

Intellectual Property Rights Protection, Ownership, and Innovation: Evidence from China

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Abstract

We study the effect of intellectual property rights (IPR) protection, ownership type, and their joint impact on innovation in China. Within China, local IPR protection is positively related to firms' R&D investments and innovation. Private firms invest more in R&D and innovate more than state-owned enterprises (SOEs), and this effect is notably stronger in regions with high IPR protection standards. Our results support theoretical arguments that IPR protection strengthens firms' incentives to innovate, and that private firms are more sensitive to IPR protection than SOEs. These findings point to the importance of stronger institutions for China's sustained growth and development.

Introduction

The influential literature on law, finance, and economic growth establishes that legal and financial institutions lead to better economic outcomes (e.g., La Porta, Lopez-de-Silanes, Shleifer, Vishny (1998), (2000); King and Levine (1993); Rajan and Zingales (1998)). However, Allan, Qian, and Qian (2005) points out that China appears an exception to this view: its staggering economic development has been achieved despite its weak legal and financial institutions. In particular, the authors note that while the law and finance literature explains the relatively slower growth of China's state-owned sector, it cannot explain the phenomenal growth of its private sector; instead, alternative mechanisms such as those based on reputation and relationships support the growth of the private sector.

In this paper, we reexamine the importance of institutions in China's development by focusing on innovation. Specifically, we examine how different levels of intellectual property rights (IPR) protection *within* China affects the investment in and outcomes of innovative activities. In addition, we contrast the role of IPR protection on the innovative activities of state-owned versus private enterprises. To the best of our knowledge, ours is the first paper to examine the joint impact of IPR protection and ownership on the innovation process.

The motivation of our work is four-fold. First, as China moves beyond being the "factory of the world", its ability to innovate and capitalize on intellectual capital is critical to its further development. As argued by Jaffe and Lerner (2004), the systematic application of technological developments laid the foundation to for the evolution of the U. S. from a colonial backwater to the pre-eminent world power. This innovation imperative is not lost on the Chinese leaders and policy makers. For example, in the country's current, 12th Five Year Plans, which lays out

China's development goals, innovation and R&D play a central role.¹ Understanding the drivers behind China's innovation is thus an important undertaking with significant policy implications.

Second, parallel to the Allen, Qian, and Qian (2005) contention that China appears an outlier in the impact of the legal regime on economic growth, existing literature presents a similar "China puzzle" in the R&D and innovation arena: Although intellectual property protection in China is weak, China has consistently ranked among the top nations globally in terms of R&D expenditure and patent application and grants. China's R&D expenditure growth also ranks among the highest among OECD countries (National Science Foundation, (2014). In cross-country studies of the relation between IPR protection and innovation, China often is such an outlier that it needs to be excluded for the positive relation predicted by many theories to hold (Gould and Gruben (1996)). Without good IPR protection, why do firms have incentives to invest in R&D and innovate? Where does China's innovation take place—in the state-owned firms or the private sector? These questions are left unanswered by prior studies focusing on cross-country evidence.

Third, many existing papers on the relations between IPR protection, innovation and growth are based on cross-country evidence, which is subject to concerns about unobservable variables. By focusing within China, we limit the impact of much of this heterogeneity: the IPR laws are the same across all provinces in the country, though local enforcement levels differ. This allows us to clearly test whether IPR protection matters for firms' incentive to invest in R&D and to innovate.

¹ In China's 12th five-year plan, R&D and innovation are specifically highlighted as the key area for investment and economic emphasis. This focus on R&D and innovation can be seen from the government's setting of specific R&D spending targets (2% of GDP, just below US's current 2.8% level), patents per capita targets (3 per 10,000 citizens as compared to 3.5 for the US), and the list of seven sectors designated as key sectors for investment: Energy; energy conservation and new energy; biotech, information technology; high-end equipment manufacturing; new materials; clean-energy vehicles.

Finally, by comparing the role of IPR protection on the innovative activities of the state versus the private sectors, our paper makes a unique contribution to the political economy question of whether control rights can substitute for legal institution. As is well-known, state-owned enterprises (SOEs), which are directly controlled and run by various administrative levels of the government, play an important role in China's economy. Meanwhile, China's judicial system is also controlled by the state, and has been shown to be biased towards SOEs (citations). If the legal institutions around IPR protection are not well developed, one hypothesis is that SOEs in China have stronger incentives to innovate relative to private sector firms: their intellectual property is less likely to be expropriated, given their state-controlled and protected status and the biased judicial system. In other words, state ownership and control act as a substitute to IPR protection. Anecdotally at least, this hypothesis holds appeal as some of China's most innovative firms such as Huawei and Lenovo have strong links to the government, if not (no longer) directly owned by the state.

In sum, our paper examines the interplay between IPR protection, firm ownership (state-owned versus private), and innovation in China. Our specific empirical questions are:

1. Where does China's R&D and innovation take place? In state-owned firms, or private enterprises?
2. Is IPR protection important within China? That is, is IPR protection positively related to R&D and innovation in China?
3. What is the interaction effect between IPR protection and state ownership on R&D and innovation? Is IPR protection more important for private firms' incentives to innovate?

We believe that these questions are of academic as well as policy interest. China is the second largest economy in the world and an increasingly important contributor in innovation. Given the importance of the topic, relatively little evidence exists regarding where and how R&D and innovation take place in China, and whether IPR protection plays an important role. Our paper takes a step towards filling this gap.

Our empirical findings are as follows. First, since 2006—the year by which all of China’s WTO commitments, including revisions to its IPR laws and regulations, were implemented—private firms in China invest more in R&D and innovate more than SOEs. Prior to 2006, our limited data suggests that SOEs led R&D investment and innovation. While by no means a proof, this time-varying pattern is consistent with the notion that in its earlier era of development, state ownership acted as a partial substitute to IPR protection. With the full implementation of WTO standards, 2006 is a critical year in China’s recent economic history that marks the completion of numerous economic and legal reforms, including the strengthening of its legal framework. The fact that after 2006, private sector innovation took off suggests the importance of legal institutions to private firms, which do not enjoy the special protection offered by state ownership.

Second, we find that within China, IPR protection matters: Firms located in provinces with stronger IPR protection invest more in R&D and innovate more than firms located in provinces with weak IPR protection. Thus, contrary to the puzzling cross-country evidence, we find a positive relation between IPR and innovation *within* China. This finding not only resolves the “China puzzle” on innovation, but also establishes the importance of institutions within China.

Finally, we find that IPR protection affects the innovation gap between private firms and SOEs: In provinces with higher IPR protection standards, private sector firms lead SOEs in R&D

investments and innovation by a wider margin than in provinces with low IPR protection standards. This result shows that not only do institutions (in our specific case, IPR protection) matter in China, but also that they matter particularly to private sector firms.

We believe these findings are not only relevant to the economic theory on the role of institutions in general and IPR protection in particular, but also have profound implications for China's development model. Allen, Qian, and Qian (2005) made it clear that within China, the fast-growing and promising sector that is driving economic growth is the private sector, and thus to sustain the country's growth momentum, nurturing and growing the private sector is key. Our results show that building better institutions—IPR protection as an example—will play an increasingly important role in allowing the growth and development of the private sector firms. While Allan, Qian, and Qian (2005) rightly point out that China—in particular its private sector—has so far been able to develop rapidly without strong institutions, our evidence suggest that stronger institutions will be important for its future development, which increasingly depend on the nation's ability to innovate and capture innovation-related wealth creation.

One concern for studies of the relation between IPR protection and innovation is endogeneity, or reverse causality: IPR protection standards may be high *because* local firms are more innovative and thus have higher demands for IPR protection; rather than the other way round. We address this issue in a number of ways. First, we use SOE privatizations as an identification instrument. SOE privatizations are elements of broad economic reforms and not primarily driven by innovation motives. Our key conclusions are robust in this setting: Firms innovate more after privatization and the increase is larger for firms in provinces with high IPR protection. We also use a difference-in-difference approach by comparing the outcomes of failed versus successful SOE privatizations (the outcome in these cases is largely due to reasons

exogenous to innovation, such as union issues and shifting government policies, etc.), and find that the change occur only in successful privatizations. Finally, we use provinces' exposure to Christian thought in the 1900 (which, as we discuss below, is related to citizens' conception of property rights but unrelated to current innovation patterns) as an instrument for IPR protection and our results are robust in this instrumental variables (IV) regression.

The rest of the paper is organized as follows. Section I describes our data and presents descriptive statistics. Section II presents the main results. Section III presents additional analyses and robustness checks. Section IV concludes.

I. Data and Descriptive Statistics

Our sample is drawn from all listed Chinese companies in the domestic A-share market. The two main outcome variables we examine are R&D investment and patenting rates, corresponding to firm-level investment and results in innovation. We obtain companies' R&D investments and other firm characteristics such as assets, liabilities, age etc. from WIND, a Chinese corporate database similar to Compustat in the US. These data is available from 1990 to 2013 except R&D expenditures, which is available only after 2006 in WIND.

