Intellectual Property Rights Protection, Ownership, and Innovation: Evidence from China[1]

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Abstract

We study how intellectual property right (IPR) protection and ownership type affect innovation singly and jointly in China. We find that stronger local IPR protection is positively related to firms' R&D investments and innovation. Private sector firms invest more in R&D and innovate more than state-owned enterprises (SOEs), and this effect is more notable in regions with high IPR protection standards. We see the same effect in privatizations and when using instrumental variables. Our results support theoretical arguments that IPR protection strengthens firms' incentives to innovate and that private sector firms are more sensitive to IPR protection than SOEs.

Key words: Innovation; China; Intellectual Property Rights; Legal Institutions; Development

JEL Classification: O31, O34, O38

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Introduction

The influential literature on law, finance, and economic growth establishes that effective 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)). Allan, Qian, and Qian (2005), however, points out that China's experience represents a puzzle. While state-owned enterprises (SOEs) have seen relatively slow growth, as the literature would predict given the country's weak legal and financial institutions, private sector firms have nonetheless achieved staggering growth. Allen et al. posits that alternative mechanisms, such as those based on reputation and relationships, supported the performance 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 affected 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.

Our work has a threefold motivation. First, parallel to the Allen, Qian, and Qian (2005) contention that China appears to be 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 in recent years ranked among the top nations globally in terms of the level and growth of R&D expenditure and patent application and grants (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 relationship predicted by many theories to hold (Gould and Gruben (1996)). Without good IPR protection, what incentives do firms have to invest in R&D and

innovate? Where does China's innovation take place—in the state-owned firms or in the private sector? These questions are left unanswered by prior studies focusing on cross-country evidence.

Second, many papers on the relationships among 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 test whether IPR protection matters for firms' incentive to invest in R&D and to innovate.

Third, by comparing the role IPR protection plays in the innovative activities of the state versus the private sector, our paper makes a unique contribution to the political economy question of whether control rights can substitute for legal institutions. As is well-known, state-owned enterprises (SOEs), which are directly controlled and run by various administrative levels of the government, are an important part of China's economy. China's court system is also controlled by the state and has been shown to be biased towards SOEs. If the legal institutions involved in IPR protection are not well developed, one hypothesis is that SOEs in China have stronger incentives to innovate than do private sector firms because their intellectual property is less likely to be expropriated given their protected status and the biased judicial system. In other words, state ownership and control act as a substitute for 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, though they are not (or are 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 SOEs or in private sector 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?

Our empirical findings are as follows. First, since 2006—the year by which all of China's World Trade Organization (WTO) commitments, including revisions to its IPR laws and regulations, were implemented—private firms in China invested more in R&D and innovated more than SOEs. (Prior to 2006, our limited data suggest that SOEs led R&D investment and innovation.) The fast growth in private sector innovation after 2006 points to the importance of effective 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 it also establishes the importance of effective 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 lower 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: Building better institutions apparently plays an increasingly important role in fostering the growth and development of private sector firms.[2]

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 three ways:

- We use SOE privatizations as an identification instrument. SOE privatizations are typically part of broad economic reforms and are not primarily motivated by innovation. Our key conclusions are robust in this setting: Firms increase innovation after privatizations, and the increase is larger for firms in provinces with high standards of IPR protection.
- We use a difference-in-difference approach by comparing the outcomes of failed versus successful SOE privatizations (the outcome in these efforts is largely due to factors exogenous to innovation, such as union issues and shifting government policies, etc.), and find that the change occurs only in successful privatizations.
- We use provinces' exposure to Christian thought in the early 1900s (which, as we discuss below, is related to citizens' concept 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.

[2] Our conclusion is broadly consistent with and related to that from Aghion et al. (2012), which studies a comprehensive sample of medium- and large-sized firms in China and concludes that industrial policies that foster competition enhance productivity growth. Both papers indicate the importance of market-based mechanisms for China's future productivity growth.

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 in and outputs from 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 U.S. All financial data are available in WIND from 1990 to 2013, with the exception of R&D expenditures, which are available only after 2006.

Firm-level patent data are 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).[3] The Chinese patent grant procedure is similar to that in Europe and the U.S. Before the application, the applicant is encouraged to search existing patent and publication databases to ensure the novelty of the application. After undertaking its own examination, the CSIPO grants three types of patents that vary with the extent of innovation: invention, application, and design. Invention patents cover truly novel technologies, application patents cover new usages of existing technology, and design patents cover 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

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

and design patents require one round of patent officer examination that lasts from three to six months, the examination process for invention patents involves two rounds of officer examination (preliminary and detailed examinations) lasting 18 to 36 months. Statistics from 2012 indicate that the application success rates are 33.2%, 77%, and 71%, respectively, for innovation, application and design patents.[4] Data on firm-level patents are available from 1990-2013, the entire period covered by the CSIPO.

Since R&D investments and patent assets are long term in nature, following prior work, we construct capitalized measures of R&D and patents as follows:

$$K_{i,t} = (1-\theta)K_{i,t-1} + r_{i,t} \qquad (1)$$

where

- $K_{i,t}$ is the capitalized measure of the variable of interest—either R&D or patents for firm *i* in year *t*,
- θ is the rate of depreciation of the capital stock, which is set to 15% in accordance with prior work, and
- $r_{i,t}$ is the flow measures of the relevant variables, either the amount of R&D investment made by firm *i* during year *t*, or ultimately granted patents applied for by firm *i* in year *t*.

We call these capitalized measures R&D stock and patent stock, respectively. Throughout the paper we use these stock measures, except in Section III.A where we analyze changes in R&D and patenting before and after SOE privatizations. In that setting, we use flows to accurately measure the change. For robustness, we repeated all our analysis using the flow measures of R&D and patents and obtain qualitatively the same results.

[4] For more information, see the CSIPO website, http://epub.sipo.gov.cn/gjcx.jsp.

Since 2001, Chinese listed firms are required to report 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 or the Central Industrial Enterprises Administration Committee), or local governments. Otherwise, we define the company as a private enterprise (i.e., if the largest ultimate owners of these firms are either individuals—we aggregate individual investors who are family members together—or private institutional investors). For the years after 2001, we use the shareholder structure as reported in firms' annual statements to make this classification. For the years before 2001, we assume that the ultimate owner is the same as in 2001 unless a change of ownership is disclosed in an annual report, e.g., in a discussion of a privatization. On average, the state's ownership is 43.1% of firm equity in our SOE sample. The data also allow us to identify whether an SOE is majority-owned by the state or whether it is owned by the central government or provincial/local governments. In additional tests discussed below, we examine these distinctions as well.

Table 1 provides summary statistics of our firm sample. Panel A tabulates the number of private enterprises and SOEs by year. SOEs account for a high fraction of our sample, 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 stock is 1.6% of assets at the end of the year. There is considerable heterogeneity: many firms have no R&D stock (the median is only 0.001%), while the maximum is 17.5%. Firms' patenting rate, as measured by patent stock divided by assets at the end of the year, also exhibits a large variation:

The median firm has no patents, the mean is 0.061 patents per 10 million RMB in assets, and the maximum is 1.391 patents per 10 million RMB in assets.

Panel C compares SOEs and private firms on these dimensions. Clear differences emerge. SOEs are significantly larger—on average ten times the size of the private firms, when measured by total book value of assets—but they appear to be less efficient, with a lower return on assets (ROA) and a lower Tobin's Q. These patterns are not surprising and support the argument in Allen, Qian, and Qian (2005) that the private sector is more economically vibrant than the state-owned sector. The two sets of firms differ significantly in their R&D and patenting rates. On average, private firms have twice as large a normalized R&D stock as SOEs: 2.3% of assets versus 1.1% for SOEs. Private firms' patenting rates are also nearly double that of SOEs: 0.095 parents per 10 million RMB assets versus 0.042 for SOEs.[5]

In 1980, China became a member of the World Intellectual Property Organization, and it 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, in practice, provinces differ significantly in their interpretation and enforcement of the law. 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, which we call IPP1 and IPP2 (IPP for Intellectual Property Protection). IPP1 is the fraction of IP infringement cases won by the plaintiffs in the provincial and municipal courts in each year. This win rate directly measures the probability that plaintiffs (i.e., IP holders) will win

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

their cases and thus is a good proxy for the enforcement of IPR by the local authorities.[6] The provincial-level variation in win rates also fairly accurately reflects protection for local firms, because in China forum-shopping (i.e., picking a court for the case) is relatively limited. Plaintiffs can either file the case in the location of the infringement or the location of the defendant. In our sample, 80% of the cases involve plaintiffs and defendants headquartered in the same province, and the cases are universally filed in that province.

