150 Years of Patent Protection

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The paper seeks to understand the impact of the patent system on innovation by examining shifts in the strength of patent protection across sixty countries and a 150-year period. An examination of 177 policy changes reveals that changes in protection had a much greater effect on patenting by foreigners than on that by domestic entities. In fact, strengthening patent protection appears to have few positive effects on patent applications by entities in the country undertaking the policy change, whether domestic patenting or that in a third country (Great Britain) is considered. Cross-sectional analyses suggest that the impact of patent protection-enhancing shifts were greater in nations with weaker initial protection and greater economic development, consistent with economic theory. I address concerns about the endogeneity of these changes by employing an instrumental variable approach.

1. Introduction

The impact of intellectual property rights on innovation is one of the most persistent empirical questions in the economics of technological change. In a memorable formulation, Penrose [1951] noted:

> If national patent laws did not exist, it would be difficult to make a conclusive case for introducing them; but the fact that they do exist shifts the burden of proof and it is equally difficult to make a really conclusive case for abolishing them.

Five decades later, a literature review by Jaffe [2000] reached a similar conclusion: "robust conclusions regarding the empirical consequences for technological innovation of changes in patent policy are few."

This paper addresses this question by examining the impact of the major patent policy shifts in sixty nations over the past 150 years. I examine the changes in patent applications around 177 policy shifts. In particular, I study the filings by domestic and foreign entities in the nation undertaking the policy change, as well as applications by residents of the nation in Great Britain. The policy shifts and their impact on patenting activity are determined from examinations of numerous guides to patenting activity, as well as the publications of the World Intellectual Property Office (WIPO) and the various national patent offices.

The basic patterns are striking. Patent protection-enhancing policy changes have a substantial impact on filings by foreign entities in the country undertaking the policy change. Once overall trends in patenting are adjusted for, however, the changes in

patenting by residents of the country undertaking the policy change are negative, both in the country itself and in Great Britain.

The extensive theoretical literature on patenting suggests at least three predictions about when strengthening patent policy should particularly boost innovation. To explore these suggestions, I examine cross-sectional differences across these events. Consistent with theoretical suggestions, I find that patent protection-enhancing shifts have a lesser impact on innovation when the nation already has strong patent protection and when its per capita gross domestic product lags further behind other nations. These patterns continue to hold when I employ an instrumental variables approach, which partially addresses the concern that the timing of these policy changes is not exogenous.

This paper takes a considerably different tack than earlier works on this question, which have largely focused on understanding the impacts of a single patent policy reform. Examples include studies of the broadening of Japanese patent scope (Sakakibara and Branstetter [2001]), the establishment of the Court of Appeals for the Federal Circuit in the United States (Kortum and Lerner [1998], Hall and Ziedonis [2001]), and the strengthening of patent protection of pharmaceuticals in Canada (McFetridge [1999]), India (Lanjouw [1998]), and Italy (Scherer and Weisburst [1995]). While the range of measures of innovation that I can employ are sharply reduced, by aggregating a large number of episodes I am able to greatly reduce the problem of confounding effects that individual case studies often face.

This paper is also related to works in the international trade literature, which have sought to relate indexes of intellectual property protection (such as those developed by Ginarte and Park [1997] and Rapp and Rozek [1990]) to the volume of trade or foreign direct investment. (This literature is reviewed in Maskus [2000].) Reflecting the nature of these indexes, these papers have typically examined these relationships at a single point in time or over a very short time period. As a result, these analyses have found it challenging to disentangle the causal relationships: *i.e.*, the possibility that countries could have greater intellectual property protection because they engage in more international trade, not *vice versa*.

The plan of this paper is as follows. The second section briefly reviews the theoretical work that motivates the analysis. I discuss the construction of the data set in Section 3. Section 4 presents the analysis. The final section concludes the paper.

2. Theoretical Perspectives

Much of the theoretical economics literature has assumed an unambiguous relationship between the strength of patent protection and the rate of innovation. To cite a few examples, in Gilbert and Shapiro [1990], Kamien and Schwartz [1974], Klemperer [1990], Tandon [1982], and Waterson [1990], an increase in the amount of patent protection offered unambiguously increases the rate of innovation. A crucial assumption behind such findings is that the nature of the patent award does not affect the incentives of subsequent researchers to pursue innovations.

This assumption has been relaxed in a line of work on sequential innovation, beginning with Scotchmer and Green [1990]. When the nature of protection offered the initial innovator affects the incentives of subsequent researchers, the conclusions may change. The effects of such an adjustment are perhaps most starkly illustrated by Bessen and Maskin [2000], who assume that a firm must be actively competing in the product market in order to introduce a next generation product. In this case, a strong patent award has the effect of precluding other firms from pursuing a subsequent innovation. They suggest that strong patent protection may actually lead to significantly less innovation than no patent protection at all.[1]

The models discussed above typically do not distinguish between patenting by domestic and foreign entities. But it is clear that the effects may be quite different. As discussed above, the impact of a change in patent protection on patenting by domestic entities may be quite positive or quite negative. For a typical foreign entity, which is likely to sell only a small fraction of its products in the country making the policy change, the impact of the policy shift on the decision to pursue an innovation will be

[1]In addition to the theoretical rationales suggested above, there could be several other reasons why enhanced patent protection could lead to a (temporary) decline in patenting. One possibility is a "crowding out" effect. Case studies suggest, for instance, that foreign pharmaceutical companies aggressively expanded their operations in countries that enhanced pharmaceutical patent protection. In some of these cases, the new entrants hired many local researchers away from basic research positions with local firms. Often, the foreign companies used the scientists for more applied roles (e.g., obtaining local regulatory approval for already-developed drugs). Since in many cases the local companies found it hard to replace these individuals, fewer domestic patents may have resulted. Alternatively, local companies may have initiated basic research programs after the policy change, but these may have taken many years to generate any patent filings.

much smaller. But the patent policy shift may influence the decision to pursue patent protection in that country. Even though an enhancement of patent protection is not likely to shift foreign firms' level of innovation, after such a policy change the companies may become much more likely to seek patent protection in that country for their inventions.

Theorists have also focused on the question of *when* strong patent protection is likely to have a powerful effect on innovation. Researchers have examined the impact of differences along two dimensions: the strength of the patent protection in the nation and the technological standing of the nation relative to other countries.

