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Estimates of the Value of Patent Rights in China

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Abstract:

We estimate the value of Chinese invention and utility model patents that were applied for during two periods, 1987–1989 and 1986–1998. We find that patents applied for by foreign entities invariably have higher value than do those applied for by domestic entities, and the gap is significant. The total value of invention and utility model patents in the 1987 cohort together represent about 40 per cent of China's 1987 governmental R&D budget.

Keywords:

Value; Patent; China; Invention Patent; Utility Model Patent; Patent Renewal

JEL code: O32; O34

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1. Introduction

In 2010, the State Intellectual Property Office of China (hereafter "SIPO") received 1,222,286 patent applications, which represents a 25-per cent annual increase from the number of applications in 2009. According to a Thomson Reuters' report, if China's patent applications figures continue to grow at this pace, China will rank first among all countries in patent applications received and will also grant the most patents in the world in 2011 (Zhou and Stembridge, 2010). However, some government officials and legal experts have expressed concerns about the low value (quality) of Chinese patents, despite the rapid increase in volume. They argue that patent application figures in China have been inflated by a government subsidy that covers patent application costs and various benefits associated with patent applications, including the opportunity for inventors to receive cash bonuses from either employers or local governments. Moreover, graduates who apply for patents are more likely to earn residency permits (*Hukou*) to live in a desirable city, and professors are more likely to be promoted if they hold patents (Economists, 2010). Despite these concerns, however, to the best of our knowledge no one has conducted a systematic, rigorous study of the value (quality) of Chinese patents. The extant evidence is largely anecdotal or is based on simple statistics.

The value of Chinese patents can be evaluated based on patent renewal information. When a patent is due for renewal annually, its holder must pay an annual renewal fee to maintain its validity. The patent holder determines whether holding a patent has a value that exceeds the value of the renewal fee. If the benefit is greater than the fee, the patent holder renews the patent. If not, she lets the patent lapse before the end of its full protection term. Patents that are renewed

for longer periods should thus confer greater economic value to holders than would those that are renewed for shorter periods. Statistics have shown that, among patents granted by SIPO, patents originating in foreign countries are held comparatively longer than were those held by domestic entities. Among domestic invention patents, 46.7 per cent were renewed beyond five years while only 4.6 per cent were renewed beyond ten years. In contrast, 83.5 per cent of foreign-held patents were renewed beyond five years and 23.8 per cent were renewed beyond ten years (SIPO, 2011). The value of patents owned by foreign applicants should, accordingly, be higher than is that of patents owned by domestic applicants. In addition, short-lived patents, such as the 46.7 per cent of patents applied for by domestic entities that are renewed for less than five years, should have very low value.

In this study, we go beyond simple statistics to undertake a comprehensive study of renewal information pertaining to Chinese invention patents that were applied for in 1987–1989 and utility model patents that were applied for in 1986–1998, and we estimate their value. We evaluate and compare the value of patents over a range of cohorts, patents applied for by various applicant types—such as domestic and foreign individuals, universities and research institutions, companies—patents falling into various technology fields, and patents originating in various provinces of China. The value is evaluated using a nonlinear least square model for estimation purposes. The unit of analysis is group of patents aggregated based on patent cohort, type of applicant, technology field, and province. As the value of a patent can be considered as a return on the investment involved in holding intellectual property rights, we are interested in evaluating the value obtained by holding granted patent rights as compensation for R&D investment. We estimate the total value of invention and utility model patents that were applied for in 1987 and

compare this figure with the total value of China's R&D investment in the corresponding period. Based on this evaluation, we reveal the significance of the patent system for R&D activities and investment in China. In addition, to examine the value of invention patents applied for in a relatively recent period, we analyse renewal information on invention patents applied for in 2002–2003 and compare that information with data on patents applied for in the 1987–1989 cohorts.

The rest of the paper is organized as follows. Section 2 introduces the estimation methodology and the model we use to estimate the value of patent rights. Section 3 describes the data on Chinese patents. Section 4 presents the estimation results. Section 5 calculates the value of the patent rights that the patent system creates as a subsidy for R&D expenditure in China. Section 6 conjectures about the value of invention patents applied for in the more recent period of 2002–2003. Section 7 concludes the paper.

2. Methodology and model

Arora et al. (2010) identify three main approaches to estimating patent value: the market value approach, the patent renewal approach, and the inventor survey approach. The market value approach, adopted in such studies as Griliches (1981) and Hall et al. (2005), uses stock market value to estimate the value of firms' tangible and intangible capital stock (which includes patent stocks) and infers the value of patents from these data. The patent renewal approach analyses patent renewal records and the costs of patenting and renewing to assess the distribution of earnings from patents (the value of patents). The inventor survey approach, exemplified by Giuri

et al. (2007) and Gambardella et al. (2008), represents a subjective evaluation made by inventors on the value of their inventions. Given the patent renewal information that we found available for Chinese patents, we use the patent renewal approach in this study to estimate the value of Chinese patents.

2.1 The basic patent renewal model

After the first patent renewal study was published by Schankerman and Pakes in 1986, a variety of models have been developed by scholars to estimate the value of patent rights. The group of models studied by Schankerman and Pakes (1986), Pakes (1986), Pakes and Simpson (1989), Lanjouw (1998), Schankerman (1998), Baudry and Dumont (2006) and Bessen (2008) model renewal decisions only. By contrast, Putnam (1996) and Deng (2007) model application and renewal decisions together. All these models differ also in the way in which constraints on patent renewal decisions are specified. Among these studies, Pakes (1986), Pakes and Simpson (1989), Lanjouw (1998), and Baudry and Dumont (2006) do not assume that returns on patent rights decay deterministically, while the other studies do. By avoiding this assumption, these three studies allow for stochastic returns, uncertainty, and learning in renewal decisions. In their models, patent value is divided into the value of current-year returns on patent protection and the value of the option of renewing in the next year. Even if the value of current-year returns on a given patent is lower than the value of renewal fees, as long as the value of the renewal option that is exercised in the next year is large enough for patentees to recover their losses, they will still renew the patent. When applying the models studied by Schankerman and Pakes (1986), Schankerman (1988), and Bessen (2008), which specify a deterministic decay rate, the patentee

will not renew. Pakes (1986), Pakes and Simpson (1989), and Lanjouw (1998) also use dynamic programming to estimate the length of time required to ascertain patent value. They find that the learning process is actually not very long. In a period of approximately five or six years, most patentees discover the value of their patent rights. Baudry and Dumont (2006) use a method similar to that of Pakes (1986), but they employ a more generalized stochastic process (a binomial tree) that is standard in the finance literature to evaluate the value of the option of renewing a patent in the next year.

The patent renewal model that allows for stochastic returns is considerably more complex than the model assuming deterministic returns is. However, the advantage of using the former model over the latter is that the former enhances the extent to which the estimated renewed proportion of patents is approximately equal to the real renewed proportion (Pakes, 1986, p.774). Weighing the trade-off between the complexity of the stochastic model and the gain in accuracy, we in this paper use the basic patent renewal model outlined in Schankerman and Pakes (1986) to estimate the value of Chinese patents. This model is built to solve a patent owner's decision problem, namely that of maximizing the discounted returns on a patent minus the cost of the patenting itself as

(1) $\max_{T\in[1,2,\ldots,\bar{T}]} V(T) = \sum_{t=1}^{T}\left(R_{tj} - C_{tj}\right)(1+i)^{-t}$,

where R_{tj} represents returns on patent protection, C_{tj} is the renewal fee, *t* is the age of the patent, *j* is its cohort, *i* is the assumed discount rate of.10 and $\bar{T}$ is the statutory limit on patent protection. Assuming that$\left(R_{tj} - C_{tj}\right)$ is n is non-increasing (R_{tj} decreases deterministically and

C_{tj} i increases or is unchanged as the age of the patent increases[1]), as long as the value of annual returns at age *t* is equal to or greater than the renewal fee, which is

(2) $R_{tj} \geq C_{tj}$,

we can see that the patent owner would choose to renew the patent in order to maximize $V(T)$. The owner stops renewing the patent at the first age that $R_{tj} - C_{tj} < 0$. This age is called the optimal lifespan T^*. If no such $T^* \in [1,2, ...,, \bar{T}]$, then $T^* = \bar{T}$. Assuming that the value of the patent decays deterministically over time, we then have

(3) $R_{tj} = R_{0j} \prod_{\tau=1}^{t}(1 - \delta_{\tau j})$,

where R_{0j} represents initial returns and $\delta_{\tau j}$ is the decay rate of those returns. Schankerman and Pakes (1986) and Lanjouw (1998) assume $\ln(R_{0j}) \sim N(\mu_j, \sigma_j^2)$ and conclude that a lognormal distribution of the initial returns R_{0j} vis-à-vis the Weibull and Pareto distributions provides the closest fit of the data. Following Equations (2) and (3), patent holders renew a patent at age t if and only if $\ln(R_{0j}) \geq lnC_{tj} - \sum_{\tau=1}^{t} ln(1 - \delta_{\tau j})$, or equivalently,

(4) $\frac{\ln(R_{0j}) - \mu_j}{\sigma_j} \geq \frac{lnC_{tj} - \mu_j - \sum_{\tau=1}^{t} ln(1-\delta_{\tau j})}{\sigma_j}$.