To construct this measure, we downloaded and read the written judgments in 13,117 patent infringement cases filed in 31 provinces between 1991 and 2013. These represent the entire sample of IP infringement cases adjudicated in Chinese provincial and municipal level courts in the Chinese Judicial Case Database maintained by Beijing University Law School.[7] This database is the oldest, most comprehensive and authoritative case law database in China (Wu, 2007; Beebe, 2010). Beijing University maintains the database to collect case law examples as precedents and references for future cases, with the ultimate aim of compiling them into legal textbooks and publications. While large, this database captures only about 25% of all legal cases adjudicated in China. The criterion for a case to be included is that it is deemed significant by Beijing University researchers. Since the same criterion is used to collect cases from all provinces, this sample selection procedure should not introduce any bias in our cross-sectional analysis. We classify a case as won by the plaintiff if the court ordered the defendant to cease infringement, to compensate the plaintiff for its economic loss due to the infringement, to destroy the infringing products and/or equipment, and/or to pay the legal cost of the lawsuit. The case is

[6] In the legal literature, the influential Priest-Klein (1984) hypothesis on litigation outcomes argues that since plaintiffs' decision to litigate is endogenous and takes into account the costs and benefits of litigation, the win rates in all courts, regardless of pro-plaintiff or pro-defendant orientation, should converge to 50%. In our sample, the overall plaintiff win rate is 69%. We believe at the current stage the win rate in China is higher than the long-run equilibrium of 50% hypothesized by Priest-Klein because of the relative lack of familiarity with litigating intellectual property in China during this period, leading to incomplete information. Thus, win rates should be far more meaningful than they would be in the steady state.

[7] http://www.pkulaw.cn/case.

classified as won by the defendant if the court dismissed the lawsuit of the plaintiff without such a ruling. For a given province-year, we calculate the plaintiff win rate as the number of cases won by the plaintiff divided by the sum of cases won by the plaintiff and the defendant. Cases that are settled are not included in calculating this ratio.

The second measure, IPP2, is the frequency in each year with which the provincial governments advocate IPR protection in their official publications, which reflects the local governments' attitude towards IPR. In China, the media is state controlled. While the central Chinese Communist Party (CCP) has the ultimate control over all newspapers, each provincial government controls the local media and publishes the main newspapers in its province. Each province has three types of newspapers. One is the "Daily," which is directly owned by the provincial CCP committee. Its management and editorial policies are 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[8] and Henan Province. Another is the "Evening" publication, which is owned by a CCP committee but enjoys substantially more editorial autonomy than the "Daily" Finally other subsidiary newspapers are owned by the previous two types, which also enjoy more autonomy.[9] In a nutshell, one can identify the official local government publications simply from the names of the publication.

We 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

[8] Beijing is a city that is directly controlled by the central CCP, and enjoys an administrative level that is equivalent to a province. Four cities have such a status: Beijing, Shanghai, Tianjin, and Chongqing.

[9] See Qin, Stromberg, and Wu (2014) and references therein for a more detailed discussion of the organization of the media industry in China. They document, for instance, that "Evening" and subsidiary newspapers contain significantly more entertainment content than do the "Daily" publications.

shape readers' views. We then divide this article count by the number of total articles published in that year to get our IPP2 measure.

Figure 1 plots the evolution of the two IPP measures over time. We divide the whole sample of 31 provinces into terciles based on each IPP measure at the beginning of the sample and trace the group mean over time. The graph shows that both IPP measures exhibit persistent cross-sectional differences among provinces.

Table 2 presents summary statistics of the two IPP measures and other provincial level statistics such as GDP growth and the urbanization rate. IPP1 has a mean of 0.69, indicating that the overall average probability for plaintiffs to win slightly exceeds two-thirds. The mean of IPP2 is 0.007, which means that, on average, out of every 1,000 articles published by provincial governments, seven are about IPR protection. Again, there is a significant amount of heterogeneity, as the highest observation is 0.023, three times the mean. Panel B shows that although constructed from entirely different sources, the two IPP measures have a significant positive correlation.

One concern is that the IPR enforcement measures might be correlated with other provincial-level characteristics, for example GDP growth, university density (a proxy for education level), and government expenditures on R&D subsidies.[10] We obtain these provincial level statistics from Annual Statistical Yearbooks published by the National Bureau of Statistics of China.[11] For each province, we also obtain information on the historical presence of Christian colleges and British Settlements from historical documents (e.g., Stauffer, Wong, and Tewksbury (1922), and Yang and Ye (1993)). These measures may proxy for differences in the concept of

[10] In China, the government routinely subsidized firms' R&D funding, especially that of SOEs. It is thus of interest to see if the IPP measures are related to this variable and if their effects on innovation are robust to controlling for this variable.

[11] http://www.stats.gov.cn/english/statisticaldata/AnnualData/

property rights among provincial residents. Panel B of Table 2 reports the correlation coefficients between the IPP measures and these provincial-level statistics. Neither IPP measures are significantly correlated with GDP growth and government R&D subsidies. They are, however, correlated with university density and the historical presence of Christian colleges and British settlements. In the analyses below, we control for provincial-level variables and use Christian college and British settlements as instrument variables for intellectual property protection.

II. Empirical Results

A. Firm types and innovation

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 3 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 types of firms. Between 2006 and 2013, R&D stock/assets increased twentyfold, from 0.2% to 4.1%, for private sector firms, and they increased from 0.1% to 2.6% for SOEs. In fact, in each year of the sample, private firms consistently have roughly twice as much R&D stock (relative to assets) as SOEs, with the difference being highly significant. Notably, China's pace of growth in R&D investment is much faster than its own remarkable GDP growth rate, which roughly doubled over the same period.

Panel B of Table 3 examines patent stock and shows that before 2004, SOEs generally had a greater normalized patent stock (though the annual differences are not significant). After 2004, private firms held a larger patent stock, and this difference was consistently significant

after 2006. The gap between the two sets of firms also increased steadily: In 2006, private firms' size-adjusted patent stock was 38% higher than SOEs (0.068/0.049-1); in 2013, the gap reached 94% (0.163/0.084-1). The results in Table 3 are visually presented in Figure 2.

It is not surprising that private sector firms began to show a significant lead in R&D and patenting beginning in 2006, a pivotal year in which the country agreed to follow the conventions set out by the WTO and fully implemented the revisions of its IPR legal framework, thus significantly strengthening its IPR protection.

B. IPR protection and innovation

Next we examine the relationship between IPR protection and innovation in the cross-section of China's provinces. For each year, we divide China's provinces into two groups based on their (one-year lagged) IPP1 and IPP2 measures and compare the rates of R&D investment (Table 4) and patenting (Table 5) among provinces with high and low IPP measures. The two panels in each table correspond to the results from sorting on our two IPP measures.

Table 4 shows that, within China, IPR protection is highly positively related to R&D investments. Either sorting leads to the same conclusion: firms in high IPR protection provinces have a 20%-40% larger normalized R&D stock than do firms in low IPR protection provinces. For instance, in 2013, the R&D stock for firms in high (low) IPP2 provinces is 3.7% (2.6%) of assets: the difference is highly significant and represents a 42% gap (3.7%/2.6%-1).

Table 5 repeats the exercise for normalized patent stock. Again we see that IPR protection is positively correlated with patenting, especially after 2006. Using IPP1 (Panel A), we find that firms in high IPR provinces have a 50% larger normalized patent stock than firms in low IPR provinces. For instance, in 2013, the patent stock of firms in high (low) IPP1 provinces

was 0.152 (0.097) patents per 10 million RMB in assets, a gap not only statistically significant but also economically large ((0.152-0.097)/0.097=56%). Results in Panel B, using IPP2, are qualitatively similar.

Overall the results in this section show that *within* China, there is a positive relation between local IPR protection and innovation, a pattern that Figure 3 also demonstrates. This result is consistent with theoretical predictions of the benefits of IPR protection and institutional quality in general, but it contrasts with earlier cross-country studies that often conclude that there is a "China puzzle," in that China appears to be an outlier, with low overall IPR protection but high R&D and patenting rates. Focusing on differences within China allows us a clearer identification of the IPR-innovation relation.

