Faster but Shorter versus Longer but Slower Patent protection- Which do Firms Prefer?

Job Market Paper

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Abstract

In addition to invention patents, the Chinese Patent Office provides utility models patents that have 10 year protection and do not involve substantive examination and hence are granted much faster. Using a dataset of successful U.S. patents originating from China, we find 19% of the patents, largely in fields of Electronic & Electrical and Mechanics featuring fast technology and product turnover, have utility model priorities in China. These patents are on average filed and granted faster, and are less likely to have continuations at the US Patent Office (USPTO), relative to those with Chinese invention patent priorities. They also tend to be less frequently renewed both China and the United States. The results suggest that applicants differ in their preference over speed and length of patent protection, that some who values speed of protection more than duration opt to protect valuable inventions with utility models.

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Keywords: patent protection, invention patent, utility model, speed, length

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1. Introduction

In the United States, patent policy is designed to promote innovation, encourage development of new technologies and increase the fund of human knowledge. Previous literatures have pointed out that firms use their patents to achieve vast different business purposes[1](Cohen et al 2000; Hall and Ziedonis, 2001; Gans et al., 2007; Graham et al., 2009). In order to achieve a patent, applicants need to submit their innovations to the United States Patent and Trademark Office (USPTO) and their application will go through an examination process of novelty, non-obviousness and utility. Patent application is thus examined in a timely manner and the effective delay of patent grant could be several years from the initially application date[2]. Moreover, patents are generally protected only for a fixed period of time. Delay of patent grant and inflexibility of protection period are therefore likely to curtail the efficacy of patent towards achieving firms' diverse goals, limiting the usage of patent as a means to protect IP[3], reducing the speed of technology propagation and lowering social welfare.

Case studies and anecdote evidences suggest patent applicants vary in their preferences over speed of patent protection. Firms seeking patents with purposes such as attracting investment, meeting a venture capital fund's milestone or building up firm and product reputation might want to secure patent right as soon as possible. Gans et al. 2007 found for startups, patent allowance significantly increases the hazard rate for securing licensing contracts. On the other hand, firms have used "deferred examination" in European countries to delay patent issuance (Hall Harhoff 2012). Hegde et al. 2009 has found in the United States, patent applicants strategically file continuing patent applications to delay patent prosecution process. One of the reasons behind such behavior is to accumulate thickets of patents for "defensive" purposes or improve bargaining position in patent cross-licensing negotiations. With respect to preferences over length of patent protection, it is well known that in industries featuring fast technology progress and short product cycles (such as electronics and information), patents have relative short value horizons.[4] Patents in industries such as Chemical and Pharmaceuticals are often renewed for full term. In fact the Hatch-Waxman Act offers

[1] See Section 2 for a more detailed description.
[2] The total pendency in USPTO ranges from 29.7 to 47.7 months. (http://www.uspto.gov/patents/stats/patentpendency.jsp)
[3] Cohen et al. 2000 points out that among a range of mechanisms used to protect profits accrued to invention, patent is viewed as the least effective. Moreover, secrecy and lead time tend to be emphasized the most.
[4] For instance, Jeff Bezos, the founder of Amazon.com and owner of the "one-click" patent, proposes that "business method and software patents should have a much shorter lifespan… (of) 3 to 5 years" of patent protection (http://oreilly.com/news/amazon_patents.html).

drug patents with an additional 30 months of patent protection, reflecting applicant's desire for longer patent protection.

Acknowledging the existence of private benefit associated with patent, it is natural to think that depending on the market environment in which the firm operates and the diverse purposes of utilizing the patent right, firm might prefer a patent policy that provides flexible means of protecting intellectual properties. This paper provides a first empirical look at firms' varying needs (or taste) for patent protection. We focus on two fundamental attributes: how fast the applicant wants her patent application to be granted ("need for speed") and how long the applicant wants to maintain her patent[5] ("need for length") after grant. The preference over these attributes is directly related to a patent's expected private value distribution over time as well as the cost structure of maintaining the patent. Since costs of maintenance generally increase over time[6], applicants pursuing patent grant and maintaining patent face a crucial dynamic tradeoff: while early patent grant gives applicant the exclusive right to gain access to the private value of the patent early, it also incurs a greater maintenance cost at any given period while the patent is active. In addition, the extent to which patent be kept active will depend on how fast the patent's private value depreciates. We therefore acknowledge that preferences for speed and length of patent protection are key considerations for patent applicants.

To explore applicants' heterogeneous preferences over speed and length of patent protection, we study a set of United States product patents of which, before applicants file their U.S. patent application, they have also sought for patent protection in China for the same innovation. China offers two kinds of patent protection for product innovations. The invention patent (*IPat*), generally with a long pending period due to substantive examination, is protected for 20 years[7]. The utility model patent (*UMs*) is granted quickly after application due to no examination and is protected for 10 years. Since the innovations are "technologically sound" (they have been granted U.S. patent), choosing *UMs* over *IPats* in China clearly sends out a signal of applicant's preference for

[5] In order to keep patent active, patent renewal fees must be submitted at certain dates. Hence the longer the patent is renewed, the more cost it incurs. Here we emphasize the "length" of patent protection counting from the patent's issue date, not from the patent's application date. This setting is consistent with the renewal structure of patent. In major patent offices in the world, the renew fees are determined by the patent age, which in turn is counted from the patent issue date to present.

[6] US renewal structure, Chinese renewal structure, see below…

[7] The Chinese invention patents is often considered as the counterpart of the U.S. utility patent. Grant of invention patents requires substantial examination of novelty, non-obviousness and utility.

flexibility in patent protection[8]: by selecting *UM* instead of *IPat*, applicant must believe the expected benefit of having patent in the initial periods outweighs the loss of having to giving up the patent early. Though the entire preference structure for patent protection is unobservable to us, we provide empirical evidence for the existence of "need for speed" and "need for length" preferences by associating variations of choice between *IPats* and *UMs* in China and variations of applicants' behaviors of hastening/ delay of their U.S. patent grant as well as variations in maintaining patents in both countries, for the same innovation. We then separate out the two preferences by comparing the results of the above analysis in different technology fields. Moreover, we explore in particular, whether "need for speed" concern depends on inventor and patent patentee's nationality.

Nineteen percent of our sample contains U.S. patent that was originally filed for *UM* protection in China (Henceforth, *UM* priority). Most of the *UMs* are in technology fields such as Electric&Electronics, Mechanics that feature fast technology progress and short product cycles. Moreover, U.S. Patents with Chinese *UM* priority are generally filed faster and granted quicker than those with Chinese *IPat* priority suggesting applicants' need for speedy patent grant in U.S. They are also less likely to be maintained at SIPO and at USPTO, after grant, suggesting need for long protection is not crucial. These results are robust to controlling for technology field fixed effects. Empirical analysis focusing on technology fields with long R&D and product cycle (e.g. Chemicals and Pharmaceuticals) demonstrates that choosing *UMs* is associated with behaviors that reveal applicants' need for speedy patent grant, but there is no substantial difference of "need for length" preference compared to patents protected with *IPats.* Interestingly, a portion of Chinese *UMs* (one third of all Chinese *UMs* of the sample) were delayed until "the last minute" (last month of the grace period) before they were filed in the United States[9]. Yet after U.S. application started, applicants still displayed stronger need for speedy grant of their U.S. patent compared to average applicants of Chinese *IPats.* The filing behaviors pre and post U.S. application, of this particular group, seems to display an inconsistency of "need for speed" preference. Interviews with lawyers suggest applicants generally utilize the grace period to assess the commercial viability of her innovation in U.S, formalize and translate her patent application. Based on this assumption, our empirical analysis supports the hypothesis that delay of filing depends

[8] Here we assume applicant's preference for patent protection for the same innovation is globally identical, i.e. if she wants to have fast/slow patent grant in China, she would also like to have fast/slow patent grant in U.S. And if she wants to keep the Chinese patent for long/short, she would also want to keep the U.S. patent for long/short.
[9] After filing patent application in one country, applicant generally has 12 months to decide whether to file in another country or file at WIPO. We define "wait until last minute" when the applicant wait until the last month (the 12th month after the Chinese filing date) to file her application to U.S.

on applicants' experience with the U.S. market environment. Thus, delaying filing until the "last minute" does not reflect applicant's desire to delay patent application but rather applicant's inexperience in deciding whether to file her innovation in the United States or not.

Our study contributes to the broad literature on the optimal design of patent systems (see, e.g. Gallini 2002; Scotchmer 2004). The results reveal the heterogeneity of applicants' preference for attributes of protection for invention, lending empirical support for the trend of major patent offices towards offering more options such as faster examination for applicants willing to pay a higher cost and shorter protection for those who do not highly value long patent life. USPTO recently launched "three-track examination"[10] which aims to "provide a comprehensive, flexible application processing model… offering different processing options that are more responsive to the real-world needs of … applicants."[11] Our study offers early insights on the likely response of inventors with the "three-track" system at USPTO, pointing to an interesting research agenda in the future when the data are accumulated sufficiently at USPTO.[12]

Our paper also makes two interesting contributions to the literature on patent evaluation. First, it provides a novel perspective on using patent renewals as one of the most widely used indicators of patent private value (See Lanjouw, Pakes and Putnam 2008; Schankerman and Pakes 1984; Pakes 1986; Bessen 2008). In our sample, patents with Chinese *UM* priorities are less likely to be maintained at USPTO and SIPO, not necessarily because they are less valuable (they are sufficiently valuable to justify the substantial expense of filing overseas at USPTO); rather, they are abandoned sooner because the value they bring to patent owners is more heavily weighted toward the early effective patent years. That is the invention's value horizon beyond which expected returns are insufficient to justify maintenance fees is relatively short. Second, it contributes to a growing research line that explores differences in patent systems and

[10] The program allows applicants, willing to pay additional special fees ($4,950 for large entities and $2,550 for small entities) to request for prioritized examination that guarantees a final decision within twelve months of the filing date (Track 1). Applicants can also request a delayed examination for up to 30 months (Track 3), or the standard examination (Track 2).

