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The Empirical Impact of Intellectual Property Rights on Innovation: Puzzles and Clues

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Economists have long seen the patent system as a crucial lever through which policymakers affect the speed and nature of innovation in the economy. It is not surprising, then, that the profound changes that have roiled the global patent system over the past 25 years are attracting increasing attention from the economics profession.

A critical question relates to the impact of these shifts: to what extent do they really affect the pace of innovative discovery and diffusion? Much of the theoretical economics literature, such as Richard Gilbert and Carl Shapiro (1990), has assumed an unambiguous relationship between the strength of patent protection and the rate of innovation. This assumption has been relaxed in a line of work on sequential innovation, beginning with Suzanne Scotchmer and Jerry Green (1990).

This research addresses this question by examining the impact of major patent policy shifts in 60 nations over the past 150 years. I examine the changes in patent applications by residents of the nation undertaking the policy change. While I tabulate domestic filings by residents and nonresidents alike, confounding factors may influence this measure. Thus, I also examine filings made by residents of the nation undertaking the policy change *in a nation with a relatively constant patent policy*, Great Britain.

Much of the earlier empirical work has focused on understanding the impacts of a single patent policy reform. Examples include studies of the broadening of Japanese patent scope (Mariko Sakakibara and Lee Branstetter 2001), the establishment of the Court of Appeals for the Federal Circuit in the United States (Bronwyn H. Hall and Rosemarie H. Ziedonis 2001), and the patenting decision of nineteenth century World's Fair exhibitors (Petra Moser 2005). The closest papers to this one are Yi Qian's (2007) examination of the changes in pharmaceutical protection worldwide and Branstetter, Raymond Fisman, and Fritz Foley's (2006) examination of the consequence of patent policy changes on foreign direct investment.

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I. Constructing the Dataset

I employed as my sample the 60 countries listed in the International Monetary Fund's *International Financial Statistics* with the highest total gross domestic product (GDP) in 1997, as described in Lerner (2002). I then identified significant changes to the amount of patent protection offered. I determined this information using guidebooks to the world patent systems, publications of the world's patent offices, and legal monographs. I focus on shifts in the most visible and controversial areas of patent policy: whether the country offered comprehensive patent protection, the length of patents, the cost of awards, and provisions for patent revocation. I did not consider changes to the breadth of patent protection: in these cases, the interpretation of changes in the volume of domestic patenting would be problematic. I identified 177 events in 51 out of the 60 nations in the sample.

The number of events and distinct policy changes occurring in each decade are depicted in Figure 1. Because the number of countries in the sample varies, I normalized the changes by the number of nations that were active at the beginning of the decade.

The next phase was to determine the patent applications filed around the time of the policy

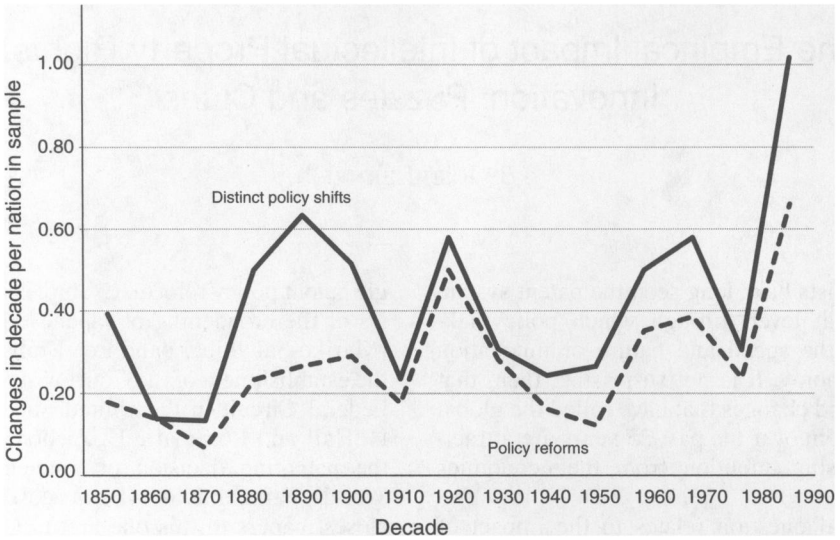

FIGURE 1. NUMBER OF CHANGES IN PATENT POLICY OVER TIME

Notes: The sample consists of the 60 largest countries (by GDP) at the end of 1997, observed from 1850 (or the date of inception as an independent entity) to 1999. The chart presents the number of policy reforms, as well as distinct policy shifts, in each decade, normalized by the number of active countries in the sample at the beginning of the decade.