C. The joint impact of ownership and IPR protection on innovation

Having examined the relation between IPR protection and innovation, in this section we focus on the impact of state ownership. We hypothesize that, since SOEs enjoy explicit state backing and are less likely to have their innovations expropriated, their innovation rates are less sensitive to IPR protection than those of private firms.

To investigate this hypothesis, we start by double-sorting our sample firms by ownership type and local IPR protection. We then compute the difference in innovative activities between SOEs and private firms and compare this difference across regions with different IPR enforcement standards.

Table 6 presents the results and reveals a few clear patterns. First, as seen above, private sector firms are more innovative than SOEs. They have larger normalized R&D and patent stocks. This is true regardless of the sorting variable used.

Second, while IPR protection is strongly related to R&D investments and patents for private firms, its effect on SOEs is weaker. For instance, focusing on R&D (Panel A), private firms in high IPP regions have 40% to 100% larger R&D stocks than private firms in low IPP regions (2.6% versus 1.8% using IPP 1; 2.6% versus 1.2% using IPP2). But the R&D stocks of SOEs are virtually the same in high or low IPP regions (1.2% in high IPP regions compared to 1.1% in low IPP regions using both IPP measures). Private firms' innovation expenditures are much more sensitive to IPR protection than SOEs. The same qualitative conclusion can be drawn about patents (Panel B).

Table 7 confirms the above conclusion in multivariate analysis. Specifically, we estimate the following panel regression:

$$Innovation_{i,t} = a + b_1 SOE_{i,t} + b_2 IPP_{i,t-1} + b_3 SOE_{i,t} \times IPP_{i,t-1} + Controls_{i,t-1} + \varepsilon_{it} \qquad (2)$$

where $Innovation_{i,t}$ is the innovation measure—either normalized R&D or patent stock—for firm *i* in year *t*, SOE is an indicator variable of whether firm *i* is an SOE in year *t*, IPP is the lagged IPR protection measure for the province in which firm *i* is located in year *t*-1, and SOE$\times$ IPP is the interaction term between the two. Control variables include firm level characteristics measured at the previous year-end: size (log of assets), intangibles (as a fraction of total assets), ROA, leverage, age, and Tobin's Q. Province-level controls include GDP growth, university density, and government R&D subsidies. (The Chinese government routinely subsidizes R&D efforts in local firms, a legacy of the centrally planned economy; hence, we control for government spending on R&D by including this last variable.) All regressions include industry fixed effects; models (2)-(6) also include province fixed effects. Recognizing that there might be

a strong serial correlation in R&D stock and patent stock, Model (6) also controls for the lagged dependent variable. All standard errors are clustered by province.[12]

The results reported in Table 7 show that the SOE indicator alone is not a strong predictor of R&D stock (Panel A), but it is somewhat positively related to patent stock (Panel B). Consistent with the notion that IPR protection is positive for innovative expenditures, both IPP variables are generally positive and mostly significant, especially for patents (Panel B). Consistent with the notion that SOEs are less sensitive to IPR protection, we find that the interaction terms between SOE and the IPP measures are significantly negative in almost all regressions.

These results have interesting implications. The positive association between state ownership and patent stock in Panel B suggests that in China, state ownership may act as a substitute for weak IPR protection; state-owned firms have stronger incentives to innovate and obtain patents as they are less likely to have their innovations and patents expropriated. The significant positive relationship between IPR measures and patenting implies that, within China, effective institutions do matter for firms' innovation. The consistent and strong coefficient on the interaction term between state ownership and IPR measures indicates that effective institutions matter more for private sector firms than for state-owned firms.

To investigate the joint impact of IPR protection and ownership on innovation further, we examine the strength of the above results for sub-categories of patents. As discussed in Section I, the CSIPO classifies all patents into one of three categories with decreasing levels of innovative content: invention, application, and design. If IPRs and their interaction with state ownership indeed have the above-documented effect on innovation, we should find that the results are stronger for innovation patents and weaker for design patents. Table 8 reports these results,

[12] In unreported analysis we cluster errors by firms and obtain similar results.

which generally supports the conjecture that the effect is stronger in innovation patents. The coefficients on the IPP variables are smaller in magnitude and weaker in significance for the design patent stock than that of inventions patent. IPP variables' interaction terms with the SOE indicator are also weaker. (Unreported Chi-tests of coefficient equality indicates that the coefficients are significantly different across equations at the 1% confidence level.)

In sum, results in this section show that within China, IPR protection is positively related with R&D and patent stocks. Furthermore, private firms' abilities to innovate are more sensitive to IPR protection than SOEs'. These effects are stronger for invention patents than for design patents that have less innovative content.

III. Additional Analyses

The evidence presented so far shows strong correlations, but not causal relationships, between IPR protection and innovation. In this section, we undertake three additional analyses that help us draw a causal inference. First we use a difference-in-difference approach by studying changes in innovation around SOE privatizations. Second, we look at the quality of issued patents for the various firms. Finally, we estimate instrumental variable (IV) regressions.

A. Evidence from SOE privatizations

Large-scale SOE privatizations began in the mid-1990s in China as 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 goal of the privatization program was to corporatize previously state-owned firms and to provide managers with profit- and market-driven incentives. 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.)

Thus, for the purpose of analyzing innovation, SOE privatizations provide a largely exogenous change to the ownership structure, which allows us to make a causal inference about the relation between ownership type and innovation. If ownership type affects firms' incentives to innovate, then the before-and-after change in innovation as a result of SOE privatizations should be a clean indication of that effect. In addition, if private firms are more sensitive to IPR protection, then the before-and-after change in innovation should be larger for privatizations that occurred in provinces with high IPR protection measures.

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 investor). We are able to identify 188 privatization attempts in our sample (roughly one-third of the firms that were ever an SOE in our sample). Out of these privatization attempts, 149 firms were successfully privatized and 39 attempts failed. If private ownership (causally) led to higher innovation, we should see that R&D investment and patenting rates went up in the years after privatization. If IPR enforcement causally affects firms' incentives to innovate, we should see that the before-and-after changes are larger in regions with high IPR enforcement. Finally, these results should be concentrated in the successful privatizations and be absent from the failed privatization attempts.

Table 9 reports the results comparing R&D investments (Panel A) and patenting (Panel B) before and after SOE privatizations.[13] The organization of this table is similar to that of Table 6; however, while Table 6 is a cross-sectional double sorting by ownership and IPP, here we examine ownership changes within the *same* firms.

Consistent with the notion that IPR protection had a causal effect on innovation, Table 9 shows that while the privatizations in high IPP regions experience higher R&D investments and patent grants after privatization, this effect is not always present for privatizations that took place in low IPP regions. Furthermore, there is no consistent innovation gain in failed privatizations.

In Table 10, we further analyze SOE privatizations using regression analyses. Consistent with Table 9, we find strong evidence supporting our predictions.[14] R&D investments (Panel A) and patenting rates (Panel B) both increase significantly in the three years after privatization in regions with high IPP measures. While the direction of change is positive in regions with low IPP measures, the coefficients are much smaller and not statistically significant. None of these effects are seen in failed privatizations (models (5)-(8)).

Since both the original motivation for privatizations and the factors influencing the success and failure of privatizations were largely exogenous and unrelated to innovation, the results in this section strongly support the notion that private ownership creates more incentives to innovate, but the effect is only strong in regions with high IPR protection.

B. Patent Quality

[13] In order to identify clearly the before-and-after change, the analysis in this section uses annual flow measures of R&D investments and patents, rather than the stock measures used in previous sections.

[14] In this analysis, since we are looking at before-and-after differences in R&D and patenting, it is important to remove the serial dependence in the variables. Thus the dependent variable in this table is not the stock measure of R&D and patents, but annual flow measures. In other words we examine whether yearly R&D spending and patents obtained go up in years after privatization.