The strength of existing patent protection in the nation. Gallini [1992] considers the impact of increasing patent life when rivals can "invent around" previous discoveries (at some cost). When patent awards are short, her model predicts that increasing the length of a patent award will lead to innovators enjoying increased rewards, and hence to them having a greater incentive to innovate: stronger patents will lead to more innovation. But above a certain threshold, increasing patent length leads rivals to seek to imitate the patent. The losses from the increased imitation may more than offset the gains from the longer patent protection: when patents are already strong, increasing patent length further may actually depress the level of innovation. This insight is refined in a series of subsequent models, such as Cadot and Lippman [1995] and Horwitz and Lai [1996]. These models suggest that the relationship between patent length and innovation will display an "inverted U" shape: when the level of patent protection is initially weak, a

patent protection-enhancing policy change will encourage innovation. When the level is initially strong, such a change will discourage innovation.

The stage of the nation's development. Much of the economics research into the determinants of the optimal degree of patent protection has focused on the nation's stage of development. Initial analyses focused on a single-country setting. In the classic model of Nordhaus [1969], a policy-maker considered how to encourage an incremental (cost saving) innovation. The greater the degree of patent protection, he assumed, the greater the resources that a private firm will devote to pursuing the innovation and the greater the probability of a discovery (though the probability is declining with the amount spent on R&D). The analysis (see also Scherer [1972]) suggests that the impact of changes in patent protection on innovation will be determined by the curvature of the R&D cost function, which may be interpreted as the ease of further discovery for a given additional expenditure. In settings where relatively modest investments are likely to lead to substantial discoveries but progress beyond a certain point is much more costly—which Nordhaus suggests will characterize nations who are technological followers—the analysis suggests that increasing patent protection will have a limited impact on the pace of innovation. This insight has been corroborated in subsequent models that depict a world with both a developed and developing nation. A number of papers (e.g., Chin and Grossman [1990], Deardorff [1992], and Helpman [1993]) suggest that mechanistically transferring the intellectual property practices in place in the developed world to

developing countries is problematic. These works suggest that the spur to domestic innovation will be modest in these settings.[2]

It is also important to discuss the mapping between what I seek to measure (innovative activity) and the dependent variable in this analysis (patent applications). It has long been recognized (see the discussion, for instance, Griliches [1990]) that the mapping between patents and innovations is not exact: many important innovations are not patented, while some patents are awarded for very modest discoveries. While it would have been desirable to assess the importance of the patents through the analysis of patent citation and renewal data, this information was not available for most countries and time periods. It is worth emphasizing, however, that what I will be analyzing here is not the absolute level of patenting, but rather the changes in patenting associated with policy shifts. As long as the propensity to patent does not change, this measure will be a reasonable proxy for the shifting level of innovative activities. I also address this problem by examining not just patent applications filed by domestic and foreign entities in the country undergoing the policy change, but also activity in a third country.

3. Constructing the Data Set

In this section, I describe the process by which the data set was created. Because of the diversity of sources employed (a number of which have not been previously employed in economic research), I discuss this aspect of the research at some length.

[2]Diwan and Rodrik [1991], however, show that if the developing country has a need for innovations that differ from that of the developed nation, strong intellectual property protection may be desirable. Otherwise, it may not be able to induce the developed nation to undertake innovations in this area.

A. Defining the Sample

I employed as my sample the sixty countries listed in the International Monetary Fund's *International Financial Statistics* [1999] with the highest total gross domestic product (GDP) in 1997.[3] This included many nations that experienced considerable economic growth, but also others (e.g., Argentina, Iraq) that underwent substantial reversals.

I included these firms in the sample back until 1850 or until the country ceased to be an independent political entity, whichever came later. My rationale for this approach was that most colonies did not have independent patent policies. Most did not grant patents at all: they simply registered patents granted by their colonial overseer without any formal review. If the colonies had patent systems, they usually closely mirrored those of their colonizers. As a result of these omissions, this sample is not balanced: the number of observations increased over time, as more nations became independent.[4]

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[3]In undertaking these rankings, if the country was missing GDP data for 1997, I used the GDP and exchange rate for the most recent year for which such data were available (inflation-adjusting the result to insure comparability). In one case (Iraq), the volume had no data for the past five years. In this case, a consensus estimate from press accounts was used. In the second case (Taiwan), a country was not listed owing to questions about its political status. In this case, data were obtained from government publications.

[4]Determining what constituted an independent country was not always a simple matter. In some cases, colonies underwent prolonged independence struggles, while in other cases, countries enjoyed a great deal of independence while under the official control or informal influence of another nation. In general, I sought to include a nation from the date that its independence was declared (conditional on its eventually becoming a widely recognized country). In cases where a country was divided into several political entities, I used the patent policy (and other characteristics discussed below) from the most economically significant portion.

B. Identifying Patent Policies

I then identified the features of the patent system at 25-year intervals. I determined this information as of mid-year 1850, 1875, 1900, 1925, 1950, 1975, and 1999. In doing so, I relied on guidebooks to the world patent systems. These handbooks—typically prepared for the use of inventors by patent lawyers and agents—have been published frequently since the early nineteenth century. In each case, I was able to identify at least five information sources published within five years of the seven dates at which I sought to characterize the patent system. While not all information was available in all years for all nations (particularly data on patent fees), I was able to construct a variety of reasonably comprehensive measures.

Tables 1 through 4 summarize the key aspects of patent protection. The first, crudest measure was whether the country had a patent system at all. While by 1999, 59 out of the 60 largest countries had patent protection, during the nineteenth and early twentieth centuries patent systems were far from universal. A related set of measures, also reported in Table 1, characterized the range of subjects for which patent protection could be obtained. I focused on a number of representative areas where considerable diversity existed. In each case, these were coded using a tri-partite scheme, indicating whether no protection was allowed, whether some protection was allowed but less than that offered other inventions, or whether full protection was extended to these classes. A variety of other special restrictions were denoted by lower-case footnotes.

A second category was the duration of the patent grant. Table 2 reports the duration of patents awarded to domestic applicants, as well as the date when the award began (e.g., from the application or award date). In some cases, patent officials could lengthen the duration of patents deemed to be important: these instances were noted. In other cases, certain classes of patents, such as those involving pharmaceuticals, had shorter or longer protection periods (noted as well). In each instance, I did not include cases where the patent extension was conditional on the renouncement of important rights: e.g., where extensions were granted only when the patentee agreed to make the award generally available for licensing.