Firm-level patent data is manually collected from the website of the Chinese State Intellectual Property Office (CSIPO), which is China's counterpart to the United States Patent and Trademark Office (USPTO).² The Chinese patent grant procedure is similar to that in Europe and the U.S. Before application, the applicant is encouraged to search existing patent and publication database to ensure the novelty of the application. After undertaking its own examination, the CSIPO grants three types of patents that vary in their innovation contents:

² <http://epub.sipo.gov.cn/gjcx.jsp>. We manually input company names to retrieve patenting data pertaining to each firm in our sample.

invention, application, and design. Invention patents refer to truly novel technologies; application patents refer to new usages of existing technology; design patents refer to innovative design and packaging. The length of time required to obtain each type of patent, and the success rates of applicants, are commensurate with the innovative content. For example, while both application and design patents require one round of patent officer examination that last from 3 to 6 months, invention patents' examination process involves two rounds of officer examination (preliminary and detailed examinations), lasting 18-36 months. Statistics from 2012 indicate that the application success rate is 33.2%, 77%, and 71% respectively for innovation, application and design patents.³ Data on firm-level patents are available from 1990-2013, the entire period covered by the CSIPO.

Since 2001, Chinese listed firms are subject to mandatory reporting of their ownership (share capital) structure. Following prior literature (e.g., Wang, Wong, and Xia 2008), we define a company as state owned if its largest ultimate shareholder is a government entity, which can either be the central government (e.g., the Ministry of Finance and the Central Industrial Enterprises Administration Committee), or local governments. Otherwise, we define the company as a private enterprise (the largest ultimate owners of these firms are either individuals or other private enterprises). For years after 2001, we use the shareholder structure reported in firms' annual statements to make this classification. For years prior to 2001, we treat the ultimate owner to be the same as in 2001 unless there is a change of ownership disclosed in prior annual reports.

Table 1 provides summary statistics of our firm sample. Panel A tabulates the number of private enterprises and SOEs in select years. SOEs account for a high fraction of our sample,

³ For more information, see the CSIPO website, <http://epub.sipo.gov.cn/gicx.jsp>.

although this ratio has steadily declined over time: In 1990, they accounted for 86% of the sample, but by 2013 they account for 49%.

Panel B reports summary firm characteristics. We see that the average firm's R&D spending is 0.8% of assets at the end of the year. There is considerable heterogeneity: many firms spent virtually none on R&D (the median is only 0.002%), while the maximum is 32.7%. Firms' patenting rate, as measured by patent grants in a given year divided by assets at the end of the year, also exhibits a large variation: At least half the firms have no patents (the median is 0), but the maximum measure is 0.6, indicating 0.6 patents per million RMB in assets, nearly four standard deviations above the mean.

Panel C compares SOEs and private firms on these dimensions. SOEs and private firms are clearly different. SOEs are significantly larger—on average ten times, the size of the private firms measured by total book value of assets—but they appear less efficient with lower return on assets (ROA), and less innovative with lower R&D expenditure (R&D/assets) and lower patenting rate (parent/assets). They also have a lower Tobin's Q, suggesting the market associates them with lower growth options. These patterns are not surprising, and support the notion in Allen, Qian, and Qian (2005) that the private sector is more economically vibrant than the state-owned sector.⁴

In the letter of the law, IPR rights have been acknowledged and protected in China since 1980, when the country acceded to the major international IPR conventions and became a member of the World Intellectual Property Organization. China patterned its IPR law on the [Berne Convention for the Protection of Literary and Artistic Works](#) and the [Agreement on Trade-Related Aspects of Intellectual Property Rights](#) (TRIPS). While the letter of the law governing IPR is the same across all provinces and conform to international conventions, in reality IPR

⁴ Appendix A shows the industry distribution of SOEs versus private firms. The list does not indicate a clear pattern.

infringement is a common occurrence in China. The enforcement of the law is carried out by the local government and local courts, whose interpretation of the law and enforcement standard vary significantly. For example, Ang, Cheng, and Wu (2014) show that the significant variation of IPR enforcement across Chinese provinces affects firms' financing and investment choices.

Following Ang, Cheng, and Wu (2014), we construct two measures of local IPR protection. The first measure, which we will call IPP1 (for Intellectual Property Protection) is fraction of the IP infringement cases won by the plaintiffs in provincial courts. This fraction directly measures the probability of winning by the plaintiffs in IPR infringement cases, and thus is a good proxy for the enforcement of IPR by the local authorities. To construct this measure, we download and read the written judgment of 7,668 IP infringement cases filed in 28 provinces between the years 2001-2005 from the China Judicial Case Database, with the IP owners as the plaintiffs. The cases include patent infringements, technology infringements, trade secret infringements, and design infringements. We classify a case as won by the plaintiff if the court ordered the defendant to cease infringement, compensate the plaintiff for its economic loss due to the infringement, destroy the infringing products and/or equipment, and/or pay the legal cost of the lawsuit. The case is classified as won by the defendant if the court dismissed the lawsuit of the plaintiff with no such rulings.

The second measure, which we will call IPP2, is the frequency by which the provincial governments advocate IPR protection in its official publications, which reflects the local governments' attitude towards IPR. In China, media is state controlled. While the central Chinese Community Party (CCP) committee has the ultimate control over all newspapers, each provincial government controls the local media and publishes the main newspapers in their province. Specifically, there are three types of newspapers in all provinces. First, each province

has a “Daily”, which is directly owned by the provincial CCP committee and its management and editorial is strictly supervised by CCP officials. For example, while the “China Daily” is the official CCP publication of the central government, the “Beijing Daily” and “Henan Daily” are the equivalents for Beijing, and He Nan Province. Second, each province has an “Evening” publication, which is owned by a CCP committee but enjoys substantially more managerial autonomy than the “Daily”. Finally there are other subsidiary newspapers owned by the previous two types which also enjoy more managerial autonomy.⁵ In a nutshell, one can identify the official local government publications simply from the names of the publication.

We manually read articles from all provincial “Daily” newspapers from 2000 to 2013, and counted for each province the number of articles advocating the protection of IPR in each year. We focus on the “Dailys” because these are the official publications used by the provincial governments to shape readers’ views. We then divide this article count by the number of total articles published in that year to get our IPP2 measure.

Table 2 presents summary statistics of the two IPR protection measures and other provincial level statistics such as GDP growth and urbanization rate. IPP1 has a mean of 0.69, which means that on average, the probability for plaintiffs to win IPR cases slightly exceeds two-thirds. In some province-years, the winning ratio is 100% and in others it is 0%. The mean of IPP2 is 0.007, which means that on average, out of every 1,000 articles published by provincial governments, 7 are about IPR protection. This variable has a relatively symmetric distribution, with a median of 0.006. Again, there is a significant amount of heterogeneity, as the highest observation is 0.023, three times the mean. Panel B shows that the two IPR enforcement

⁵ See Qin, Stromberg, and Wu (2014) and references therein for a more detailed discussion of the media industry organization in China. They document, for instance, that “Evening” and subsidiary newspapers contain significantly more entertainment content, as compared to the “Daily” publications.

measures, though constructed from entirely different sources, are significantly positively correlated with a correlation coefficient of about 18%.

Figure 1 plots the evolution of the two IPR enforcement measures over time. In these graphs, we divide the whole sample (consisting of 28 provinces) into terciles based on each IPR enforcement measure, and trace the group mean over time. Figure 1a, which pertains to our first measure, shows that overall IPR enforcement increased in all three sub-samples, but persistent differences remain across provinces. In the high-enforcement region, the probability for a plaintiff to win its IP case increased from near 90% to over 95%. In the low-enforcement region, the same probability increased from 40% to 60%: while a large relative gain, the figure still trails far behind high-enforcement regions. Figure 1b, based on our second IPR enforcement measure, shows similar cross-sectional variation. Unlike in the case of IPP1, the evolution of IPP2 is not monotonic. The media coverage of IPR issues may be subject to the ebb and flow of the provincial government's focus. The main point is that the measure shows considerable cross-sectional variation, which will be the focus of our analysis.

One concern is that the IPR enforcement measures might be correlated with other provincial level characteristics. Table 3 compares provincial characteristics in sub-samples sorted by IPR enforcement measures. The left panel sorts the provinces by IPP1 and the right panel sorts the provinces by IPP2. The table shows that IPP1—plaintiff win probability—is generally uncorrelated with other provincial level characteristics. IPP2—media mentions of IPR—is correlated with a number of other provincial characteristics, such as the per capita GDP, urbanization rate and education level of the population. Provincial governments in more affluent regions with higher percentage of urban and educated population are more likely to advocate IPR

protection. Because of these correlations, it is important to control for province level variables or provincial fixed effects in our subsequent regression analyses.

II. Empirical Results

A. Innovation and firm types

We begin by examining the relation between ownership (SOE or private ownership) and firms' investment in R&D and rates of innovation at the firm level. Table 4 is a univariate comparison of R&D investment (Panel A) and patenting rates (Panel B) between SOEs and private firms.

Our first observation is that both R&D and patenting rates have been steadily increasing over time in both sets of firms. Figure 1 graphically represents this time trend and indicates that since 2006, R&D investments experienced a monotonic and explosive increase: R&D/assets increased from 0.2% to 4.1% for private firms over the seven year span, a twenty-fold increase, and from 0.1% to 2.6% for SOEs over the same period, a twenty-six fold increase, albeit from a low base. As a rough benchmark, the World Bank reports that the US spends about 2.8% of GDP in R&D. Thus, Chinese firms in our sample are investing at a similar rate; with the private firms investing more.⁶ The magnitude of the growth in R&D investment is remarkable, as it is a much higher growth rate than the overall GDP (China's GDP roughly doubled in the same period). Panel B (Figure 1b) shows that patenting rates have also increased steadily for both types of firms over the sample period.