Because $\frac{\ln(R_{0j}) - \mu_j}{\sigma_j}$ has a standardized normal distribution, the proportion of patents in cohort *j* that are not renewed at age t is given by

$$(5)\ 1 - P_{tj} = \Phi\left(\frac{lnC_{tj} - \mu_j - \sum_{\tau=1}^{t} ln(1-\delta_{\tau j})}{\sigma_j}\right),$$

where P_{tj} is the proportion of patents in cohort *j* that are renewed at age *t* and $\Phi(.)$ is the standardized normal distribution function. The estimation problem based on Equation (5) is to choose μ_j (R_{0j}), σ_j and $\delta_{\tau j}$, which make the predicted renewal proportions at each age *t* and cohort *j* as close to the observed proportions as possible. An estimation function based on Equation (5) can be written as

$$(6)\ y_{\tau j} \equiv \Phi^{-1}(1 - P_{tj}) = \frac{lnC_{tj} - \mu_j - \sum_{\tau=1}^{t} ln(1-\delta_{\tau j})}{\sigma_j} + \varepsilon_{\tau j},$$

where $\varepsilon_{\tau j}$ has a mean of zero and variance of σ_ε^2. Equation (6) can be estimated by the nonlinear least square method. The estimated values of μ_j (R_{0j}), σ_j and $\delta_{\tau j}$ are used to simulate the value of a single patent based on

$$(7)\ V(T) = \sum_{t=1}^{T^*}[R_{0j} \prod_{\tau=1}^{t}(1 - \delta_{\tau j}) - C_{tj}](1 + i)^{-t}.$$

We draw 50,000 variables from a lognormal distribution with the estimated value of $\widehat{\mu_j}$, $\widehat{\sigma_j}$ and $\widehat{\delta_j}$, calculate *V* for each of them, and then derive the quantiles of the implied distribution of *V*. The process is repeated three more times, each time perturbing one of the estimated parameters ($\widehat{\mu_j}$, $\widehat{\sigma_j}$ or $\widehat{\delta_j}$) by one per cent. Through this process, we obtain the numerical estimates of the derivatives of each of the quantiles with respect to the parameters. Together with the variance-

covariance matrix of the parameter estimates, we can calculate the standard errors of each of the quantiles through the delta method (Equation 8).

(8) $\mathrm{Var}(V_{quantiles}) =$

$$\left[\frac{\partial V_{quantiles}}{\partial \widehat{\mu_J}} \quad \frac{\partial V_{quantiles}}{\partial \widehat{\sigma_J}} \quad \frac{\partial V_{quantiles}}{\partial \widehat{\delta_J}}\right]\begin{bmatrix} var(\widehat{\mu_J}) & cov(\widehat{\mu_J}, \widehat{\sigma_J}) & cov(\widehat{\mu_J}, \widehat{\delta_J}) \\ cov(\widehat{\sigma_J}, \widehat{\mu_J}) & var(\widehat{\sigma_J}) & cov(\widehat{\sigma_J}, \widehat{\delta_J}) \\ cov(\widehat{\delta_J}, \widehat{\mu_J}) & cov(\widehat{\delta_J}, \widehat{\sigma_J}) & var(\widehat{\delta_J}) \end{bmatrix}\begin{bmatrix} \frac{\partial V_{quantiles}}{\partial \widehat{\mu_J}} \\ \frac{\partial V_{quantiles}}{\partial \widehat{\sigma_J}} \\ \frac{\partial V_{quantiles}}{\partial \widehat{\delta_J}} \end{bmatrix}$$

3. Data

3.1 Data source

The renewal records and other patent information are collected from the China Patent Abstract Database. The database includes over four million patent applications submitted by domestic and foreign applicants to the Chinese Intellectual Property Office during 1985–2009. The information provided in the database on each patent includes patent application and publication number, application and publication date, patent number, title, International Patent Classification (IPC) class, abstract, claims, renewal records, and so on.

There are three types of patents in the Chinese patent system: invention, utility model, and design.[2] Invention patent applications are subject to substantive examination. Patent examiners are required to conduct a search of prior art before granting invention patents. Utility model patents are granted on a registration basis and need not undergo a substantive examination process, which usually represents incremental technological improvements. Currently invention

patents are protected for 20 years, while utility model and design patents are protected for only ten years.

China's patent law was promulgated in 1985 and amended in 1992, 2000, and 2008. SIPO first received patent applications in 1985. The 1985 version of the patent law stipulates that invention patents be protected for 15 years while utility model and design patents be protected for five years, but the protection of utility model and design patents can be extended to eight years. The 1992 amendment extends the protection period for invention patents (covering those applied for after December 31st, 1992) to 20 years and for utility model and design patents (covering those applied for after December 31st, 1992) to ten years. To harmonize China's intellectual property rights standards with international rules, as China anticipated signing, in 2001, the Agreement of Trade-Related Aspects of Intellectual Property Rights as part of its World Trade Organization obligations, SIPO extended the protection period for invention patents that were applied for before December 31st, 1992 and were still valid until December 11th, 2001 to 20 years. Being protected for only for 15 years under the 1985 version of the patent law, invention patents that were applied for before December 11th, 1986 would have expired before December 11th, 2001. Therefore, this decision virtually extended the protection period for all invention patents applied for after December 11th, 1986 to 20 years.

We designate a cohort of patents as all the patents applied for in a given year. The China Patent Abstract Database provides full information on the lifespan of invention patents in the 1985–1989 cohorts and of utility model patents in the 1985–2000 cohorts. Therefore, the latest cohort

of invention patents that we can include in the analysis is 1989. Obviously, the value of invention patents with full protection terms of 20 years would be higher than the value of patents with full protections terms of 15 years would be. Similarly, the value of utility model patents with full protection terms of ten years would be higher than that of patents with full protection terms of eight years would be. We thus focus on invention patents that are covered by the full protection term of 20 years, that is, those that were applied for after December 11th, 1986, namely those that were applied for in 1987, 1988, and 1989. We integrate the 285 patents applied for between December 11th, 1986 (inclusive) and December 31st, 1986 (inclusive) into the 4347 patents applied for in 1987. The numbers of granted patents from the 1987, 1988, and 1989 cohorts are thus 4632, 4835, and 4337, respectively. We examine the renewal records for utility model patents that have maximal lifespans of ten years, that is, patents on the 1986–1998 cohorts.[3]

3.2 Descriptive statistics

We define the renewal proportion as the proportion of patents in cohort *j* that are renewed at age *t*. Conversely, the dropout proportion is defined as the proportion of patents in cohort *j* that are not renewed at age *t*. Figure 1 shows that the renewal proportion of invention patents starts to decline after age three while that of utility model patents begins to decline after age two. Only about 16–17 per cent of invention patents were renewed to full term. Less than ten per cent of utility model patents were renewed until age ten. For the invention and utility model patents that were not renewed to full term, the dropout proportion peaked at age eight and age five, respectively (Figure 2).

(Here insert Figure 1)

(Here insert Figure 2)

The nominal renewal fees for Chinese patents are obtained through various Announcements of SIPO (No. 4, No. 33, No. 36, No. 43, and No.75). The nominal renewal fees are converted to real costs using the implicit GDP deflator provided by the World Bank. The age paths of the nominal and deflated renewal fees are demonstrated in Figure 3, which indicates that the average deflated renewal fee for invention patents increases until age 16 and declines afterwards. This result differs from those associated with the fee schedule examined by Schankerman and Pakes (1986), in which the renewal fee monotonically increases along the patent lifecycle until age 20 in Germany, the UK, and France. However, because we assume that $(R_{tj} - C_{tj})$ is non-increasing even though C_{tj} decreases after age 16, the basic model established by Schankerman and Pakes (1986) is still valid for the Chinese data. Differing from the fee schedule for invention patents, the renewal fee for utility model patents increases monotonically.