One concern is that the results may be distorted due to low patent quality. The previous analysis looked only at patent stocks and did not capture the quality of the awards. If private firms are increasingly filing for lower-quality awards, their increase in patenting may not reflect a true boost in innovation. To address this concern, we collected, for the 331 firms in our sample with the most Chinese patents, their global patent application and citation data. Of these 331 firms, 162 are SOEs (49%), 169 (51%) are private enterprises. (We look at data across multiple patent offices, rather than just using the U.S. filings, because a relatively modest share of Chinese firms' patents has been filed in the U.S. To analyze these, we use data from Patent Sight GmbH, which has compiled a rich array of information on global patent families.) These data allow us to compare patent quality across firm types and over time. Firms are classified as SOEs or private firms based on their status in the year of publication of the patent (which typically occurs 18 months after filing). We concentrate on a number of key measures:

- Citations per patent family is the number of citations received worldwide per patent family owned by each firm as of year-end 2014. This is akin to the typical measure of importance as explored in Jaffe and Trajtenberg (2003) and many subsequent works.
- IPC groups per patent is the mean number of IPC groups that each patent family has been assigned to (a proxy for patent scope, as in Lerner, 1994).
- Patents active in the U.S., Japanese, and European Patent Offices are the fraction of a firm's patent families awarded through that date that are pending and/or are granted in the respective patent offices as of year-end 2014. Patent active in WIPO is the share of the firm's patents active under the Patent Cooperation Treaty as of year-end

2014.[15] Again, the extent of patent families has been used as a proxy for patent importance by Lanjouw et al. (1998) and many subsequent authors.

We examine these patterns using all patents (in Panel A), those published between the beginning of 1990 and the end of 2005 (Panel B), and those published between 2006 and 2014 (Panel C). We use 2006 as a division since our earlier evidence shows that 2006 was a critical transition year.

Table 11 shows the results. When we examine the overall sample, we see that private firms' patents, far from being of lower quality, actually have significantly more citations and fall into more four-digit IPC groups (a proxy for broader scope). Moreover, they are significantly more likely to be still active in the U.S. and at the WIPO. The results regarding citations and patents active in the U.S. are statistically significant in both time periods examined; the remaining results are only present in the 2006-2014 period. (The result regarding the greater tendency of SOE patents in the later period to be active in Japan is harder to explain.) In short, the results are inconsistent with the notion that the growth of private firm patenting is due to a proliferation of low-quality awards: if anything, the opposite pattern is at work.

C. IV Regressions

In this section, we use instrumental variable regressions to provide a further check on the robustness of our results and to provide support for the view that IPR and ownership type jointly have causal effects on firms' innovative activities. In our baseline panel regression, we regress innovative activities (R&D and patent stock) on IPR protection proxies. But if the IPR protection

[15] The World Intellectual Property Organization (WIPO) administers the Patent Cooperation Treaty, which provides a streamlined way for firms to apply for patent protection in multiple patent offices. Applicants need not use the WIPO and can file directly with the national patent offices, but going through WIPO provides a number of advantages,

in a province is endogenous to the innovative activities of the firms in that province (for example, stronger IPR protection may be driven by greater 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 missionaries in a province by 1920 (Stauffer, Wong, and Tewksbury, 1922). Educational institutions were important in instilling Western values among the Chinese people. Colleges sponsored by Christian churches helped instill such Christian values as the respect for private property, e.g., as manifested in the Ten Commandments.[16] The second instrument is British settlement, an indicator variable that equals one if a province had a 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.[17]

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)).

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

[17] 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 (Yang and Ye, 1993).

Table 12 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 our IVs are strong instruments for IPR protection. The second-stage results show that IPR protection positively affects R&D and patent stock, 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 of 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 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 results contribute to the literature in two ways. First, these results unravel to a large degree the "China puzzle," that is, the perception that China is an outlier in the law-growth framework by virtue of having weak intellectual property right protections but rapid growth in innovations and patents. We find that, after taking account of the facts that such protections vary from province to province and that private sector firms respond differently from SOEs, things work more according to the standard theoretical view: IPR protection does matter for firms'

incentives to engage in innovative activities. Second, we show that in the presence of weak institutions, private firms are more sensitive to IPR protection in their innovative efforts than state owned firms. This may be because when the legal framework is state-controlled, state-owned firms are less likely to have their property 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. 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. For example, in the country's current, 12th Five-Year Plan, which lays out China's development goals, innovation and R&D play a central role.[18] As argued by Mokyr (1990) and many others, the systematic application of technological developments laid the foundation for the evolution of the U.S. from a colonial backwater to a pre-eminent world power. But as the country develops and increasingly depends on innovation and the private sector to drive its growth, our results suggest that the strengthening of those institutions that protect intellectual property will become increasingly critical.

[18] 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, neat the 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.

References

Aghion, P., Dewatripont, M., Du, L., Harrison, A., Legros, P., 2012, Industrial policy and competition, *American Economic Journal: Macroeconomics* forthcoming.

Allen, F., Qian, J., Qian, M., 2005, Law, finance, and economic growth in China, *Journal of Financial Economics* 77, 57-116.

Ang, J., Cheng, Y., Wu, C., 2014, Does enforcement of intellectual property rights matter in China? Evidence from financing and investment choices in the high tech industry, *Review of Economics and Statistics* 96, 332-348.

Beebe, B., 2010, Intellectual property law and the sumptuary code, *Harvard Law Review* 123, 810-889.

Gan, J., 2009. Privatization in China: Experiences and Lessons, *China's Emerging Financial Markets: Challenges and Opportunities* (J. Barth, J. Tatom, and G. Yago, 2008 eds.), The Milken Institute Series on Financial Innovation and Economic Growth.

Gan, J., Guo, Y., Xu, C., 2008, A nationwide survey of privatized firms in China, Unpublished working paper.

Gould, D., Gruben, W., 1996. The role of intellectual property rights in economic growth. *Journal of Development Economics* 48, 323-350.

Jaffe, A., Lerner, J., 2004, *Innovation and its discontents*, Princeton: Princeton University Press.

Jaffe, A., Trajtenberg, M., 2005. *Patents, Citations, and Innovations: A Window on the Knowledge Economy*, Cambridge, MIT Press.

King, R., Levine, R., 1993. Finance and growth: Schumpeter might be right. *Quarterly Journal of Economics* 108, 717–738.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., Vishny, R., 1998. Law and finance. *Journal of Political Economy* 106, 1113–1155.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., 1999. Corporate ownership around the world. *Journal of Finance* 54, 471–517.

Lanjouw, J., Pakes, A., Putnam, J., 1998, How to Count Patents and Value Intellectual Property: The Uses of Patent Renewal and Application Data, *Journal of Industrial Economics* 46, 405–432.

Lerner, J., 1994, The Importance of Patent Scope: An Empirical Analysis, *The RAND Journal of Economics* 25 (2), 319—333.

Levine, R., Zervos, S., 1998. Stock market, banks, and economic growth. *American Economic Review* 88, 537–558.

Mokyr, J., 1990, *The Lever of Riches: Technological Creativity and Economic Progress*, New York, Oxford University Press.

Priest, G., and Klein, B., 1984. The selection of disputes for litigation. *Journal of Legal Studies* 13, 1-55.

Qin, B., Stromberg, D., Wu, Y., 2014. The determinants of media bias in China. Unpublished working paper.

Rajan, R., Zingales, L., 1998. Financial dependence and growth. *American Economic Review* 88, 559–586.

Snyder, N. D., 2012. Putting numbers to feelings: Intellectual property rights enforcement by Chinese courts—Evidence from Zhejiang trademark infringements 2004-2009. *Northwestern Journal of Technology and Intellectual Property* 10, 349-376.

Stauffer, M. T., Wong, C. T., and Tewksbury, M. G. (editors), 1922, *The Christian Occupation of China: A General Survey of the Numerical Strength and Geographical Distribution of the Christian Forces in China*, Shanghai, China Continuation Committee Press.

U.S. National Science Foundation, 2014, *Science and Engineering Indicators—2014*, Washington: Government Printing Office.