Table 4 and Figure 2 also reveal interesting patterns regarding the private firm/SOE difference in R&D investments and patenting. Panel A shows that since 2006, private firms have

⁶ We expect the overall private sector R&D investment to GDP in China to be lower as our sample of firms are drawn from the listed sector of the economy.

always invested more in R&D (relative to their size) than SOEs. The difference is significant each year, and in terms of magnitude, private firms invest nearly twice as much in R&D, adjusted by their size as do SOEs. Unfortunately we do not have R&D data prior to 2006. Turning to patenting (Panel B), the longer times series shows that prior to 2004, SOEs have generally led the way in terms of patenting rates (though the annual differences are not significant). Post-2004, private firms surpassed SOEs, with the differences becoming statistically significant after 2006. The gap between the two sets of firms also increased steadily: In 2006, private firms' patenting rates was 38% higher than SOEs ($0.068/0.049-1$); in 2013, the gap has reached 94% ($0.163/0.084-1$).

Overall, the evidence so far suggests that since 2006, private firms have invested more in R&D and innovated more than SOEs. Prior to that year, our limited evidence suggests that SOE had a slight lead. Although it is difficult to ascertain, the fact that private sector firms began to show significant lead in R&D and patenting after 2006 may not be coincidental. 2006 is a critical year in China's recent economic history as it is the year in which the country fully acceded to the conventions set out by the WTO and fully implemented the revisions of its IPR legal framework. In other words, 2006 is the cut-off year after which China's IPR protection (along with a number of other institutional qualities) significantly strengthened. The fact that private firms have become more innovative relative to SOEs after 2006 could be a result of improved institutional quality, including IPR protection.

B. Innovation and IPR protection

Next we examine how IPR protection is related to innovation in the cross section of provinces. Each year, we divide all Chinese provinces into three groups based on their IPR

scores: low IPR, mid IPR, and high IPR, and compare the rates of R&D investment and patenting between high and low IPR regions. Tables 5 and 6 present the results on R&D and patenting, respectively. Each table has three panels, corresponding to the results from sorting on our three different IPR protection measures.

Table 5 shows that within China, IPR protection is highly positively related to R&D investments. Panel A shows the results when sorting provinces by IPP1. Not only is the difference in R&D highly significant between the high IPR and low IPR provinces for each year of the sample, R&D rates are also monotonically increasing in IPP1 from low to high. In terms of magnitude, firms in high IPR regions invest roughly twice as much (adjusted for size) in R&D as firms in low IPR regions. Results in Panel B, using IPP2 as the sorting variable, is qualitatively the same.

Table 6 repeats the exercise for patenting rates. Again we see that IPR protection is positively correlated with patenting, especially after 2005. Using IPP1 (Panel A), we find that firms in high IPR provinces patent twice as much as firms in low IPR provinces. Results in Panel B, using IPP2 are qualitatively similar.

Thus *within* China, there is a positive cross-sectional relation between local IPR protection and innovative activities. This is consistent with theoretical predictions of the benefits of IPR protection to intellectual property owners. Our result contrasts with earlier cross-country studies which often conclude a “China puzzle,” whereby China’s low overall IPR protection and high R&D and patenting rates appear as an outlier. Focusing on differences within the single country allows us a clearer identification of the IPR-innovation relation.

Figure 3 plots the evolution of R&D investments rates and patenting rates over time. The figure reveals significant increases in innovative activities across the board and also shows the differences between high and low-IPR protection regions.

Combining the results in the previous two subsections show that over time, Chinese companies across the board have dramatically increased R&D investments and patenting. Cross-sectionally, there is a positive relation between IPR protection and innovation. These results do not allow us to draw any causal inferences however, as many other provincial factors that could be correlated with IPR protection are not controlled for. In subsequent analyses, we control for covariates and use other identification techniques in order to make sharper causal inference.

C. Regression Results – Ownership, IPR protection, and innovation

In this section, we examine how IPR protection, state ownership, and their interaction affect firm innovation. Specifically, we estimate the following panel regression:

$$Innovation_{i,t} = \alpha + b_1 SOE_{i,t} + b_2 IPP_{i,t} + b_3 SOE_{i,t} * IPP_{i,t} + Controls_{i,t} + \varepsilon_{i,t} \quad (1)$$

Where $Innovation_{i,t}$ is the innovation measure—either R&D investment or patenting rate—for firm i in year t , SOE is an indicator variable of whether firm i is an SOE in year t , IPP is the IPR protection score for the province in which firm i is located in year t , and $SOE*IPP$ is the interaction term between the SOE indicator and the IPP measure. Control variables include firm level characteristics: size (log of assets), intangibles (as a fraction of assets), ROA, leverage, age, and Tobin's Q, and province level variables such as GDP growth and urbanization rate. These covariates are potentially related to the IPR protection level in a given province, and therefore it is important to control for them. In alternative specifications, we include province fixed effects to control for province level variations.

A priori, we are agnostic about the sign of b_1 , the coefficient on the SOE indicator. It could be positive or negative, indicating, controlling for other factors, SOEs invest more or less in R&D and obtain more or fewer patents than private enterprises. We expect the coefficient on the IPR score, b_2 , to be positive, if IPR protection increases firms' incentive to innovate. We expect the sign on the interactive term, b_3 , to be negative because IPR protection should be more important for privately owned firms that do not have the benefit of state backing. In a country where legal institutions are generally weak, and where the judicial system is not independent from the state and biases towards the SOEs, private firms face a significant chance of being expropriated. This would reduce their incentives to invest in R&D and to innovate, unless there are formal IPR protection mechanisms that alleviate these concerns. The risk of expropriation is lower for SOEs which enjoy explicit state backing.

Table 7 reports the regression results. Panel A focuses on R&D investments and Panel B focuses on patenting rates. In both panels, Models (1) and (2) do not include province fixed effects and Models (3) and (4) include province fixed effects. Panel A shows that in this multivariate setting, there is no difference in R&D investments between private and state-owned firms. The IPR protection measures are positively associated with R&D, but the coefficient is significant only in one of the four models. As we expected, the interaction term between SOE and the IPR protection measures are negative and is significant in three of the four models.

Panel B focuses on firms' ability to generate patents, and results here show that state ownership per se is generally positively associated with patenting rates. There is also a positive and highly significant relation between IPR protection and patenting: the coefficients on all four models are highly significant at the 1% level. In addition, the interaction term between SOE and the IPR protection measures are consistently negative and highly significant at the 1% level.

These results have interesting implications. The positive association between state ownership and patenting rates suggests that in China, where overall IPR protection is weak, state ownership possibly acts as a substitute for intellectual property protection; state-owned firms have stronger incentives to innovate and obtain patents as they are less likely to be expropriated. The significant positive impact of IPR measures on patenting implies that, as argued before, within China, institutions matter for firms' innovation. Finally, the consistent and strong coefficient on the interaction term between state ownership and IPR measures indicate that formal institutions such as strong IPR protection matters more for private sector firms than for state-owned firms.

To further investigate the impact of IPR and ownership on innovation, we examine the strength of the above results in sub-categories of patents. As discussed in Section I, the CSIPO classifies all patents into three categories with decreasing level of innovative content: invention, application, and design. If IPR and its interaction with state ownership indeed have the above-documented effect on innovation, we should see that the results to be stronger for innovation patents and weaker for design patents.

Table 8 reports these results, and generally supports the conjecture that the effect is stronger in innovation patents. For example, using our first IPR protection measure, neither the IPR measure itself nor the interaction term with the SOE indicator is significant in the regression for design/appearance patents, but they are—as in the baseline results—highly significant in the regression of innovation patents. Chi-tests of coefficient equality indicates that the coefficients are significantly different from one another, with p-values lower than 1%. Thus, indeed the effect of IPR and its interaction with state ownership is significantly stronger for invention patents.

Overall, results in this section show that within China, IPR protection is positively related to R&D investments and patenting. Furthermore, private firms' ability to innovate is more sensitive to IPR protection than SOEs. These effects are stronger for inventions than less innovative patents.

III. Additional Analyses

While the evidence shown in the last section is promising, there is a concern that the evidence does not show a causal relation between IPR protection, ownership and innovation. In this section, we undertake two additional analyses to address potential endogeneity concerns. First, we use SOE privatizations as an exogenous shock to examine firms' innovation patterns in a difference-in-difference approach. Second, we use instrumental variables (IV) regressions to address this concern.

A. Evidence from SOE privatizations

In China, large-scale SOE privatizations occurred as a part of broad economic reforms. Gan, Guo, and Xu (2008) report that between 1995 and 2005, 100,000 firms with 11.4 trillion RMB in assets were privatized in China, comprising two-thirds of China's SOE and state assets. The intent of the privatization program was (and remains) to change the ownership structure and managerial incentives in order to enhance profitability and rarely seemed motivated by concerns about innovation (Gan (2009)).⁷

⁷ China's massive SOE privatization was unleashed by policy directives from the Third Plenum of the Fourteenth Chinese Communist Party Congress in the fall of 1993, which endorsed the creation of a modern enterprise system and approved diversified forms of ownership, including private ownership in China. In 1997, the Chinese Communist Party's 15th Congress gave a green light to privatizing the majority of SOEs nationwide. The goal of the privatization program is to corporatize previously state-owned firms, and to provide managers with profit and market-driven incentives. Gan (2009) documents that at the beginning of the SOE privatization wave (in the mid-1990s), most SOEs were losing money and close to half of SOEs had zero or negative book equity, due to decades

Thus, for our analysis of firms' innovative activities, SOE privatizations provide an exogenous change to the ownership structure. If ownership structure affects firms' incentives to innovate, then the before-and-after change in innovation as a result of SOE privatization should be a clean indication of that effect. In addition, we can use these events to investigate the interactive effect of ownership and IPR protection on innovation. If private firms' incentives to invest in R&D and their ability to innovate are particularly sensitive to IPR protection, then the before-and-after change in these outcome measures should be particularly large for privatizations that occurred in provinces with high IPR protection scores.