(Here insert Figure 3)

We obtain information along three dimensions for each patent directly from the Database: cohort, technology field, and location of patent origin. We clean the patent records to produce information along an additional dimension: applicant type. Summary statistics on granted invention patents show that three per cent, 45 per cent, and 71 per cent of such patents were not renewed at ages five, ten, and 15. Only 17 per cent of patents were renewed to full term (Table 1).

There is no material difference across the three cohorts in terms of dropout rate and the share of patents renewed to full term. However, a significant difference exists between patents applied for by domestic entities and those applied for by foreign entities. Less than five per cent of patents applied for by domestic entities were renewed to full term. More than 90 per cent of such patents were not renewed at age 15. Among patents applied for by domestic entities, those applied for by universities and research institutions lapsed soonest. In contrast, from 14 per cent to 25 per cent of patents applied for by foreign entities were renewed to full term. Patents applied for by foreign corporations enjoy the longest lives, as 58 per cent were renewed at age 15 and 25 per cent were renewed to full term. Among patents belonging to eight technology fields, patents in fixed construction exhibited the shortest lives. Only nine per cent of patents in this category were renewed to full term. By comparison, 14 per cent to 21 per cent of patents in the other seven fields were renewed to full term. The lives of patents originating in China were shorter than were those of patents originating in foreign countries.[4] Twenty-four per cent of patents originating in foreign countries were renewed to full term. However, only three per cent of patents originating in China were renewed to full term.

(Here insert Table 1)

Summary statistics on granted utility model patents show that, on average, 61 per cent were not renewed at age five. Only six per cent of such patents were renewed to full term (Table 2). Dropout rates at age five across the 13 cohorts vary from 47 to 73 per cent and shares of patents renewed to full term vary from two to 12 per cent. However, the dropout rate at age five declined gradually after the mid-1990s and the share of patents renewed to full term increased in the same

period, which shows that patent holders began gradually to renew utility model patents for a longer period following the mid-1990s.

As was true in the case of invention patents, a significant difference exists between utility model patents applied for by domestic entities and those applied for by foreign entities. First, foreign entities applied for much fewer utility model patents than domestic entities did. Of 349,703 utility model patents, only 30,706 (8.7 per cent) originated abroad. Sixty-seven per cent of utility model patents were applied for by domestic individuals alone. Second, foreign applicants renewed a higher proportion of patents to full term than domestic entities did. Only about three, seven, and 12 per cent of patents applied for by domestic individuals, universities and research institutions, and corporations, respectively, were renewed to full term. In contrast, 14 per cent, 37 per cent, and 37 per cent of patents applied for by foreign individuals, universities and research institutions, and corporations, respectively, were renewed to full term. Among patents in eight technology fields, those for human necessities had the shortest lives, as only four per cent of patents in this category were renewed to full term. In comparison, ten per cent of patents in chemistry and metallurgy were renewed to full term. As was true in the case of invention patents, utility model patents originating in China had shorter lives than did patents originating in foreign countries. Nineteen per cent of patents originating in foreign countries were renewed to full term. However, only three to six per cent of patents originating in the three Chinese regions were renewed to full term.

(Here insert Table 2)

4. Empirical analyses and results

We estimate Equation (6) by incorporating information pertaining to our four dimensions—cohort, applicant type, technology field, and nationality and region—separately in the regressions (see Table 3 and Table 4). The first column of Table 3 shows the results for the no-effects model, which is run with no variation in μ. Two dummy variables representing patents in the 1988 and 1989 cohorts are added to the fixed-effects model in the second column. The reference group is the 1987 cohort. Therefore, μ represents the initial returns on the 1987 cohort. Five dummy variables for applicant type and seven dummy variables for technology field are included in the regression (see column 3 and 4). In these regressions, μ represents the initial returns of the reference groups "domestic universities and research institutions" and "textile; paper," respectively. As seen in Table 4, 30 dummy variables that represent the 30 provinces and three dummy variables that represent the eastern, central, and western regions are also included in the model. The reference group for these two groups of dummies is comprised of patents originating in foreign countries.

(Here insert Table 3)

(Here insert Table 4)

The Wald test statistic for the null hypothesis that the coefficient of Cohort1988 equals that of Cohort1989 is F (1, 1921) = 2.3, which is not statistically significant at the 0.1 level. This result indicates that the differences in initial returns on invention patents from the 1987, 1988, and 1989 cohorts are not statistically significant. Consistent with the summary statistics, patents applied for by foreign entities have higher value than do patents applied for by domestic entities.

Invention patents applied for by foreign corporations have the highest value, and those applied for by domestic universities and institutions (the reference group) have the lowest value. The value of invention patents applied for by foreign individuals, foreign universities and research institutions, domestic individuals, and domestic corporations are intermediate and ranked in descending order. Patents belonging to the technology fields human necessities, chemistry and metallurgy, and electricity have higher value than do patents in textile and paper, performing operations and transportation, fixed construction, mechanical engineering, lighting, heating, weapons and blasting, and physics. The Wald test shows that the values of patents belonging to the latter technology fields do not differ significantly from each other. The results of the fixed-effects model with respect to location in Table 4 demonstrate that patents originating in economically developed provinces in China's eastern and coastal region are more valuable than are those from the economically underdeveloped provinces in the central and western regions. The Wald test proves that the difference between the coefficients of the three regions is statistically significant. However, patents of foreign origin are invariably more valuable than are those from any of the three Chinese regions.

Using the estimated results of column 3 in Table 3 and Equations (7) and (8), we are able to delineate the distribution of the value of the invention patents that were applied for by various types of applicants. Our model cannot estimate accurately the value of patents renewed to full term, as the value of these patents is affected by the fat tail of the lognormal distribution. Therefore, the estimated median value of invention patents is more accurate than the estimated mean value is because the latter reflects the estimated value of patents renewed to full term. As seen in Table 5, all medians (50^{th} per centile) are greater than their standard deviations are. In

contrast, half of the means are smaller than their standard deviations are. The 90th per centiles are also estimated less precisely than the 25th, 50th, and 75th per centiles are. The medians of invention patents applied for by foreign corporations, foreign individuals, foreign universities and research institutions, domestic individuals, domestic corporations, and domestic universities and research institutions are (at constant 2008 prices) RMB 1,072,829, RMB 616,443, RMB 354,164, RMB 86,392, RMB 59,157 and RMB 41,434, respectively.[5] Consistent with the findings on the summary statistics, the median value of invention patents applied for by foreign corporations is 18 times higher than the value of patents applied for by domestic corporations is. The median value of patents applied for by foreign individuals and foreign universities and research institutions also is significantly higher than is the value of patents applied for by their Chinese counterparts.

(Here insert Table 5)

The estimation of the value of utility model patents is provided in Tables 6 and 7. The μ figure in Column 2 in Table 6 represents the initial returns on the 1986 cohort, the reference group in the regression. The value of patents increases gradually after 1993 and value of the 1993–1998 cohorts is statistically significantly higher than is the value of the 1986–1992 cohorts. It seems that the 1992 amendment to the Patent Law, which prolongs the protection period for utility model patents from eight years to ten years, boosts the value of patent rights. The amendment went into effect on January 1st, 1993. Patents applied for during and after 1986 could be still valid in 1993 (at age eight) and could possibly be renewed to full term. Although holders of these patents can, in theory, renew their patents for up to ten years, many of them probably choose to

let their patents lapse before they reach age eight. We argue that that is the reason that patents applied for after 1993 are renewed for longer periods than are patents applied for before 1993; accordingly, patents in the 1993–1998 cohorts have higher value.

(Here insert Table 6)

(Here insert Table 7)

As seen in Column 3, Table 6, utility model patents applied for by foreign corporations and universities and research institutions have the highest value, and those applied for by domestic individuals (although they are the largest in number) have the lowest value. The value of utility model patents applied for by foreign individuals, domestic corporations, and domestic universities and research institutions is intermediate and ranked in descending order. Patents belonging to the technology fields performing operations and transportation, mechanical engineering, lighting, heating, weapons and blasting, physics, and electricity have higher value than do those falling into human necessities, chemistry and metallurgy, fixed construction, and textile and paper (the reference group). In addition, the Wald test shows that the value of patents in human necessities is lower than is that of patents in chemistry and metallurgy and fixed construction, but the value of patents in the latter two fields does not differ significantly. As is true in the case of invention patents, utility model patents originating in economically developed provinces in China's eastern and coastal region are more valuable than are those from the economically underdeveloped provinces in the central and western regions. The Wald test proves that the differences among the coefficients on the three regions are statistically significant.

