Review of International Economics, 18(5), 882–895, 2010
DOI:10.1111/j.1467-9396.2010.00914.x

Does the Protection of Foreign Intellectual Property Rights Stimulate Innovation in the US?

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Abstract

Although standard theories suggest that patent protection helps stimulate innovative activities, some new theories argue the opposite. Empirical studies do not generate conclusive results either. This paper investigates empirically the impacts of foreign patent reforms on innovation in the US, using data on successful patent applications in the US over 33 years and major IPR reforms in 21 countries, in addition to the patent reforms in the US and the TRIPS Agreement of the WTO. We find that the TRIPS Agreement has had significant impacts on innovation in the US, which highlights the importance of international cooperation in patent protection. However, the effects of strengthening patent protection by individual countries are not statistically significant. This result seems to imply that the US market is already sufficiently large/profitable to provide innovation incentives in the US and therefore further strengthening foreign patent protection simply increases the US innovators' rent, but not their innovation.

1. Introduction

There is no disagreement on the importance of innovation for economic growth. Since the 1980s, many countries have strengthened their intellectual property rights (IPR) protection in order to stimulate innovation.[1] Standard theories predict that IPR protection stimulates innovation because protection raises incentives to create innovations by enabling innovators to reap the benefits of innovation (through monopoly profits) and recoup the costs of research and development (R&D) investments. However, some recent studies argue the opposite.[2] Naturally, the heated IPR–innovation debate has largely shifted its focus to empirical investigations. Unfortunately, the actual (empirical) effects of IPR protection on innovation have been found to be also inconclusive. After surveying the empirical literature, Jaffe (1999) makes a disquieting conclusion that there is little empirical evidence to support the widely accepted theory that strengthening IPR protection has a significant impact on innovation.[3] Granstrand (2005) echoes Jaffe's concern in a more recent survey of the literature. Researchers continue to search for evidence and answers with regard to the efficacy of IPR protection on innovation.

In this study, we analyze the effect of strengthening foreign countries' IPR protection on innovation in the United States. In theory,[4] increased IPR protection in other countries should spur innovation in the US because it enables US innovators to reap more profits from foreign markets, via export or foreign direct investment (FDI). However, there is no systematic empirical analysis to confirm such a link. To make a contribution to this literature, we examine US patents over 33 years (from 1967 to 1999)

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and find that strengthening IPR protections in individual or a small group of countries has no significant impact on US innovations, but the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement, which is a collective action by a large group of countries, does have a positive and significant effect on innovation in the US.

Although the above issue, to be analyzed in this study, has not been examined in the literature, there exist some studies on foreign IPR protection. Mansfield's (1994) survey evidence reveals that US multinational firms are more likely to locate research facilities in a country that has strong IPR protection. Similar effects on technology transfer and FDI are also found in some recent studies.[5] Based on a small sample and interviews in India, Lanjouw (1998) and Lanjouw and Cockburn (2000) argue that less-developed countries' (LDC) patent protections on drugs may induce more research throughout the world on treatments for diseases that are prevalent in the developing world. However, it is unlikely that a particular country's (like India's) patent reforms can substantially increase innovators' profits. This latter view is consistent with the main findings in the present study that uses cross-country and cross-industry data.

Many earlier studies in the industrial organization literature focus on understanding the impacts of a single patent policy reform on innovation.[6] Some studies in the international trade literature consider comprehensive IPR reforms in a number of countries, but focus on the IPR effects on trade and FDI, not innovation.[7] In contrast, Lerner (2002) examines the impacts on innovation by 177 IPR policy changes across 60 countries and over a 150-year period. He finds that strengthening patent protection has few positive effects on patent applications by entities in the country undertaking the policy change. However, foreign patent applications in countries undertaking policy changes increase. As a complement to Lerner's (2002) study, this paper uses cross-country time-series data to examine the effects of foreign IPR reforms on innovation in the US.

Since the 1980s, IPR protection has been in the forefront of international trade negotiations. Developed countries, led by the US, exert great pressure on developing countries to adopt more stringent standards in protecting IPR.[8] The signing of the World Trade Organization's (WTO's) TRIPS Agreement in 1994 was a result of such pressure. One of the most important features of the TRIPS Agreement was a substantial increase in IPR protection in developing countries, although developed countries were also required to make adjustments in their IPR laws. For example, all countries were required to protect their patents for at least 20 years. Our finding, mentioned earlier, does not lend support to the US complaints that inadequate IPR protection in developing countries reduces innovation incentives in the US. It probably implies that the patent-protected US market is sufficiently large for innovators to recoup the costs of R&D investments and further strengthening IPR protection by individual foreign countries merely adds pure rent to the proceeds that US innovators earn. This hypothesis has an indirect support from McCalman's (2001) estimation that the TRIPS Agreement adds billions of dollars to the US patent holders.[9]