The third table reports the cost of the patent. The fee was calculated based on the patent grant of the longest duration, without any provision for extraordinary extensions. Some countries applied surcharges for particularly lengthy patent applications, ones with numerous illustrations, or for the privilege of having the review process expedited or kept secret. I assumed that the patent was a short application without these extra features. I also assumed that the patent was awarded for the entire country (*i.e.*, I ignored provisions for discounts for patentees who only wanted an award for a particular region, such as were offered British patentees prior to 1852). The table presents the value of the payments, discounted back to the date of the original patent application using the U.S. 10-year treasury yield (or an estimated yield of government bonds in earlier years), and expressed in 1998 U.S. dollars.[5]

[5]This calculation presented a number of issues. The first was determining the period between the patent application and the award for the countries that based the award length (and the dates that payments were due) on the award date. In making the computations, for 1950 and afterwards, I assumed that awards occurred two years after

The fourth table reports several limitations on patent awards. Probably most important are provisions that patents could be revoked or compulsorily licensed if they were not reduced to practice ("worked") in a set period. The table presents the period in which domestic patentees had to work patents. Occasionally, when patentees could choose patents of different lengths, the minimum period in which the patent had to be worked differed. I recorded the working period for the patent of the longest duration (without any provision for extensions due to extraordinary circumstances). The table also reports a number of other restrictions on patent rights. In some cases, the government could declare patents invalid or force compulsory licensing for reasons other than non-working. These restrictions were recorded as being true in no, some,[6] or all cases. Other limitations were whether the awards limited the patentees' ability to prosecute prior users of the patented technology or to collect damages from infringers beyond a set amount.

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the application date (one year after publication date). Between 1900 and 1949, I assumed awards occurred one year after the application date (and publication date). Before 1900, I assumed awards occurred only a nominal period after application. The patent fees were converted into U.S. dollars using the exchange rate current at the time (found in such sources as Board of Governors [1943], Global Financial Data [1999], and Schneider, Schwarzer, and Zellfelder [1991-97]), and then converted into 1998 dollars using the U.S. GDP deflator (back to 1889) or the U.S. consumer price index (for earlier years).

[6]In some cases, certain classes of patents were explicitly exempted from compulsory licensing or revocation. (I did not include instances where general terms are used, such as when licensing was restricted to when it was "in the public interest"). Since virtually all countries had provisions for the government to compulsorily license for its own use patents for national defense on an emergency basis, I did not include these provisions.

C. Finding Patent Policy Shifts

These tabulations allowed me to identify cases where nations had changed their patent policies. In order to undertake the analyses below, however, I needed to determine the exact dates of the policy changes.

To determine this information, I examined publications of the British Patent Office (*Commissioners of Patents' Journal*), the Patent Office Society (*Journal of the Patent Office Society* and related titles), the publisher Trade Activities (*Patent and Trade Mark Review*), and the WIPO (*Industrial Property* and *La Propriete Industrielle*). These publications summarized contemporary policy changes across many nations. But many changes were not discussed, or the summaries were contradictory. In order to resolve these ambiguities, I reviewed the legal monographs on individual nations' patent systems. These volumes were found in the collections of Harvard University and the Max Planck Institute for Foreign and International Patent, Copyright and Competition Law.

Four principles guided my selection of events to include in the analysis. First, I wished to focus on episodes where the government consciously set out to shift its patent policy. I consequentially eliminated policy changes that occurred within five years of the establishment of a nation, its restoration after a period of being a part of another state, or a revolution that involved a change of the form of government. I also excluded measures that were designated as temporary measures during a time of war.

Second, I wanted to be sure that the included changes were substantive shifts in patent policy. I consequentially did not include the shifts in idiosyncratic policies denoted with lower-case footnotes in Tables 1 through 4, nor the provisions regarding patent life extensions (which often appear to have been rarely invoked). A special challenge was posed by changes in patent costs: many nations adjusted their costs on a periodic basis, often to keep up with inflation. In order to insure that I just identified real policy shifts, I only included changes in the cost of patents if they entailed at least a 100% increase or a 50% decrease in patent cost.[7]

Third, I wanted to be sure that the events were precisely dated. I thus eliminated changes where I could not determine the year of the policy shift. For instance, some nations during the nineteenth century simply began issuing patents on chemicals, even though legislation remained on the books for many years thereafter indicating that these subjects were not patentable. Because it was exceedingly difficult to identify changes in compulsory licensing, prior user, and revocation policies, I did not include most of these events in the analysis.

[7]In many cases, countries raised the price of a patent dramatically after a period of hyperinflation, but the change returned the real fee back to what it was before the inflationary episode. These changes did not appear to be real policy shifts. I eliminated changes that followed periods of hyper-inflation or deflation (*i.e.*, cases where the currency depreciated by 100% against the dollar or depreciated by 50%) unless the new cost of the patent was less than half or more than double the cost before the period in real terms.

Finally, I wanted to compare the reactions to the policy changes by domestic and foreign entities. I thus eliminated policy changes that happened at the same time that discriminatory provisions against foreign applicants were either imposed or relaxed.

In total, I ended up with 177 events in 51 out of the 60 nations in the sample. The first change in the sample occurred in 1852 and the last in 1998. In many cases, the policy shift affected several elements of the patent system, or two closely related bills were passed in the same year. Consequentially, the number of distinct policy changes was larger, a total of 271.

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 figure makes clear that there have been five waves of patent policy changes since 1850:

- The first period, in the 1850s and 1860s, was triggered by the "Patent Controversy." Questioning the value of patent protection, many nations considered abolishing patents, and a number weakened aspects of their systems.

- The second wave, from the mid 1880s to the early 1890s, followed the adoption of the Paris Convention of 1883 (and the important amendments adopted at Rome in 1886 and Madrid in 1890-1891). This convention established minimum standards for treating patent applicants from other nations, and triggered a number of nations to strengthen their patent systems.

- The third, in the 1920s, was largely driven by the European nations, who took numerous steps to insure that patent protection would be more consistent across the various nations.

- The fourth wave, from the late 1960s to the mid 1970s, was characterized by two types of changes: initiatives by developing nations to scale back the protection offered patentees and continued integration of the European system.

- The fifth, during the 1990s, saw nations strengthening their patent systems as a response to the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs), signed as part of the Uruguay Round of the General Agreement on Tariffs and Trade in 1993.

The interested reader is referred to Ladas [1975], Penrose [1951], and Wegner [1993] for detailed accounts of these changes.

D. Identifying Patenting around the Policy Shifts

The next phase was to determine the patent applications filed around the time of the policy changes. I identified three distinct measures of activity: patent applications by domestic entities in the country undertaking the policy change, applications by foreign entities in that country, and patent filings by residents of the country undertaking the policy change in Great Britain. I chose Great Britain because its patent office has consistently tabulated the national identity of the patent applicants since 1884 (except during the years of World War I). In these tabulations, I sought to only include traditional patent awards, eliminating various weaker variants that nations have sometimes also offered to inventors. These included design patents, inventors' certificates, patents of addition, plant patents, and utility model patents.