We present the distribution of the value of utility model patents that are applied for by various types of applicants in Table 8. As is true in the case of the value of invention patents, the 90th per centile and means are estimated with less precision than are the 25th and 50th per centiles. The medians (50th per centile) of utility model patents applied for by foreign corporations, foreign universities and research institutions, foreign individuals, domestic corporations, domestic universities and research institutions, and domestic individuals are (at constant 2008 prices) RMB 541,284, RMB 513,162, RMB 218,644, RMB 88,070, RMB 69,284, and RMB 38,564, respectively.[6] Utility model patents applied for by domestic individuals are greatest in number but least in value. The median value of invention patents applied for by foreign corporations, universities and research institutions, and foreign individuals is significantly higher than is that of patents applied for by their counterparts based in China.

(Here insert Table 8)

Comparing the median value of invention and utility model patents, we find that invention patents applied for by foreign corporations are twice as valuable as are utility model patents applied for by such corporations. Invention patents applied for by foreign individuals are three times as valuable as utility model patents applied for by such individuals are. Invention patents can be renewed for 20 years but utility model patents can be renewed for only ten years; it seems only natural that the value of the former would be higher than that of the latter would be. However, this is not always the case. Utility model patents applied for by domestic universities and research institutions, domestic corporations, and foreign universities and research institutions are more valuable, respectively, than are invention patents applied for by the same applicant

types. Although invention patents can be protected longer than utility model patents can be, apparently most of the above three types of applicants have not chosen to do so. Instead, they maintain invention patents for shorter periods than they do with utility model patents, which lowers the value of the former in comparison with that of the latter.

Our finding that foreign corporations are able to realize greater value from their patents than applicants of the other five types are is consistent with Bessen's (2008) study of US patent renewal records. He found that, regarding renewal records for 1991 cohort US patents, those owned by individuals, small companies, and non-profit organizations have much lower value than do those owned by large companies. Foreign companies that patented in China in 1987 are, arguably, large multinational companies. They simply had greater resources than did their counterparts in universities or research institutions, foreign individuals, or domestic applicants with which to renew patents for a longer period and realize greater value out of those patents.

5. Value of patents as an equivalent subsidy for R&D

The value of patents is determined by the returns that patent applicants can appropriate by investing in R&D and subsequently applying for patents on the results. Patent value can be also understood as a subsidy that the patent system provides for patent applicants' R&D investments. In this section, we estimate the scale of this subsidy by calculating the ratio of the total value of patent rights to R&D expenditure spent to produce those patents, which is termed by Schankerman (1998) the "equivalent subsidy rate." The total value of patent rights is computed by multiplying the estimated mean value in Table 5 and Table 8 by the number of patents in the

1987 cohort in each category and summing them. There is no data available on China's gross expenditure on R&D in 1987. The next best available data reflects the expenditure on R&D from the 1987 government budget, which amounted to RMB 11.38 billion, which is 5.03 per cent of the government budget (National Bureau of Statistics, 1999). We argue that this figure by and large captures the R&D expenditure in China in 1987 because as of that year China had not yet started formally transforming its planned economy to a market-oriented economy (the transformation began after the then-leader Deng Xiaoping's southern tour in 1992). Most R&D activities are still carried out by the Chinese Academy of Sciences, universities, public research institutions affiliated with ministries, and local governments. In the era of the planned economy, little R&D was done in state-owned enterprises and there were very few private firms (Huang et al., 2006).

As seen in Table 9, the total value of invention patents originating in China accounted for only three per cent of the total value of invention patents in the 1987 cohort. The total value of invention patents applied for by foreign corporations amounted to a staggering RMB 83.6 billion, accounting for 91.1 per cent of the total value of invention patents. Foreign corporations were thus the major users and beneficiaries of the Chinese invention patent system in 1987.[7] The total value of invention patents applied for by domestic entities reached RMB 2.7 billion (in constant 2008 prices), which generated an equivalent subsidy rate of 6.7 per cent. Schankerman and Pakes (1986) estimated that the value of patent rights from age five in the UK, France, and Germany represented 5.7 per cent, 6.8 per cent, and 5.6 per cent, respectively, of business expenditure on R&D in these countries in 1970. Our estimation of the equivalent subsidy rate based on Chinese

invention patents is on the same order of magnitude as that of the estimation provided by Schankerman and Pakes of the total in three Western countries.

The total value of invention patent rights is six times that of the total value of utility model patent rights. Contrary to what happens with invention patents, domestic individuals and organizations are the major users and beneficiaries of utility model patent systems. The value of utility model patent rights appropriated by domestic entities accounted for 94.4 per cent of the total value of utility model patents in the 1987 cohort. The value of domestic individuals' utility model patents alone accounted for 46.8 per cent of the total value. The total value of utility model patents applied for by domestic entities amounted to RMB 13.9 billion, rendering an equivalent subsidy rate of 34.2 per cent. Invention and utility model patents in the 1987 cohort together provide equivalently 41 per cent of China's R&D expenditure in 1987, which demonstrate that the patent system in China has offered a substantial incentive to inventive activity in the country.

6. Renewal of invention patents applied for in the 2000s

The methodology that we use to evaluate the value of Chinese invention patents requires that we observe renewal information for patents over their full terms. This dictates that we cannot evaluate the value of Chinese invention patents applied for more recently than 20 years ago. Given the dramatic economic and social changes taking place in China over the last three decades, we would expect the intellectual property protection environment, incentives for patent application and renewal, and the behaviour of corporations, universities, and individuals regarding intellectual property rights to be very different in the late 1980s compared with the

situation today. It would thus be very useful and interesting to conjecture on the value of patents applied for in the relatively recent past based on available information and compare it with statistics for patents in the 1987–1989 cohorts.

We choose the 2002 and 2003 cohorts for this exercise because SIPO extended the protection period for invention patents that were applied for before December 31st, 1992 and were valid until December 11th, 2001 to 20 years in anticipation of China's 2001 entry into the WTO. It is likely that, following these changes, renewal decisions made by corporations, universities, and individuals regarding invention patents applied for after 2001 would differ from decisions regarding patents applied for before 2001. We do not choose to study even more recent cohorts because the examination period for invention patents lasts, on average, four years. Accordingly, there is much less renewal information available for more recent cohorts than is available for the 2002 and 2003 cohorts. Even for the 2002 and 2003 cohorts, we have renewal information only until patents reach the ages of seven and six, respectively.

As seen in Figure 4, dropout rates in the 2002 and 2003 cohorts are lower than are the corresponding rates in the 1987–1989 cohorts when patents are between five and seven years old. The lower dropout rate indicates that a higher proportion of patents are renewed for a longer period and, accordingly, the value of those patents is higher. If the dropout rates regarding the 2002 and 2003 cohorts are consistently lower than are those of the 1987–1989 cohorts that are more than seven years old, the value of patents in the 2002 and 2003 cohorts would be higher those in the 1987–1989 cohort would be.

An important finding regarding the value of Chinese patents applied for in 1987–1989 is that patents applied for by foreign entities are higher in value than are patents applied for by domestic entities. The median value of invention patents applied for by foreign corporations, foreign individuals, foreign universities and research institutions, domestic individuals, domestic corporations, and domestic universities and research institutions is ranked in descending order. The order changes based on renewal information pertaining to the 2002 and 2003 cohorts.

Figure 5 confirms that, irrespective of applicant type, patents lasting fewer than seven years in the 2002 and 2003 cohorts exhibited lower dropout rates than did such patents in the 1987–1989 cohorts. Patents applied for by foreign universities and research institutions seem to have the highest value (or the lowest dropout rates), followed by patents applied for by foreign corporations. Differing from patents in the 1987–1989 cohorts, patents in the 2002 and 2003 cohorts with the third highest value were applied for not by foreign individuals but by domestic corporations, with patents applied for by foreign individuals, domestic individuals, and domestic universities and research institutions following in descending order. This finding indicates that, in the 2000s, Chinese companies have invested more resources in maintaining their invention patents than they did in the late 1980s. Accordingly, the value of their patents applied for in the former period should be higher than is that of patents applied for in the latter period. Figure 6 confirms that, as is the case with patent in the 1987–1989 cohorts, the value of patents in the 2002 and 2003 cohorts originating in eastern provinces is higher than is that of patents originating in central and western provinces.