In searching for the sources of innovation in the US, we focus on economic factors (GDP), innovative capabilities (education expenditure), and IPR policies (domestic and foreign). In addition to the TRIPS Agreement, we find that the US GDP and the country's spending on higher education have significant and positive effects on the number of patent applications that are awarded by the United States Patent and Trademark Office (USPTO). According to Jaffe (1999), among the major changes in patent policy and practices that occurred in the 1980s and 1990s in the US, the most important policy change is the creation of the Court of Appeals for the Federal Circuit (CAFC) in 1982.[10] However, we do not find a significant effect of this policy shift on US innovations. This observation is consistent with that of Kortum and Lerner (1998, 2003), but in contrast to some others (e.g. Hall and Ziedonis, 2001, who find that the policy change causes an otherwise perplexing surge in US patenting rates, at least in the semiconductor industry).

The rest of the paper is organized as follows. The regression model and data are discussed in section 2. The empirical findings are presented and discussed in section 3. In section 4, we conduct robustness checks of our results. Concluding remarks are given in section 5.

2. Empirical Design and Data

The objective of this study is to explore the effects of strengthening foreign IPR protection on innovation in the US. We should first determine how to measure innovation and what factors may affect innovation.

There are two ways to measure technological innovation: the output and the input. Although there is no perfect measurement of innovation input and output, it is common to use the number of patent applications within a certain period of time to capture innovation output, and to use the R&D expenditures within a certain period of time to indicate innovation input. Since we have industry-level patent data, but only economy-wide R&D data, in this study we will use patents to capture innovation in the US. Specifically, we use the successful number of patent applications in the US in each year to measure the innovation output in the US. Every year, thousands of patent applications are submitted to the USPTO and, on average, about 60% of them are eventually awarded for patent protection. We call these successful patent applications. Patent application in the US started to surge in the mid-1980s. US inventors filed 149,825 applications in 1999, while in 1984 there were only 61,841 applications filed. The USPTO awarded US inventors 85,072 patents in 2000, while only 38,367 patents were awarded in 1984 (Kim and Marschke, 2004). Detailed patent data can be downloaded from Bronwyn H. Hall's website http://emlab.berkeley.edu/users/bhhall. This dataset consists of information about almost 3.4 million US patents granted by the USPTO between 1963 and 2002. However, in this study we use the data between 1967 and 1999 because data for some explanatory variables beyond this period are not available.

Following Hall et al. (2002), we decompose the patented inventions into six technological categories: Chemical; Computers and Communications; Drugs and Medical; Electrical and Electronics; Mechanical; and Others.[11]

Existing studies in the literature choose different sets of control variables to explain innovation activities. They include GDP, per capita GDP, domestic savings, human capital, openness to trade and FDI, the political environment, and the extent of patent protection. Given the specific focus of our study and the data limitations, we choose some of those variables and introduce some new variables in our regression model given below:

$$\ln Y_{it} = \alpha_0 + \alpha_1 \ln GDP_{t-1} + \alpha_2 EDU_{t-1} + \sum_{i=1}^{5} \beta_i IND_i + \sum_{j=1}^{10} \theta_j IPR_j + \theta_0 TRIPS + \theta_{US} IPR_{US} + \varepsilon_{it},$$

where t indicates time, i represents the industry, α, β, and θ are parameters to be estimated, and ε is the disturbance term. The left-hand-side variable, Y_{it}, is the number of patent applications filed by US nongovernment organizations in industry i and eventually awarded by the US patent office in year t. Table 1 shows the minimum

Table 1. Patent Distribution in the US, 1967–99

Industry	*Mean*	*Std. dev.*	*Min.*	*Max.*
1. Chemical	8816	1164	7122	12,149
2. Computers and Communications	5510	5184	1928	20,062
3. Drugs and Medical	3675	3201	762	11,776
4. Electrical and Electronics	7240	2567	5023	13,563
5. Mechanical	7413	1388	5095	9,929
6. Others	6964	1303	5193	10,092

number, maximum number, and average number of successful patent applications per year in each of the six industries from 1967 to 1999. There are large variations over time, within the same industry and across industries.