To identify SOE privatizations in our sample, we examine the reported share capital structure in firms' annual statements. As discussed in Section 1, since 2001, Chinese listed firms are required to disclose share ownership. This allows us to trace the change of ultimate owners over time. We define a listed SOE as privatized if the largest ultimate owner changes from a government entity to a non-government entity (either an individual or a private enterprise). We are able to identify 187 privatizations in our sample (roughly one third of the firms that were ever an SOE in our sample).

Table 9 reports the results comparing R&D investments (Panel A) and patenting (Panel B) before and after SOE privatizations. We divide the sample of privatization events into two groups: Those that occurred in provinces with high IPR scores, and those with low scores, and report their results in separate columns for comparison.

Table 9 offers a few clear patterns. First, consistent with earlier findings, IPR protection is positively related to innovative activities: the difference between high- and low-IPR protection

of state ownership and weak managerial incentives. Thus, the government's policy objective for the privatization program is to transition the Chinese economy to be market-based. Notably, spurring innovation was not an important policy objective at the time. Innovation as a national priority did not appear in the policy lexicon until the 12th Five Year Plan in 2011. See Gan (2009) for more details on China's SOE privatization program.

regions is always positive and highly significant. Second, private ownership leads to more investments in R&D and more patents: the after (privatization) minus before (privatization) difference is always positive, and highly significant in most cases. However, the after minus before difference is much larger in provinces with high IPR protection. For example if we look at R&D investments (Panel A) we see that after privatization, firms in low-IPP1 regions increase R&D by 0.10% of assets while affirms in high-IPP1 regions increase R&D by 0.14% of assets. Thus the magnitude of the change is 40% larger in high IPR protection regions, and this difference is statistically significant. Results on patenting are similar. For example, Panel B shows that while patenting rate goes up by an insignificant 0.3% in low IPP1 regions, it increases by a highly significant 7.2% in high IPP1 regions.

SOE privatizations offer a quasi-experiment to examine the impact of ownership type on firm innovation as they provide a plausibly exogenous shock to the ownership structure of the firm. The evidence in this section thus provide causal evidence that ownership type affects innovation: within the same firm, innovation increases significantly after privatization. Moreover, we find that this increase is concentrated in regions with high IPR protection, again supporting our earlier conclusion that IPR protection is particularly important for private sector firms.

In Table 10, we analyze changes in innovation around SOE privatizations using regression analyses. We further divided our sample of SOE privatizations into successful and unsuccessful cases. As discussed previously, since the motivation of privatizations is largely unrelated to innovation, the success or failure of privatizations is also essentially unrelated the firms' innovation efforts. Indeed, when we examined the causes of privatization failure found that they were overwhelmingly related to disagreements over the ownership of the transferred equity. But if change of ownership type causes changes in innovation rates, we should so

positive changes associated with successful privatizations and no change with unsuccessful cases. This is exactly what we find in Table 10: when SOEs are successfully privatized, R&D investments and patenting both increase afterwards. Both outcome variables do not experience significant changes in failed privatizations.

B. IV Regressions

In this section, we use instrumental variable regressions to further check the robustness of our results and provide support for the view that IPR and ownership type jointly have causal effects on firms' innovative activities. The concern is that, in our baseline panel regression, we regress innovative activities (R&D investments and patenting) on IPR protection scores. But if the IPR protection score in a province is endogenous to the innovative activities of the firms in that province (for example, higher IPR protection may be caused by higher demand for such protection by local, highly innovative firms), then the conventional regression estimates will generate inconsistent results. Similarly, if our regression specification has an omitted explanatory variable, the estimation results will also be inconsistent. In these cases, the instrumental variable approach alleviates these concerns.

Following Ang, Cheng, and Wu (2014), we use two instruments for IPR protection to implement the IV regression. The first is the number of Christian colleges founded by Christian missionaries in a province by 1920. Educational institutions are important in instilling Western values among Chinese people. Colleges sponsored by Christian churches helped instill Christian value such as the respect for private property, e.g., as manifest in the Ten Commandments.⁸ The second instrument is British settlement, an indicator variable that equals one if a province had a

⁸ Well-known Christian colleges include, for example, St John's University, which was founded by the American Episcopal Church, and Soochow University founded by the American Methodist Missionaries.

British concession during the Qing dynasty. The British, along with other colonial powers, modeled the local administrative and legal systems according to their own values. British settlements would be instrumental in spreading common-law values such as property rights.⁹

Thus, these two variables should be correlated with provincial IPR protection, as they measure the provinces' historical exposure to the idea of property rights. At the same time, they do not appear to be directly correlated with firms' R&D investment and patenting rates in the modern day (Ang, Cheng, and Wu (2014)).

Table 11 reports the results from the IV regressions. Panel A reports the 1st stage results and Panel B reports the 2nd stage results. The first stage results show that the instruments are strong instruments for IPR protection. Consistent with prior results, the second-stage results show that IPR protection positively affects R&D investments and patenting, and the interaction term between state ownership and IPR negatively affects both outcome variables, indicating that private ownership is associated with higher levels of innovative activities in regions with high IPR protection.

IV. Conclusions

We empirically examine how local IPR protection, firm ownership type, and their interaction influence firms' incentives to engage in innovative activities in China. Consistent with theories on IPR protection, we find that within China, IPR protection matters and is positively associated with firms' innovative activities. In addition, we find that ownership type—whether a firm is owned by the state or by private investors—interacts in important ways with IPR protection in affecting innovation. In particular, while private ownership is associated with

⁹ The British concessions or leased territory include Xiamen city in Fujian, Hankou city in Hubei, Jiujiang city in Jiangxi, Zhenjiang City in Jiangsu, Guangzhou City in Guangdong, Weihaiwei in Shandong, Tianjin, and Shanghai.

higher incentives to engage in innovative activities, this effect is stronger (the private-SOE gap in innovation bigger) in regions with high IPR protection. This suggests that private firms' innovative activities are more sensitive to IPR protection.

Our main contributions are two-fold. First, China has appeared puzzling to economists in numerous ways: it has developed very rapidly despite of having weak institutions, and it has ramped up its innovation efforts rapidly despite of having weak intellectual property protection. Compare to other countries, China appears an outlier in the law-growth framework. We provide within-country evidence and demystify some of this "China puzzle". We find that within China, things work more according to the standard theoretical view: IPR protection does matter for firms' incentives to engage in innovative activities.

Our second contribution is to show that in the presence of weak institutions, private firms, compared to state-owned enterprises, are more sensitive to IPR protection in their innovative efforts. This may be because when the legal framework is weak and state-controlled, state-owned enterprises are less likely to be expropriated than private firms. Our findings have important policy implications. So far, China has been able to sustain impressive economic and innovative growth despite weak institutions. But as the country develops and increasingly depend on innovation and the private sector to drive its next stages of growth, strengthening of its intellectual property institutions will become increasingly critical.

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Figure 1. IPR Enforcement Over Time

This graph depicts the evolution of the IPR enforcement measures over time. IPP1 (Intellectual Property Protection measure 1) is the percentage of IP infringement cases won by the plaintiff in the province in a given year. IPP2 is the number of articles advocating IPR protection in the provincial governments' official Daily publication each year, as a percentage of total articles in that year. IPP2 We partition the 28 provinces in our sample into three groups based on the values of each IPP measure. The plot shows the group means over time.