[11] Quote from David Kappos, the Under Secretary of Commerce for Intellectual Property and Direct of USPTO during 2009-2012.

[12] Patent offices in many other countries including the EPO also offer "accelerated" or "deferred" examination options. However, it should be noted that unlike the choice of *UMs vs. IPats* in our study, these "accelerate" or "deferred" examination options do not involve a tradeoff between speed and length of patent protection. When an applicant chooses an accelerated (deferred) examination, the patent would be granted faster (slower) and the protection length would be longer (shorter) since the effective patent term would start from the filing date.

applicant/patentee behavior regarding equivalent inventions in these patent systems, to gain better understanding of firms' different evaluation of various patent attributes.[13]

Section 2 introduces the research design and a simple model based on which we derive our empirical hypotheses. Section 3 describes our data. Section 4 presents our empirical results. Section 5 examines the robustness of results by analyzing an interesting case. Section 6 concludes.

2. Research Design and Model

2.1 Applicant's filing procedure: from China to U.S.

Unlike the United States, but like many other countries in the world[14], China offers two types of patent protection for industrial product innovations, namely the invention patent (*IPat*) and the utility model patent (*UM*), respectively. Allowance of *IPats* requires a substantive examination of utility, novelty and non-obviousness, and entails a statutory patent protection of 20 years. Grant of *UM*s entails only payment of (a lower) filing fee and confirmation that the application complies with the filing requirements; if both requirements are satisfied, grant is quick and almost certain. An applicant can simultaneously file "dual applications," for both an *IPat* and a *UM*, for the same invention at SIPO. If both are granted, she has to choose one patent protection and abandon the other immediately[15].

Table 1 presents a detailed comparison between *IPat* and *UM* at SIPO. According to the patentability standards, filing for *UM* does not require substantial examination of novelty or non-obviousness. Innovations protected with *UMs* are thus often viewed as "petty inventions" that fall short of the standard for *IPats*. *UMs* are likely to cause negative reputation effect and reduce probability of securing licensing contract, limiting technology partnership.

However, *UM* offers an advantage that might be important to patent applicants: a relatively short grant lag of an average 12 months, as opposed to an average of 36 months for *IPat*. Another minor advantage of *UM* compared to *IPat* is that it is cheaper

[13] See, for example, Graham et al. 2009; Lei and Wright 2012; Harhoff 2011.

[14] Patent offices in many other countries also provide some form of UM protection, including developed countries such as Germany, Denmark, Greece, Spain, France, Ireland, Italy, Netherlands, Austria, Portugal, Finland, Japan, South Korea etc. (Suthersanen, 2006; Moga, 2012)

[15] Article 30 the Chinese Patent Law 2009. Two applications in a "dual application," for an *IPat* and for a *UM*, respectively, did not even need to be filed at SIPO on the same date, until the 3rd amendment to the Chinese Patent Law in 2008. However, most of dual applications in our sample were filed on the same dates.

in terms of application, attorney and maintenance fees. Furthermore, applicants, if concerned about the validity of their UMs, can ex post obtain substantive examination reports from SIPO to affirm their validity[16]. In summary, a Chinese patent applicant would prefer filing *UM* to filing *IPat* if one or several of the following reasons occur:

(i) She wants to have a fast patent grant. ("need for speed" preference)
(ii) She does not expect long patent protection (over 10 years) to be crucial ("need for length" preference)
(iii) Her innovation is not eligible to file *IPat.* ("petty innovations")
(iv) Cost consideration.

Because the purpose of this study is to examine patent applicant's heterogeneous preference for patent protection, we need the choice of *UM* to reflect applicant's concerns about speed and length of patent instead of eligibility or cost. We overcome this difficulty by constructing a dataset that consist of United States patents with Chinese priority[17]. USPTO offers one major means of patent protection, the utility patent,[18] which requires substantive examination and provides a statutory patent life of 20 years. Innovations covered by Chinese *UMs* and are granted U.S. patent are hence eligible to file *IPat*. Further, the costs are less likely to be relevant for this sample as the differences in the fees between filing for IPat and UM are relatively small given that the applicants in our data spent much more to apply for patents at USPTO. We can thus say that conditioning on the innovation been granted U.S. patent, if applicants opt to select *UM* at SIPO, it is very likely that the speed of patent protection is important and the length of patent protection is not crucial.

After filing at SIPO, there is a grace period to decide whether to file the same innovation at USPTO[19]. Interviews with patent attorneys suggest applicants generally utilize this period of time to assess the commercial viability of their innovation, formalize and

[16] Lawyers from various law firms located in Beijing advise us that in infringement suits, *UMs* are not necessarily more likely to be invalidated and Chinese damages for infringing *UMs* could be very high. See Chint Vs. Schneider Electronic http://www.law360.com/articles/37050/ip-enforcement-in-china-chint-v-schneider-electric

[17] Ideally, we should not restrict our sample to including only U.S. patents that were filed in China first. However, due to the strong adversity towards *UMs* by foreigners (as they were educated by lawyers not to file for *UM*), less than 0.01% of Chinese patent filing by foreign entities choose to file for *UM*.

[18] USPTO also allows design patents and plant patents for ornamental design and asexually produced plant variety, respectively. These two types of patent protection also exist at SIPO.

[19] To file a foreign patent application at USPTO, applicant can either file directly at USPTO or file at WIPO (World Intellectual Property Office) and designate U.S. as a destination country. For the former route, she has a grace period of 12 months; for the latter, she can generally wait for up to 30 months before the patent application enters the national stage. In our data, we have 15% of patent applications that are filed through the PCT route. In our empirical analysis, we control for the PCT dummy.

translate her patent application[20]. The patent prosecution process at USPTO ranges between 29 months to 48 months[21]. Backlog and communication delays are the two most important components of grant lag (Popp et al. 2004). During the patent prosecution process, applicants have the option to file continuation applications. The continuation procedure offers applicants a new round of examination to revise claims submitted in the initial application or to pursue rejected claims with new information and evidence. While retaining patent term to start from the filing date of the initial application, filing continuation introduces a significant delay in patent grant (Hegde et al. 2009).

From the filing procedure described above, we generalize several partial indicators for "need for speed" preference for patent protection:

(i) **Filing lag**: time difference between the Chinese filing date and the first U.S. filing date;
(ii) **File at Last minute**: dummy equals to 1 if the applicant files her U.S. patent application in the last month of the grace period[22];
(iii) **Continuation**: dummy equals to 1 if applicant files continuation application;
(iv) **Continuation lag**: time difference between the first U.S. filing date and the filing date of the last continuation application;
(v) **Grant lag**: time difference between the last U.S. filing date and the U.S. patent issue date.

If applicants prefer to have fast U.S. patent grant, we expect she will file in U.S. sooner, be less likely to file in the "last minute", less likely to file continuation applications, conditional on filing continuation, file it sooner and pursue for shorter grant lag. As mentioned before, patent applicants use the grace period partially to determine whether it will be profitable to file the patent in United States. If they have decided to file and there is still time left during the grace period, they might then strategically choose to delay their patent application if they do not value fast patent application (hence fast patent grant) to be crucial. However, filing late may also be due to applicant's inexperience with the U.S. market environment or the USPTO patent prosecution process. Therefore, the variables **Filing lag** and **File at Last minute** only

[20] One lawyer responded that their firm charges 220rmb ($36)/100 English word and the translation generally takes 2-4 weeks. This amounts to $1,000-$1,800 of translation fee per application given a patent application generally has 3000-5000 English words.
[21] See footnote 2 for references.
[22] We have used several cutoffs in our empirical analysis, including last ten days, last five days or last day. The results are qualitatively consistent.

partially reflect applicant's "need for speed" preference. We will explore this issue later. Similarly, a big portion of **Grant lag** is the significant delay in queuing time. We control for patent filing year fixed effect to mitigate this bias. We use the patent maintenance data at SIPO and USPTO to reflect patent owner's "need for length" preference.

2.2 **Model**

Based on previous empirical literatures and case studies (Pakes Shankerman 1986; Lanjouw Schankerman 1994; Hegde et al. 2009; Hall and Harhoff 2012), we present a simple model that demonstrates applicant's diverse preferences over speed and length of patent protection. For illustrative purposes, we make a strong assumption: the time distributions of the private value of patents in China and U.S. protecting the same invention are broadly consistent, i.e. the shape and length of the Chinese and U.S. patents' value horizons share the same features. To give an example, suppose the Chinese patent has high private value in initial periods but a relatively short value horizon, we assume the U.S. patent has the same features. This assumption captures a global characteristic of differences in how industries innovate: in industries such as Chemical and Pharmaceuticals, the entire period of R&D is often very long so the patent has long value horizon whereas in Electronics, semiconductor industries, patent has relatively short value horizon. In practice, there is by no means to assume that patent values in different market environments are equal. Asides from heterogeneity in technology, patent value also depends on the overall R&D strength, the protection effort from patent office, the richness of complementary assets etc, characteristics that are different from country to country. Fortunately, both China and the United States adopt similar patentability standard in terms of "novelty"[23], so the relative distance of technology progress described in patents between the two countries will not be too large.