On the right-hand side of the regression, GDP_{t-1} is the real US GDP in year $t-1$ measured in 1996 dollars.[12] A country's total innovation is influenced by the size of the economy (total GDP) and the quality of the economy (GDP per capita), as suggested by Stern et al. (2000) who use the latter to represent the national knowledge stock. We use total GDP as one of the explanatory variables in our main regression model and let the education variable (discussed below) partially reflect the quality of the economy. Note that we replace total GDP with GDP per capita in the next section for robustness checks, and we find that the main results of this study do not change. Also note that we use the previous year's GDP, rather than concurrent GDP data, because innovation and patent awards take time.[13]

Education level, especially tertiary education, is one of the most relevant measures of human capital to affect technological innovation. Following Stern et al. (2000), we capture education investment, denoted as EDU_{t-1}, using the share of total expenditures for all colleges and universities in GDP, in year $t-1$ in the US.[14] Over the entire period (1967–99), the mean value of this variable is 2.6567 (percent) and the standard deviation is 0.1490. The variable takes the value 2.4712 for 1967, which is close to the lowest level (2.4097), and 2.8969 for 1999, which is the highest level.

As Table 1 indicates, innovation varies across industries. Innovators' responses to GDP and other control variables may also be different across industries. To allow for such differences, we include industry dummies IND_i. Since there are totally six industry groups, we need only five dummies.

Recall that the main objective of our study is to investigate the impacts of strengthening IPR protection in other countries on innovation in the US. Therefore, we need to identify major IPR reforms in foreign countries. According to Branstetter et al. (2007), from 1982 to 1999, there were 16 country-level major IPR reforms in the world (excluding the US).[15] Based on Ginarte and Park's (1997) patent rights index, we also identify the major IPR reforms between 1967 and 1981. Table 2 is a list of those reforms. Our IPR dummy variables are constructed based on Table 2, where IPR_j is a dummy variable that takes the value of 0 before a particular year, j, and equals unity from that year onward. For example, we set $IPR_{77} = 0$ for all the years before 1977 and $IPR_{77} = 1$ from 1977 onward, which corresponds to the year when four European countries enacted IPR reforms.

We first explain how we identify the major IPR reforms during the 1967–81 period, based on Ginarte and Park's (1997) patent rights index. The index is used to

Table 2. Major IPR Reforms in Foreign Countries

Reforming years	*Countries/Regions*	*IPR dummies*
1977	France, Germany, the Netherlands, Switzerland	IPR_{77}
1978	Sweden	IPR_{78}
1986	Taiwan, Spain	IPR_{86}
1987	Japan, South Korea	IPR_{87}
1991	Mexico, Chile, Indonesia	IPR_{91}
1992	Thailand, Portugal	IPR_{92}
1993	China	IPR_{93}
1994	Venezuela, Colombia	IPR_{94}
1995	Turkey	IPR_{95}
1996	Argentina	IPR_{96}
1997	Brazil, the Philippines	IPR_{97}

represent the degree of patent protection quinquennially (i.e. the time distance between two consecutive indices is five years). It is constructed for 110 countries from 1960 to 1990, based on five categories of each country's patent law: (1) extent of coverage, (2) membership in international patent agreements, (3) provisions for loss of protection, (4) enforcement mechanisms, and (5) duration of protection. Each category is scored a value in the range of [0, 1] and the index is the sum of these five values. A higher index represents a stronger protection level. To identify major IPR reforms, we choose the following criterion: a country has a major IPR reform if its Ginarte–Park patent rights index increases by no less than 0.5 between two consecutive (five-year) periods. When an IPR reform is identified, we treat the middle year of the five-year reforming period as the year of the corresponding reform. Based on this criterion, seven countries stand out: Denmark, Finland, France, Germany, the Netherlands, Sweden, and Switzerland. They are all European countries and their indices jump in the 1975–80 period, with 1977 being the middle year. This observation is consistent with these countries' (except for Denmark and Finland's) participation in the European Patent Convention.[16] The Convention was signed by many countries in Munich in 1973. Germany, France, the Netherlands, and Switzerland all began to enforce the Convention in 1977 while Sweden did so in 1978. Therefore, we choose these years as their IPR reforming years. Some other countries, such as Belgium, Luxembourg, and the United Kingdom, also participated in the Convention in 1977, but since their indices did not jump over the 0.5 bar, they are not included in our IPR dummies.[17]

The TRIPS Agreement was signed in 1994 and came into force on 1 January 1995. We use the dummy *TRIPS* to capture the effects of the Agreement on US innovations. Specifically, let $TRIPS = 0$ for all the years before 1995 and $TRIPS = 1$ from 1995 onward. Since Turkey's own IPR reform also took place in 1995, we drop IPR_{95}.