I identified this information from a variety of sources. The WIPO has tabulated these filings since 1962 in *La Propriete Industrielle* and (subsequently) *Industrial Property*, and Great Britain has reported filings in the *Annual Report of the Comptroller General*. WIPO has also compiled older data in *100 Years Protection of Industrial*

Property [1983]. Unfortunately, the data were in some cases inaccurate. In particular, during the early years of the European Patent Office, filings through the central office were not always properly credited to the individual countries selected. I corrected the data through an examination of the databases and publications of the European Patent Office and Organisation for Economic Co-operation and Development.

More problematic was the fact that the data were quite incomplete. In many cases, the WIPO publications did not present any information on applications prior to 1960, or failed to divide the applications between domestic and foreign filings. (While a few other compilations exist, such as Federico [1964], they were largely based on WIPO data and had similar failings.) Thus, I was forced to turn to publications of the various national patent offices to compile this information. I found the volumes in the Science Reference Library (formerly the Patent Office Library) of the British Library. This collection has had a policy of acquiring all patent office publications since its formation in the 1850s. The publications that contained the necessary data were identified through Rimmer and van Dulken [1992] and consultations with the reference librarian.

The data in the national publications were sometimes inconsistent. In some cases, the tabulations employed a different interval than the calendar year that I sought to use throughout. In these cases, I used the reporting year that corresponded most closely to the calendar year of interest. In other cases, certain other patent awards (e.g., utility model awards) were included in the total count of patent applications. I used the data as

long as additional awards did not appear to constitute more than 10% of the patent applications in the total.[8]

I sought to collect the data for "event window" from five years before to five years after the policy change. In all, I was able to identify data on domestic and foreign patent filings in the country for 145 of the 177 event windows, and British application data for 171. (In some cases, the information was insufficient to compute the changes from two years before the policy change to two years afterwards, as analyzed below.) I also collected similar data for the "estimation period" from twenty to five years prior to the event.

E. Supplemental Data

I also collected a variety of additional information about the countries at the time of the shifts. This information was drawn from a wide variety of sources, but most important were Banks [1999], International Monetary Fund [1999], Maddison [1995], and Mitchell [1998]. The variables employed in this analysis included:

- Population of the country.
- Per capita gross domestic product. The variable was converted into current U.S. dollars using, if possible, a purchasing power parity-based deflator. It was then

[8]In certain cases in the nineteenth and early twentieth century, nations reported the breakdown of the nationality of their patent awards, but just the number (not the breakdown) of applications. In many instances, a large fraction of applications were accepted, making it possible to impute the breakdown of applications quite accurately. In these cases, if the number of applications and awards (lagged one year) were within 25% of each other, I used the data at hand to impute the number of applications. In particular, I assumed that the applications in a given year were divided proportionately to the awards in the subsequent year.

converted into 1998 dollars using the U.S. GDP deflator (back to 1889) or the U.S. consumer price index (for earlier years).

- The coincidence of the event window and a change in either the country's national borders (representing either at least 10% of its surface area or population) or a war within the territory of the country (lasting at least three months and affecting at least 10% of the nation's territory). These indicators were coded as +1 if there was a war in progress at the end of the period that was not present at the beginning or an expansion of territory. They were coded as –1 if there was a war in progress at the beginning of the period and not at the end or a contraction of territory.[9]

I sought to match the dates of these measures as closely as possible to the patent policy change, typically using the same calendar year. For the nineteenth century, however, I relaxed these requirements: I employed an observation as long as it was within five years of the patent policy change. This was particularly true of the estimates of gross domestic product, which were frequently only periodically available.

4. Analysis of Patent Protection

A. Summary Statistics

I began by simply summarizing the changing level of patent applications in the years before and after the policy shift. Panel A of Table 5 reports the changes in patent applications filed from two years before to two years after the policy shift. In order to

[9]In the tabulations in Table 8 and some unreported regressions, I also used some additional control variables. The manner in which the effective ruler responsible for day-to-day governance of the country was selected (direct election, indirect election, or non-elective) was primarily determined through Banks [1999]. From this source, I also determined whether the legislature was selected through an elective process, a ranking of the effectiveness of the legislative body, and the mixture between agricultural, industrial, and services employment. I determined the family into which the nation's commercial laws fell from La Porta, Lopez-de-Silanes, Shleifer, and Vishny [1999]. I made two adjustments that reflected the panel nature of my data set. First, many legal systems classified by the authors as communist previously were based in another legal tradition. In the observations before the communist take-over, the countries were so classified. Second, some countries originally had legal systems that were quite distinct from any of the major families. These cases were lumped together in an "other" category.

enhance the sample size, when the necessary observation was missing, I substituted data from either three years before or after the change or one year before or after.

I divided the observations by the type of policy change. Most shifts (64%) unambiguously increased patent protection. The remainder either unambiguously reduced patent protection (24%) or else contained both protection-enhancing and detracting elements (12%). In view of the small sample sizes, I treated the ambiguous and negative changes together in the reported analysis. (In unreported univariate and regression analyses, I undertook the same analyses without the ambiguous cases. The results were little changed.)

Domestic and foreign patent applications both 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 number of domestic, foreign, and British patent applications during the year of the policy change were 13,296, 14,118, and 739 respectively.) No evidence appeared of a rise in British patent applications.

Panel A does not, however, control for changes in the overall propensity to seek patent protection over the period. In event studies of stock price returns, it is standard to present returns net of an appropriate market index. I similarly sought to control for the changing global patenting trends. 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.

To control for the changing patenting environment, I computed the "adjusted" difference: the difference in the number of patent applications filed in this 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 in other countries, I constructed an index using the ten nations with the longest time series of patent application data. These 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.[10]

[10]It might be wondered why I did not examine the percentage change in the number of applications filed. In some cases, countries had a very small number of applications before a policy change. Even a modest rise in the number of filings thus led to a huge percentage jump in applications. While the same patterns appear in the percentage tabulations, the presence of such extreme cases made the comparisons very noisy.

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 domestic filings or those in the United Kingdom were considered. The response of foreign patenting was much more modest in magnitude in the case of protection-reducing and ambiguous changes. The table also reports similar tabulations for the three most frequently encountered classes of changes: enhancements to the subject matter covered by patent protection or the scope of protection (56% of 177 events involved such a change), the length of patent protection (50%), and the length of the working period (21%).

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 Brown and 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 twenty years to five years prior to the policy shift. I weighted both the t-tests and the regression analyses by the inverse of the standard deviation.[11] The changes around the time of protection-enhancing policy shifts proved to be significant.

