of patent claims,
Numb4DigitIPC	The number of four-digit International Patent Classifications,
Numb3DigitUSClass	The number of three-digit US Classifications,
AppLength	The length of patent application
Purgatory	The difference in months between the continuing patent application's filing date and its original filing date. This variable is only applicable to patents stemming from continuing applications.

Table A.2. Summary Statistics of patent characteristics.

	New Applications			
	File Before N=16528		File After N=11764	
Variable	Mean	Std. Dev.	Mean	Std. Dev.
Purgatory	0.00	0.00	0.00	0.00
BackCitations	12.58	16.93	11.58	11.89
BackCitationsNonPat	2.36	8.54	1.42	4.68
ForwardCitations	19.32	30.76	17.88	28.43
Claims	15.59	11.76	15.21	11.22
NumberUSClass	2.02	1.16	1.99	1.15
NumberIPCClass	1.84	1.13	1.81	1.07
ApplicationLength	2.16	0.83	2.20	0.83

	Continuing Applications			
	File Before N=19689		File After N=3015.00	
Variable	Mean	Std. Dev.	Mean	Std. Dev.
Purgatory	2.94	2.61	2.02	1.44
BackCitations	20.98	32.53	16.31	18.61
BackCitationsNonPat	9.50	26.89	3.12	10.60
ForwardCitations	18.67	30.63	20.85	32.29
Claims	15.14	15.16	14.72	12.88
NumberUSClass	2.19	1.22	2.08	1.17
NumberIPCClass	2.08	1.41	1.77	1.09
ApplicationLength	2.21	1.03	1.96	0.91