The US set up the CAFC in 1982, which broadens the rights of patent holders and has been considered as the cornerstone of IPR policy shift in the past 20-plus years. Accordingly, we introduce the dummy variable IPR_{US}, which is equal to 0 for all the year before 1982, and 1 for all the years from 1982 onward.[18]

3. Analysis and Results

With 31 years and six industry groups, the number of observations of the left-hand-side variable in our regression model is 186. Table 3 reports the preliminary OLS results derived based on our main model introduced in the preceding section. Note that except for a few industry dummies, none of the explanatory variables is significant. The two IPR dummies that have lower p-values are $TRIPS$ (0.300) and IPR_{87} (0.312). Other IPR_j, including IPR_{US}, have very high p-values. While IPR reforms in one or a few countries may not have significant impacts on US innovations, their joint impacts might be significant. To test this, we conduct the F-test on the 10 IPR dummies (excluding $TRIPS$ and IPR_{US}). We obtain $F(10, 166) = 0.60$ and Prob > $F = 0.8103$. Thus, the 10 IPR dummies are not jointly significant.

Since the IPR dummies are not jointly significant, following the approach taken by Evenson and Kanwar (2001), we delete the high p-value IPR dummies from the main model and re-run the regression. In fact, we do this through a few steps. We run various regression models and report their results in Table 4. Note that cross-industry patenting is not our focus and there is no change to the sign and significance of each industry dummy in all the regressions in this study. Hence, to save space, we do not report the estimates of the industry dummies any more.

In Model 1, we keep IPR_{US} because of its particular interest. The new regression does not improve the significance of IPR_{87} by very much. Although the p-value of IPR_{US} is reduced, the 1982 US IPR reform is still not significant. However, three other variables, GDP_{t-1}, EDU_{t-1}, and $TRIPS$, are statistically significant.

In Model 2, we further delete IPR_{US}, but there is no change to the significance of the 1987 IPR reforms in Japan and Korea. In Model 3, we delete IPR_{87} but add IPR_{US} back

Table 3. Preliminary Regression Results

Independent variable	*Coefficient*	*Standard error*	*t-Statistics*	*p-Value*
GDP	0.262	0.541	0.48	0.629
EDU	0.197	0.594	0.33	0.741
IND_1	0.248	0.081	3.07	0.002
IND_2	–0.474	0.081	–5.88	0.000
IND_3	–0.873	0.081	–10.82	0.000
IND_4	0.018	0.081	0.22	0.826
IND_5	0.055	0.081	0.69	0.493
IPR_{77}	–0.050	0.155	–0.33	0.745
IPR_{78}	–0.013	0.180	–0.07	0.942
IPR_{86}	0.046	0.155	0.29	0.768
IPR_{87}	0.163	0.161	1.01	0.312
IPR_{91}	0.093	0.165	0.56	0.574
IPR_{92}	0.073	0.185	0.39	0.694
IPR_{93}	0.057	0.184	0.31	0.758
IPR_{94}	0.126	0.184	0.68	0.497
IPR_{96}	–0.067	0.184	–0.37	0.715
IPR_{97}	0.079	0.158	0.50	0.618
$TRIPS$	0.192	0.184	1.04	0.300
IPR_{US}	–0.004	0.100	–0.04	0.966
Constant	5.906	4.096	1.44	0.151
R-squared	0.750			

Table 4. Revised Regression Results

	Independent variable	*Coefficient*	*Standard error*	*t-Statistics*	*p-Value*
Model 1	*GDP*	0.367	0.256	1.44	0.153
	EDU	0.788	0.315	2.50	0.013
	IPR_{87}	0.138	0.123	1.12	0.262
	TRIPS	0.365	0.092	3.97	0.000
	IPR_{US}	–0.043	0.092	–0.47	0.641
	Constant	3.496	2.341	1.49	0.137
	R-squared	0.743			
Model 2	*GDP*	0.286	0.188	1.52	0.129
	EDU	0.795	0.314	2.53	0.012
	TRIPS	0.380	0.086	4.41	0.000
	IPR_{87}	0.138	0.122	1.13	0.261
	Constant	4.146	1.878	2.21	0.029
	R-squared	0.742			
Model 3	*GDP*	0.517	0.218	2.37	0.019
	EDU	1.021	0.238	4.30	0.000
	TRIPS	0.338	0.089	3.80	0.000
	IPR_{US}	–0.043	0.093	–0.47	0.642
	Constant	1.657	1.676	0.99	0.324
	R-squared	0.741			
Model 4	*GDP*	0.436	0.133	3.29	0.001
	EDU	1.028	0.237	4.34	0.000
	TRIPS	0.353	0.083	4.26	0.000
	Constant	2.306	0.930	2.48	0.014
	R-squared	0.740			

to the regression. The 1982 US IPR reform remains an insignificant factor for US innovations. In both Models 2 and 3, the three common factors, namely GDP, education, and the TRIPS Agreement, are significant. Based on the results from these two models, we drop both IPR_{US} and IPR_{87} to get Model 4. In Model 4, all remaining variables have significant impacts on innovation in the US.