Starting from the application date, we assume the per-period value of a patent is a function of time t:

$$v(t;k,\lambda), t \geq 0$$

The parameters k, λ describe the shape and scale of the distribution. We assume that only patent owners can enjoy the value of patent and applicants has the flexibility to hasten/delay her patent grant. The cost of maintaining a patent per period is a constant

[23] Both China and U.S. adopt the "relative novelty" standard and admits a grace period of 12 months. See Chinese patent law Art 22 for a detailed description. Also see U.S. patentability requirement at http://www.uspto.gov/web/offices/pac/mpep/s2133.html

proportional function of time counted from the issue period[24]:

$r(t), r^{'}() \equiv \alpha > 0, t \in (0, \overline{T})$ where $\overline{T}$ is the maximum statutory term for a patent. Let t_G, t_L denote the optimal period of patent grant and the optimal last period that the patent will be maintained. Then, in an ideal world with perfect efficiency of patent examination, patent applicant chooses the optimal t_G^*, t_L^* to maximize:

$$\underset{t_G, t_L}{Max} \int_{t_G}^{t_L} v(t;k,\lambda) e^{-rt} dt - \int_{t_G}^{t_L} r(t - t_G) e^{-rt} dt \qquad s.t. \quad t_G, t_L \in (0, \bar{T})$$

Taking First order conditions w.r.t. t_G, t_L and assuming there is an interior solution gives:

$$v(t_G^*; k, \lambda) = r(0) + (1 - \frac{\alpha}{r} e^{-r(t_L^* - t_G^*)}) \qquad (1)$$

$$v(t_L^*; k, \lambda) = r(t_L^* - t_G^*) \qquad (2)$$

The 2nd F.O.C. indicates the optimal period to stop maintaining a patent is the period when the renewal fee is about to exceed the value of patent, in that particular period. We also see that the last period of renewing cost depends on the total length of renewing periods ($t_L^* - t_G^*$), not on the particular period when the patent is issued or abandoned (t_G^*, t_L^*).

The 1st F.O.C. shows that the optimal period to have patent grant is the period in which the patent value equals the initial period renewal cost plus the burden of increase in renewal per period due to having patent granted one period earlier. Since renewal cost is an increasing function of time starting at the issue date, moving patent grant one period earlier will not only induce more periods to pay but also more to pay per period. In other words, the optimal period for patent grant is not the period when the patent value equals the initial renewal cost, but a period with patent value big enough to justify the disproportional increase of renewing burden.

Let $\overline{T}_{UM}, \overline{T}_{IPat}$ denote the maximum statutory life of *UM* and *IPat*. Assume due to substantial examination, the minimum grant lag of filing *IPat* is $\underline{T}$. Thus $t_G \in (0, \bar{T}_{UM})$ if the applicant chooses to file *UM* but $t_G \in (\underline{T}, \overline{T}_{IPat})$ if the applicant chooses to file *IPat*. Let $v(1), v(2)$ denote the sum of maximized discounted value from choosing *UM* and

[24] Generally, the per period renew cost is an increasing function of time with positive 2nd derivative. Here we assume constant proportion for simplicity.

IPat and the per period maintenance cost functions are $r_1(t), r_2(t)$ that satisfies $r_2(t) > r_1(t)$ (*IPat* is more expensive in terms of renew):

$$v(1) = \underset{t_G, t_L}{Max} \int_{t_G}^{t_L} v(t;k,\lambda)e^{-rt}dt - \int_0^{t_L - t_G} r_1(t - t_G)e^{-rt}dt, \quad s.t. \;\; t_G, t_L \in (0, \bar{T}_{UM}) \qquad \text{(choosing } UM\text{)}$$

$$v(2) = \underset{t_G, t_L}{Max} \int_{t_G}^{t_L} v(t;k,\lambda)e^{-rt}dt - \int_0^{t_L - t_G} r_2(t - t_G)e^{-rt}dt \quad s.t. \;\; t_G, t_L \in (\underline{T}, \bar{T}_{IPat}) \qquad \text{(choosing } IPat\text{)}$$

Applicant's maximization problem becomes:

$$\underset{C \in \{1,2\}}{Max} v(c)$$

Let $T_G^1, T_L^1; T_G^2, T_L^2$ denote the solution of t_G, t_L that maximizes $v(1)$ and $v(2)$.

So applicant will always prefer *UM* instead of *IPat iff*:

$$\int_{T_G^1}^{T_G^2} v(t;k,\lambda)e^{-rt}dt - \int_{T_L^1}^{T_L^2} v(t;k,\lambda)e^{-rt}dt \geq \int_{T_G^1}^{T_L^1} [r_1(t - T_G^1)]e^{-rt}dt - \int_{T_G^2}^{T_L^2} r_2(t - T_G^2)e^{-rt}dt \qquad (3)$$

The 1st integral is the discounted sum of patent value accumulated through $[T_G^1, T_G^2]$, the additional periods "in the front" when the invention is protected under *UM* instead of *IPat.* Similarly, the 2nd integral represents the discounted sum of patent value accumulated through the additional periods $[T_L^1, T_L^2]$ "in the back" when the invention is protected under *IPat* as opposed to *UM.* The RHS represents the differences in the renewal costs between *IPat* and *UM.*

The intuition is that applicants opt to choose *UM if and on if* the benefit of accumulating patent value in early periods outweighs the loss of having to give up the patent early as well as excessive renewal burden.

Let $t_G^1, t_L^1; t_G^2, t_L^2$ denote the unconstrained solution of t_G, t_L that maximizes $v(1)$ and $v(2)$. Depending on whether $t_L^1 \geq \bar{T}_{UM}$, $t_G^2 \geq \underline{T}$ and $t_L^2 \geq \bar{T}_{UM}$ (we subsumed uninteresting cases derived from extremely high/low patent value. As they do not reflect applicant's heterogeneous preference for speed and length of patent protection), we have 8 different situations to compare. Excluding two impossible situations and summarizing similar cases, we get:

(1) $t_G^2 \geq \underline{T}$, $t_L^1 \geq \overline{T}_{UM}$ and $t_L^2 \geq \overline{T}_{UM}$.

$t_L^1 \geq \overline{T}_{UM}$ means the optimal period to stop renewing a patent is longer than $\overline{T}_{UM}$ when applicant files for *UM. UM* is not able to satisfy applicant's "need for length" preference. $t_L^2 \geq \overline{T}_{UM}$ indicates the patent has long value horizon so filing *IPat* has the advantage of capturing more value "in the back." $t_G^2 \geq \underline{T}$ means that when applicant chooses *IPat*, patent value in initial periods is not high enough to justify early patent grant. In this case, applicant will prefer *IPat iff:*

$$\int_{\overline{T}_{UM}}^{T_L^2} v(t;k,\lambda)e^{-rt}dt - \int_{T_G^1}^{T_G^2} v(t;k,\lambda)e^{-rt}dt \geq \int_{T_G^2}^{T_L^2} r_2(t-\underline{T})e^{-rt}dt - \int_{T_G^1}^{\overline{T}_{UM}} [r_1(t-T_G^1)]e^{-rt}dt$$

Since the patent value in early period is low, the 2nd term is unlikely to be larger than the 1st. So under the case that patent has long value horizon and value in early periods is low, it is very likely for applicants to choose *IPat.*

(2) $t_G^2 \geq \underline{T}$, $t_L^2 \leq \overline{T}_{UM}$.

$t_L^2 \leq \overline{T}_{UM}$ indicates the patent has short value horizon. $t_G^2 \geq \underline{T}$ means the patent value in initial period is low. The applicant is opt to choose *UM Iff:*

$$\int_{T_G^1}^{T_G^2} v(t;k,\lambda)e^{-rt}dt - \int_{T_L^1}^{T_L^2} v(t;k,\lambda)e^{-rt}dt \geq \int_{T_G^1}^{T_L^1} [r_1(t-T_G^1)]e^{-rt}dt - \int_{T_G^2}^{T_L^2} r_2(t-T_G^2)e^{-rt}dt$$

Because $r_2(t) > r_1(t)$ and $t_L^2 \leq \overline{T}_{UM}$, we have $T_L^2 \leq T_L^1$. In this case, the optimal period to stop renewing patent is less than $\overline{T}_{UM}$ even when filing for *IPat*. The total period of renewal for *UM* is longer than that for *IPat* because the renewal cost for *UM* is lower. The 2nd term in the above inequality is thus negative and the RHS is negative too. So in this case, applicant will always prefer *UM.*

(3) $t_G^2 \leq \underline{T}$, $t_L^2 \leq \overline{T}_{UM}$.

Similar to the above case, $t_G^2 \leq \underline{T}$ indicates the optimal grant date for applicant when filing for *IPat* is smaller than the minimum grant lag for *IPat. IPat* thus fails to satisfy applicant's "need for speed" preference. Combined with the argument about short value horizon in case (2), applicant will always prefer *UM.*

(4) $t_G^2 \leq \underline{T}$, $t_L^1 \geq \overline{T}_{UM}$ and $t_L^2 \geq \overline{T}_{UM}$.

In this case, though *IPat* gives the advantage of longer protection periods, *UM* is also attractive because the early period patent value is high. Applicant will prefer *UM iff*

$$\int_{t_G^1}^{\underline{T}} v(t;k,\lambda)e^{-rt}dt - \int_{\overline{T}_{UM}}^{t_L^2} v(t;k,\lambda)e^{-rt}dt \geq \int_{T_G^1}^{\overline{T}_{UM}} [r_1(t-T_G^1)]e^{-rt}dt - \int_{\underline{T}}^{T_L^2} r_2(t-T_G^2)e^{-rt}dt$$

or the benefit of benefit of accumulating patent value in initial periods (since the early period value is high) outweighs the patent value in the additional periods beyond the maximum term of *UM* but provided by *IPat.*

Summarizing the above 4 cases, we have:

	Long patent value horizon	Short patent value horizon
High initial value	*IPat/UM*	*UM*
Low initial value	*IPat*	*UM*

Patent applicant's preference for speed and length of patent grant is associated with the initial value as well as the length of value horizon of the patent value. Substituting this into the above matrix, we have:

"need for length" / "need for speed"	Need for long protection period	Long protection is not crucial
fast grant is curcial	*IPat/UM*	*UM*
Fast grant is not crucial	*IPat*	*UM*

From the above model, we generalize our empirical predictions as follow:

(i) Compared to applicants that opt for *IPat* at SIPO, applicants that chose *UM* at SIPO is more likely to hasten their patent grant at USPTO;

(ii) Compared to applicants that opt for *IPat* at SIPO, applicants that chose *UM* at SIPO are less likely to renew their Chinese and U.S. patent after grant.