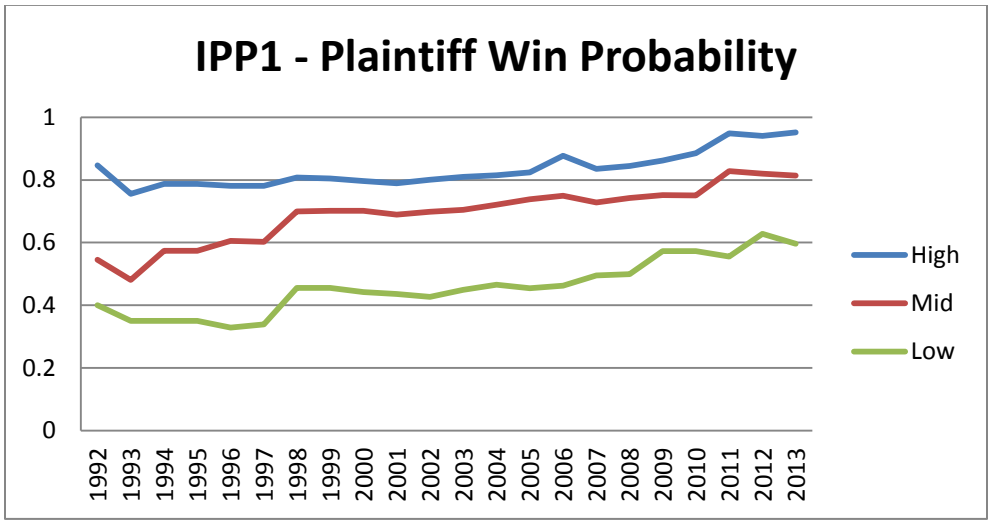
Wang, Q., Wong, T. J., Xia, L., 2008, State ownership, the institutional environment, and auditor choice: Evidence from China, *Journal of Accounting and Economics* 46, 112-134.

Wu, M., 2007, Piercing China's corporate veil: open questions from the new company law, *The Yale Law Review* 117, 329-338

Yang, Z., and Ye, F., 1993, *Studies on Semi-colonization of Qing Dynasty*, Beijing, Higher Education Press, 1993.

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 31 provinces in our sample into three groups based on the values of each IPP measure. The plot shows the group means over time.



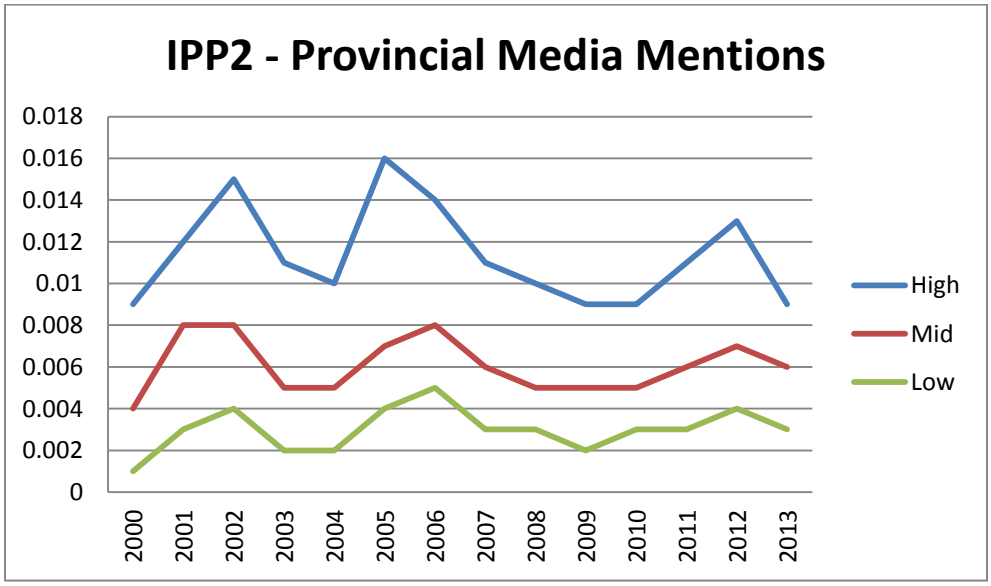
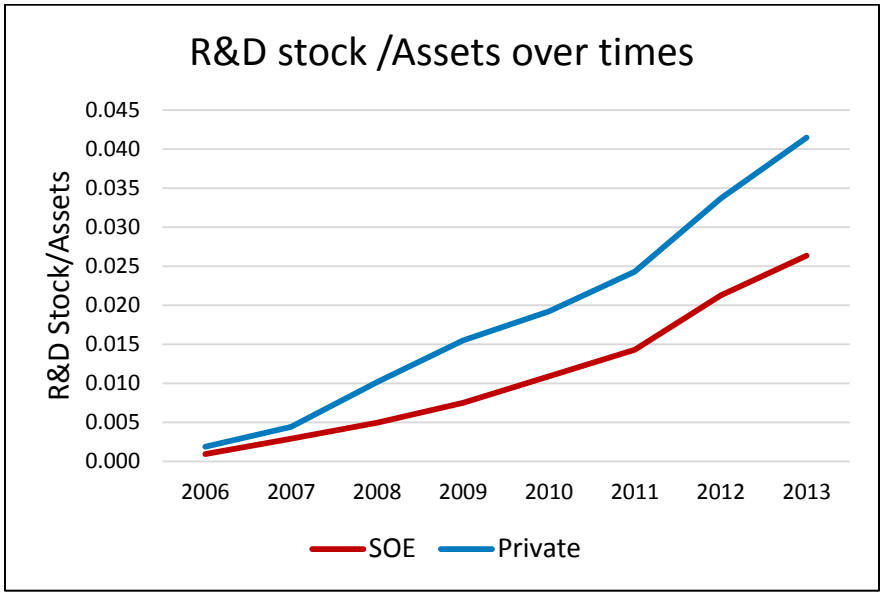


Figure 2. R&D and Patenting Rates Over Time

This figure plots the R&D investment (R&D stock/assets) and patenting rate (patent stock/assets) over time for privately owned firms and state-owned enterprises (SOEs). R&D stock and patent stock are calculated as Equation (1). Private-owned enterprises and state-owned enterprises (SOEs) are classified using the ultimate largest shareholder disclosed in firms' annual reports.



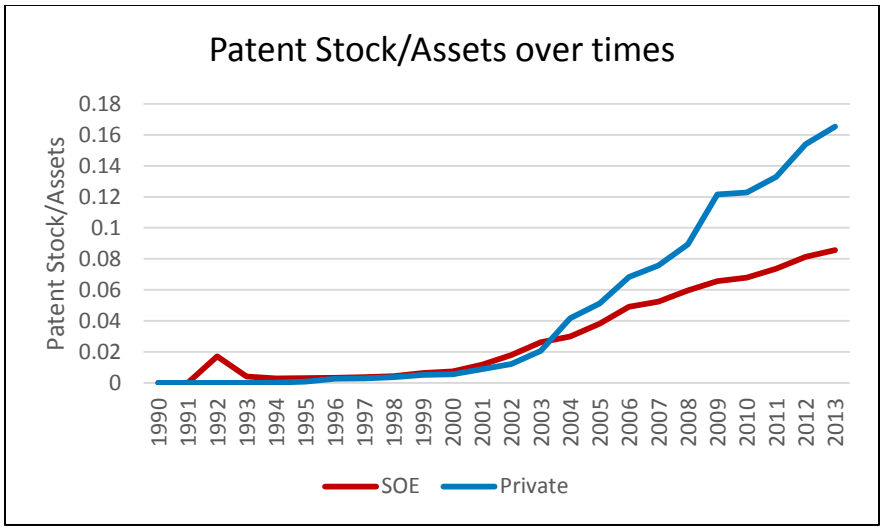
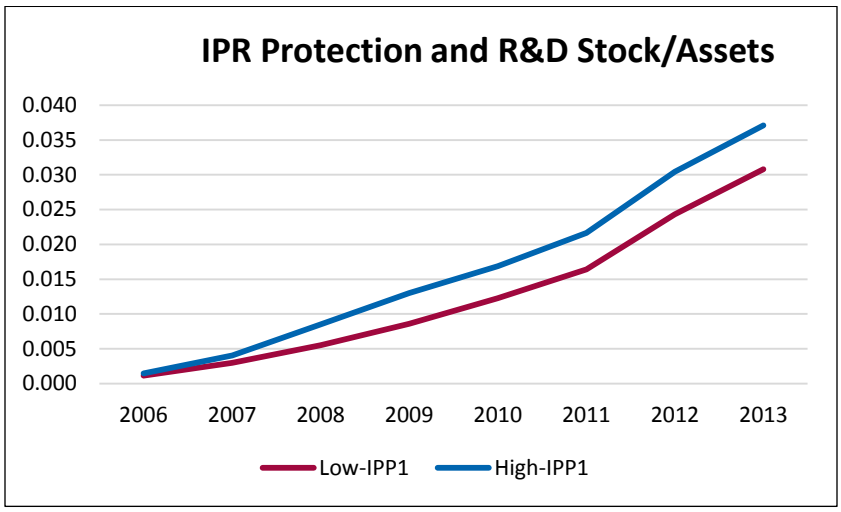


Figure 3. IPR Protection and Innovation

This figure plots the R&D investment (R&D stock /assets) and patenting rate (patents stock/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.