7. Conclusion

In this paper, we estimate the value of Chinese invention patents that were applied for in 1987–1989 and utility model patents that were applied for in 1986–1998. We evaluate and compare the value of patents in several cohorts, patents owned by several types of entities (including domestic and foreign individuals, universities and research institutions, and companies), patents falling into a range of technology fields, and patents originating in various provinces of China. The medians of invention patents applied for by foreign corporations, foreign individuals, foreign universities and research institutions, domestic individuals, domestic corporations, and domestic universities and research institutions are (at constant 2008 prices) RMB 1,072,829, RMB 616,443, RMB 354,164, RMB 86,392, RMB 59,157, and RMB 41,434, respectively. The medians of utility model patents applied for by foreign corporations, foreign universities and research institutions, foreign individuals, domestic corporations, domestic universities and research institutions, and domestic individuals are (at constant 2008 prices) RMB 541,284, RMB 513,162, RMB 218,644, RMB 88,070, RMB 69,284, and RMB 38,564, respectively.

We find that utility model patents that were applied for after their protection period was extended from eight years to ten years in 1993 following the first amendment of China's Patent Law have higher value than those applied for before do. Patents applied for by foreign entities invariably have higher value than do those originating from domestic entities and the gap in value between these two groups of patents is significant. For example, the median value of invention patents applied for by foreign corporations is 18 times higher than is that of patents applied for by

domestic corporations. Patents originating in economically developed provinces in China's eastern and coastal region are more valuable than are those from the economically underdeveloped provinces in the central and western regions.

We also calculate the equivalent subsidy rate, which is defined as the ratio of the total value of patent rights to the R&D expenditure spent to produce those patents, a measure of the subsidy that would be paid to patent rights holders to produce the same level of R&D if patent protection was eliminated. We find that the value of invention patents and utility model patents in the 1987 cohort applied for by domestic applicants represents, equivalently, 6.7 per cent and 34.2 per cent of China's R&D expenditure in 1987. The equivalent subsidy from both types of patents together amount to about 41 per cent of China's R&D investment for the same period, which indicates that the patent system in China has offered substantial incentives to those willing to undertake inventive activity in the country. Foreign corporations were the major users and beneficiaries of the Chinese invention patent system in 1987, appropriating about 91 per cent of the total value of invention patents in that cohort. On the other hand, domestic individuals and organizations are the major users and beneficiaries of the utility model patent system. They accounted for 94.4 per cent of the total value of utility model patents in the 1987 cohort.

Although we are able to estimate the value of Chinese invention patents applied for from 1987 to 1989, the intellectual property rights protection environment and the behaviour of companies, universities, and individuals regarding patent application and renewal in the late 1980s bear little similarity to what occurs today in modern China. To project the value of patents applied for

recently, we examine incomplete renewal information pertaining to invention patents in the 2002 and 2003 cohorts. The analysis demonstrates that the value of patents in these two recent cohorts is likely higher than is that of patents in the 1987–1989 cohorts. Differing from those in the 1987–1989 cohorts, patents in the 2002 and 2003 cohorts applied for by foreign entities did not have invariably higher value than do those of patents applied for by domestic entities. The value of patents applied for by domestic corporations was higher than was the value of patents applied for by foreign individuals, domestic individuals, and domestic universities and research institutions, but was lower than the value of patents applied for by foreign universities and research institutions, and foreign corporations. The gap in the value of patents applied for by domestic corporations and foreign corporations was significantly narrower in the 2000s.

Footnote:

1. The nominal patent renewal fee C_{tj} does not decrease as the age of the patent increases. However, the deflated patent renewal fee might decrease when the nominal renewal fee, being unchanged for a few years, is deflated. We will return to discuss this issue in Section 3.

2. We are not able to estimate the value of design patents because the derivatives cannot be calculated by the nonlinear least square model based on available design patent data.

3. We exclude utility model patents in the 1999 and 2000 cohorts because the renewal records for some patents from these two cohorts have not been fully updated in the database.

4. The provinces in the eastern, central, and western regions are listed in Table 4.

5. The value is US$154,473, US$88,759, US$50,995, US$12,439, US$8,518 and US$5,966, respectively. The US$ value is obtained by using the 2008 annual average exchange rate between the US dollar and the RMB: 1 US$=6.9451 RMB.

6. The value is US$ 77,938, US$73,888, US$31,482, US$12,681, US$9,976, and US$5,553, respectively.

7. Because foreign applicants applied for more invention patents than their domestic applicants did, and the value of invention patents held by foreign entities is higher, the total value of invention patents originating abroad has predominated after the Chinese patent system was established in the mid-1980s. However, since 2003 domestic entities have applied for more invention patents than foreign entities have. Accordingly, the share of the total value of invention patents taken by invention patents originating abroad should have declined gradually.

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Table 1: Summary Statistics on Invention Patents

	Number	Dropout rate (Per centage)			Renewed to full term (Per centage)
		Age 5	Age 10	Age 15	
All	13,804	3	45	71	17
Cohort					
Cohort 1987	4,632	2	47	72	16
Cohort 1988	4,835	2	45	70	18
Cohort 1989	4,337	5	45	71	17
Applicant type					
Domestic individuals	1,356	5	66	91	3
Domestic universities and research institutions	2,254	6	79	94	2
Domestic corporations	1,028	6	71	90	4
Foreign individuals	641	3	39	70	14
Foreign universities and research institutions	236	4	50	72	14
Foreign corporations	8,297	1	30	58	25
Technology field					
Human necessities	1,312	3	45	71	17
Performing operations; transportation	2,540	4	46	72	17
Chemistry; metallurgy	4,210	2	44	70	17
Textiles; paper	422	5	53	74	16
Fixed construction	509	3	56	80	9
Mechanical engineering; lighting; heating; weapons; blasting	1,247	4	48	73	14
Physics	1,892	3	46	70	17
Electricity	1,672	4	38	64	21
Nationality and region					
East	2,844	5	72	92	3
Central	1,018	6	76	93	2
West	742	5	76	94	3
Foreign	9,200	2	31	59	24

Table 2: Summary Statistics on Utility Model Patents

	Number	Dropout rate at age 5 (per centage)	Renewed to full term (Per centage)
All	349,703	61	6
Cohort			
Cohort 1986	7,881	47	4
Cohort 1987	12,712	53	4
Cohort 1988	17,109	56	3
Cohort 1989	17,842	70	3
Cohort 1990	22,225	66	3
Cohort 1991	27,520	69	2
Cohort 1992	34,886	73	2
Cohort 1993	35,702	68	6
Cohort 1994	33,664	62	7
Cohort 1995	32,973	57	8
Cohort 1996	35,159	54	10
Cohort 1997	33,387	52	10
Cohort 1998	38,643	55	12
Applicant type			
Domestic individuals	234,410	66	3
Domestic universities and research institutions	29,663	58	7
Domestic corporations	54,846	52	12
Foreign individuals	22,941	41	14
Foreign universities and research institutions	156	33	37
Foreign corporations	7,609	25	37
Technology field			
Human necessities	93,979	66	4
Performing operations; transportation	83,829	61	7
Chemistry; metallurgy	7,202	54	10
Textiles; paper	6,011	58	9
Fixed construction	30,952	60	6
Mechanical engineering; lighting; heating; weapons; blasting	61,603	58	7
Physics	35,062	59	7
Electricity	31,065	57	9
Nationality and region			
East	189,828	61	6
Central	77,968	69	3
West	51,095	64	4
Foreign	30,706	37	19

Table 3: Estimates of Patent Renewal Models of Invention Patents (no-effects model and fixed-effects model on cohort, applicant type, and technology field)

Parameter	No-effects model	Fixed-effects model on cohort[2]	Fixed-effects model on applicants[2]	Fixed-effects model on technology field[2]
	(1)	(2)	(3)	(4)
M	11.5(.73)***	11.4(.74)***	10.2(.38)***	11.3(.71)***
Σ	2.7(.35)***	2.6(.36)***	2.6(.24)***	2.7(.36)***
δ	.28(.050)***	.28(.051)***	.29(.034)***	.29(.050)***
Cohort1988	-	.16(.094)*	-	-
Cohort1989	-	.0059(.097)	-	-
Domestic individuals	-	-	.66(.11)***	-
Domestic corporations	-	-	.32(.094)***	-
Foreign individuals	-	-	2.6(.25)***	-
Foreign universities and research institutions	-	-	2.0(.21)***	-
Foreign corporations	-	-	3.1(.30)***	-
Human necessities	-	-	-	.76(.20)***
Performing operations; transportation	-	-	-	.18(.17)
Chemistry; metallurgy	-	-	-	.57(.18)***
Fixed construction	-	-	-	.11(.17)
Mechanical engineering; lighting; heating; weapons; blasting	-	-	-	.22(.17)
Physics	-	-	-	.025(.17)
Electricity	-	-	-	.38(.18)**
R^2	.63	.63	.83	.63
Observation	1926	1926	1926	1926

Note:
1. Data in parentheses refer to standard deviations. *** denotes a significance level of 1%, ** denotes a significance level of 5%, * denotes a significance level of 10%.
2. The reference group for regression (2) is cohort 1987. The reference group for regression (3) is domestic universities and research institutions. The reference group for regression (4) is the technology field "textiles; paper." Accordingly, μ represents the initial returns on patents in these reference groups.