(iii) In technology fields that feature long R&D and product cycles, patent's expected value horizon should be long. Compared to applicants that opt for *IPat* at SIPO, applicants that chose *UM* at SIPO is more likely to hasten their patent grant at USPTO;

(iv) In technology fields that feature long R&D and product cycles, patent's expected value horizon should be long. There should be no difference in terms of renewal behavior between applicants that opt for *IPat* and *UM* at SIPO.

Hypothesis (i) is derived from comparing the top and bottom rows of the above 2-by-2 matrix. If our theory is not rejected, this feature should be reflected by our data and is especially salient if we can somehow restrict our sample to including only patents with long value horizon (comparing the bottom row with the top row for the left column). Hypothesis (iii) tries to test the above claim by restricting our sample to technology fields with long R&D and product cycles, as average length of patent value horizon is expected to be long in these technologies. Hypothesis (ii) is motivated by comparing the left with the right column of the 2-by-2 matrix. Another interesting motivation for having hypotheses (iii) and (iv) is that we would like to separate the preference for "need for speed" and "need for length." That is, we expect applicant's behavior of choosing *IPat* (*UM*) cannot be entirely determined just by one of these preferences, but there is a tradeoff between "need for speed" and "need for length." As shown in case (4) of our model. Comparing (iii) (iv) with (i) (ii). We see choosing *UM* over *IPat* reflects that the concern for "need for speed" is dominating the concern for "need for length."

3. Data description and summary statistics

To address our hypotheses, we use a sample of successful U.S. utility patents of which applicants has previously sought for patent protection in China for the same invention. Since the first Chinese patent law was put into practice in 1985, we search the USPTO patent database from 1985 to 2010 and collect all patents with Chinese priority. We then use the priority number associated with each U.S. patent to match with the Chinese patent database (1985-2010) and to extract relevant information of the Chinese patents.

For the analysis of this paper, we restricted the sample to U.S. patents whose Chinese priority application date ranges from Jan 1st 1993 to Dec 31st 2008. Since the establishment of SIPO in 1984, three major amendments to the Chinese patent law were carried out in 1992, 2000 and 2008. In 1992, the statutory life term for *IPat* and *UM* were extended from 15 years to 20 years and 5 years to 10 years, both counted from the filing date. In addition, *UM* owners can no longer petition for 2 years of protection beyond the maximum term. The 2000 revision eliminated the provisions under the old law that prevented state-owned enterprises from trading their patents in technology markets. It also introduced new provisions that make it more rewarding for enterprise employees to innovate. In 2008, SIPO relaxed the prerequisite of domestic filing for any domestically produced invention to file abroad; the amendment was put into practice in 2009. Between Jan 1st 2003 and Dec 31st 2008, there is no change in length and scope of patent terms, enforcement and restrictions in foreign filing.

One of the major differences between *IPat* and *UM* is that only product inventions can be protected by *UM*. We manually identify process inventions by reading the title and abstract of each patent in the sample. 441 U.S. patents on process innovations are excluded[25]. We also exclude “dual applications” of simultaneous applications for *IPat* and *UM* as the numbers are too few to provide statistically interesting results. To identify “dual applications,” we search the entire Chinese *UM* patent dataset and look for *IPat* applications that have similar abstract and identical patentees and inventors[26]. 77 “dual-applications” are excluded. Finally, our dataset include 3450 U.S. patents with Chinese priority.

Table 2 presents summary statistics for patent attributes, “need for speed” and “need for length” preferences indicators. On average, U.S. patents with Chinese priorities have 13 claims, 3 inventors, span across 3 U.S. patent classifications, cite 11 patents and are cited by 1 patent. 40% of the patents filed have involved either foreign patentee or foreign inventor. 19% of the U.S. patents in our sample involve a Chinese *UM.* The U.S. grant lag and the Chinese grant lag are extremely similar both in terms of mean and standard deviation; on average, the grant lags in both countries are slightly less than 3 years. There is an average gap of 8 months between the Chinese filing date and the first U.S. filing date (continuation filings are counted as separate filing dates in U.S.). 1.98% of the sample has a filing lag more than 12 months and 40% of the data were filed in the last month of grace period. Only 7% of the U.S. patents have continuation applications and the average delay in filing continuation is about 2 months. 90% of U.S. patents with Chinese priority are renewed after 3.5 years and 72% are renewed after 7.5 years. To the contrary, Chinese patents protecting the same inventions are renewed slightly longer; 95% of Chinese patents are renewed after 4 years and 82% are renewed after 8 years[27].

Table 3 displays the distribution of patents in different technology fields as defined in Hall, Jaffe and Trajtenberg (1999). The percentages of Chinese *UMs* in the sample vary across different technologies. In *Electric&Electronics*, *Mechanicals* and *Others*, where

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[25] Our empirical results largely hold if we do not exclude those patents.

[26] The titles for an *IPat* and a *UM* in a dual application are often not identical. The title for the *UM* usually starts with “a product that ..,” while the title for the *IPat* starts with “a method and product that …”

[27] Although the application, attorney fees for Chinese patent is only about 10% of that for U.S. patent, the Chinese renew cost is on average higher than the U.S. renew cost. Using the Chinese and U.S. renewal structure, a simple calculation indicates that for a patent that is renewed for 20 years in China, the patentee pays $ 581 dollars per year while for a patent that is renewed for 20 years in U.S, the owner pays only $441 dollars per year (Using the U.S. renew cost structure for large entities before Mar 19th 2013).

technology progress is fast and products has relatively short cycle, one third to one half of the Chinese applications were filed for *UM*, whereas few are seen in technologies such as *Chemicals, Computer&Communication* and *Drugs&Medical*.

Figure 1 displays the percentage of U.S. patents with *UM* priority from 1993-2008 and compares the distribution of *UM* patents in different technology fields. There is a significant increase in the use of *UMs* starting from 1995 for the three technology fields *Electric&Electronics*, *Mechanicals* and *Others*. The trend reaches a peak around 1997 and gradually decreases yet remains at a relatively high percentage level (approximately 40 percent) until 2005 before it falls sharply. To the contrary, in technology fields *Chemicals, Computer&Communication* and *Drugs&Medical*, there is virtually no existence of *UM* before 1998. In the next year, *UM* is picked up and since then, it has become more and more popular. The patterns are interesting but hard to generalize because of a right-truncation problem of the data.

One of the concerns about *UM* is that it serves as a “cheap ticket” to arrive at the USPTO. Why not just file a *UM* then quickly abandon it since it’s cheap and the Chinese patent law requires you to do so in the first place? To address this issue, we examine the annual abandon rates for Chinese patent applications in this sample. In figure 2, the “hook-shaped” curve represents the annual amount of Chinese patent applications (the amount was divided by 1000 to match amplitudes of other curves). Starting from 1993 (17 applications), the Chinese patent filing increases gradually before it takes off in 2000 (140 applications). The trend reaches a maximum in 2005 (648 applications) then drops quickly due to a right-truncation problem. We find in the initial periods there is a relative high percentage of both *IPats* and *UMs* being abandoned. However, due to the small numbers of applications in the first few years, the total abandon rates are 0.9% for *IPat* and 0.3% for *UM*, suggesting the “cheap ticket” motivation might not be a serious concern.

Table 4 compares “need for speed” and “need for length” indicators between U.S. patents with Chinese *IPat* and *UM* priorities. Chinese *UM* applicants have significantly shorter filing lags between the SIPO filing date and the first USPTO filing date, are less likely to file in the “last minute,” less likely to file continuations and when they file, file them earlier. The differences in U.S. patent renewal decisions indicate that U.S. patents with *UM* priorities have shorter value horizons; In U.S, they are less likely to be maintained by patentees at the end of 3.5, 7.5 and 11.5 year, respectively, after issuance. Compared to the U.S. renewal, the differences in Chinese renew decisions illustrate a consistent yet more continuous change of maintenance behaviors. Although the percentage of renewed *UM* and renewed *IPat* are significantly different at the 2^{nd}

and 3rd year after patent grant, the difference is small and there are more than 98% of *UMs* being renewed by the end of 3rd year. However, after the 5th year of issuance, there is a dramatic drop in the percentage of *UMs* that are being renewed. The U.S. and Chinese renewal data supports the idea of heterogeneity in length of value horizon and applicant's diversity in "need for length" preference. Figure 2-4 display the survival function estimates for filing lags, Chinese and U.S. patent renewal, between U.S. patents with *IPat* and *UM* priorities.

4. Empirical strategy and results

4.1 Patent quality comparison: *IPat vs. UM*

The key assumption of our model is that applicant has the flexibility to choose between *IPat* and *UM*; not because her invention is not eligible to file for *IPat*. We thus select the "technologically sound" Chinese patents by including those that have also been granted U.S. patents. To further check whether this assumption holds for our dataset, we compare the technological quality between U.S. patents with Chinese *UM* priorities and those with Chinese *IPat* priorities. We look at: number of claims (Lanjouw and Shankerman 2004), number of patent classifications[28], number of cited and citing patents (Trajtenberg 1990, Hall et all. 1999, Lanjouw and Shankerman 2004, Harhoff et al. 2003) and whether the patent has foreign patentee or inventor. More specifically, for patent i in technology field j with U.S. filing year t, we estimate the following equation:

$$Y_{ijt} = \alpha_0 + \alpha_1 * UM_i + u_j + v_t + \varepsilon_{ijt}$$

In this estimating equation, Y_{ijt} represents the five patent quality indicators described above. The key regressor is UM_i, a dummy variable that is equal to one if the applicant files for *UM* in China. The equation is estimated using fixed effects at technology (u_j) and U.S. filing year v_t level. So the effect is estimated from variation within technology fields over time. The technology field fixed effect is particularly important because it controls for structural features of technology that may both make filing for *UM* more attractive and induce systematic changes in the technology quality indicators.

As shown in Table 5, the results from OLS regressions do not indicate significant differences between these two groups, except that patents with *UM* priorities have

[28] Lerner (1994) uses number of international patent classifications (IPCs). We use the number of U.S. patent classifications (USPCs).

significantly more foreign patentees or inventors. The results lend support to the assumption that Chinese *UMs* in the sample are likely to qualify for *IPats* protection at SIPO.