[11]I undertook separate calculations when examining domestic, foreign, and British applications. When I was unable to find data on patent applications in the estimation

Panel D formally tests whether the reaction of foreign patent applications in the country undertaking the policy change was significantly different from domestic applications. The differences were significant for the patent protection-enhancing policy changes, but not for the ambiguous or protection-reducing ones. The differences were also significant for two of the three subclasses of changes that I considered. The differences continued to be significant when I added controls for confounding events that occurred at the same time, the population of the nation, and the presence of discriminatory provisions against foreign patentees.[12]

Figures 2 and 3 depict graphically the average changes in patent applications around protection-enhancing and other patent policy changes, net of the value-weighted index. Around protection-enhancing changes, the same striking pattern appeared: patent application by foreign entities increased dramatically, while filings by domestic entities (whether in the country undergoing the policy change or in Great Britain) fell on an adjusted basis.[13] The pattern was much more muted in the case of the ambiguous or

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period, or if the nation did not extend patent protection during this period, I assigned the observation a weight equal to that of the median event. Brown and Warner [1980] also suggest more complex ways to compute these weights, which correct for the cross-sectional correlation of changes in the estimation period. To introduce such refinements, I would have had to undertake much greater data collection on patenting outside the event windows. In light of the time and expense of this effort, I did not pursue these suggestions.

[12]Such discriminatory provisions included granting foreign patentees a shorter patent award and requiring them to pay higher fees.

[13]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 at least partially anticipated. In a number of cases, in fact, there

patent protection-reducing changes. Domestic filings changed little and the growth of foreign patenting was much more modest.

One concern with the above analysis 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 overstated.

To address this concern, in an unreported analysis I explored the robustness of these patterns to the use of an alternative index based on just the same type of patenting. In other words, instead of using the index based on all applications in the ten countries to adjust the number of applications, I employed an index based on domestic filings in the ten nations to adjust the domestic filings, and so forth. The change had a very modest impact on the analysis. In some countries, such as the United States, the ratio of domestic to foreign filings fell sharply over the twentieth century. But in others, such as Japan, this ratio rose considerably. Thus, the effects of the change were small. For instance, in the case of patent protection-enhancing changes, the differences in domestic and British patenting remained negative and the foreign patenting difference remained positive. These shifts continued to be statistically significant, at least at the 10% confidence level.

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was a significant lag between the decision to change the policy and its actual implementation.

In other unreported analyses, I adjusted the composition of the countries in the indexes. For instance, I was concerned that since many of the nations undertaking policy changes were developing ones, the index might be distorted by the presence of the most developed nations. I recomputed the index, restricting it at all times to nations whose per capita gross domestic product was below 75% of that of the wealthiest nation. The results were little changed.

B. Regression Analyses

The univariate analysis discussed in the previous section suggested that patent applications originating in the nation undertaking a patent policy shift (whether filed domestically or in Great Britain) did not increase significantly in response to policy changes. But the cross-sectional differences in the sample may nonetheless be of interest.

The theoretical literature discussed in Section 2 offered a number of predictions about when strengthened patent policy should be most efficacious in spurring innovation. In particular, it suggested that protection-enhancing changes would have less impact when patent protection was already strong, would have more of an effect when protection was weak, and would be less effective when countries were far behind the technological frontier. This section examines these suggestions.

Following the finance event study literature, I estimated regressions in which the "adjusted" growth in patenting by residents of the country undertaking the policy change was the dependent variable. (I considered both patenting in the country undertaking the

change and in Great Britain.) As independent variables, I employed a dummy variable denoting whether the policy represented a patent protection-enhancing change and one of three alternatives: a dummy denoting whether protection prior to the policy change was particularly strong, a dummy denoting whether protection was particularly weak, and the per capita GDP of the country relative to that of the wealthiest nation at that time. In the reported regressions, I used the length of patent protection to designate countries with particularly strong (those where patents extended eighteen or more years from the application date) or weak (those where patent life was ten years from the application date or less) protection. Of greatest interest was the interaction of the positive change measure with the three additional variables.

I also employed a variety of control variables. These included 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 analysis of patent applications in the country undertaking the policy change, reported in Table 6, was quite disappointing. The only significant variables were two control variables. Policy changes in larger countries tended to lead to a greater growth in patenting, which was not surprising in light of the fact that most changes were patent protection-enhancing. The size of the reaction declined with the number of the patent

applications at the beginning of the event period, consistent with suggestions that there may be diminishing returns to patenting (Griliches [1990]).

Table 7, which examines patenting by the residents of the country undertaking the patent policy change in Great Britain, was more interesting. The dummy variable indicating a patent protection-enhancing policy shift was not significantly positive on a consistent basis. But in two out of three cases, the interaction term took on the predicted sign and was significant at the 5% confidence level. In the first and second regressions, the interaction between the dummy variable denoting strong patent protection prior to the policy change and that denoting a protection-enhancing change was significantly negative. In the fourth regression, the interaction between the relative GDP measure and a protection-enhancing change was significantly positive. This suggests that enhancing patent protection was less effective when patent protection was already strong and in poorer countries. For instance, in a country whose per capita GDP was three-quarters of the richest nation, a patent policy-enhancing change stimulated 636 additional British patent applications than an ambiguous or negative change. In a country whose per capita GDP was about one-quarter of that of the richest nation, such a change generated no additional patents.

In supplemental unreported analyses, I explored the robustness of these results. The use of longer event windows made little difference, as did adding more detailed controls for the nature of the policy change, the employment mixture of the country, its political system, or its legal family. I also explored the robustness of the results to

employing an alternative definition of the initial strength or weakness of patent protection. I used a measure based on the presence or absence of restrictive provisions on patent holder rights (e.g., compulsory licensing provisions, prior user rights, provisions allowing the government to revoke patents at its discretion, working periods of under three years). Again, patent protection-enhancing changes had significantly less of an impact on patent applications filed in Britain from countries that already had strong protection. I also employed the alternative indexes discussed in the previous section to adjust the change in patent applications and estimated Heckman sample selection regressions, which controlled for the fact that data were missing for some policy changes. The results were little changed.

C. Addressing Concerns about Causality

One concern with the above analysis was that patent policy changes might not be exogenous. For instance, a nation may enhance patent protection at times when its domestic industry is becoming particularly innovative. While the same concern has not deterred academics from pursuing hundreds, if not thousands, of event studies using stock price data (see, for instance, the discussion in Eckbo, Maksimovic, and Williams [1990]), I can at least partially address this issue by exploiting the history of the patent policy.