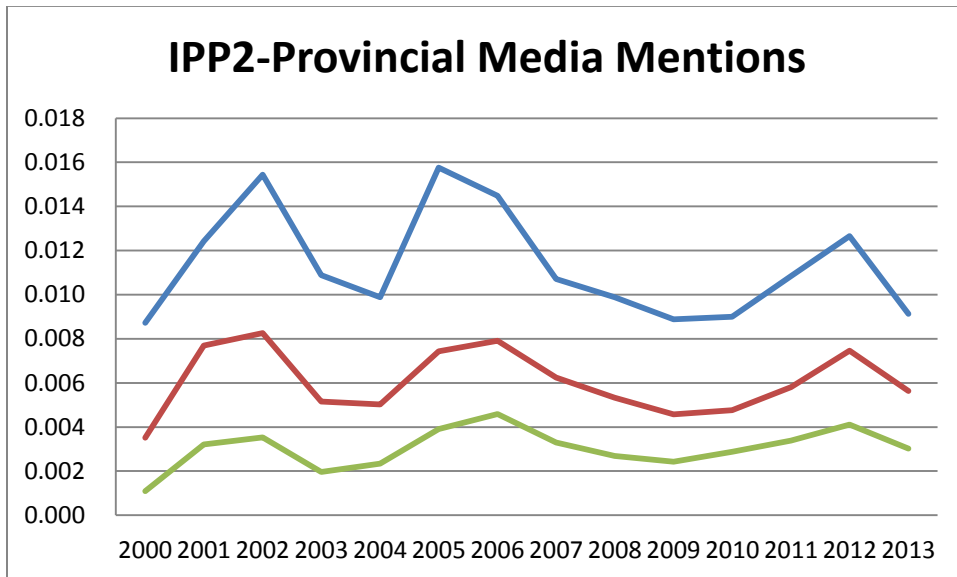
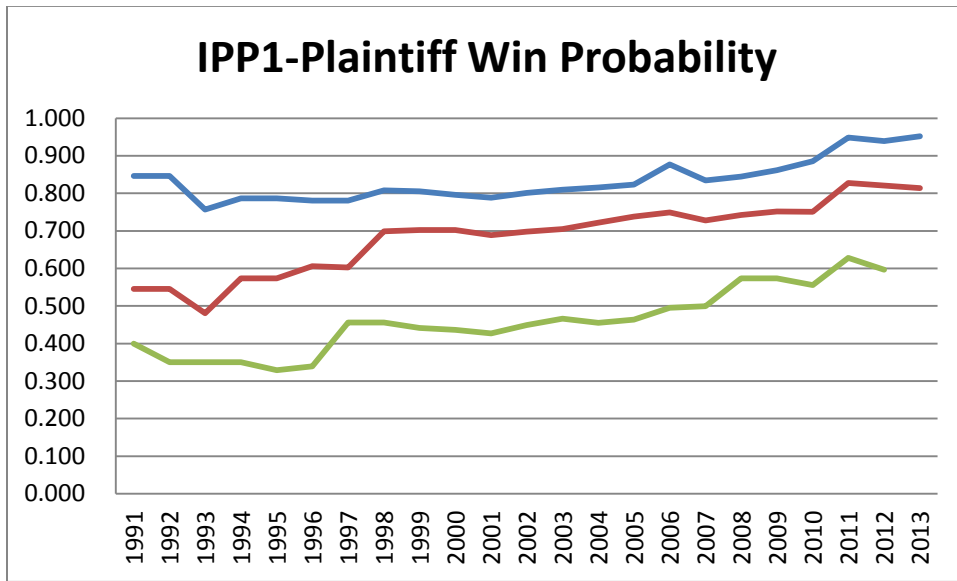


Figure 2. R&D and Patenting Rates Over Time

This figure plots the R&D investment rate (R&D/assets) and patenting rate (Patents/assets) over time for privately owned firms and state-owned enterprises (SOEs). Private-owned enterprises and state-owned enterprises (SOEs) are classified using the ultimate largest shareholder disclosed in firms' annual reports.

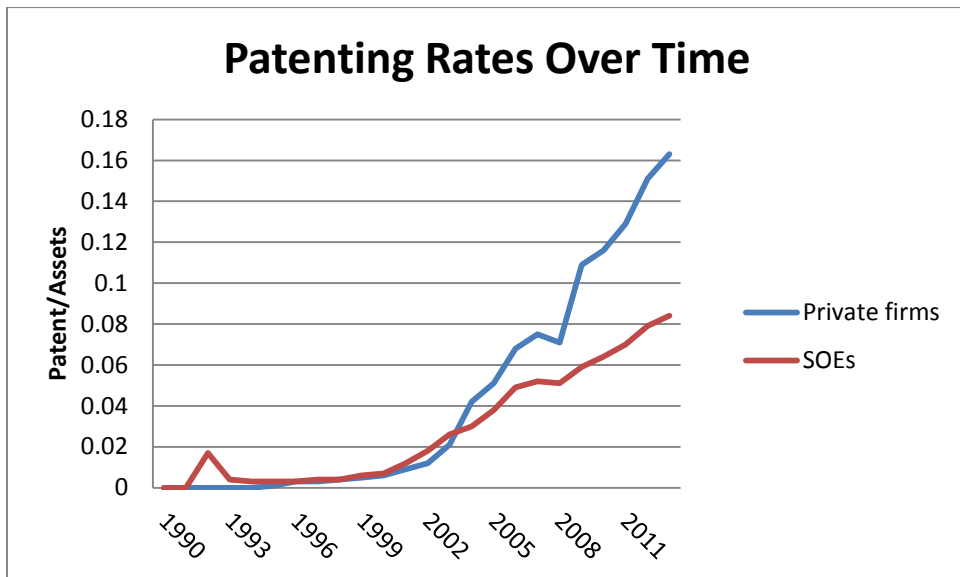
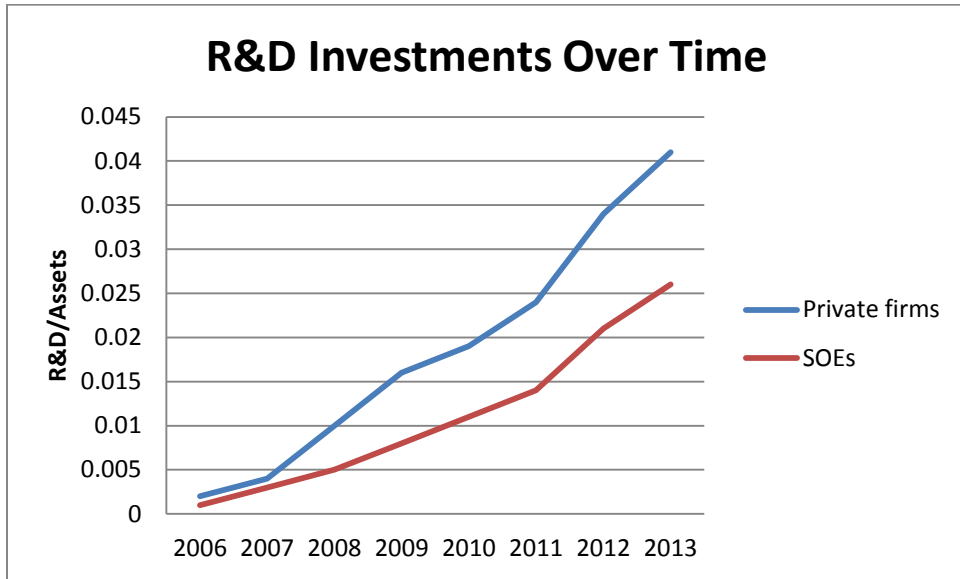


Figure 3. IPR Protection and Innovation

This figure plots the R&D investment rate (R&D/assets) and patenting rate (Patents/assets) over time for provinces sorted by IPR enforcement. The sorting variable in these graphs is IPP1, which measures the probability for a plaintiff to win its IP infringement case against the plaintiff in provincial courts.

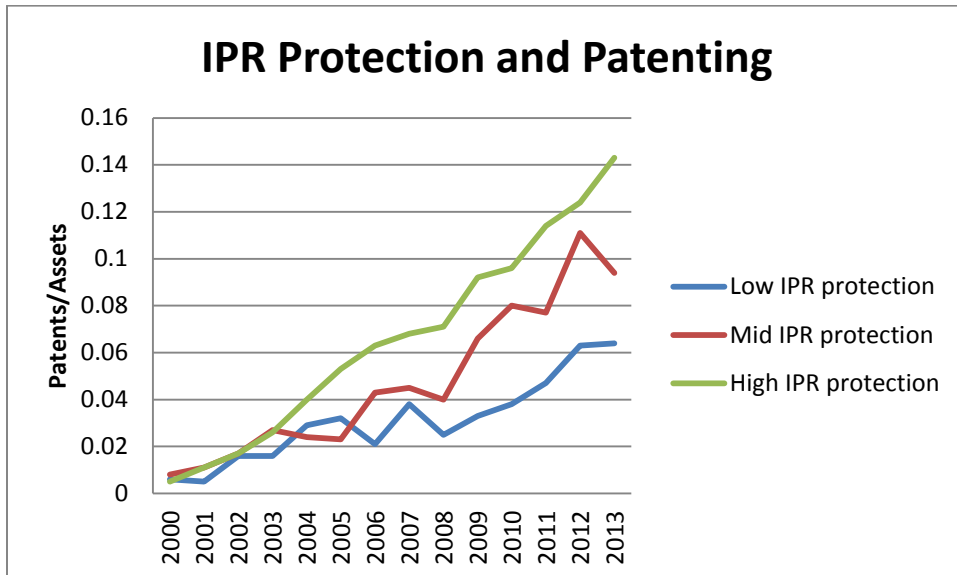
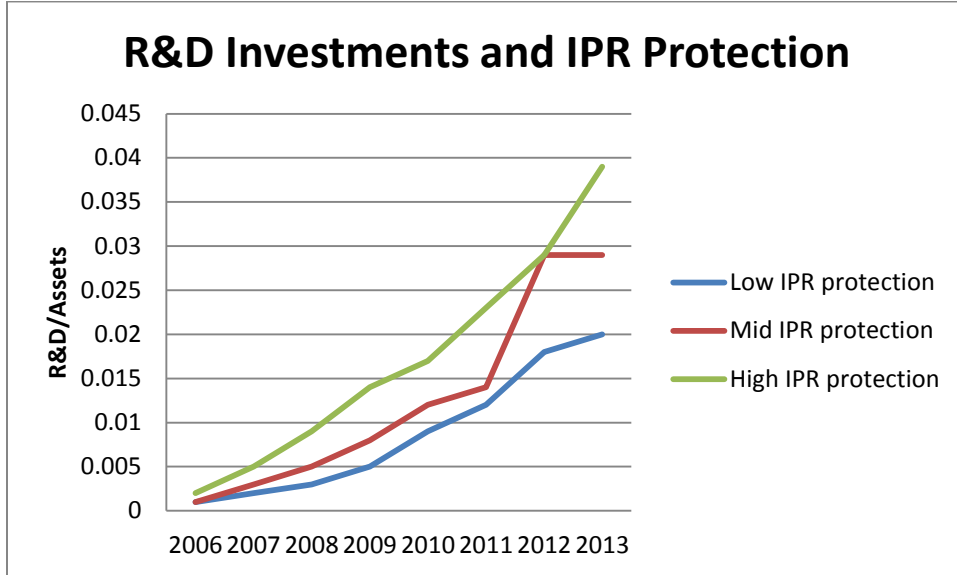