4.2 Prediction (i)

We now test the 4 predictions derived from our model. Prediction (i) of the model states that applicants filed for *UM* at SIPO is more likely to hasten their patent grant at USPTO. This prediction motivates an estimating equation of the form:

$$Y_{ijt} = \alpha_0 + \alpha_1 * UM_i + \alpha_2 * X_i + u_j + v_t + \varepsilon_{ijt}$$

Y_{ijt} represents one of "need for speed" indicators for U.S. patent i in technology field j with USPTO filing year t. The "need for speed" indicators include continuous variables filing lags, continuation lags and grant lags and dummy variables filing in "last minute" and continuation. We employ OLS if the outcome variable is continuous and Logit if the outcome is a dummy. The X_i are control variables including number of claims, number of inventors, number of U.S. patent classifications, number of cited references and number of citing patents. The key variable of interest UM_i is an indicator for whether the US patent i has a Chinese *UM* priority. For each "need for speed" indicator Y_{ijt}, we always estimate the equation using year fixed effect v_t. However, it is interesting to compare the results obtained from using technology fixed effect u_j with the results from not using technology fixed effect u_j. One reason is that if both are statistically significant and have same signs, the results are robust to controlling for technology fixed effect. A more important reason is that if the coefficient estimates are significantly different, we can understand that how much of the difference of "need for speed" preferences from applicants that opt for *IPat* compared to applicants that opt for *UM* can be attributed to inter-technology variation and how much can be attributed to within-technology variation. So we estimate both.

In Table 6, Panel A reports the OLS coefficient estimates of UM_i when the dependent variables are continuous. As shown in column 1, applicants that opt for *UM* in China generally file their U.S. patents 32 days earlier than applicants that opt for *IPat*, the coefficient is significant at 1% level. The difference reflects variations across technology fields as well as variations within technology fields. When controlling for technology fixed effects, the coefficient drops to 15 days, a 50% decrease in absolute term but still significant at 1% level. In columns 3-6, regression results for continuation lag and grant lag are reported. *UM* users on average, file U.S. continuation patent applications 40 days earlier and their U.S. patents are granted 62 days ahead. Panel B repots Logit coefficient estimates when Y_{ijt} are dummies for filing "last minute" and filing continuations. Setting the other RHS variables at mean level, we find *UM* users are, on average, 8.6% and 14.5% less likely to file in the last month of the grace period, with and without technology fixed effect, respectively. In terms of choosing to file for continuation, the differences are 10% and 7%. This is consistent with prediction (i).

4.3 Prediction (ii)

To test prediction (ii) that applicant filed for *UM* at SIPO is less likely to renew their patent at SIPO and USPTO, we estimate a similar equation of form:

$$Y_{ijt} = \alpha_0 + \alpha_1 * UM_i + \alpha_2 * X_i + u_j + v_t + \varepsilon_{ijt}$$

In this equation, Y_{ijt} represents the "need for length" indicators for patent protection that include dummy variables of whether the patentee maintains her patent at USPTO after 3.5 years, 7.5 years and 11.5 years of issuance as well as whether she maintains patent at SIPO after 2^{nd}-9^{th} year of issuance. For each regression, if Y_{ijt} is the renewal decision at m^{th} year, we restrict our sample to include patents that are at least m years old. In addition, to understand more precisely of how the renewal behaviors change over time, we test whether m^{th} year renewal is significantly different between *IPat* and *UM* patentees conditional on they have renewed their patents in the last period.

Table 7 presents the conditional renewal regression estimates. For Chinese renewal decisions from year 3 to year 5, the coefficients on UM_i are close to zero and not statistically significantly different from zero. Starting from the 6^{th} year after issuance, the coefficient estimates for renewal decisions become statistically significantly less than 0 (except the 8^{th} year renewal). The propensities to keep renewing patent are 6.7% to 36.4% less for patentees with *UM* compared to patentees with *IPat*, controlling for technology fixed effect (evaluating the other independent variables at mean level). The gaps between the renewal propensities are larger as patents become older. For U.S. renewal decisions, the coefficients at 3.5 year renewal is statistically significant; the differences in probability of renewal between U.S. patents with Chinese *IPat* and *UM* priorities are 10% and 15% with or without controlling for technology fields. Since after renewing the patent at the 3.5 year mark, the patent will be effective for year 3.5 to year 7.5, the differences of U.S. renewal decisions at 3.5 year is broadly consistent with the differences of Chinese renewal decisions for year 6-8. Conditional on renewing at 3.5 year and 7.5 year in U.S, the propensities to keep renewing patents with *IPat* and *UM* priorities are indifferent at 7.5 and 11.5 year. In China, to the contrary, conditional on renewing at the 8th year, there is an even bigger portion of *UM* that are dropped out in the 9th year. This discrepancy in the tail distribution of renewal decisions between Chinese patents and U.S. patents protecting the same innovation might be explained by the differences in statutory patent life between U.S. patents and Chinese *UM*. Since the *UM* is only protected for 10 years, and at the 9th year the renewal fee reaches its maximum, it might not be worthwhile to submit the renew fee while having 1 additional year of protection; in U.S, however, submitting renewal fee at 7.5 and 11.5 year will extend the patent life for 4 and 8.5 years respectively. It is therefore less likely for patentees to drop out their patents.

4.4 Prediction (iii) and prediction (iv)

Predictions (iii) and (iv) state that in technology fields that have long R&D and product cycles, the patent's expected value horizon should be long. Hence, *UM* has the advantage to satisfy applicant's "need for speed" preference while it may not be attractive in terms of protection length. To test these predictions, we divide our sample into two groups. The first group consists of technologies that feature long R&D and product cycles: *Chemicals, Computer&Communications* and *Drugs&Medicals.* The second group includes *Electrical&Electronics*, *Mechanicals* and *Others*, in which technology moves fast and new products have relatively short market cycle. We then conduct the same analysis with respect to the comparisons of "need for speed" and "need for length" indicators between *IPat* and *UM* patentees in these two sub-samples and compare the results.

Table 8 and 9 reports the results for "need for speed" indicators. In technology fields *Chemicals, Computer&Communications* and *Drugs&Medicals*, U.S. patents with *UM* priorities are filed faster, with shorter continuation filing lag and shorter grant lags, less likely to file continuation and less likely to file in the last months. In technology fields *Electrical&Electronics*, *Mechanicals* and *Others*, the results are broadly similar except that the magnitudes of the point estimates are smaller. In table 9, there is no difference in terms of filing lag and filing in "last minute" between *UM* priority patents and *IPat* priority patents. As mentioned in section 2, these two indicators only partially reflect the "need for speed" preference. In summary, both in long product cycle technology fields and short product cycle technology fields, applicant filed for *UM* at SIPO is more likely to hasten their patent grant at USPTO.

Table 10 and 11 present the results for "need for length" indicators. We find significantly different renewal behaviors between *IPat* and *UM* patentees in long product cycle technology fields as compared to the renewal behaviors in short product technology fields both in China and U.S. In *Chemicals, Computer&Communications* and

Drugs&Medicals, the difference in renewal behaviors between *IPat* and *UM* patentees is statistically insignificant from zero. While in *Electrical&Electronics*, *Mechanicals* and *Others*, *UM* patentees tend to renew their Chinese and U.S. patents less often than *IPat* patentees.

In summary, even in long R&D and product cycle technology fields, *UM* might still be attractive to patent applicants because of the advantage of fast patent grant. To the contrary, in short R&D and product cycle technology fields, *UM* is the optimal choice when applicant prefer speedy patent grant while the patent's value horizon is not too long. The two sets of results are consistent with prediction (iii) and (iv). We find "need for speed" and "need for length" are separate concerns that patent applicants must consider carefully before choosing which type of patent protection to file.

5. Robustness Check

Interviews with patent attorneys suggest applicants generally utilize this period of time to assess the commercial viability of their innovation, formalize and translate her patent application. If this is indeed the case, we suspect that patent applicants that have some sort of "foreign cooperation" might thus require less time to make up the decision and prepare their U.S. filing. For each patent, we define a dummy variable "foreign cooperation" if the patent has at least one non-Chinese patentee or non-Chinese inventor. By this definition, the patents that have no "foreign cooperation" are those that are filed by Chinese firms with Chinese inventors only. To test this hypothesis, we estimate the following empirical equation:

$$Y_{ijt} = \alpha_0 + \alpha_1 * Foreign_i + \alpha_2 * UM_i + \alpha_3 * X_i + u_j + v_t + \varepsilon_{ijt}$$

In this equation, Y_{ijt} is either filing lag or filing in "last minute." The Dummies $Foreign_i$ and UM_i are defined previously. Our null hypothesis is $H_0 : \alpha_1 < 0$.

Table 12 presents the result. The coefficient estimates of α_1 is statistically significantly less than zero, supporting our hypothesis.

In our data, one third of U.S. patents with *UM* priority is delayed until the "last minute" before filing in U.S. If the hypothesis is true and filing *UM* reflects applicant's desire for speedy patent grant, then after the U.S. patent filing starts, the applicant should hasten her patent prosecution process more than the applicants with *IPat* priority. Table 13 presents the results. The results are consistent with our predictions.

6. Conclusion

Patent right provides a legal right to exclude others from using the same technology. In industries where the R&D and product cycle is long, patent applicants would like their patent rights to be long enough to secure revenue. In industries where pace of technology is fast and current products are quickly replaced by new, more advanced products, patent applicants would like to secure their patent right as soon as possible. The importance of the speed of patent prosecution and the length of patent term may vary across different technologies and patentees' diverse purposes of how to utilize the patent right**.**

This paper provides a first empirical look at patent applicant's heterogeneous preferences over the prosecution speed ("need for speed") and the protection life ("need for length") of patent protection. By conducting quantitative analysis using a set of successful U.S. patents with Chinese priorities from 1993-2008, we provide strong empirical evidence of the existence of both "need for speed" and "need for length" preferences. China provides two types of patent protection. The invention patent (*IPat)* is the counterpart of the U.S. utility patent; the utility model patent (*UM)* does not require substantive examination and is protected for 10 years. We find applicants opt for the appropriate type of protection that best suit their diverse preferences of "need for speed" and "need for length." More specifically, those that value prosecution speed over patent protection duration will opt to choose *UM*.