In order to address endogeneity problems, a standard approach is to identify an instrumental variable. Such a variable ought to be positively correlated with the explanatory variable of interest, but not correlated with the potentially confounding factor. I sought an instrument for the measure of whether the patent policy change was a positive one or not.

I used 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 TRIPs agreement of 1993.[14] The rationale for the use of this instrument was that these agreements compelled nations to make protection-enhancing changes to their patent systems. This measure had a strong positive correlation with the indicator of protection-enhancing policy changes. Fully 90% of the policy changes in these years were protection enhancing, as opposed to 57% in other periods, a difference significant at the one percent confidence level. But because the impetus to adopt these changes was largely exogenous to the country, the endogeneity problem should be reduced. (Of course, some nations, such as Ecuador in the 1885, chose to resign from the International Union rather than make the required changes, or did not join the Union in the first place.)

Helping underscore the reasonableness of this instrument was that fact that the initial patent policies of many nations were quite diverse, and influenced by many factors other than economic considerations. Case studies of patent policy make clear that many of the aspects of patent policy were determined by a diverse array of actors with very narrow agendas in mind.[15]

[14]I defined the aftermath as the years 1883 to 1893 and 1992 to 1998 (the end of the sample). I included 1992, even though the agreement was signed in 1993, because a detailed draft of the TRIPs agreement was released in December 1991 (Wegner [1993]).

[15]To cite one example, Walterscheid [1995] documents how the decision by the U.S. Congress to introduce a unique way of resolving the priority of patent applicants in the Patent Act of 1793 (many elements of which continue to this day) was driven by the lobbying by James Rumsey and John Fitch, who were locked in a dispute over the ownership of the rights to riverboat engine technology.

More generally, Table 8 gives an indication of the diverse factors that influenced the initial allocation of patent policies. While patent policies today are increasingly homogeneous, a variety of factors contributed to differences in previous years. Some of these, to be sure, were economic in nature: relatively wealthier countries were more likely to offer patent protection. But many others are not. More democratic countries—those with elected heads and legislatures, as well as with more effective legislative bodies—were more likely to have a patent system and to extend protection for longer periods. In addition, a number of differences across legal families were significant. Civil law countries were more likely to offer patent protection, while those not in the major legal families were much less likely to do so. Common law countries typically allowed considerably longer to put patents into practice, while civil law counties required working in significantly less time. In unreported regression analyses, these patterns remained largely robust to the addition of other control variables.

The results reported above continued to be robust when this instrumental variable was used. Table 9 presents two representative regressions each from Tables 6 and 7, with the reform period dummy now used as an instrument for the protection-enhancing dummy. The results discussed above continued to hold: for instance, the interaction between positive changes and strong protection was again significantly negative in the British applications regression.

5. Conclusions

This paper examined the impact of changes in patent policy on innovation. Rather than analyzing a single case study, I studied 177 of the most significant shifts in patent policy across sixty countries and 150 years. I found that the effects of patent policy shifts were far greater for foreign entities than for residents of the country undertaking the policy change. In fact, adjusting for the change in overall patenting, the impact of patent protection-enhancing shifts on applications by residents was actually negative, whether domestic filings or those in Great Britain were considered. The cross-sectional differences in the impact of these shifts were largely consistent with the predictions of economic theorists.

This analysis had two limitations, which suggest the need for further research. The first of these is to understand the interaction between patenting and other forms of technology policy. As highlighted in papers by Kremer [1998], Shavell and van Ypersele [1999], and Wright [1983], in a number of historical instances nations have offered prizes or recognitions to discoverers of important inventions. To what extent did these or other policy tools—such as trade secrecy and government subsidies and procurement—change at the same time as shifts in patent policy? On a related note, did shifts in judicial doctrine mirror those in statutory protection, or serve to dampen their impact?

The second limitation relates to the crudeness of my measures of innovative output. Due to the broad scope and long time frame of this analysis, I was required to use three patent-based measures of innovation. In an ideal world, I would have been able to

examine a wide variety of measures, including R&D spending, total factor productivity growth, and counts of innovations. 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 impact innovation. (Of course, the noisiness of the measures would have also increased substantially.) Despite these caveats, the failure of domestic patenting to respond to enhancements of patent protection, and the particularly weak effects seen in developing nations, were quite striking.

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Figure 1. Number of changes in patent policy over time. The sample consists of the sixty largest countries (by gross domestic product) 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 that of distinct policy shifts, in each decade, normalized by the number of active countries in the sample at the beginning of the decade.