Summary

Both the US GDP and investment in education have positive effects on innovation in the US. A 10% increase in GDP leads to a 4.36% increase in successful patent applications, while a 10% increase in the share of higher education expenditure in GDP increases successful patent applications by 10%. Strengthening an individual country's IPR protection does not help to stimulate innovation in the US. A series of individual countries' IPR reforms, which spread over a long period of time, do not affect the successful patent applications in the US either. However, the TRIPS Agreement does have a significant positive effect on innovation in the US. In contrast to a series of IPR reforms, the TRIPS Agreement involves all countries and occurs in the same year (although it took a few years for developing countries to completely enforce the Agreement). This finding underscores the importance of international agreements.

We also find that the US IPR reform in 1982 did not significantly affect successful patent applications in the US. This finding is consistent with some of the studies in the literature (see Jaffe, 1999).

4. Robustness Examination

In this section, we analyze several possibilities that might undermine or overturn the results obtained in the preceding section. Nonetheless, these robustness checks confirm our conclusions stated above.

Elimination

Recall that before deleting some IPR dummies from the main model, none of the IPR variables, the GDP variable, or the education variable shows statistically significant influences on the successful patent applications in the US. Instead of removing those high *p*-valued IPR dummies from the main model, should we drop the GDP and/or education variables? To answer this question, we conduct the following experiments. First, by deleting *EDU* only, the *p*-value of the GDP variable reduces from 0.629 (see Table 3) to 0.464, that of IPR_{87} reduces from 0.312 to 0.245, that of *TRIPS* increases from 0.300 to 0.329, while all other IPR dummies retain high *p*-values. That is, none of remaining factors becomes statistically significant. Second, by deleting both the GDP and education variables from the main model, the *p*-values of IPR_{87} and *TRIPS* change to 0.165 and 0.292, respectively, while all other IPR dummies have quite high *p*-values. That is, none of the remaining variables becomes statistically significant explanatory variables for innovation in the US. Third, if we delete *GDP* from the main model, the *p*-values of *EDU*, IPR_{87}, and *TRIPS* are 0.59, 0.282, and 0.271, respectively. Further deleting other high *p*-value IPR variables does not help us to find any significant explanatory variables. Therefore, the approach adopted in the preceding section for Model 4 seems to be the only option to identify the factors that have statistically significant effects on innovation in the US.

GDP Per Capita

As shown earlier, a country's total innovation is affected by the size of the economy (total GDP), but it could also be influenced by the richness of the country (GDP per capita). To examine the latter effect, we replace the total GDP in the main model with per capita GDP, denoted as *PGDP*.[19] The regression results do not change: when we include all variables on the right-hand side of the main model, none of them (except a few industry dummies as before) is statistically significant; when we drop some IPR dummies with high *p*-values, we obtain the upper part of Table 5, which indicates that IPR_{87} and IPR_{US} are not significant either; when we further delete IPR_{87} from the model, we obtain the lower part of Table 5. Thus, *PGDP*, *EDU*, and *TRIPS* are statistically significant, but other IPR dummies are not.

Time Lag

In the main regression model, we set the dummy variables of various countries' IPR reforms according to the years when their IPR regimes were changed. However, it could take a few years for US innovations to respond to changes in those IPR systems.[20] To see whether our results are sensitive to the choice of timing the IPR dummies, we modify the main regression model by taking a lag of two years for the IPR dummy variables. For example, we let $IPR_{86} = 0$ for all the years before 1988 and $IPR_{86} = 1$ from 1988 onward, which corresponds to the IPR reforms of Taiwan and Spain in 1986. The dummies IPR_{US} and *TRIPS* are also amended accordingly.[21] We delete high *p*-value

Table 5. GDP Per Capita

Independent variable	*Coefficient*	*Standard error*	*t-Statistics*	*p-Value*
PGDP	0.543	0.380	1.43	0.154
EDU	0.819	0.318	2.58	0.011
IPR_{87}	0.126	0.128	0.98	0.327
TRIPS	0.372	0.090	4.14	0.000
IPR_{US}	–0.036	0.089	–0.40	0.687
R-squared	0.743			
PGDP	0.757	0.312	2.43	0.016
EDU	1.030	0.235	4.38	0.000
TRIPS	0.348	0.086	4.03	0.000
IPR_{US}	–0.038	0.089	–0.42	0.674
R-squared	0.741			