changes. Using patent office publications, I identified three distinct measures of activity: patent filings in Great Britain by residents of the country undertaking the policy change, patent applications by domestic entities in the country undertaking the policy change, and applications by foreign entities in that country. I chose Great Britain because its patent office has consistently tabulated the national identity of the patent applicants since 1884 (except during World War I) and because of the relative constancy of its patent policy. In these tabulations, I sought to include only traditional patent awards, eliminating various weaker variants that nations have sometimes also offered.

II. Analysis

Panel A of Table 1 reports the changes in patent applications filed from two years before to two years after the policy shift. I divided the observations by the type of policy change. Most shifts (64 percent) unambiguously increased patent protection. The remainder either unambiguously reduced patent protection (24 percent) or contained both protection-enhancing and detracting elements (12 percent). In view of the small sample sizes, I treated the ambiguous and negative changes together in the reported analyses.

Both domestic and foreign patent applications increased in countries undertaking patent protection–enhancing shifts. The increase was larger, on both an absolute and percentage basis, among the foreign applicants. (In the sample as a whole, the mean numbers of British, domestic, and foreign patent applications during the year of the policy change were 739, 13,296, and 14,118, respectively.) No evidence appeared of a rise in British patent applications by residents of the nation where the policy change occurred.

Panel A does not, however, control for changes in the overall propensity to seek patent protection over the period. Some periods, such as the Depression years of the 1930s and the two world wars, saw a dramatic decline in patent applications across all nations, while others saw a substantial increase. I thus computed the "adjusted" difference: the difference in the number of patent applications filed in the $(-2, +2)$ interval, less the difference that would have been expected, had the applications grown at the same rate as in other countries. To determine the growth rate elsewhere, I constructed an index using the ten nations with the longest time series of patent application data. These

TABLE 1—CHANGE IN PATENTING ACTIVITY AROUND POLICY SHIFTS (YEAR −2 TO +2)

	Residents' patenting in Great Britain	Residents' patenting in country	Foreign patenting in country
Panel A: Unadjusted changes in patenting around policy changes			
Positive patent policy changes	−27	+2,424	+8,662
Ambiguous/negative changes	+210	+529	+1,401
Panel B: Changes in patenting, adjusted by equal-weighted index			
Positive patent policy changes	−101 −(4.61)***	−1,617 (1.86)*	+4,979 (2.41)**
Ambiguous/negative changes	−217 −(3.19)***	−525 (0.34)	+390 (1.28)
Panel C: Changes in patenting, adjusted by value-weighted index			
Positive patent policy changes	−100 −(4.52)***	−932 (1.69)*	+5,617 (2.85)***
Ambiguous/negative changes	−137 (2.40)**	−408 (0.07)	+501 (1.65)

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

nations included some where patenting has grown dramatically (e.g., the United States) and others where it has not (for instance, Argentina). In panels B and C, I report the analysis using two indexes, one assigning an equal weight to each of the ten nations, and one weighting each observation by the total patent applications filed. In each case, I compute:

$$A_{+2} - A_{-2} - \left[\frac{I_{+2} - I_{-2}}{I_{-2}} A_{-2}\right],$$

where A_{+2} is the number of applications filed two years after the policy shift, A_{-2} is the number of applications filed two years before, I_{+2} is the level of the index two years after the policy change, and I_{-2} is the index two years before.