Our paper shed empirical lights on the literature of the optimal design of patent system. Although we provide evidences that suggest a flexible patent protection regime would better suit the diverse needs for patent applicants. There remain several questions to be answered. What is the overall social welfare implication if the patent system provides flexible patent protection? Under what conditions will the benefit outweigh the cost? In our empirical analysis, we find for the same invention, the Chinese renewal behaviors are broadly consistent with the U.S. renewal behaviors, but not precisely. A natural question to ask is to what extent is an average U.S. patent over-renewed, or not renewed enough? Offering a more frequent renewal schedule definitely introduces more cost. Yet on the other hand, renewing only 2 to 3 times in a patent's life time might as well induce too many over-protected patents or firms' incapability of fully utilizing the patent system. Then the question is what is the optimal numbers of renewal that a patent office should require? This study underlines the importance of continuing theoretical and empirical research on the design of a more flexible regime aimed on fully extend firms' capability of utilizing the patent system.

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Table1. Invention Patents (IPats) vs. Utility Models (Ums) in China

		Invention Patents	Utility Models
Definition		Any new technical solution or improvement relating to a product or a process.	Any new technical solution or improvement relating to the shape, the structure or their combination of a product.
Subject Matter		Process and product innovations	Product innovations
Patentability		Substantial examination of novelty, non-obviousness and utility.	No substantial examination of novelty, inventiveness.
Grant Lag		Average 36 months	Within 12 months
Term		20 years	10 years
Cost (YMB)	Application fee	950	500
	Examination fee	2,500	N/A; 2,400 for post-grant substantive examination
	Attorney fee	4,000-10,000	2,500-6,000
Maintenance fees (YMB) (annual renewals starting from grant date)		900, 1st-3rd years; 1200, 4th-6th years; 2000, 7th-9th years; 4000, 10th-12th years; 6000, 13th-15th years; 8000, 16th-20th years.	600, 1st-3rd years; 900, 4th-5th years; 1200, 6th-8th years; 2000, 9th-10th years.

Note: Mean grant lags for *IPats* and *UMs* are estimated, using SIPO patent dataset which contains all Chinese patents with filing dates between 1985 and 2008. The cost of patent application and renewal are obtained from SIPO website at www.sipo.gov.cn. For estimation of attorney fees, we interviewed several lawyers from different law firms located in Beijing, China, and asked for the attorney fees they charge for *IPats* and *UMs*. In general, law firms charge the same rate regardless of the locations of their clients (applicants).

Table2. Sample Statistics

U.S. utility patents with Chinese priority

3450 observations, U.S. filing date 1993-2010

Variable Name	Mean	S.D.	Min	Max
Panel A: Patent attributes				
UM priority (D)	0.19	0.39	0	1
No. of claims	13.23	6.91	1	88
No. of inventors	2.77	1.44	1	5
No. of uspc	3.23	2.99	1	28
No. of cited patents	10.73	11.07	0	190
No. of citing patents	1.15	3.19	0	59
Chinese grant lag (2036 obv. granted)	1016.59	509.66	216	2995
Have foreign patentee or inventor	0.41	0.49	0	1
Panel B: "need for speed" preference indicators				
filing lag (days)	258.66	135.34	0	916
filing in last month (D)	0.39	0.48	0	1
continuation (D)	0.07	0.26	0	1
continuation lag (days)	57.61	194.03	0	2307
grant lag (days)	1061.31	481.33	144	3617
Panel C: "need for length" preference indicators				
U.S. renewal dummies				
Renew at 3.5 year after issue	0.89	0.31	0	1
Renew at 7.5 year after issue	0.72	0.44	0	1
Renew at 11.5 years after issue	0.52	0.50	0	1
Chinese renewal dummies				
Renew at 2nd year after issue	0.98	0.10	0	1
Renew at 3rd year after issue	0.97	0.15	0	1
Renew at 4th year after issue	0.95	0.21	0	1
Renew at 5th year after issue	0.91	0.28	0	1
Renew at 6th year after issue	0.85	0.35	0	1
Renew at 7th year after issue	0.97	0.15	0	1
Renew at 8th year after issue	0.82	0.38	0	1
Renew at 9th year after issue	0.77	0.41	0	1

Note: the notation (D) means the variable is a dummy.

Table3. Distribution of Invention Patents vs. Utility Models, by Technology Fields

	IPat	*UM*
Chemicals	419	13
Computers& Communications	705	43
Drugs& Medical	207	8
Electrical& Electronic	1004	337
Mechanical	234	98
Others	227	155
Total	2796	654

Note: the six technology fields are defined as in Hall, Jaffe and Trajtenberg (1999), based on US patent classifications.

Table4. Comparison of "need for speed" and "need for length" preferences between *IPat* and *UM*

	UMs (mean)	*IPats* (mean)	*Difference* (*UM-IPat*)
(A) "need for speed" preference indicators			
Filing lag	238.445	263.398	-24.953***
Filing in last month	0.305	0.419	-0.113***
Continuation	0.024	0.085	-0.061***
Continuation lag	19.183	66.608	-47.425***
Grant lag	965.512	1083.722	-118.210***
(B) U.S. "need for length" preference indicators			
Maintain4	0.826	0.918	-0.092***
Maintain8	0.562	0.763	-0.198***
Maintain12	0.42	0.53	-0.10
(C) Chinese "need for length" preference indicators			
Maintain2	0.982	0.993	-0.0109**
Maintain3	0.957	0.980	-0.022***
Maintain4	0.935	0.952	-0.017
Maintain5	0.904	0.910	-0.006
Maintain6	0.783	0.881	-0.097***
Maintain7	0.666	0.856	-0.189***
Maintain8	0.622	0.857	-0.235***
Maintain9	0.484	0.836	-0.352***

Note: Units of *Filing lag, continuation lag and grant lag* are days; *Continuation, Filing in last month* and all the maintenance variables are dummies. * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table5. Attributes of US patents: Chinese UM priorities vs. Chinese IPat priorities (OLS)

	Number of Claims	Have foreign patentee/inventor	Number of USPC	Number of cited references	Number of citing patents
UM	-0.69	0.08	-0.17	0.96	0.44
	[0.48]	[0.02]***	[0.13]	[0.57]	[0.26]
R^2	0.02	0.03	0.10	0.03	0.23
N	3450	3450	3450	3450	3450
Filing year dummies	Yes	Yes	Yes	Yes	Yes
Technology dummies	Yes	Yes	Yes	Yes	Yes

Note: Robust Standard errors clustered at technology level, are in bracket.
* Significant at 10%; ** significant at 5%; *** significant at 1%. Specifications in the Table are $Y_{ijt} = \alpha_0 + \alpha_1 * UM_i + u_j + v_t + \varepsilon_{ijt}$, where Y_{ijt} is one of the patent quality indicators for U.S. patent i in technology field j (HJT 6) with a USPTO filing year t. The key variable UM_i is an indicator for whether US patent *i* has a Chinese UM priority.

Table6. “Need for speed” preferences comparison:

US Patents with Chinese *UM* priorities vs. with Chinese *IPat* priorities

	[1]	[2]	[3]	[4]	[5]	[6]
			Panel A (OLS)			
	Filing Lag	Filing Lag	Continuation Lag	Continuation Lag	Grant Lag	Grant Lag
UM	-32.475	-15.038	-55.189	-40.63	-133.775	-62.082
	[4.972]***	[5.099]***	[6.64]***	[6.912]***	[17.080]***	[17.306]**
R2	0.19	0.21	0.07	0.09	0.32	0.08
N	3450	3450	3450	3450	3450	3450
			Panel B (Logit)			
	“Last minute” filing	“Last minute” filing	Continuation	Continuation		
UM	-0.612	-0.362	-1.580	-1.103		
	[0.104]***	[0.101]***	[0.276]***	[0.290]***		
Pseudo-R2	0.17	0.15	0.12	0.17		
L-Likelihood	-1986.003	-1962.067	-792.153	-749.675		
N	3450	3450	3450	3450		
Filing year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Technology dummies	No	Yes	No	Yes	No	Yes
Marginal effects						
UM	0.143	0.086	0.074	0.106		

Note: Robust Standard errors, clustered at firm level, are in bracket. * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table7. “Need for length” preferences comparison:

Conditional renewal behaviors between *UM* and *IPat* patentees

	[1]	[2]	[3]	[4]	[5]	[6]
CN Renewal	Maintain2	Maintain2	Maintain3	Maintain3	Maintain4	Maintain4
UM	-1.201	-0.994	-0.895	-0.264	-0.072	-0.241
	[0.393]***	[0.415]**	[0.549]	[0.608]	[0.507]	[0.675]
R2	0.11	0.16	0.05	0.08	0.07	0.07
L-Likelihood	-104.028	-98.434	-88.613	-81.434	-99.908	-99.289
N	1710	1710	993	747	1075	1075
	Maintain5	Maintain5	Maintain6	Maintain6	Maintain7	Maintain7
UM	0.513	0.046	-1.657	-1.247	-3.438	-2.674
	[0.445]	[0.469]	[0.446]***	[0.522]***	[0.834]***	[0.707]***
R2	0.07	0.118	0.172	0.20	0.32	0.35
L-Likelihood	-113.429	-106.868	-80.601	-77.28	-29.588	-25.768
N	795	795	464	464	299	299
	Maintain8	Maintain8	Maintain9	Maintain9	Maintain10	Maintain10
UM	-1.663		-3.94	-4.522		
	[1.518]		[1.37]***	[1.664]***		
R2	0.35		0.33	0.39		
L-LIkelihood	-5.859		-19.115	-17.315		
N	69		85	83		
US Renewal	Maintain4	Maintain4	Maintain8	Maintain8	Maintain12	Maintain12
UM	-1.31	-0.944	-0.186	0.227	-0.937	0.757
	[0.221]***	[0.241]***	[0.692]	[0.778]	[1.852]	[2.053]
R2	0.12	0.14	0.13	0.16	0.18	0.30
L-LIkelihood	-397.153	-386.075	-78.627	-75.567	-18.252	-13.293
N	1303	1303	276	276	40	30
Filing year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Technology dummies	No	Yes	No	Yes	No	Yes

Note: Robust Standard errors, clustered at firm level, are in bracket. * Significant at 10%; ** significant at 5%; *** significant at 1%. For the Chinese renewal regressions, the filing years are the Chinese filing years; for the U.S. renewal regressions, the filing years are the U.S. filing years.