Table 4: Estimates of the Patent Renewal Model on Invention Patents (fixed-effects on location)

Parameter	Fixed-effects model on province[2]	Fixed-effects model on region[2]
μ	12.5(.54)***	12.3(.58)***
σ	2.1(.17)***	2.1(.18)***
δ	.25(.029)***	.24(.032)***
East region	-	-2.2(.24)***
Beijing	-2.2(.24)***	-
Tianjin	-2.5(.26)***	-
Hebei	-2.6(.27)***	-
Liaoning	-2.6(.28)***	-
Shanghai	-1.9(.23)***	-
Jiangsu	-2.3(.25)***	-
Zhejiang	-2.1(.24)***	-
Fujian	-2.2(.25)***	-
Shandong	-2.1(.24)***	-
Guangdong	-1.9(.23)***	-
Hainan	1.2(.34)***	-
Central region	-	-2.41(.26)***
Shanxi	-2.5(.28)***	-
Jilin	-2.5(.27)***	-
Heilongjiang	-2.5(.27)***	-
Anhui	-2.1(.25)***	-
Jiangxi	-2.8(.30)***	-
Henan	-2.3(.25)***	-
Hubei	-2.2(.25)***	-
Hunan	-2.5(.27)***	-
West region	-	-2.36(.26)***
Inner Mongolia	-2.7(.31)***	-
Guangxi	-2.4(.27)***	-
Sichuan	-2.2(.25)***	-
Guizhou	-1.3(.21)***	-
Yunnan	-2.6(.28)***	-
Shaanxi	-2.6(.27)***	-
Gansu	-2.4(.27)***	-
Qinghai	-2.9(.31)***	-
Ningxia	-2.2(.47)***	-
Xinjiang	-3.5(.37)***	-
Chongqing	-2.1(.25)***	-
R^2	.86	.83
Observation	1170	1170

Note:

1. Data in parentheses refer to standard deviations. *** denotes a significance level of 1%, ** denotes a significance level of 5%, * denotes a significance level of 10%.
2. The reference group is patents originating in foreign countries. Accordingly, μ represents the initial returns on patents in this reference group.

Table 5: Distribution of the Value of Invention Patent Rights, by Applicant Type: 1987 Cohort (RMB, constant 2008 prices)

Quantile	Domestic individuals	Domestic universities and research institutions	Domestic corporations	Foreign individuals	Foreign universities and research institutions	Foreign corporations
.25	11,958 (28,944)	4,575 (933)	7,160 (2,274)	99,496 (12,234)	56,208 (15,193)	179,653 (214,761)
.50	86,392 (84,919)	41,434 (24,007)	59,157 (12,215)	616,443 (407,841)	354,164 (347,912)	1,072,829 (727,550)
.75	537,794 (504,499)	264,503 (252,857)	365,979 (327,287)	3,606,545 (4,430,076)	2,120,003 (1,706,398)	6,401,764 (5,489,436)
.90	2,646,904 (1,821,124)	1,315,156 (3,029,127)	1,801,391 (3,034,954)	1.78E+07 (3.07E+07)	1.06E+07 (3.40E+06)	3.15E+07 (7.51E+06))
Mean	2,712,743 (2,430,904)	1,247,026 (16,052,396)	1,964,602 (9,446,152)	1.94E+07 (1.61E+07)	1.11E+07 (1.90E+06)	3.02E+07 (1.94E+08)

Note: Data in parentheses refer to standard deviations.

Table 6: Estimates of the Patent Renewal Model on Utility Model Patents (no-effects model and fixed-effects model on cohort, applicant type, and technology field)

Parameter	No-effects model	Fixed-effects model on cohort[2]	Fixed-effects model on applicants[2]	Fixed-effects model on technology field[2]
	(1)	(2)	(3)	(4)
μ	15.8(1.5)***	8.7(.22)***	11.8(.46)***	15.6(1.5)***
σ	3.9(.56)***	1.3(.075)***	2.5(.18)***	3.9(.56)***
δ	.79(.054)***	.31(.025)***	.61(.034)***	.79(.054)***
Cohort1987	-	.048(.073)	-	-
Cohort1988	-	-.18(.074)**	-	-
Cohort1989	-	-.044(.071)	-	-
Cohort1990	-	-.042(.071)	-	-
Cohort1991	-	-.024(.071)	-	-
Cohort1992	-	-.091(.072)	-	-
Cohort1993	-	.12(.071)*	-	-
Cohort1994	-	.37(.068)***	-	-
Cohort1995	-	.49(.069)***	-	-
Cohort1996	-	.70(.070)***	-	-
Cohort1997	-	.80(.071)***	-	-
Cohort1998	-	.80(.070)***	-	-
Domestic individuals	-	-	-.57(.073)***	-
Domestic corporations	-	-	.25(.064)***	-
Foreign individuals	-	-	1.2(.10)***	-
Foreign universities and research institutions	-	-	2.0(.18)***	-
Foreign corporations	-	-	2.0(.16)***	-
Human necessities	-	-	-	-.21(.16)
Performing operations; transportation	-	-	-	.47(.18)***
Chemistry; metallurgy	-	-	-	.27(.18)
Fixed construction	-	-	-	.16(.17)
Mechanical engineering; lighting; heating; weapons; blasting	-	-	-	.67(.19)***
Physics	-	-	-	.31(.17)*
Electricity	-	-	-	.39(.18)**
R^2	.71	.75	.82	.71
Observation	3472	3472	3472	3472

Note:

1. Data in parentheses refer to standard deviations. *** denotes a significance level of 1%, ** denotes a significance level of 5%, * denotes a significance level of 10%.
2. The reference group for regression (2) is cohort 1986. The reference group for regression (3) is domestic university and research institutions. The reference group for regression (4) is the technology field "textiles; paper." Accordingly, μ represents the initial returns on patents in these reference groups.

Table 7: Estimates of the Patent Renewal Model on Utility Model Patents (fixed-effects on location)

Parameter	Fixed-effects model on province[2]	Fixed-effects model on region[2]
μ	13.7(.57)***	13.6(.57)***
σ	2.3(.15)***	2.2(.15)***
δ	.64(.031)***	.63(.031)***
East region	-	-1.7(.16)***
Beijing	-1.4(.17)***	-
Tianjin	-1.9(.19)***	-
Hebei	-2.1(.20)***	-
Liaoning	-2.0(.20)***	-
Shanghai	-1.2(.17)***	-
Jiangsu	-1.7(.19)***	-
Zhejiang	-1.5(.18)***	-
Fujian	-1.8(.19)***	-
Shandong	-2.0(.20)***	-
Guangdong	-1.3(.17)***	-
Hainan	-2.0(.21)***	
Central region	-	-2.2(.18)***
Shanxi	-2.0(.20)***	-
Jilin	-2.2(.21)***	-
Heilongjiang	-2.1(.20)***	-
Anhui	-2.0(.20)***	-
Jiangxi	-2.6(.23)***	-
Henan	-2.1(.20)***	-
Hubei	-2.0(.20)***	-
Hunan	-2.4(.22)***	-
West region	-	-2.0(.18)***
Inner Mongolia	-2.0(.20)***	-
Guangxi	-2.0(.20)***	-
Sichuan	-1.8(.19)***	-
Guizhou	-2.1(.20)***	-
Yunnan	-1.8(.19)***	-
Shaanxi	-2.0(.20)***	-
Gansu	-2.0(.20)***	-
Qinghai	-2.4(.22)***	-
Ningxia	-2.7(.24)***	-
Xinjiang	-2.0(.20)***	-
Chongqing	-1.6(.18)***	-
R^2	.88	.87
Observation	2818	2818

Note:

1. Data in parentheses refer to standard deviations. *** denotes a significance level of 1%, ** denotes a significance level of 5%, * denotes a significance level of 10%.
2. The reference group is patents originating in foreign countries. Accordingly, μ represents the initial returns on patents in this reference group.