Table 6. Two-Year Lags

Independent variable	*Coefficient*	*Standard error*	*t-Statistics*	*p-Value*
GDP	0.251	0.175	1.43	0.155
EDU	0.673	0.333	2.02	0.045
IPR_{86}	0.197	0.126	1.56	0.120
IPR_{93}	0.342	0.108	3.17	0.002
TRIPS	0.058	0.118	0.49	0.624
R-squared	0.744			
GDP	0.262	0.174	1.51	0.133
EDU	0.666	0.332	2.00	0.047
IPR_{86}	0.194	0.125	1.55	0.124
IPR_{93}	0.375	0.084	4.48	0.000
R-squared	0.744			

IPR dummies (but still keep TRIPS for its particular importance) and report the regression results in the upper part of Table 6. Note that the *p*-value of IPR_{86} is quite small, which closely corresponds to IPR_{87} in the main model for IPR reforms in Japan and Korea. We further delete the high *p*-value *TRIPS* and report the new regression results in the lower part of Table 6.

Why does IPR_{93} become statistically significant, when the *TRIPS* does not? Note that when using the two-year lag, IPR_{93} represents China's IPR reform. The year 1995 corresponds to the TRIPS Agreement if the US innovations are affected immediately by foreign IPR reforms, but it corresponds to China's IPR reform if IPR reforms have a two-year lag. Therefore, the above analyses, as summarized in Tables 4 and 6, suggest two possible explanations: (1) if foreign IPR reforms have immediate impacts on the successful patent applications in the US, then the TRIPS Agreement has significant impacts on innovation in the US (Table 4); (2) if there is a two-year lag before foreign IPR reforms affect innovation in the US, then it is China's IPR reform, not the TRIPS Agreement, that has significant impacts on innovation in the US (Table 6). How do we know which explanation is more plausible?

It is reasonable to assume that although China had its IPR reforms stipulated in its law, the implementation of these reforms was still very weak even up to today. As

Table 7. Time Trend

Independent variable	*Coefficient*	*Standard error*	*t-Statistics*	*p-Value*
T	–0.035	0.035	–1.02	0.310
GDP	1.576	1.127	1.40	0.164
EDU	1.088	0.244	4.46	0.000
TRIPS	0.353	0.083	4.27	0.000
R-squared	0.742			

pointed out by Branstetter et al. (2007), foreign managers still regard China as an insecure place as far as IPR is concerned. This casts doubt on the China-effect explanation. But then, if the TRIPS-effect explanation holds, why does innovation not take time to respond to policy changes? It does, perhaps. Although the TRIPS Agreement was signed in 1995, it had been negotiated for several years before 1995. Hence, people might have well anticipated the establishment of the WTO and introduction of the TRIPS Agreement.[22]

Time Trend

There may exist some time-related factors that affect innovation in the US. For example, past cumulative innovation helps future innovation. We can include a time trend to capture the unobservable time-related explanatory variables (other than *GDP* or *EDU*). In particular, we add a time variable T ($T = 1, 2, \ldots, 33$, for 33 years) to the right-hand side of the main regression model. We conduct the same analysis as before by first running the regression including all IPR dummies and then deleting some high *p*-value IPR dummies and re-running the regression. The final results are reported in Table 7. The *p*-value for T is high (0.310). Thus, there is no other unobservable time trend that significantly affects US innovations. Moreover, including the time trend does not affect the results obtained in section 3.

Export and FDI

A country's IPR protection may be important for innovation in the US because it leads to higher incentives for innovation creation by US inventors by allowing them to reap more profits from that country's market. There are two channels through which US inventors can earn profits from foreign markets: exporting and FDI. Therefore, the total value of US exports to and FDI in a foreign country at least partially capture the extent of the importance of that country's IPR protection to innovation in the US. To capture this idea, we replace the IPR dummies in the main model with $IPR_j * \ln EX_{jt}$, where EX_{jt} is the total value of US exports to and FDI in country j in year t (or a group of countries j when there is more than one country undertaking IPR reforms in the same year, referring to Table 2), measured in millions of 1996 dollars. For example, in IPR_{87}, 87 represents Japan and Korea together and so EX_{87t} is the sum of the US exports to and FDI in Japan and Korea in year t. However, in $TRIPS * \ln EX_{TRIPSt}$, we use one-half of total US exports and outward FDI in the calculation. This is because not all countries in the world participate in the TRIPS Agreement. Also note that there is no change to the US IPR dummy, i.e. IPR_{US}. The data on goods exports of the US to the IPR reforming countries in each year can be obtained from the Foreign Trade Division of