Table8. “Need for speed” preferences comparison:

US Patents with Chinese *UM* priorities vs. with Chinese *IPat* priorities in *Chemicals, C&C* and *Drugs&Medical*.

	[1]	[2]	[3]	[4]	[5]	[6]
			Panel A (OLS)			
	Filing Lag	Filing Lag	Continuation Lag	Continuation Lag	Grant Lag	Grant Lag
UM	-66.554	-66.42	-80.720	-80.347	-127.423	-125.541
	[13.972]***	[14.061]***	[19.251]***	[19.778]***	[62.113]***	[61.021]**
R2	0.03	0.03	0.09	0.09	0.33	0.35
N	1394	1394	1392	1392	1392	1392
			Panel B (Complementary Log-Log)			
	“Last minute” filing	“Last minute” filing	Continuation	Continuation		
UM	-0.840	-0.843	-1.324	-1.353		
	[0.239]***	[0.240]***	[0.584]**	[0.597]**		
Pseudo-R2						
L-Likelihood	-902.148	-889.08	-495.739	-484.962		
N	1393	1393	1393	1393		
Filing year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Technology dummies	No	Yes	No	Yes	No	Yes

Note: Robust Standard errors, clustered at firm level, are in bracket. * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table9. "Need for speed" preferences comparison:

US Patents with Chinese *UM* priorities vs. with Chinese *IPat* priorities in *E&E, Mechanical and Others*.

	[1]	[2]	[3]	[4]	[5]	[6]
Panel A (OLS)						
	Filing Lag	Filing Lag	Continuation Lag	Continuation Lag	Grant Lag	Grant Lag
UM	1.149	1.492	-17.67	-17.384	-41.33	-48.391
	[5.866]	[5.877]	[6.911]**	[6.951]**	[17.253]**	[17.179]***
R2	0.11	0.11	0.04	0.05	0.28	0.29
N	2055	2055	2050	2050	2055	2055
Panel B (Logit)						
	"Last minute" filing	"Last minute" filing	Continuation	Continuation		
UM	-0.031	-0.011	-0.711	-0.753		
	[0.123]	[0.124]	[0.343]**	[0.346]**		
Pseudo-R2	0.10	0.11	0.06	0.06		
L-Likelihood	-1097.20	-1095.69	-272.77	-271.97		
N	2054	2054	2034	2034		
Filing year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Technology dummies	No	Yes	No	Yes	No	Yes

Note: Robust Standard errors, clustered at firm level, are in bracket. * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table10. "Need for length" preferences comparison:

Conditional renewal behaviors between *UM* and *IPat* patentees in *E&E, Mechanical and Others*.

	[1]	[2]	[3]	[4]	[5]	[6]
CN Renewal	Maintain2	Maintain2	Maintain3	Maintain3	Maintain4	Maintain4
UM	-0.009	-0.010	0.002	-0.004	0.014	0.013
	[0.007]	[0.007]	[0.002]	[0.010]	[0.011]	[0.012]
R2	0.02	0.03	0.09	0.02	0.04	0.04
N	1129	1129	942	849	622	622
	Maintain5	Maintain5	Maintain6	Maintain6	Maintain7	Maintain7
UM	0.001	0.001	-0.096	-0.088	-0.098	-0.097
	[0.02]	[0.02]	[0.036]***	[0.035]**	[0.044]**	[0.045]**
R2	0.14	0.14	0.13	0.16	0.22	0.24
N	462	462	269	269	169	169
	Maintain8	Maintain8	Maintain9	Maintain9	Maintain10	Maintain10
UM	0.028	0.025	-0.359	-0.370		
	[0.028]	[0.026]	[0.137]**	[0.135]***		
R2	0.16	0.17	0.46	0.47		
N	101	101	49	49		
US Renewal	Maintain4	Maintain4	Maintain8	Maintain8	Maintain12	Maintain12
UM	-0.095	-0.092	0.045	0.039		
	[0.024]***	[0.025]***	[0.059]	[0.057]		
R2	0.13	0.13	0.11	0.12		
N	756	756	113	113		
Filing year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Technology dummies	No	Yes	No	Yes	No	Yes

Note: Due to the limitation in the number of observations, our estimations are based on linear probability model. Robust Standard errors, clustered at firm level, are in bracket. * Significant at 10%; ** significant at 5%; *** significant at 1%. For the Chinese renewal regressions, the filing years are the Chinese filing years; for the U.S. renewal regressions, the filing years are the U.S. filing years.

Table11. "Need for length" preferences comparison:

Conditional renewal behaviors between *UM* and *IPat* patentees in *Chemicals, C&C* and *Drugs&Medical*.

	[1]	[2]	[3]	[4]	[5]	[6]
CN Renewal	Maintain2	Maintain2	Maintain3	Maintain3	Maintain4	Maintain4
UM	0.002	0.002	0.002	0.002	-0.011	-0.012
	[0.001]	[0.001]	[0.002]	[0.002]	[0.030]	[0.030]
R2	0.06	0.06	0.09	0.08	0.04	0.05
N	907	907	942	742	589	589
	Maintain5	Maintain5	Maintain6	Maintain6	Maintain7	Maintain7
UM	0.021	0.019	0.005	0.004	0.002	0.003
	[0.009]**	[0.009]**	[0.010]	[0.012]	[0.003]	[0.005]
R2	0.04	0.04	0.05	0.05	0.04	0.04
N	478	478	355	355	250	250
	Maintain8	Maintain8	Maintain9	Maintain9	Maintain10	Maintain10
UM	-0.167	-0.162	-0.230	-0.220		
	[0.149]	[0.142]	[0.222]	[0.225]		
R2	0.20	0.22	0.27	0.28		
N	136	136	68	68		
US Renewal	Maintain4	Maintain4	Maintain8	Maintain8	Maintain12	Maintain12
UM	-0.047	-0.047	-0.016	-0.051		
	[0.051]	[0.051]	[0.037]	[0.045]		
R2	0.06	0.07	0.14	0.16		
N	606	606	177	177		
Filing year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Technology dummies	No	Yes	No	Yes	No	Yes

Note: Due to the limitation in the number of observations, our estimations are based on linear probability model. Robust Standard errors, clustered at firm level, are in bracket. * Significant at 10%; ** significant at 5%; *** significant at 1%. For the Chinese renewal regressions, the filing years are the Chinese filing years; for the U.S. renewal regressions, the filing years are the U.S. filing years.

Table12. Comparing filing lags and propensity of filing in last month between indigenous Chinese inventors and Chinese inventors with foreign cooperation

	[1]	[2]	[3]	[4]		
	Filing Lag	Filing Lag	"Last minute" filing	"Last minute" filing		
Foriegn	-81.952	-72.962	-0.998	-0.920		
	[7.684]***	[7.854]***	[0.096]***	[0.097]***		
UM	-72.454	-52.499	-0.433	-0.256		
	[8.627]***	[8.904]***	[0.107]***	[0.114]***		
R2	0.27	0.29	0.16	0.17		
N	3450	3450	3450	3450		
Filing year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Technology dummies	No	Yes	No	Yes	No	Yes

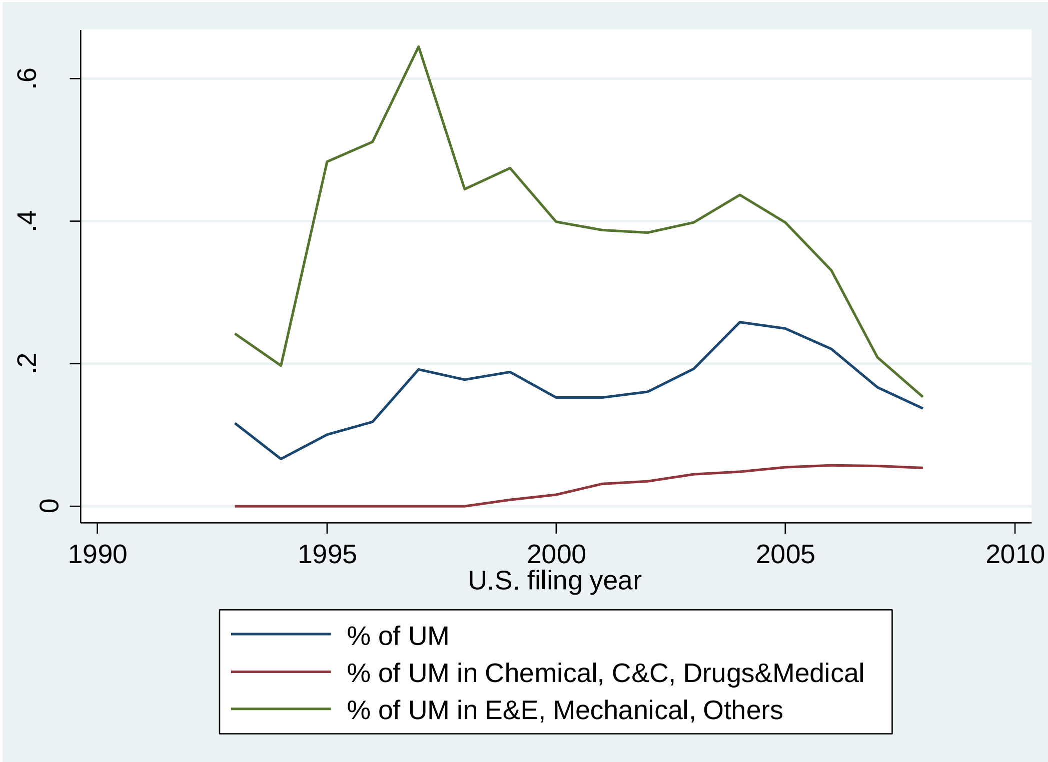
Note: Robust Standard errors, clustered at firm level, are in bracket. * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table13. Is "need for speed" preference consistent prior vs. post U.S. application date? Examining filing behaviors of U.S. patents with *UM priority* that are delayed until "last minute" before filing