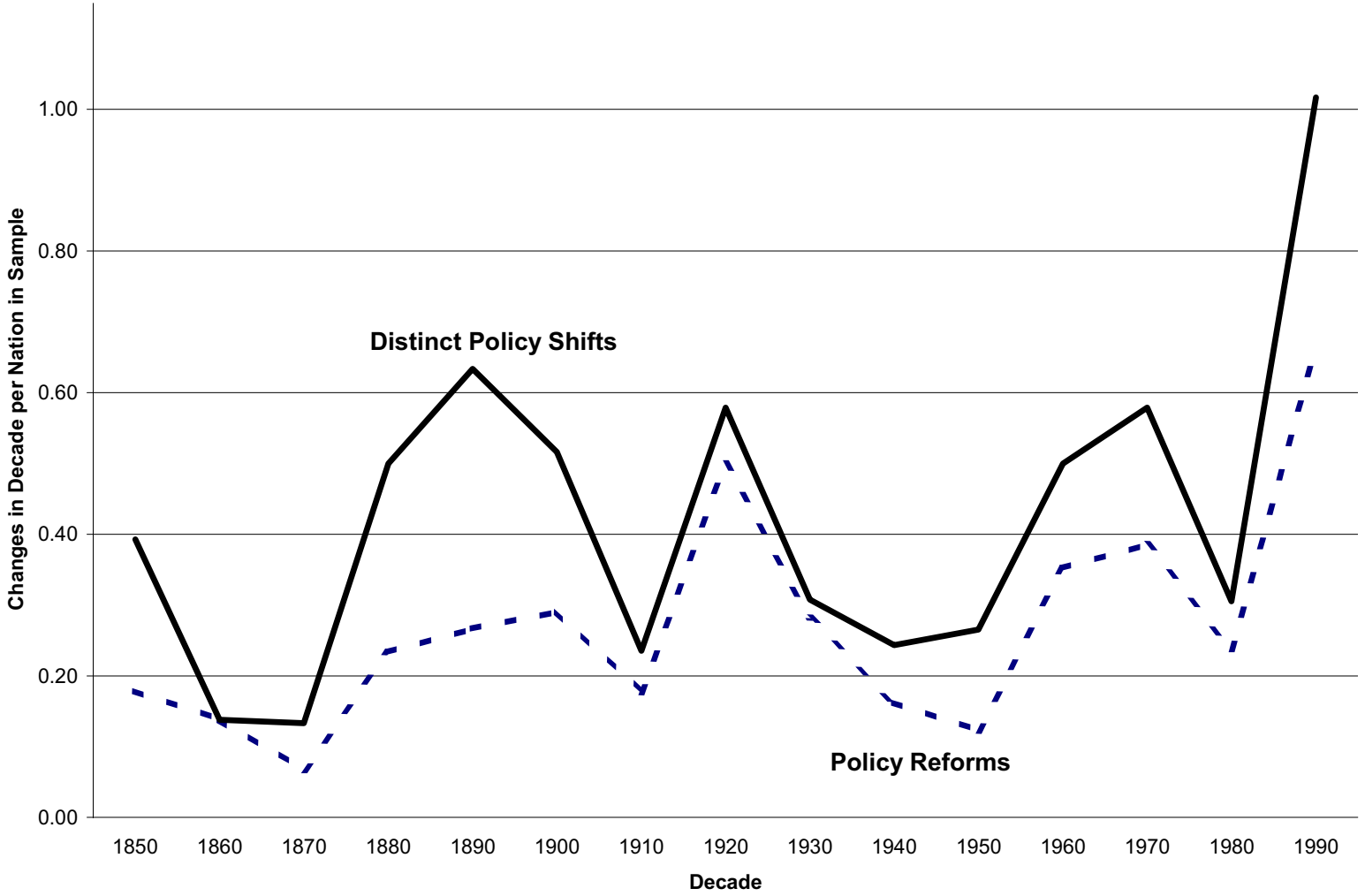

Figure 2. Patenting changes around the time of patent protection-enhancing policy changes. The sample consists of 177 changes in patent policy between 1852 and 1998 in the sixty largest countries (by gross domestic product) at the end of 1997. The figure displays the change in the number of patent applications 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.

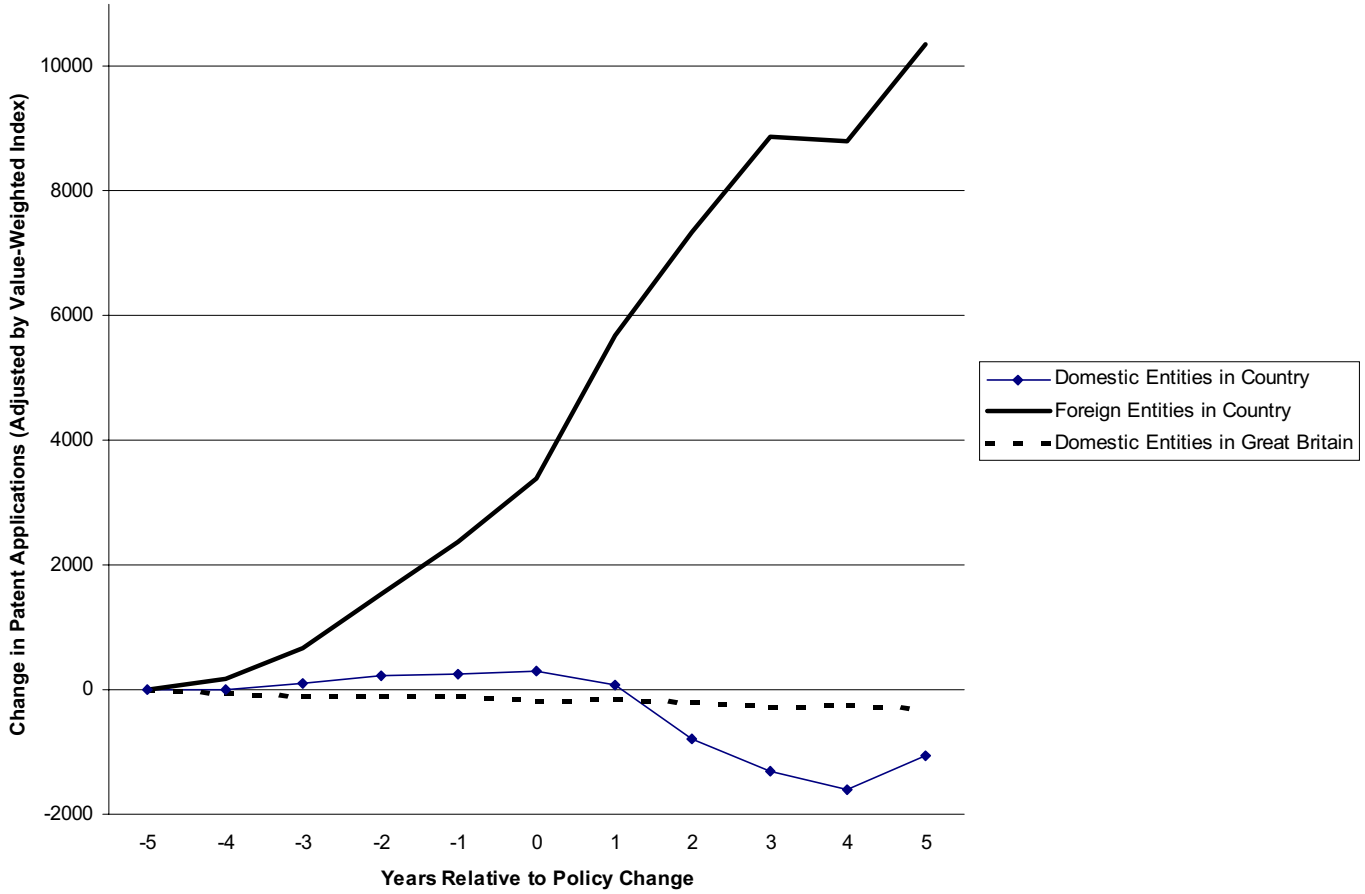

Figure 3. Patenting changes around the time of patent protection-reducing or ambiguous policy changes. The sample consists of 177 changes in patent policy between 1852 and 1998 in the sixty largest countries (by gross domestic product) at the end of 1997. The figure displays the change in the number 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.