Table 8. Linkage Term

Independent variable	*Coefficient*	*Standard error*	*t-Statistics*	*p-Value*
GDP	0.278	0.189	1.47	0.142
EDU	0.781	0.318	2.46	0.015
$IPR * \ln EX_{87t}$	0.013	0.011	1.17	0.244
$TRIPS * \ln EX_{TRIPSt}$	0.029	0.007	4.42	0.000
R-squared	0.742			
GDP	0.435	0.133	3.28	0.001
EDU	1.029	0.237	4.35	0.000
$TRIPS * \ln EX_{TRIPSt}$	0.027	0.006	4.26	0.000
R-squared	0.740			

the US Census Bureau. We obtained the US outward direct investment data from the websites of the Bureau of Economic Analysis and the World Bank. We first run the regression with all explanatory variables. Similar to the results reported in the previous section, most variables do not exhibit having significant effects on innovations in the US. Again, $IPR_{87} * \ln EX_{87t}$ and $TRIPS * \ln EX_{TRIPSt}$ have the lowest p-values at, respectively, 0.315 and 0.320, among all IPR variables. We delete the other high p-value IPR variables and re-run the regression. The results are reported in the upper part of Table 8. $IPR_{87} * \ln EX_{87t}$ is still not statistically insignificant. We delete it and re-run the new regression. The results are reported in the lower part of Table 8. Again, the TRIPS Agreement has a statistically significant impact on innovations in the US.

5. Conclusion

Conventional wisdom suggests that IPR protection will stimulate innovation activities, but some recent theories argue the opposite. Empirical studies do not generate conclusive results on this supposition. This paper empirically investigates the impacts of foreign IPR reforms on innovation in the US, using data on successful patent applications in the US over 33 years and major IPR reforms in 21 countries, in addition to the reforms in the US and the TRIPS Agreement of the WTO. We find that the TRIPS Agreement, which represents worldwide IPR reforms, has significant impacts on innovations in the US, but the effect of strengthening patent protection by individual countries is not statistically significant. This finding generates many implications. It perhaps suggests that the US market is large/profitable enough to provide innovation incentives in the US, and so further strengthening foreign patent protection simply increases the US innovators' rent, but not innovation. It also indicates the importance of international cooperation in IPR protection.

Data limitations constrain our research. There are a number of directions that we would like to take in order to improve the paper once we are able to collect more detailed data. First, in this paper, we use numbers of patent to measure innovation activities. We would like to check the result using other measures of innovation activities; for example, R&D investments. These two measures (innovation output and input) may not lead to the same conclusion, especially in cross-industry analysis (Scherer, 1983). However, we do not have industry-level R&D expenditures data.

Second, although the time coverage is quite long in our dataset, the industry breakdown is too broad (only six groups), and, as a result, our dataset is not sufficiently large.

A more detailed industry-level dataset would allow us to test the IPR–innovation linkage more precisely by separating cross-industry effects.

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Notes

1. IPR includes patent rights, copyrights, trade secrets, and others. However, in this paper the most relevant part of IPR is patent rights and hence we use the two terms, IPR protection and patent protection, interchangeably.
2. See Jaffe and Lerner (2004) and Bessen and Maskin (2009) for examples. These studies argue that patents may be counterproductive because they incur additional application costs, discourage attempts to invent around patents, and delay spillover to sequential innovations.
3. Hall and Ziedonis (2001) also draw the same conclusion with regard to R&D investment when innovation is cumulative; as they put it, "there remains little systematic evidence on how a shift toward stronger patent rights affects the innovative activities of firms in the context of rapidly changing, cumulative technologies." Sakakibara and Branstetter (2001) find that the Japanese response (in innovation) to the 1988 patent reform in Japan was very small. However, Evenson and Kanwar (2001) and Chen and Puttitanum (2005) find some positive effects of strengthening IPR protection on innovation.
4. In a closed economy, a country's optimal patent protection should balance the tradeoff between the *ex ante* incentives to pursue research that patent protection offers and the monopolies created by patent protection. In an open economy, the incentive–monopoly tradeoff extends to international markets. Lai and Qiu (2003) and Grossman and Lai (2004) provide a theoretical analysis of the optimal length of patent protection in an open economy.
5. It is found that a host country's stronger IPR protection encourages technology transfer from the US to that country (Branstetter et al., 2005) and attracts US FDI in that country (Branstetter et al., 2007).
6. Examples include Sakakibara and Branstetter (2001) on the broadening of the Japanese patent scope, Kortum and Lerner (1998) and Hall and Ziedonis (2001) on the establishment of the Court of Appeals for the Federal Circuit in the US, and Lanjouw (1998) on the strengthening of patent protection of pharmaceuticals in India.
7. See the literature review by Maskus (2000) and the recent study by Branstetter et al. (2007) on FDI.
8. As early as in the 1980s, the US pushed to move IPR issues from the framework of WIPO, which was seen by the US as too weak and narrowly focused, into the Uruguay Round of multilateral trade negotiations of the General Agreement on Tariffs and Trade during 1986 and 1994.
9. McCalman (2001) estimates that enforcement of the TRIPS Agreement will benefit the US with a net increase in the present value of patent rights of $4.5 billion (1988 dollars) on the patents applied for in 1988 and developing countries make contribution to this by transferring the rent to the US patent holders. The benefits of any increase in innovation in response to the TRIPS Agreement have not been included.
10. The establishment of the CAFC is widely believed to have had a profound impact on the substantive outcomes of patent litigation. According to Granstrand (2005), the new court changes the validity of litigated patents from 30% to 89%.