Once the adjustment for overall patent application growth was made, a stark difference appeared in the case of patent protection-enhancing changes. While the change in foreign patenting was positive, adjusted patent applications by residents of the country undergoing the policy change declined, whether British or domestic filings were considered. The response of foreign patenting was much more modest in magnitude in the case of protection-reducing and ambiguous changes. I also report the statistical significance of these changes. In the financial event study literature, a standard procedure for computing test statistics for event studies has emerged. First, the standard deviation of returns during an estimation period, which does not overlap with the event window, is computed. Each observation is then weighted by the inverse of the standard deviation when undertaking univariate or regression analyses (see Stephen J. Brown and Jerold B. Warner 1980). In this way, observations where the stock price is very volatile are assigned less weight. In the same spirit, I computed the standard deviation of the change in patent applications filed in the period from 20 years to 5 years prior to the policy shift. I weighted both the *t*-tests and the regression analyses by the inverse of the standard deviation. Not only did the adjusted patenting by residents of the country undertaking the policy change not increase after patent protection–enhancing policy shifts, it actually fell by a significant amount. Foreign applications, however, reacted positively to protection-enhancing changes, suggesting that I had identified a set of significant policy shifts.

Figure 2 depicts graphically the average changes in patent applications around protection-enhancing changes, net of the value-weighted index. Around protection-enhancing changes, the same striking pattern appeared: patent applications by foreign entities increased dramatically,

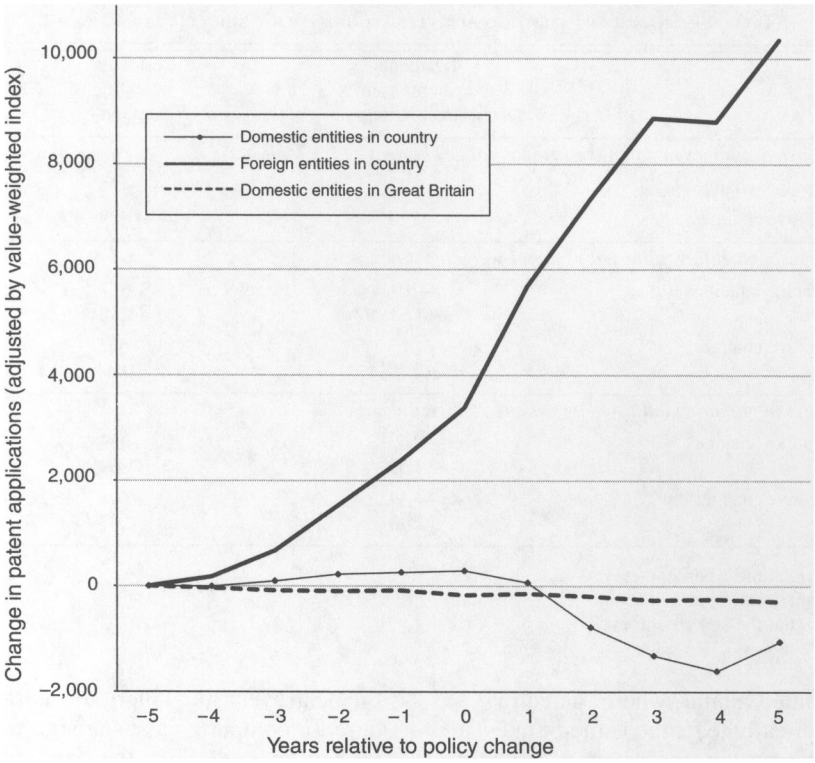

FIGURE 2. IMPACT OF PATENT PROTECTION–ENHANCING POLICY CHANGES

Notes: The figure displays the change in the number of patent applications filed between five years before the event and five years after the event by domestic entities filing in the country undertaking the change, foreign entities filing in the country undertaking the change, and residents of the country undertaking the policy change in Great Britain. These changes are shown net of a value-weighted index of patenting in the ten nations with the longest time series of application data.

while filings by domestic entities (whether in Great Britain or in the country undergoing the policy change) fell on an adjusted basis. (The fact that these changes began in the years before the policy change may reflect lags in the policy process. In many instances, changes were discussed for years before being implemented, and hence partially anticipated.) Around ambiguous or protection-reducing changes, the changes in filings were much more modest.