Table 8: Distribution of the Value of Utility Model Patent Rights, by Applicant Type: 1987 Cohort (RMB, 2008 constant price)

Quantile	Domestic individuals	Domestic universities and research institutions	Domestic corporations	Foreign individuals	Foreign universities and research institutions	Foreign corporations
.25	6,514 (5,427)	11,968 (6,276)	15,443 (5,607)	40,364 (31,245)	92,945 (5,788)	100,174 (7,330)
.50	38,564 (6,586)	69,284 (5,002)	88,070 (22,567)	218,644 (174,452)	513,162 (430,275)	541,284 (539,469)
.75	210,480 (261,447)	373,811 (324,636)	477,601 (519,287)	1,148,460 (1,947,520)	2,729,341 (973,011)	2,909,231 (1,132,180)
.90	953,027 (609,919)	1,694,523 (2,377,135)	2,115,377 (1,743,489)	5,245,121 (16,049,010)	1.22E+07 (6.18E+06)	1.30E+07 (7.47E+05)
Mean	832,370 (9,939,448)	1,391,938 (12,846,177)	1,834,789 (8,203,055)	4,830,111 (4,302,938)	1.04E+07 (1.84E+07)	1.14E+07 (1.78E+07)

Note: Data in parentheses refer to standard deviations.

Table 9: Total Value of Invention and Utility Model Patents in the 1987 Cohort

	Number of patents	Mean value (Million RMB, constant 2008 prices)	Total Value (Million RMB, constant 2008 prices)	Per centage in total
		Invention patents		
Domestic individuals	373	2.71	1,012	1.1%
Domestic universities and research institutions	811	1.25	1,011	1.1%
Domestic corporations	364	1.96	715	0.8%
Foreign individuals	225	19.4	4,365	4.8%
Foreign universities and research institutions	94	11.1	1,043	1.1%
Foreign corporations	2,768	30.2	83,593	91.1%
Sum	4,632		91,740	
		Utility model patents		
Domestic individuals	8,298	.832	6,907	46.8%
Domestic universities and research institutions	2,056	1.39	2,862	19.4%
Domestic corporations	2,261	1.83	4,148	28.1%
Foreign individuals	30	4.83	145	1.0%
Foreign universities and research institutions	0	10.4	0	0.0%
Foreign corporations	60	11.4	684	4.6%
Sum	12,712		14,746	