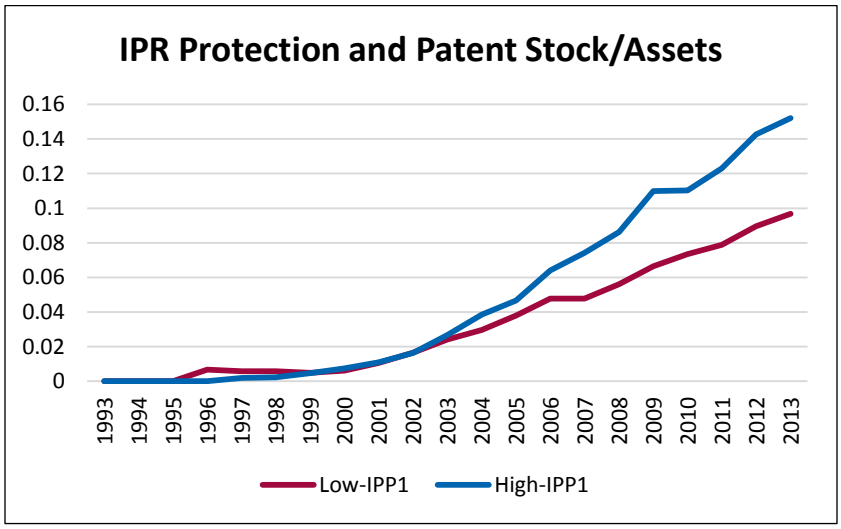


Table 1. Summary Statistics

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 stock/assets is firms' capitalized R&D investments divided by total assets at the end of the year. Patent stock/assets is firms' capitalized patent stock divided by total assets at the end of the year. R&D stock and Patent stock are calculated as Equation (1). Intangible is intangible assets divided by total assets, measured at the end of the year. Log(asset) is the natural logarithm of total assets. Total Assets is the amount of total assets in billion RMB. 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.

Panel A: Firms

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 stock/assets	0.016	0.029	0	0.001	0.175	12863
Patent stock/assets	0.061	0.169	0	0	1.391	22112
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 stock/assets	0.023	0.011	0.016***
Patent stock/assets	0.095	0.042	0.053***
Total assets	2.58	29.60	-27.02***
Intangible	0.047	0.040	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. Gov't subsidy/GDP is the amount increase in government R&D subsidy divided by provincial GDP. University density is the number of 4-year universities per 10,000 population in the province. 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.

Panel A: Province-year statistics

	Mean	SD	Min.	Median	Max
IPP1	0.69	0.192	0	0.738	1
IPP2	0.007	0.004	0	0.006	0.023
GDP growth	0.167	0.077	0.006	0.157	0.534
Gov't subsidy/GDP	0.001	0.001	-0.001	0.001	0.006
University density	0.015	0.01	0.005	0.013	0.062
Christian college	0.645	0.915	0	0	3
British settlement	0.258	0.445	0	0	1

Panel B: Correlation with other provincial statistics

	IPP1	IPP2	GDP growth	Gov't subsidiary/GDP	University density	Christian college	British settlement
IPP1	1						
IPP2	0.231***	1					
GDP growth	-0.014	-0.072	1				
Gov't subsidy/GDP	-0.055	0.009	-0.008	1			
University density	0.138***	0.164***	0.085**	0.403***	1		
Christian college	0.150***	0.354***	0.024	0.071*	0.243***	1	
British settlement	0.172***	0.341***	0.039	-0.071*	0.112***	0.478***	1

Table 3. R&D and Patenting, by Ownership Type

This table compares R&D investment rates (R&D stock/assets) and patenting rates (Patent stock/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 stock and patent stock are calculated as in Equation (1). Both are scaled by assets as the end of each year. *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: R&D stock/Assets

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***

Panel B: Patent stock /Assets

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 4. IPR Protection and R&D Investments

This table compares the rate of R&D investment (R&D stock/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. R&D stock is calculated as in Equation (1). *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Sorting by IPP1

Year	Low-IPP1	High-IPP1	Diff.(High-Low)	t-stat.
2006	0.001	0.001	0.0003	1.02
2007	0.003	0.004	0.001	1.58
2008	0.005	0.008	0.003	3.11***
2009	0.009	0.013	0.004	3.67***
2010	0.012	0.017	0.005	3.67***
2011	0.016	0.022	0.005	3.78***
2012	0.024	0.030	0.006	3.75***
2013	0.031	0.037	0.006	3.42***

Panel B: Sorting by IPP2

Year	Low-IPP1	High-IPP1	Diff.(High-Low)	t-stat.
2006	0.001	0.002	0.001	1.87*
2007	0.002	0.004	0.002	2.23**
2008	0.004	0.008	0.004	3.52***
2009	0.006	0.013	0.006	4.40***
2010	0.011	0.016	0.006	3.90***
2011	0.014	0.021	0.007	4.38***
2012	0.020	0.030	0.010	5.16***
2013	0.026	0.037	0.011	5.03***

Table 5. IPR Protection and Patenting

This table compares size-adjusted patent stock (Patent stock/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. Patent stock is calculated as in Equation (1). *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Sorting by IPP1				
Year	**Low-IPP1**	**High-IPP1**	**Diff.(High-Low)**	**t-stat.**
1996	0.007	0	-0.007	-1.02
1997	0.006	0.002	-0.004	-0.87
1998	0.006	0.002	-0.004	-0.9
1999	0.005	0.005	-0.0002	-0.06
2000	0.006	0.007	0.001	0.56
2001	0.011	0.011	0	-0.38
2002	0.016	0.016	0.0005	0.005
2003	0.024	0.027	0.003	0.5
2004	0.03	0.038	0.009	1.33
2005	0.038	0.047	0.009	1.19
2006	0.048	0.064	0.016	1.76*
2007	0.048	0.074	0.026	2.79***
2008	0.056	0.086	0.03	3.07**
2009	0.066	0.11	0.043	4.05***
2010	0.073	0.11	0.037	3.64***
2011	0.079	0.123	0.044	4.41***
2012	0.09	0.143	0.053	4.99***
2013	0.097	0.152	0.055	4.99***
Panel B: Sorting by IPP2				
Year	**Low-IPP2**	**High-IPP2**	**Diff.(High-Low)**	**t-stat.**
2000	0.003	0.003	0.001	0.53
2001	0.005	0.005	-0.0005	-0.02
2002	0.005	0.011	0.005	1.04
2003	0.008	0.015	0.008	1.85*
2004	0.007	0.018	0.01	2.88***
2005	0.005	0.02	0.014	3.75***
2006	0.008	0.025	0.017	4.06***
2007	0.008	0.027	0.019	4.32***
2008	0.011	0.027	0.017	4.66***
2009	0.019	0.037	0.018	4.17***
2010	0.023	0.041	0.018	4.00***
2011	0.028	0.044	0.016	4.00***
2012	0.027	0.047	0.02	4.43***
2013	0.026	0.04	0.015	4.36***

Table 6. The Joint Impact of Ownership Type and IPR Enforcement on Innovation: Difference-in-Difference Approach

This table reports firms' innovative activities double sorted by ownership type and IPR protection. Panel A compares R&D investments (R&D stock/assets) of state-owned enterprises (SOE) and privately owned firms. Panel B compares patents (Patent stock/assets) of state-owned enterprises (SOE) and privately owned firms. R&D stock and patent stock are calculated as in Equation (1). 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.