Table 1. Summary Statistics

This table presents summary statistics of our sample. Private enterprises and state-owned enterprises (SOEs) are classified using the ultimate largest shareholder disclosed in firms' annual reports. R&D/asset is firms R&D investment divided by total assets at the end of the year. Patent/asset is the number of patents held by the firm divided by total assets at the end of the year. Intangible is intangible assets divided by total assets, measured at the end of the year. Log(asset) is the natural logarithm of total assets. Log(age) is the natural logarithm of firm age. Leverage is total debt divided by total assets. Return on asset is total profit divided by total asset. Tobin's Q is the market value of assets divided by book value of assets. *, **, *** indicate statistical significance using a two-tailed test at the 10%, 5%, and 1% level, respectively.

<i>Panel A: Firms</i>			
year	Private Enterprises	State-owned Enterprises (SOEs)	Percentage of SOEs
1990	1	6	86%
1991	1	6	86%
1992	10	30	75%
1993	30	105	78%
1994	53	167	76%
1995	60	181	75%
1996	106	304	74%
1997	141	440	76%
1998	155	517	77%
1999	169	579	77%
2000	200	667	77%
2001	216	727	77%
2002	228	774	77%
2003	247	817	77%
2004	321	830	72%
2005	342	822	71%
2006	413	832	67%
2007	496	859	63%
2008	536	871	62%
2009	597	899	60%
2010	773	934	55%
2011	901	934	51%
2012	954	944	50%
2013	978	942	49%
Average	330	591	64%

Panel B: Firm characteristics

	Mean	Std. Dev.	Min	Median	Max	Obs.
R&D/asset	0.008	0.015	0	0.00002	0.327	12863
Patent/asset	0.026	0.152	0	0	0.6	22115
SOE	0.641	0.48	0	1	1	22115
Log(asset)	21.38	1.326	12.314	21.219	30.571	22112
Intangible	0.042	0.065	-0.033	0.024	0.895	21963
Log(age)	2.276	0.612	0	2.398	3.466	21875
Leverage	0.494	0.293	0.039	0.476	2.992	22111
ROA	0.035	0.078	-0.458	0.036	0.318	19053
Tobin's q	2.669	2.172	0.654	2.056	19.352	21402

Panel C: Private firms vs. SOEs

	Private	SOE	Diff.
R&D/asset	0.023	0.011	0.011***
Patent/asset	0.091	0.041	0.050***
Invention patent/asset	0.029	0.013	0.016***
Application patent/asset	0.038	0.016	0.023***
Design patent/asset	0.019	0.01	0.009***
Total asset	2.60	30.00	0.000***
Intangible	0.047	0.04	0.007***
Age	10.951	9.981	0.970***
Leverage	0.487	0.498	-0.011***
ROA	0.041	0.037	0.004***
Tobin's q	3.092	2.423	0.669***

Table 2. IPP Measures and Other Provincial Level Statistics

This table reports average IPR protection measures and other provincial statistics. IPP1 (Intellectual Property Protection measure 1) is the percentage of IP infringement cases won by the plaintiff in the province in a given year. IPP2 is the number of articles advocating IPR protection in the provincial governments' official Daily publication each year, as a percentage of total articles in that year. GDP growth is the annual rate of nominal GDP increase. Urbanization is the percentage of population that are urban residents in a year. Christian college is the number of Christian colleges in a province founded by missionaries by 1920. British settlement is an indicator variable that equals 1 if the province had British concessions during the Qing dynasty and 0 otherwise.

<i>Panel A: Province-level statistics</i>							
	Mean	SD	Min.	Median	Max	Obs.	Data period
IPP1	0.69	0.192	0	0.738	1	472	1991-2013
IPP2	0.007	0.004	0	0.006	0.023	397	2000-2013
GDP growth	0.167	0.077	0.006	0.157	0.534	713	1990-2013
Urbanization	0.435	0.173	0.155	0.42	0.896	649	1990-2013
Christian college	0.645	0.915	0	0	3	31	1990-2013
British settlement	0.258	0.445	0	0	1	31	1990-2013

<i>Panel B: Correlations</i>		
	IPP1	IPP2
IPP1		
IPP2	0.178***	

Table 3. Comparison of Provincial Characteristics

This table compares various provincial characteristics in groups sorted by IPR enforcement measures. The sorting variables are IPP1 or IPP2, the two IPR enforcement measures. IPP1 is the probability of the plaintiff winning its IP infringement cases in local courts. IPP2 is the frequency with which provincial governments published articles advocating IPR protection in its official Daily newspapers. Per capital GDP is measured in RMB. GDP growth rate is the annual rate of increase in total provincial GDP. University per 1,000 people is the number of universities in the province per 1,000 citizens. Urbanization is the percentage of provincial population that has urban residency. Educated population is the percentage of the population that has a university degree. *, **, *** denote statistical significance at the 10%, 5%, and 1% level, respectively.

	IPP1			IPP2		
	<u>Low</u>	<u>High</u>	<u>Diff.</u>	<u>Low</u>	<u>High</u>	<u>Diff.</u>
Per capital GDP (RMB)	23,000	20,000	3,000	18,000	30,000	-12,000***
GDP growth rate	0.151	0.161	-0.01	0.161	0.153	0.008
Universities per 1,000 people	0.16	0.17	-0.01	3.624	4.146	-0.523***
Urbanization rate	0.487	0.473	0.014	0.421	0.519	-0.098***
Educated population	0.083	0.08	0.004	0.064	0.095	-0.031***

Table 4. R&D and Patenting, by Ownership Type

This table compares R&D investment rates (R&D/assets) and patenting rates (Patents/assets) between privately owned enterprises (POEs) and state-owned enterprises (SOEs). We define SOE as a firm whose largest ultimate shareholder is a government entity. Ownership information is obtained from company annual reports. POEs are firms whose largest ultimate owner is a private individual or enterprise. R&D/Asset is R&D expenditure divided by total assets. Patent/Asset is the total number of patents divided by total assets. *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

<i>Panel A: R&D/Assets</i>				
year	Private	SOE	Diff.(Private-SOE)	t-stat.
2006	0.002	0.001	0.001	2.08**
2007	0.004	0.003	0.002	2.12**
2008	0.01	0.005	0.005	4.8***
2009	0.016	0.008	0.008	6.21***
2010	0.019	0.011	0.008	6.58***
2011	0.024	0.014	0.01	7.4***
2012	0.034	0.021	0.012	7.8***
2013	0.041	0.026	0.015	8.45***
<i>Panel B: Patent/Assets</i>				
year	Private	SOE	Diff.(Private-SOE)	t-stat.
1992	0	0.017	-0.017	-1.08
1993	0	0.004	-0.004	-1.27
1994	0	0.003	-0.003	-1.62
1995	0.001	0.003	-0.002	-1.51
1996	0.003	0.003	-0.001	-0.29
1997	0.003	0.004	-0.001	-0.42
1998	0.004	0.004	-0.001	-0.28
1999	0.005	0.006	-0.001	-0.58
2000	0.006	0.007	-0.002	-0.89
2001	0.009	0.012	-0.003	-0.98
2002	0.012	0.018	-0.006	-1.63
2003	0.021	0.026	-0.006	-1.13
2004	0.042	0.03	0.012	1.42
2005	0.051	0.038	0.013	1.5
2006	0.068	0.049	0.019	1.87*
2007	0.075	0.052	0.023	2.29**
2008	0.071	0.051	0.02	2.22**
2009	0.109	0.059	0.05	4.74***
2010	0.116	0.064	0.053	5.40***
2011	0.129	0.07	0.058	6.05***
2012	0.151	0.079	0.072	7.07***
2013	0.163	0.084	0.079	7.46***

Table 5. IPR Protection and R&D Investments

This table compares the rate of R&D investment (R&D/Assets) across regions sorted by IPR protection measures. In Panel A the sorting variable is IPP1, which is the probability of the plaintiff winning its IP infringement cases in provincial courts. IPP2 is the frequency with which provincial governments published articles advocating IPR protection in its official Daily newspapers. *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