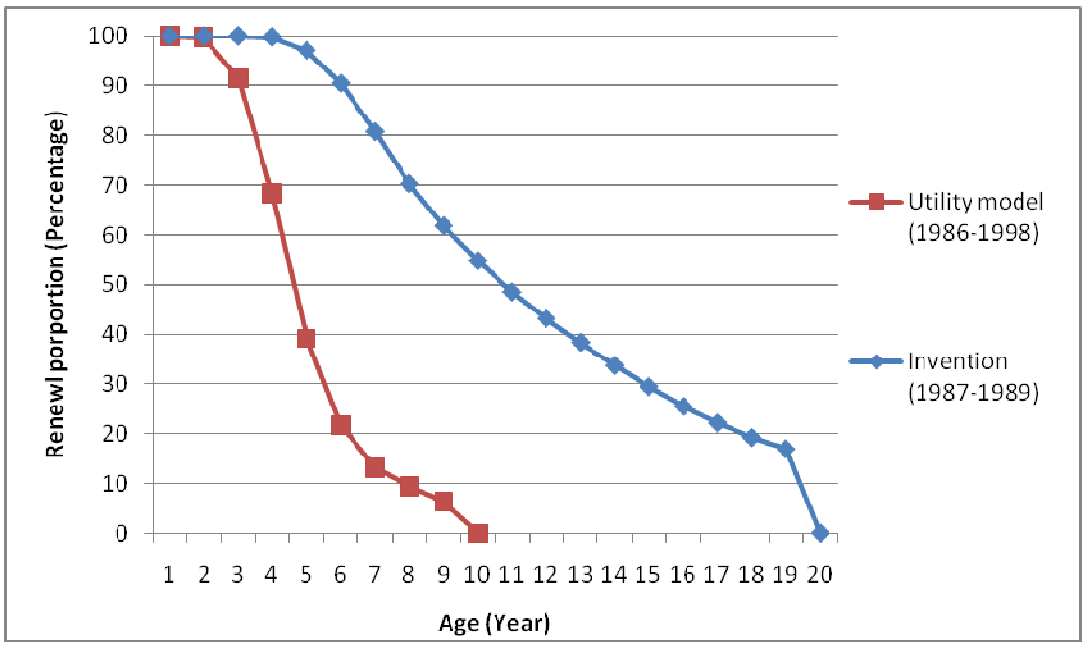

Figure 1: Age paths of renewal proportion

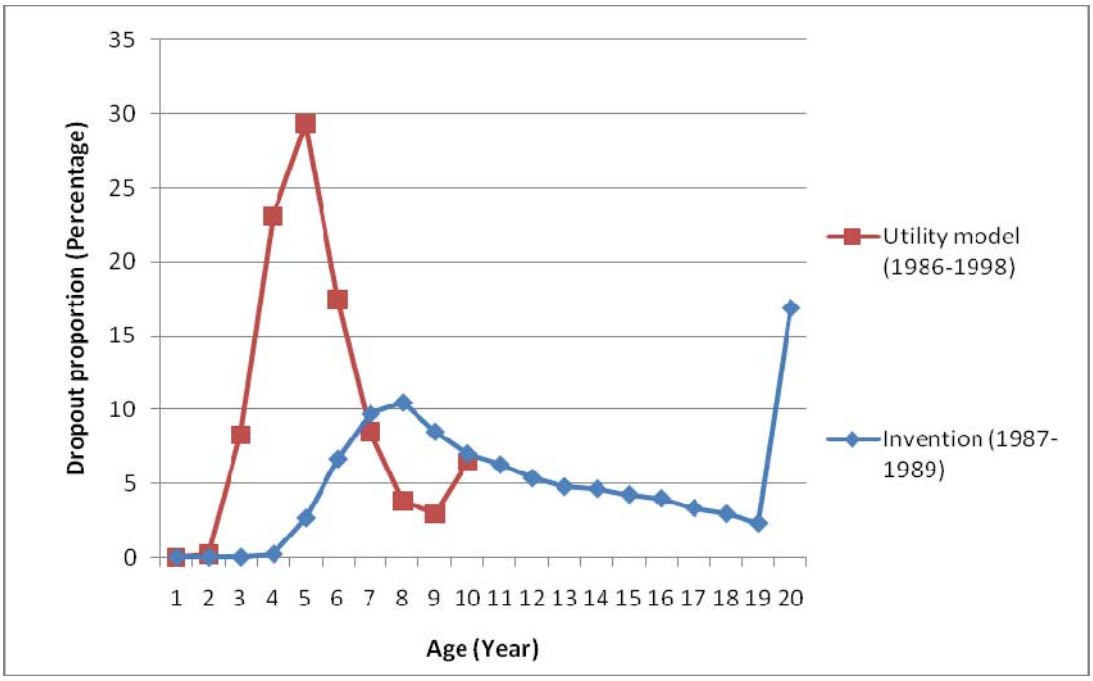

Figure 2: Age paths of dropout proportion

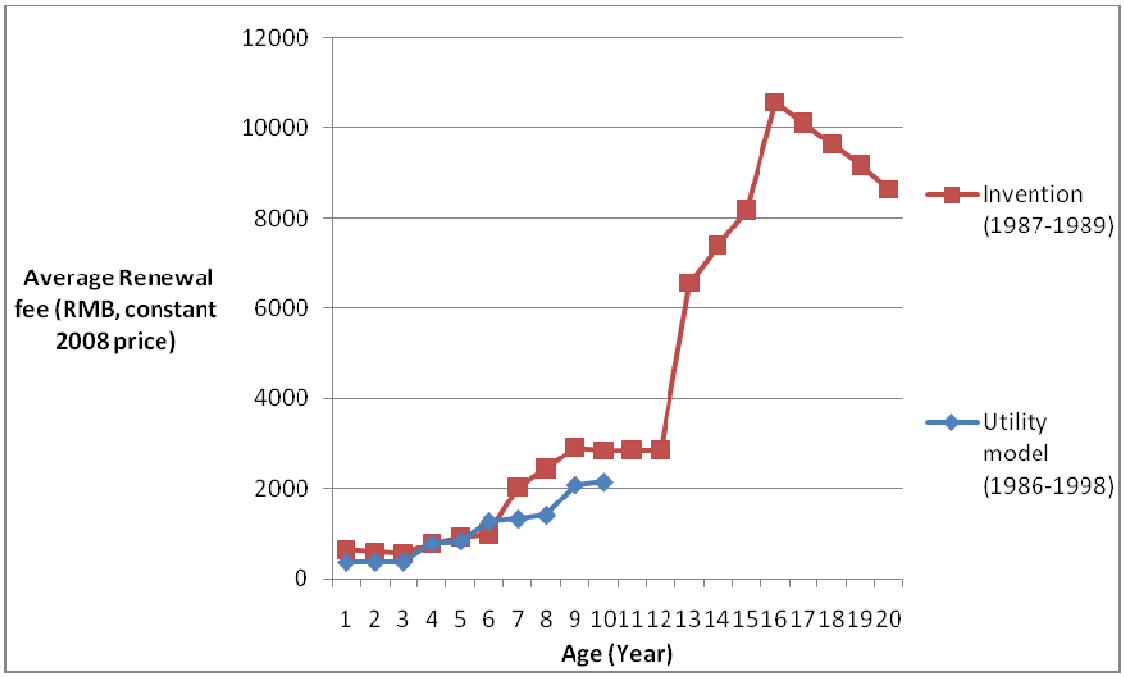

Figure 3: Age paths of deflated renewal fee

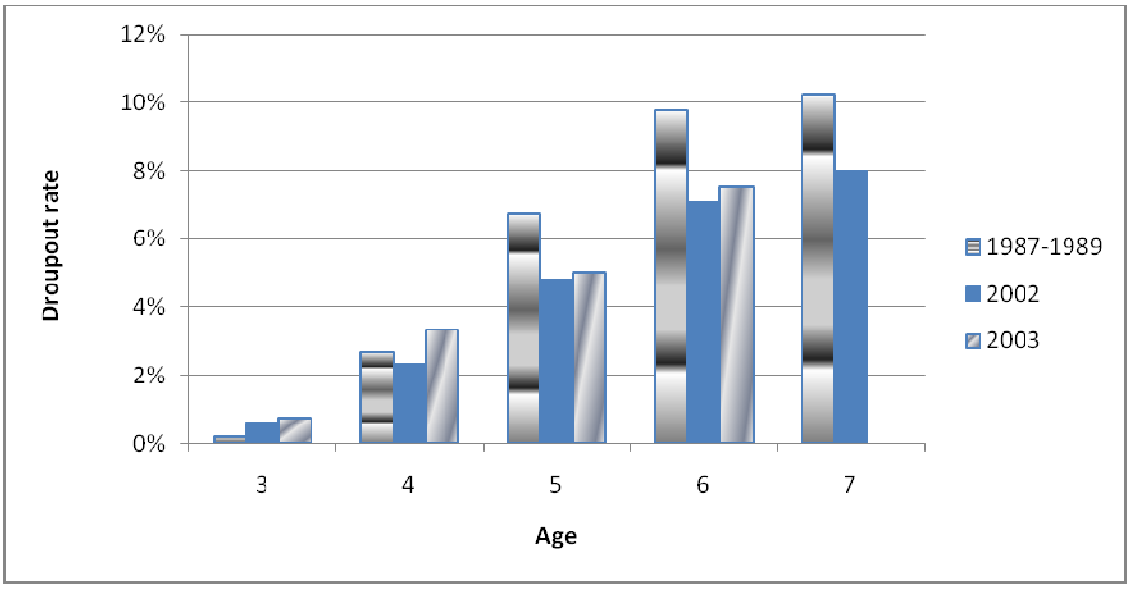

Figure 4: Dropout rates of the 1987-1989, 2002, and 2003 cohorts

Note: The dropout rate of the 2003 cohort at age seven is not available from the Database as the latest year covered in the Database is 2009.

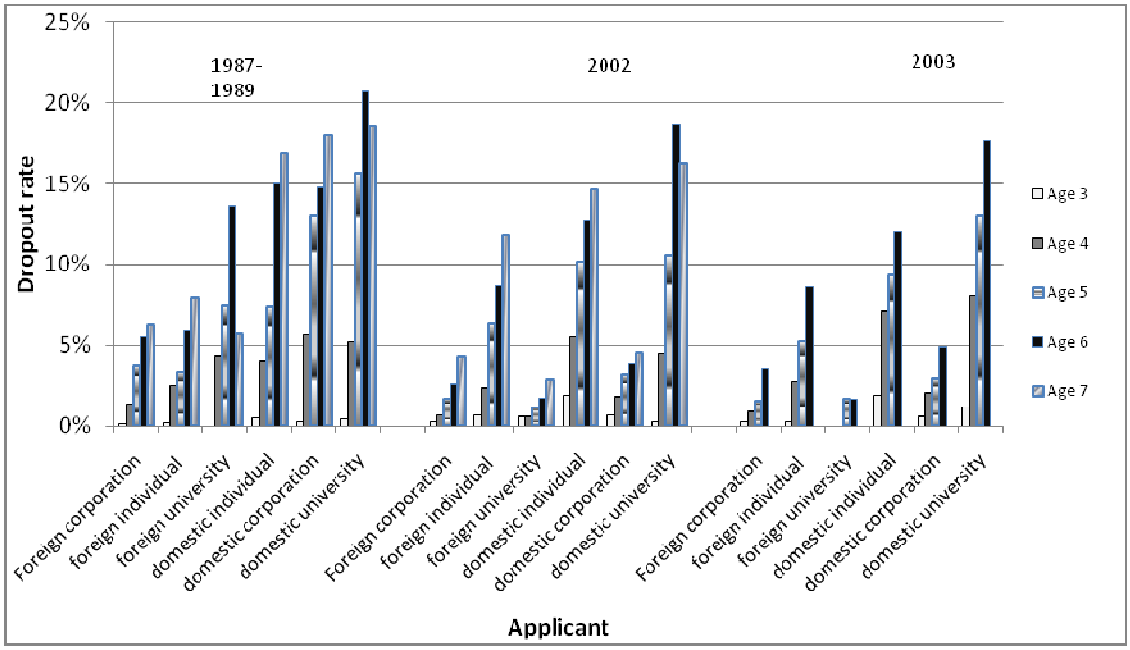

Figure 5: Dropout rate of the 1987–1989, 2002, and 2003 cohorts by applicant type

Note: The dropout rate in the 2003 cohort at age seven is not available from the Database as the latest year covered in the Database is 2009.

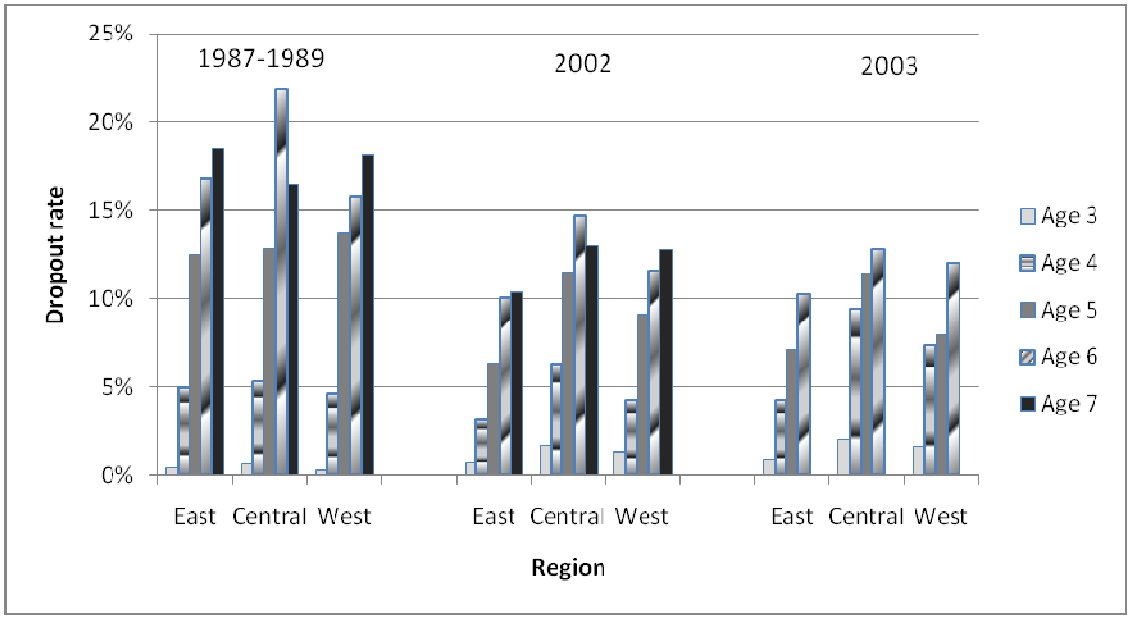

Figure 6: Dropout rate of the 1987–1989, 2002, and 2003 cohorts by region of origin

Note: The dropout rate in the 2003 cohort at age seven is not available from the Database as the latest year covered in the Database is 2009.

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