Panel A: R&D stock/assets

	Sorting by IPP1				Sorting by IPP2			
	Private	SOE	Private - SOE	t-stat	Private	SOE	Private - SOE	t-stat
High IPP	0.026	0.012	0.014	18.93***	0.026	0.012	0.014	12.14***
Low IPP	0.018	0.011	0.007	9.36***	0.012	0.011	0.001	1.79*
High - Low	0.008	0.001	0.007	6.30***	0.014	0.001	0.013	9.99***
t-stat	7.85***	0.91			21.32***	1.89*		

Panel B: Patent stock/assets

	Sorting by IPP1				Sorting by IPP2			
	Private	SOE	Private - SOE	t-stat	Private	SOE	Private - SOE	t-stat
High IPP	0.131	0.053	0.078	18.78***	0.122	0.053	0.069	19.59***
Low IPP	0.067	0.044	0.023	7.22***	0.047	0.036	0.011	3.07***
High - Low	0.064	0.009	0.055	10.40***	0.075	0.017	0.058	9.25***
t-stat	12.44***	3.59***			11.80***	5.81***		

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

This table reports regression results of the determinants of firm level R&D investments and patents. The dependent variable is R&D stock/Assets in Panel A and Patent stock/Assets in Panel B. R&D stock and patent stock are calculated as in Equation (1). 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. Lag R&D stock/Asset is the last year's R&D stock/asset. Lag patent stock/Asset is the last year's patent stock/asset. 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. Gov't subsidy is the increase in the amount of government subsidy divided by provincial GDP. University density is the number of four-year universities per 10,000 population. GDP growth rate is the rate of increase of provincial level nominal GDP. Standard errors are clustered by province. P-values are in parenthesis. *, **, *** indicates statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Dependent var = R&D stock/assets						
	(1)	(2)	(3)	(4)	(5)	(6)
SOE	-0.003	-0.001	-0.003	-0.001	-0.002	-0.0003
	(0.24)	(0.77)	(0.26)	(0.89)	(0.24)	(0.54)
IPP1	0.023***		0.017***		0.002	
	0.00		0.00		(0.51)	
SOE×IPP1	-0.007**		-0.005*		0.0004	
	(0.02)		(0.09)		(0.83)	
IPP2		0.472		0.301		0.127
		(0.33)		(0.66)		(0.17)
SOE×IPP2		-0.714*		-0.611*		-0.122**
		(0.06)		(0.08)		(0.01)
Lag R&D stock/assets					1.062***	1.057***
					0.00	0.00
Log(asset)	0.002***	0.002***	0.001***	0.002**	0.0002	0.0002*
	0.00	0.00	0.00	(0.01)	(0.12)	(0.08)
Intangible	-0.006*	-0.005	-0.008**	-0.008	-0.004***	-0.004***
	(0.07)	(0.29)	(0.01)	(0.16)	(0.00)	(0.00)
ROA	0.031***	0.031***	0.029***	0.028***	0.005***	0.005***
	0.00	0.00	0.00	0.00	(0.01)	(0.01)
Leverage	-0.011***	-0.012***	-0.011***	-0.011***	-0.002***	-0.002***
	0.00	0.00	0.00	0.00	0.00	0.00
Age	-0.002***	-0.002	-0.002***	-0.002	-0.001***	-0.001***
	(0.01)	(0.17)	(0.00)	(0.37)	(0.00)	(0.00)
Tobin’s q	0.001***	0.001***	0.001***	0.001**	-0.0001	-0.0001
	0.00	(0.01)	0.00	(0.02)	(0.13)	(0.30)
Gov't subsidy	0.425	0.114	0.641	0.403	0.299	0.255
	(0.30)	(0.82)	(0.17)	(0.39)	(0.57)	(0.58)
University density	0.166***	0.146**	1.621***	1.593	0.232	0.222
	0.00	(0.04)	0.00	(0.22)	(0.22)	(0.27)
GDP growth	-0.075***	-0.072***	-0.078***	-0.072***	-0.001	-0.001
	0.00	0.00	0.00	0.00	(0.60)	(0.61)
Constant	-0.027***	-0.018	-0.036***	-0.029	-0.003	-0.002
	0.00	(0.20)	0.00	(0.16)	(0.54)	(0.67)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	No	No	Yes	Yes	Yes	Yes
Observations	11,344	10,816	11,344	10,816	10,252	9,760
R-squared	0.282	0.282	0.3	0.304	0.893	0.895

Panel B: Dependent var = Patent stock/assets						
	(1)	(2)	(3)	(4)	(5)	(6)
SOE	0.043**	0.005	0.041***	0.01	0.002	-0.003
	(0.03)	(0.74)	(0.00)	(0.41)	(0.59)	(0.35)
IPP1	0.170***		0.090***		0.015*	
	0.00		(0.00)		(0.07)	
SOE×IPP1	-0.109***		-0.085***		-0.011*	
	0.00		(0.00)		(0.08)	
IPP2		6.851***		3.423**		0.443
		(0.00)		(0.01)		(0.16)
SOE×IPP2		-4.669**		-3.616**		-0.324
		(0.03)		(0.04)		(0.21)
Lag patent stock/assets					0.984***	0.978***
					0.00	0.00
Log(asset)	-0.004	-0.002	-0.008*	-0.006	-0.001	-0.001
	(0.32)	(0.58)	(0.06)	(0.12)	(0.34)	(0.52)
Intangible	0.035	0.013	0.027	0.007	0.019	0.013
	(0.37)	(0.68)	(0.44)	(0.82)	(0.15)	(0.30)
ROA	0.077***	0.063**	0.057**	0.042	-0.002	-0.003
	(0.01)	(0.03)	(0.04)	(0.13)	(0.88)	(0.85)
Leverage	-0.032***	-0.033***	-0.030***	-0.029***	-0.007**	-0.008**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.04)	(0.03)
Age	0.007	0.006	-0.016	-0.015	-0.013***	-0.012***
	(0.34)	(0.48)	(0.20)	(0.26)	(0.00)	(0.01)
Tobin’s q	0.001	0.002	0	0.002	-0.001**	-0.001*
	(0.70)	(0.16)	(0.78)	(0.27)	(0.01)	(0.08)
Gov't subsidy	1.261	-2.059	4.075*	2.823	1.970**	1.816**
	(0.66)	(0.47)	(0.08)	(0.17)	(0.05)	(0.04)
University density	0.054	-0.025	9.357***	8.395***	0.941**	0.978**
	(0.89)	(0.96)	0.00	0.00	(0.03)	(0.04)
GDP growth	-0.03	0.044	-0.150***	-0.113**	0.038***	0.037**
	(0.58)	(0.43)	(0.01)	(0.01)	(0.01)	(0.02)
Constant	-0.007	0.014	0.077	0.093	0.034	0.033
	(0.91)	(0.85)	(0.27)	(0.23)	(0.13)	(0.20)
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effects	No	No	Yes	Yes	Yes	Yes
Observations	15,827	14,687	15,827	14,687	15,827	14,687
R-squared	0.156	0.161	0.191	0.196	0.878	0.871

Table 8. Different Types of Patents

This table reports regression results on the determinants of patents rates (Patent stock/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 stocks/assets	Invention patent stocks/assets	Design patent stocks/assets	Design patent stocks/assets
SOE	0.011*	0.008	0.018**	0.001
	(0.07)	(0.13)	(0.01)	(0.82)
IPP1	0.031**		0.018**	
	(0.01)		(0.02)	
SOE×IPP1	-0.025**		-0.026***	
	(0.01)		(0.00)	
IPP2		1.465***		0.426
		(0.01)		(0.30)
SOE×IPP2		-1.649***		-0.304
		(0.01)		(0.59)
Controls	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Province fixed effects	Yes	Yes	Yes	Yes
Observations	15,827	14,687	15,827	14,687
R-squared	0.174	0.181	0.074	0.076

Table 9. Evidence from SOE Privatizations

This table reports changes in firms' innovative activities before and after SOE privatization attempts (completed and failed). The sample of firms are SOE privatization attempts, 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 patens (Patent/assets) before and after. Note that since this analysis focuses on before-after changes in R&D and patenting, we use flow measures of R&D and patents, rather than stock measure in previous analysis. R&D is the amount of R&D investment in a year and patents is the number of patents applied in a given year that are ultimately granted. R&D stock and patent stock are calculated as in Equation (1). 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.