	[1]	[2]	[3]	[4]	[5]	[6]
	Continuation	Continuation	Continuation lag	Continuation lag	Grant lag	Grant lag
UM filed in last month	-1.656	-1.144	-69.465	-52.181	-246.850	-159.972
	[0.441]***	[0.453]**	[12.737]***	[13.277]***	[29.510]***	[30.233]***
R2	0.11	0.16	0.06	0.09	0.34	0.39
L-Likelihood	-746.619	-703.112				
N	2989	2989	2989	2989	2989	2989
Filing year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Technology dummies	No	Yes	No	Yes	No	Yes

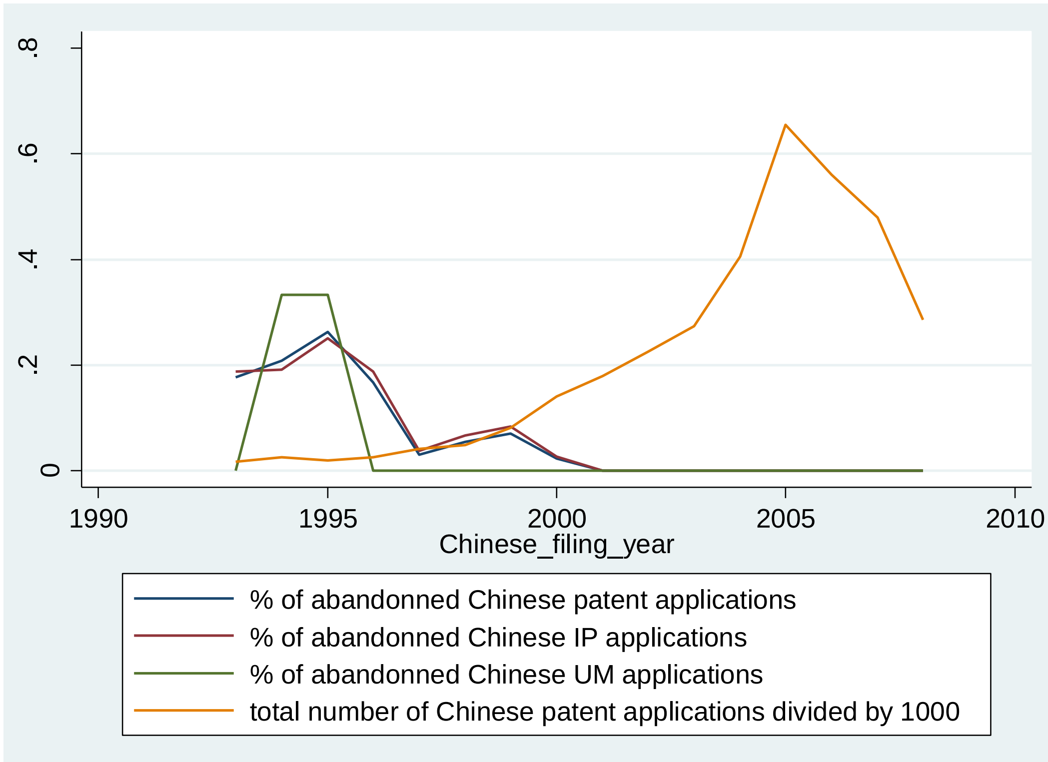
Note: Robust Standard errors, clustered at firm level, are in bracket. * Significant at 10%; ** significant at 5%; *** significant at 1%.

Figure1. % of U.S. patent with UM priority through the period 1993-2008



Note: there are 6 technology fields Chemical, Computer and Communication, Drugs and Medical, Electrical and Electronics, Mechanical, Others as defined in Hall, Jaffe and Trajtenberg (1999). The x-axis represents Chinese filing year.

Figure2. Abandon rate of Chinese patent applications (the same inventions have been granted U.S. patent) through the period 1993-2008



Note: The total number of patent applications is 3450. The drop in applications after 2005 (648 applications) is due to right-truncation. The x-axis represents Chinese filing year.

Figure4. Kaplan Meier Survival Function Estimate for Chinese Patent Renewal

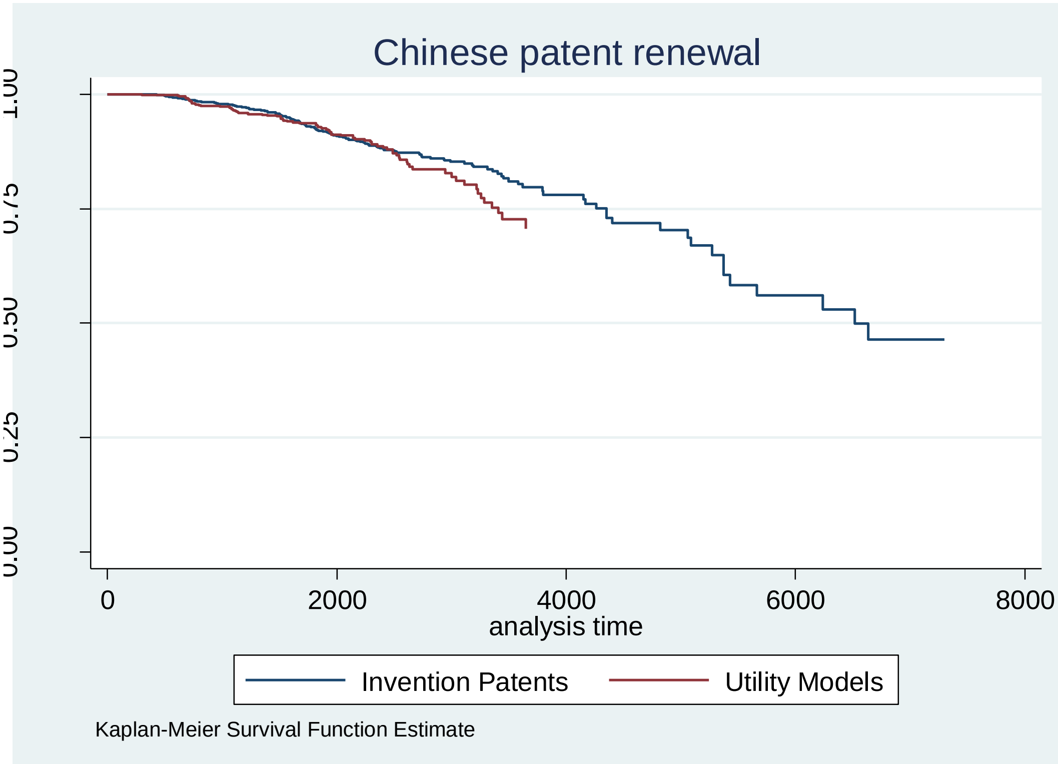


Figure5. Kaplan Meier Survival Function Estimate for U.S. Patent Renewal

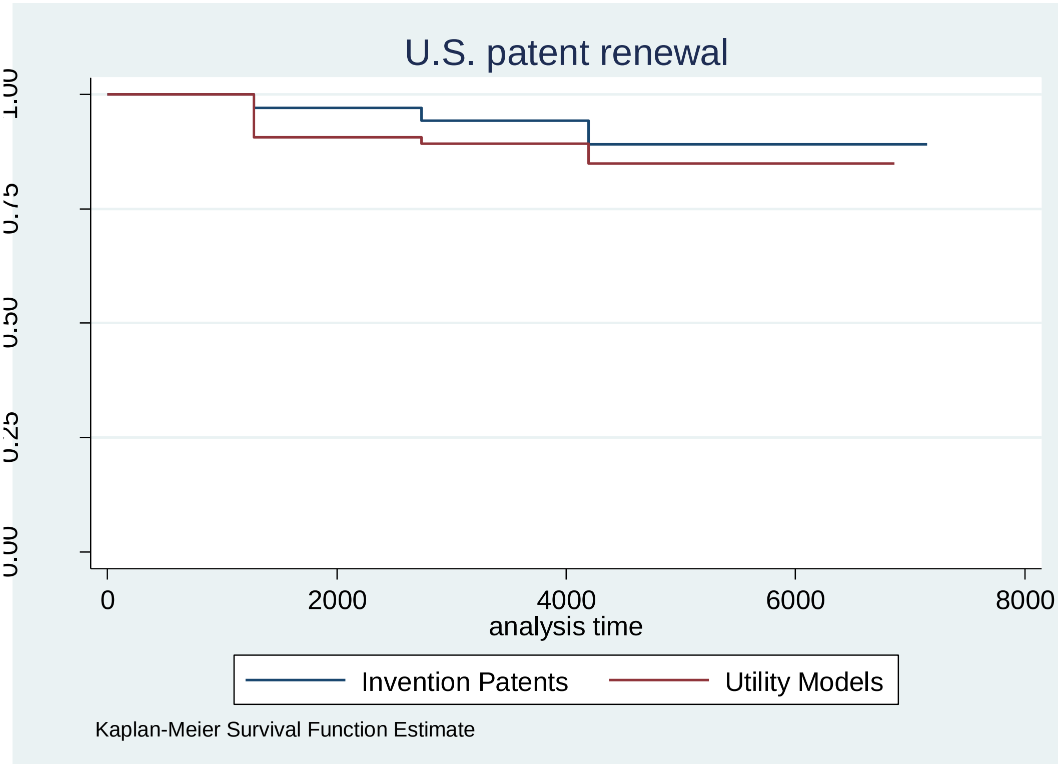


Figure6. Kaplan Meier Survival Function Estimate for Filing lag