<i>Panel A: Sorting by IPP1</i>					
year	Low-IPP2	Middle-IPP2	High-IPP2	Diff.(High-Low)	t-stat.
2006	0.001	0.001	0.001	0	1.15
2007	0.002	0.004	0.004	0.002	3.13***
2008	0.006	0.007	0.007	0.001	0.65
2009	0.006	0.011	0.011	0.004	3.69***
2010	0.01	0.015	0.015	0.006	4.55***
2011	0.017	0.023	0.023	0.006	3.57***
2012	0.024	0.032	0.032	0.008	4.19***
2013	0.033	0.039	0.039	0.006	2.6***
<i>Panel B: Sorting by IPP2</i>					
year	Low-IPP1	Middle-IPP1	High-IPP1	Diff.(High-Low)	t-stat.
2006	0.001	0.001	0.002	0.001	3.95***
2007	0.002	0.003	0.005	0.003	4.05***
2008	0.003	0.005	0.009	0.006	5.81***
2009	0.005	0.008	0.014	0.009	7.37***
2010	0.009	0.012	0.017	0.009	5.98***
2011	0.012	0.014	0.023	0.011	6.47***
2012	0.018	0.029	0.029	0.011	5.38***
2013	0.02	0.029	0.039	0.018	8.42***

Table 6. IPR Protection and Patenting

This table compares the rate of patenting (Patents/Assets) across regions sorted by IPR protection measures. In Panel A the sorting variable is IPP1, which is the probability of the plaintiff winning its IP infringement cases in provincial courts. IPP2 is the frequency with which provincial governments published articles advocating IPR protection in its official Daily newspapers. *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

<i>Panel A: Sorting by IPP1</i>					
year	Low-IPP2	Middle-IPP2	High-IPP2	Diff.(High-Low)	t-stat.
1996	0.015	0.002	0.002	-0.013	-1.37
1997	0.006	0.006	0.006	0	-0.03
1998	0.01	0.003	0.003	-0.006	-0.99
1999	0.008	0.003	0.003	-0.005	-1.18
2000	0.008	0.007	0.007	-0.001	-0.33
2001	0.013	0.011	0.011	-0.002	-0.47
2002	0.018	0.019	0.019	0.001	0.16
2003	0.024	0.03	0.03	0.006	0.87
2004	0.032	0.04	0.04	0.008	0.88
2005	0.023	0.047	0.047	0.024	3.05***
2006	0.056	0.045	0.045	-0.011	-1.16
2007	0.061	0.064	0.064	0.003	0.19
2008	0.036	0.073	0.073	0.037	3.59***
2009	0.068	0.085	0.085	0.017	1.3
2010	0.076	0.092	0.092	0.016	1.29
2011	0.065	0.129	0.129	0.065	6.39***
2012	0.076	0.15	0.15	0.074	6.97***
2013	0.101	0.143	0.143	0.042	3.46***

<i>Panel B: Sorting by IPP2</i>					
year	Low-IPP1	Middle-IPP1	High-IPP1	Diff.(High-Low)	t-stat.
2000	0.006	0.008	0.005	-0.002	-0.62
2001	0.005	0.011	0.011	0.006	1.76*
2002	0.016	0.017	0.017	0	0.06
2003	0.016	0.027	0.026	0.01	1.45
2004	0.029	0.024	0.04	0.011	1.25
2005	0.032	0.023	0.053	0.022	2.46**
2006	0.021	0.043	0.063	0.041	5.09***
2007	0.038	0.045	0.068	0.03	2.96***
2008	0.025	0.04	0.071	0.046	5.74***
2009	0.033	0.066	0.092	0.059	5.75***
2010	0.038	0.08	0.096	0.058	6.96***
2011	0.047	0.077	0.114	0.067	7.46***
2012	0.063	0.111	0.124	0.062	5.06***
2013	0.064	0.094	0.143	0.079	6.83***

Table 7. Ownership, IPR Protection, and Innovation – Regression Analysis

This table reports regression results of the determinants of firm level R&D and patenting. The dependent variable is R&D/Assets in Panel A and Patents/Assets in Panel B. SOE is an indicator variable that equals 1 if the firm’s largest ultimate owner is a government entity and zero otherwise. IPP1 is the probability of the plaintiff winning its IP infringement cases in provincial courts. IPP2 is the frequency with which provincial governments published articles advocating IPR protection in its official Daily newspapers. Log(asset) is the natural log of (one plus) the firm’s total assets. Intangible is the firm’s intangible assets divided by total assets. ROA is the total profit divided by total assets. Leverage is total debt divided by total assets. Age is the number of years since firm inception. Tobin’s q is the market value of assets divided by book value of assets. GDP growth rate is the rate of increase of provincial level nominal GDP. Urbanization is the percentage of population that has urban residency. P-values are in parenthesis. *, **, *** indicates statistical significance at the 10%, 5%, and 1% level, respectively.

<i>Panel A: Dependent var = R&D/assets</i>				
	(1)	(2)	(3)	(4)
SOE	-0.003 (0.14)	-0.001 (0.39)	0.001 (0.95)	0.002 (0.14)
IPP1	0.023*** (0.00)		0.004 (0.15)	
SOE×IPP1	-0.005* (0.06)		-0.004 (0.17)	
IPP2		0.137 (0.21)		0.181 (0.14)
SOE×IPP2		-0.717*** (0.00)		-0.486*** (0.00)
Log(asset)	0.002*** (0.00)	0.002*** (0.00)	-0.000* (0.07)	0.000 (0.17)
Intangible	-0.004 (0.23)	-0.004 (0.19)	-0.008*** (0.01)	-0.008*** (0.01)
ROA	0.030*** (0.00)	0.030*** (0.00)	0.027*** (0.00)	0.026*** (0.00)
Leverage	-0.011*** (0.00)	-0.012*** (0.00)	-0.008*** (0.00)	-0.008*** (0.00)
Age	-0.002*** (0.00)	-0.002*** (0.00)	-0.007*** (0.00)	-0.007*** (0.00)
Tobin’s q	0.001*** (0.00)	0.001*** (0.00)	0.001 (0.36)	0.001 (0.13)
GDP growth	-0.064*** (0.00)	-0.065*** (0.00)	-0.050*** (0.00)	-0.048*** (0.00)
Urbanization	0.017*** (0.00)	0.020*** (0.00)	0.331*** (0.00)	0.323*** (0.00)
Constant	-0.031*** (0.00)	-0.016*** (0.00)	-0.093*** (0.00)	-0.090*** (0.00)
Industry fixed effects	Yes	Yes	Yes	Yes
Province fixed effects	No	No	Yes	Yes
Observations	11,344	10,816	11,344	10,816
R-squared	0.286	0.286	0.364	0.368

<i>Panel B: Dependent var = Patents/assets</i>				
	(1)	(2)	(3)	(4)
SOE	0.031*	0.004	0.035***	0.004
	(0.06)	(0.76)	(0.00)	(0.47)
IPP1	0.149***		0.101***	
	(0.00)		(0.00)	
SOE×IPP1	-0.090***		-0.075***	
	(0.00)		(0.00)	
IPP2		5.908***		2.629***
		(0.01)		(0.00)
SOE×IPP2		-4.564**		-3.059***
		(0.03)		(0.00)
Log(asset)	-0.005*	-0.003	-0.009***	-0.007***
	(0.08)	(0.36)	(0.00)	(0.00)
Intangible	0.038	0.016	0.029	0.012
	(0.29)	(0.60)	(0.16)	(0.53)
ROA	0.064**	0.052*	0.045**	0.033
	(0.03)	(0.08)	(0.05)	(0.16)
Leverage	-0.028***	-0.029***	-0.023***	-0.024***
	(0.00)	(0.00)	0.00	0.00
Age	0.002	0.004	-0.016***	-0.013***
	(0.82)	(0.70)	(0.00)	(0.00)
Tobin's q	0.00	0.002	-0.001	0.001
	(0.94)	(0.33)	(0.34)	(0.54)
GDP growth	-0.052	0.004	-0.061**	-0.035
	(0.37)	(0.94)	(0.03)	(0.20)
Urbanization	0.064*	0.039	0.473***	0.444***
	(0.08)	(0.27)	0.00	0.00
Constant	0.027	0.033	0.041	0.051
	(0.67)	(0.65)	(0.20)	(0.10)
Industry fixed effects	Yes	Yes	Yes	Yes
Province fixed effects	No	No	Yes	Yes
Observations	14,580	13,733	14,580	14,580
R-squared	0.162	0.165	0.195	0.192

Table 8. Different Types of Patents

This table reports regression results on the determinants of patenting rates (Patents/asset) for different types of patents. All explanatory variables are as defined in Table 7. P-values are reported in parentheses. *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)
	Invention patent/asset	Invention patent/asset	Design patent/asset	Design patent/asset
SOE	0.007 (0.22)	0.005 (0.36)	0.016** (0.02)	0.00 (0.96)
IPP1	0.045*** (0.00)		0.034*** (0.00)	
SOE×IPP1	-0.025*** (0.01)		-0.028*** (0.00)	
IPP2		2.027*** (0.00)		1.102* (0.05)
SOE×IPP2		-1.744*** (0.00)		-0.643 (0.33)
Log(asset)	-0.001 (0.43)	0.0002 (0.80)	-0.001 (0.36)	-0.001 (0.53)
Intangible	0.00 (0.96)	-0.003 (0.71)	0.012 (0.31)	0.008 (0.51)
ROA	0.038*** (0.00)	0.032*** (0.00)	-0.002 (0.83)	0.001 (0.91)
Leverage	-0.010*** (0.01)	-0.011*** (0.00)	-0.008* (0.05)	-0.007* (0.07)
Age	0.001 (0.73)	0.001 (0.74)	0.003* (0.08)	0.004* (0.08)
Tobin's q	0.00 (0.89)	0.001 (0.18)	0.001 (0.30)	0.001 (0.25)
GDP growth	-0.023 (0.24)	-0.002 (0.90)	0.00 (0.96)	0.005 (0.58)
Urbanization	0.030*** (0.00)	0.021** (0.02)	0.009 (0.33)	0.003 (0.73)
Constant	-0.013 (0.47)	-0.016 (0.36)	0.003 (0.91)	0.009 (0.79)
Observations	14,580	13,733	14,580	13,733
R-squared	0.155	0.159	0.059	0.061