Panel A: R&D/Assets

	Privatization completed (N=149)			Privatization failed (N=39)			
	Before (SOE)	After (Private)	After – Before (1)	Before (SOE)	After (SOE)	After – Before (2)	Diff. in Diff. (1) – (2)
Sorted by IPP1							
High IPP1	0.001	0.004	0.003***	0.001	0.001	0.0001	0.003***
Low IPP1	0.002	0.003	0.001	0.001	0.002	0.001	0.000
Sorted by IPP2							
High IPP2	0.001	0.003	0.002**	0.001	0.002	0.001	0.001
Low IPP2	0.001	0.004	0.003*	0.001	0.001	0.0001	0.002

Panel B: Patent /Assets

	Privatization completed (N=149)			Privatization failed (N=39)			
	Before (SOE)	After (Private)	After – Before (1)	Before (SOE)	After (SOE)	After – Before (2)	Diff. in Diff. (1) – (2)
Sorted by IPP1							
High IPP1	0.006	0.013	0.007*	0.009	0.01	0.001	0.006*
Low IPP1	0.012	0.008	-0.004	0.0004	0.001	0.0006	-0.0046
Sorted by IPP2							
High IPP2	0.005	0.012	0.007*	0.008	0.009	0.001	0.006*
Low IPP2	0.013	0.009	-0.004	0.001	0.001	0	-0.004

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

This table reports regression analysis of changes in R&D investments and patents before and after SOE privatization. We estimate the regressions for the completed SOE privatizations and failed SOE privatizations separately. The dependent variable is the annual R&D investment/assets in Panel A and number of patents obtained/assets in Panel B. 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. Note that since this analysis focuses on before-after changes in R&D and patenting, we use flow measures of R&D and patents, rather than stock measure in previous analysis. R&D is the amount of R&D investment in a year and patents is the number of patents applied in a given year that are ultimately granted. After(1st year) is one year after the attempted SOE privatization. After (2nd year) and After(≥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.

Panel A: R&D/Asset

	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(1st year)	0.002**	0.002	0.001	0.002**	-0.000	-0.002	0.002	-0.002
	(0.012)	(0.272)	(0.486)	(0.031)	(0.756)	(0.443)	(0.384)	(0.225)
After(2nd year)	0.003*	0.001	0.003*	0.000	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(≥3rd year)	0.003**	0.002	0.003**	0.001	0.000	-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

Panel B: Patent/Asset

	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(1st year)	0.009**	0.003	0.006*	0.006	-0.008**	0.007**	0.004	0.003**
	(0.040)	(0.457)	(0.076)	(0.148)	(0.011)	(0.027)	(0.681)	(0.040)
After(2nd year)	0.007**	0.004	0.008*	0.004	-0.005	0.004	0.001	0.001
	(0.046)	(0.228)	(0.096)	(0.460)	(0.222)	(0.473)	(0.883)	(0.948)
After(≥3rd year)	0.011**	0.006	0.009**	0.006	0.010	0.001	0.014	-0.008
	(0.029)	(0.150)	(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. Patent Quality – Global Patent Office Information

This table compares patent quality measures between private firms and SOEs using patent data from global patent offices for the 300 top filing firms in our sample. Citations per patent is the number of citations received worldwide per patent family owned by each firm, as of year-end 2014 (Panel A) and 2006 (Panel B). IPC groups per patent is the mean number of IPC groups that each patent family has been assigned to as of year-end 2014 and 2006. Patents active in the US, Japanese and European Patent Office are the fraction of a firm's patent families awarded through that date that are pending and/or are granted in the respective patent offices as of the year-end 2014 and 2006. Patent active in WIPO is the share of the firm's patents active under the Patent Cooperation Treaty in 2014. *, **, *** indicates statistical significance at the 10%, 5%, and 1% level using a one-tailed test, respectively.

Panel A: Entire sample: Patents published between 1990 - 2014				
	Private	SOE	t-stat (diff)	
Citations received per patent	0.76	0.47	2.74	***
IPC groups per patent	1.81	1.66	3.15	***
% patents active in US	6.1%	4.2%	2.40	**
% patents active in Japan	1.6%	1.9%	-0.90	
% patents active in EPO	0.6%	0.9%	-1.21	
% patents active in WIPO	1.4%	0.5%	3.15	***
Panel B: Period 1 -- Patents published between 1990 - 2005				
	Private	SOE	t-stat (diff)	
Citations received per patent	2.89	1.17	4.06	***
IPC groups per patent	1.89	1.77	1.04	
% patents active in US	17.6%	9.9%	2.81	***
% patents active in Japan	5.6%	3.8%	1.20	
% patents active in EPO	0.3%	0.5%	-0.52	
% patents active in WIPO	0.0%	0.0%	.	
Panel C: Period 2 -- Patents published between 2006 - 2014				
	Private	SOE	t-stat (diff)	
Citations received per patent	0.30	0.19	2.17	**
IPC groups per patent	1.80	1.61	3.31	***
% patents active in US	3.6%	2.0%	2.76	***
% patents active in Japan	0.7%	1.2%	-1.84	**
% patents active in EPO	0.6%	1.0%	-1.31	
% patents active in WIPO	1.8%	0.7%	2.72	***

Table 12. IV Regression Results

This table reports IV regression 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.

Panel A: First Stage Results		
	IPP1	IPP2
Christian College	0.041***	0.001***
	0.00	(0.01)
British Settlement	-0.006	0.003***
	(0.30)	0.00
Christian College×SOE	-0.020***	-0.0003
	(0.00)	(0.24)
British Settlement×SOE	-0.001	-0.0003
	(0.85)	(0.60)
SOE	0.008	-0.0001
	(0.53)	(0.69)
Controls	Yes	Yes
Observations	15,830	14,690
R-squared	0.071	0.292
Partial-F test for IVs	25.29	18.58
	(p=0.000)	(p=0.000)

Panel B: Second Stage Results				
	(1)	(2)	(3)	(4)
	R&D stock/assets	R&D stock/assets	Patent stock/assets	Patent stock/assets
SOE	0.110***	0.0002	0.151*	0.039
	0.00	(0.95)	(0.08)	(0.16)
IPP1	0.098***		0.240***	
	0.00		(0.00)	
SOE×IPP1	-0.157***		-0.258**	
	0.00		(0.03)	
IPP2		0.809**		11.275***
		(0.05)		0.00
SOE×IPP2		-0.866**		-8.358**
		(0.02)		(0.02)
Controls	Yes	Yes	Yes	Yes
Observations	11,344	10,816	15,827	14,687
R-squared	0.17	0.281	0.152	0.158

Appendix A. Industry distribution

Code	Industry Name	SOE	%	Private	%	SOE Privatization	%	SOE Privatization - Completed	%	SOE Privatization - Failed	%
A	Agriculture	14	1.49%	18	1.83%	2	1.06%	1	0.67%	1	2.56%
B	Mining	41	4.36%	20	2.03%	11	5.85%	9	6.04%	2	5.13%
C0	Food and drinks	40	4.25%	42	4.27%	9	4.79%	7	4.70%	2	5.13%
C1	Textiles and apparel	16	1.70%	52	5.28%	10	5.32%	9	6.04%	1	2.56%
C2	Wood and furniture	1	0.11%	12	1.22%	1	0.53%	1	0.67%	0	0.00%
C3	Paper and printing	12	1.28%	26	2.64%	8	4.26%	6	4.03%	2	5.13%
C4	Petrochemical and plastics	103	10.95%	113	11.48%	20	10.64%	14	9.40%	6	15.38%
C5	Electronics	31	3.29%	59	6.00%	8	4.26%	8	5.37%	0	0.00%
C6	Metals and minerals	77	8.18%	87	8.84%	14	7.45%	12	8.05%	2	5.13%
C7	Equipment	151	16.05%	231	23.48%	19	10.11%	15	10.07%	4	10.26%
C8	Pharma biotech	33	3.51%	66	6.71%	14	7.45%	11	7.38%	3	7.69%
C9	Other manufacturing	2	0.21%	11	1.12%	0	0.00%	0	0.00%	0	0.00%
D	Utilities	68	7.23%	7	0.71%	3	1.60%	1	0.67%	2	5.13%
E	Construction	29	3.08%	26	2.64%	3	1.60%	3	2.01%	0	0.00%
F	Transportation and storage	69	7.33%	5	0.51%	2	1.06%	1	0.67%	1	2.56%
G	Information technology	42	4.46%	55	5.59%	5	2.66%	2	1.34%	3	7.69%
H	Retail	76	8.08%	62	6.30%	24	12.77%	23	15.44%	1	2.56%
I	Finance	18	1.91%	2	0.20%	1	0.53%	1	0.67%	0	0.00%
J	Real estate	60	6.38%	55	5.59%	23	12.23%	18	12.08%	5	12.82%
K	Social services	33	3.51%	23	2.34%	5	2.66%	3	2.01%	2	5.13%
L	Media and culture	16	1.70%	5	0.51%	3	1.60%	1	0.67%	2	5.13%
M	Diversified	9	0.96%	7	0.71%	3	1.60%	3	2.01%	0	0.00%
Total		941	100.00%	984	100.00%	188	100.00%	149	100.00%	39	100.00%