One concern with the analysis above was that it might be inappropriate to use the same index for each class of patent applications. For instance, the propensity of applicants to file foreign patents may have grown much more quickly than the tendency to file domestically. In this case, the adjustment process may lead to the growth of domestic patenting being understated, and that of foreign patenting being overstated. To address this concern, in an unreported analysis, I explored the robustness of these patterns to the use of alternative indexes based on just the same type of patenting. In other unreported analyses, I adjusted the composition of the countries in the indexes. The changes had a very modest impact on the analysis.

I analyze econometrically in Table 2 the adjusted growth in patenting in Great Britain by residents of the country undertaking the policy change. For independent variables, I employed dummy variables denoting whether the policy represented a patent protection–enhancing change and whether protection prior to the policy change was particularly strong, and their interaction. I used the length of patent protection to designate countries with particularly strong protection (those where patents extended 18 or more years from the application

TABLE 2—WEIGHTED LEAST SQUARES REGRESSION ANALYSIS

Dependent variable	*Change in UK applications, net of EW index*
Positive patent policy change?	598.53 (3.24)***
Strong protection prior to change?	86.93 (0.35)
Strong protection × positive change	−980.07 (3.34)***
Inception of conflict?	−332.82 (1.09)
Change in territory?	130.20 (0.43)
Applications two years before event	−0.13 (13.14)***
Population of nation	0.27 (0.29)
Dummies for policy change type	Included
Observations	159
F-statistic	23.14
p-value	0.000
Adjusted R^2	0.61

Notes: The dependent variable is the change in the number of patent applications filed by residents of the country undertaking the policy change in Great Britain from two years prior to the policy change to two years afterward, net of an equal-weighted (EW) index of patenting in the ten nations with the longest time series of application data. Each observation is weighted by the inverse of the standard deviation of the annual change in patent applications in Great Britain from 20 to 5 years before the policy change. Absolute *t*-statistics in parentheses.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

date). For controls, I used the type of policy change, the inception of a conflict on the territory of or a change in the boundaries of the nation during the event window, the number of patent applications filed two years before the policy change, and the population of the nation (in millions). I again weighted each observation by the inverse of the standard deviation of changes in patent applications during the estimation period. The dummy variable indicating a patent protection–enhancing policy shift was significantly positive, while the interaction was significantly negative. This suggests that enhancing patent protection was less effective when patent protection was already strong, consistent with Nancy T. Gallini (1992).

In unreported analyses, I addressed concerns that patent policy changes might not be exogenous by using as an instrument another dummy variable, which indicated whether the policy change took place in the aftermath of the Paris Convention of 1883 or the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement of 1993. The rationale for the use of this instrument was that these agreements compelled nations to make protection-enhancing changes to their patent systems. The results reported above continued to be robust when this instrumental variable was used.

III. Conclusions

This paper examined the impact of changes in patent policy on innovation. Rather than analyzing a single case, I studied 177 of the most significant shifts in patent policy across 60 countries and 150 years. Adjusting for the change in overall patenting, the impact of patent protection–enhancing shifts on applications by residents was actually negative, whether filings in Great Britain or domestically were considered.

The lack of a positive impact of strengthening of patent protection on innovation is a puzzling result. It runs not only against our intuition as economists that incentives affect behavior, but also counter to the findings in the "law and finance" literature that stronger property rights (e.g., those giving equity holders more prerogatives) encourage economic growth.

Three explanations can address this seeming paradox:

- The measures of innovative output are crude ones. Due to the broad scope and

long time frame of this analysis, I was required to use patent-based measures of innovation. The mapping between what I seek to measure (innovative activity) and the dependent variable in this analysis (patent applications) is not exact, though only examining the changes in patenting levels should limit this problem.

- The time frames may be too short. Other effects might have also been identified had I examined changes over longer event windows, since some of the policy changes could have taken more than five years to affect domestic innovation. In the short run, for instance, increased foreign investment may "crowd out" innovation by domestic entities. In the longer run, as the experiences of the Indian and Israeli information technology industries suggest, increases in foreign patenting and investment (Branstetter et al. 2006) may be an important channel through which domestic innovation is spurred.

- Despite these caveats, the failure of domestic patenting to respond to enhancements of patent protection, and the particularly weak effects seen in developing nations (in the unreported regressions), were quite striking. The impact of strengthened patent protection may simply be far less on innovative activities than much of the economics and policy literature assumes.

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