Table 9. Changes in Innovation around SOE Privatizations

This table reports changes in firms' innovative activities before and after SOE privatization. The sample of firms are SOE privatizations, identified from changes in ultimate owners reported in firms' annual statements. Before privatization, the firms are state-owned enterprises (SOE). After privatization, they become privately owned firms. Panel A compares R&D investments (R&D/assets) before and after, and Panel B compares patenting rates (Patents/assets) before and after. The sample is further split into regions sorted by IPR protection measures. IPP1 is the probability of the plaintiff winning its IP infringement cases in provincial courts. IPP2 is the frequency with which provincial governments published articles advocating IPR protection in its official Daily newspapers. t-stats based on two-tailed tests are reported. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

<i>Panel A: R&D/Assets</i>									
	Sorting by IPP1				Sorting by IPP2				
	Low	High	High-Low	t-stat	Low	High	High-Low	t-stat	
Before (SOE)	0.009	0.012	0.003	4.56***	0.012	0.01	-0.002	2.62***	
After (Private)	0.009	0.027	0.017	17.47***	0.021	0.018	-0.002	1.94*	
After - Before	0.001	0.014			0.009	0.008			
t-stat. (After - Before)	0.62	19.22***			8.18***	9.18***			

<i>Panel A: Patents/Assets</i>									
	Sorting by IPP1				Sorting by IPP2				
	Low	High	High-Low	t-stat	Low	High	High-Low	t-stat	
Before (SOE)	0.032	0.054	0.022	7.21***	0.044	0.04	-0.003	-1.11	
After (Private)	0.035	0.126	0.091	18.1***	0.073	0.094	0.021	3.56***	
After - Before	0.003	0.072			0.029	0.054			
t-stat. (After - Before)	0.59	16.68***			6.29***	10.81***			

Table 10. Changes in Innovation around SOE Privatization: Regression Analysis

This table reports regression analysis of changes in R&D investments and patenting rates around SOE privatization. We estimate the regressions for the completed SOE privatizations and failed SOE privatizations separately. IPP1 is the probability of the plaintiff winning its IP infringement cases in provincial courts. IPP2 is the frequency with which provincial governments published articles advocating IPR protection in its official Daily newspapers. After(1st year) is one year after the attempted SOE privatization. After (2nd year) and After(\geq 3rd year) are similarly defined. Control variables (unreported) are identical to those in Table 7. *, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

<i>Panel A: R&D/Asset</i>								
	Privatization completed				Privatization failed			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	High IPP1	Low IPP1	High IPP2	Low IPP2	High IPP1	Low IPP1	High IPP2	Low IPP2
After(1 st year)	0.002**	0.002	0.001	0.002**	0	-0.002	0.002	-0.002
	-0.012	-0.272	-0.486	-0.031	-0.756	-0.443	-0.384	-0.225
After(2 nd year)	0.003*	0.001	0.003*	0	0.003	-0.002	0.002	-0.003
	-0.083	-0.225	-0.059	-0.836	-0.396	-0.429	-0.237	-0.198
After(\geq 3 rd year)	0.003**	0.002	0.003**	0.001	0	-0.002	0.004*	-0.004*
	-0.049	-0.128	-0.044	-0.168	-0.903	-0.224	-0.064	-0.074
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	525	588	646	422	143	153	181	107
R-squared	0.194	0.172	0.225	0.206	0.33	0.428	0.358	0.514
<i>Panel B: Patent/Asset</i>								
	Privatization completed				Privatization failed			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	High IPP1	Low IPP1	High IPP2	Low IPP2	High IPP1	Low IPP1	High IPP2	Low IPP2
After(1 st year)	0.009**	0.003	0.006*	0.006	-0.008**	0.007**	0.004	0.003**
	-0.04	-0.457	-0.076	-0.148	-0.011	-0.027	-0.681	-0.04
After(2 nd year)	0.007**	0.004	0.008*	0.004	-0.005	0.004	0.001	0.001
	-0.046	-0.228	-0.096	-0.46	-0.222	-0.473	-0.883	-0.948
After(\geq 3 rd year)	0.011**	0.006	0.009**	0.006	0.01	0.001	0.014	-0.008
	-0.029	-0.15	-0.039	-0.299	-0.282	-0.883	-0.208	-0.525
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	773	881	914	679	228	243	271	198
R-squared	0.144	0.089	0.175	0.108	0.265	0.173	0.201	0.352

Table 11. IV Regression Results

This table reports IV regression results. Panel A reports the 1st-stage results and Panel B reports the 2nd-stage results. We use two instrumental variables for local IPR protection: Christian College is the number of colleges founded by Christian missionaries in a province before 1920; British Settlement is a dummy variable that equals one if the province had a British concession in the Qing Dynasty and zero otherwise. Other variables are as defined in Table 7. P-values are reported in parentheses. *, **, *** indicates statistical significance at the 10%, 5%, and 1% levels, respectively.

<i>Panel A: First Stage Results</i>			
	IPP1	IPP2	
Christian College	0.044*** (0.00)	0.001*** (0.00)	
British Settlement	-0.005 (0.14)	0.002*** (0.00)	
Christian College×SOE	-0.018*** (0.00)	-0.000*** (0.00)	
British Settlement×SOE	-0.001 (0.81)	0 (0.94)	
SOE	0.006 (0.33)	0.001 (0.29)	
Controls	Yes	Yes	
Observations	14,580	13,733	
R-squared	0.07	0.40	
Partial-F test for IVs	153.34 (p=0.000)	315.93 (p=0.000)	

<i>Panel B: Second Stage Results</i>				
	(1)	(2)	(3)	(4)
	Patent/asset	Patent/asset	R&D/asset	R&D/asset
SOE	0.037*** (0.00)	0.199 (0.12)	0.001 (0.75)	0.123 (0.13)
IPP1	10.133*** (0.00)		0.319* (0.06)	
SOE×IPP1	-8.121*** (0.00)		-0.908** (0.02)	
IPP2		0.099** (0.01)		0.093* (0.07)
SOE×IPP2		-0.324* (0.07)		-0.174 (0.10)
Controls	Yes	Yes	Yes	Yes
Observations	13,733	14,580	10,816	11,344
R-squared	0.162	0.131	0.286	0.129

Appendix A. Industry distribution

Code	Industry Name	SOE		Private		SOE Privatization		SOE Privatization - Completed		SOE Privatization - Failed	
		SOE	%	Private	%	SOE Privatization	%	SOE Privatization - Completed	%	SOE Privatization - Failed	%
A	Agriculture	24	0.02	20	0.02	5	0.03	2	0.05	3	0.02
B	Mining	37	0.01	5	0.04	2	0.01	0	0.00	2	0.01
C0	Food and drinks	46	0.05	41	0.04	11	0.06	4	0.10	7	0.05
C1	Textiles and apparel	38	0.06	48	0.04	13	0.07	2	0.05	11	0.07
C2	Wood and furniture	22	0.01	10	0.02	0	0.00	0	0.00	0	0.00
C3	Paper and printing	121	0.03	22	0.12	9	0.05	2	0.05	7	0.05
C4	Petrochemical and plastics	39	0.12	101	0.04	32	0.17	8	0.21	24	0.16
C5	Electronics	94	0.07	61	0.09	8	0.04	0	0.00	8	0.05
C6	Metals and minerals	172	0.09	82	0.16	12	0.06	2	0.05	10	0.07
C7	Equipment	44	0.24	209	0.04	30	0.16	5	0.13	25	0.17
C8	Pharma biotech	6	0.07	58	0.01	8	0.04	1	0.03	7	0.05
C9	Other manufacturing	58	0.02	17	0.06	0	0.00	0	0.00	0	0.00
D	Utilities	29	0.01	4	0.03	3	0.02	1	0.03	2	0.01
E	Construction	62	0.02	21	0.06	2	0.01	0	0.00	2	0.01
F	Transportation and storage	46	0.01	8	0.04	3	0.02	1	0.03	2	0.01
G	Information technology	65	0.08	66	0.06	10	0.05	2	0.05	8	0.05
H	Retail	15	0.04	32	0.01	15	0.08	0	0.00	15	0.10
I	Finance	23	0.00	1	0.02	0	0.00	0	0.00	0	0.00
J	Real estate	37	0.02	14	0.04	3	0.02	2	0.05	1	0.01
K	Social services	13	0.02	18	0.01	6	0.03	3	0.08	3	0.02
L	Media and culture	56	0.00	1	0.05	1	0.01	1	0.03	0	0.00
M	Diversified	24	0.04	39	0.02	14	0.08	3	0.08	11	0.07
Total		1071	1.00	878	1.02	187	1.00	39	1.00	148	1.00