11. The classification of these industries is (1) *Chemical*, which includes Agriculture, Food, Textiles; Coating; Gas; Organic Compounds; Resins; Miscellaneous-Chemical; (2) *Computers and Communications*, which includes Communications; Computer Hardware & Software; Computer Peripherals; Information Storage; (3) *Drugs and Medical*, which includes Drugs; Surgery & Medical Instruments; Biotechnology; Miscellaneous-Drug & Med.; (4) *Electrical and Electronics*, which includes Electrical Devices; Electrical Lighting; Measuring & Testing; Nuclear & X-rays; Power Systems; Semiconductor Devices; Miscellaneous-Elec.; (5) *Mechanical*, which includes Materials Processing & Handling; Metal Working; Motors, Engines & Parts; Optics; Transportation; Miscellaneous-Mechanical; and (6) *Others*, which includes Agriculture, Husbandry, Food; Amusement Devices; Apparel & Textile; Earth Working & Wells; Furniture, House Fixtures; Heating; Pipes & Joints; Receptacles; Miscellaneous-Others. Note that "Agriculture" appears in both industry 1 and industry 6, but it refers to different items (e.g. fertilizers (patent code 071)), and plant protecting and regulating compositions (054) belong to industry 1's agriculture group while harvesters (056), planting (111) and crop threshing or separating (460) belong to industry 6's agriculture group.

12. The GDP data are obtained from the website of the United States Bureau of Economic Analysis (http://www.bea.gov/bea/dn/home/gdp.htm).

13. Generally speaking, it takes a long time for an application to be approved: the percentage of granted patents issued two years after application is about 85%, and the percentage for three years is about 95%. However, we have tested the model using GDP of year $t-2$ and year $t-3$, respectively, and found no qualitative changes in the results.

14. The information is obtained from the website of the United States National Center for Education Statistics (http://nces.ed.gov/).

15. This information comes from Ginarte and Park (1997), Maskus (2000), and Qian (2007).

16. Branstetter et al. (2005) also include this dummy in their study.

17. Denmark joined the Convention in 1990 and Finland joined in 1996. The year of their indices jumping and that of their participation in the Convention do not match. In any case, their markets for the US exports and FDI were much smaller than the above-mentioned countries. For that reason, we do not include these two countries in the IPR dummies. For the same reason, Branstetter et al. (2005) do not include these two countries in their study either.

18. Branstetter et al. (2005) also include this dummy in their study.

19. For a given country, GDP and GDP per capita are highly correlated. Thus, we should not include both variables in the same regression.

20. In fact, it also takes some time for the policy-changing countries to fully implement their IPR reforms.

21. This is particularly true for TRIPS as the Agreement allows some developing countries to fully amend their IPR laws a few years after 1995.

22. In order to further "test" the TRIPS-effect story, let us perform another analysis: assume that there is a one-year lag for the IPR reforms to impact innovations in the US. For example, let $IPR_{86} = 0$ for all the years before 1987, and $IPR_{86} = 1$ from 1987 onward. Other IPR variables are defined similarly. As a result, the only IPR dummy that has significant explanatory power is IPR_{94}. The year 1994 corresponds to IPR reforms in Venezeula and Colombia. However, we can hardly argue that these two countries' IPR reforms have more significant effects on innovations in the US than other countries, such as Japan, Korea, and Mexico. Therefore, it is more plausible that it is the TRIPS Agreement that spurs innovation in the US.