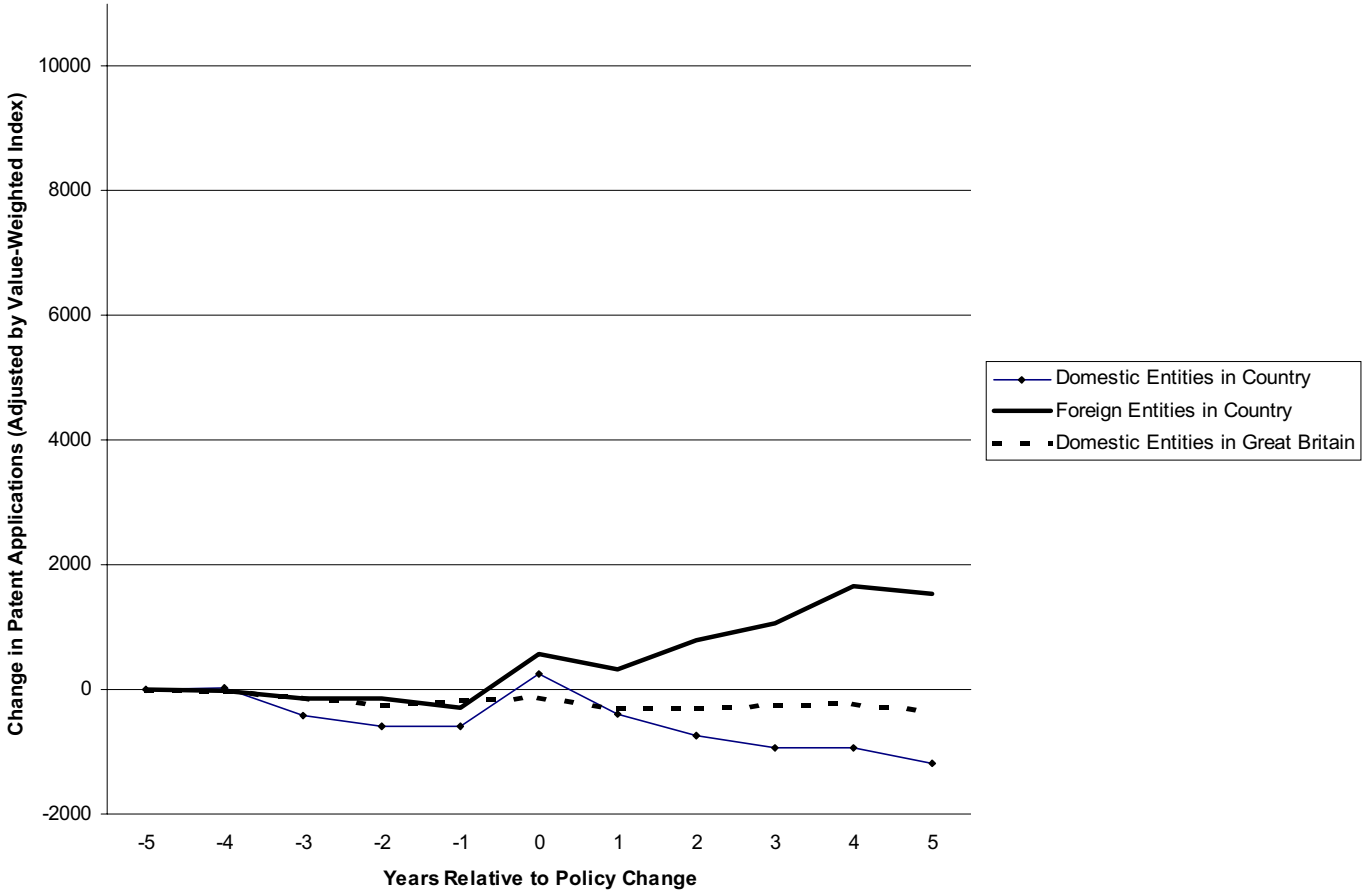

Table 1. The presence of patent protection. The sample consists of the sixty largest countries (by gross domestic product) at the end of 1997, observed at 25-year intervals from 1850 to 1999. The table denotes whether the given country had patent protection at the beginning of a given year ("Y" denotes cases where such protection existed, "N" cases where it did not, and "R" that the country automatically recognized patents granted by another country, also noted). The footnotes denote whether patent protection was available in whole or part for a number of important technologies. Observations where the country was not an independent entity are filled in.

	1850	*1875*	*1900*	*1925*	*1950*	*1975*	*1999*
Algeria						$Y^{CC,FF,MM,a}$	$Y^{CC,FF,MM,a}$
Argentina	N	$Y^{CC,FF}$	$Y^{CC,FF}$	$Y^{CC,FF}$	$Y^{CC,FF,M}$	$Y^{CC,FF,M}$	$Y^{CC,FF,MM,P}$
Australia				$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM,P}$
Austria	$Y^{CC,FF}$	Y^{CC}	$Y^{C,F,M}$	$Y^{C,F,M}$	$Y^{C,F,M}$	$Y^{CC,F,M}$	$Y^{CC,FF,M,PP}$
Bangladesh						$Y^{C,FF,M}$	$Y^{C,FF,M}$
Belgium	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,M}$	$Y^{CC,FF,MM,PP}$	$Y^{CC,FF,MM.PP}$
Brazil	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{C,F,M}$	Y^{C}	$Y^{CC,FF,MM}$
Canada		$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,F,M}$	$Y^{C,F,M}$	$Y^{CC,FF,MM,P}$
Chile	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,M}$	$Y^{C,F,M}$	Y^{C}	$Y^{CC,FF}$
China	N	N	N	N	N	N	$Y^{CC,FF,MM,P}$
Columbia	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,F,M}$	$Y^{CC,FF,M}$	$Y^{CC,FF,M}$
Czech Republic				$Y^{C,FF,PP}$	$Y^{C,F,M,PP}$	Y	$Y^{CC,FF,MM}$
Denmark	N	$Y^{CC,FF,MM}$	Y^{CC}	Y^{CC}	$Y^{C,M}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$
Egypt						$Y^{CC,F,M}$	$Y^{CC,FF,M}$
Finland				$Y^{C,F,M}$	$Y^{C,F,M}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$
France	$Y^{CC,FF}$	$Y^{CC,FF}$	$Y^{CC,FF}$	$Y^{CC,FF,M}$	$Y^{CC,FF,M}$	$Y^{CC,FF,M,PP}$	$Y^{CC,FF,MM.PP}$
Germany	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	Y^{C}	$Y^{C,F,M}$	$Y^{C,F,M}$	$Y^{C,FF,M,PP}$	$Y^{C,FF,M.PP}$
Greece	N	N	N	$Y^{CC,FF,MM}$	$Y^{CC,FF,M}$	$Y^{CC,FF,M}$	$Y^{CC,FF,MM}$
Hungary				$Y^{C,F,M,PP}$	$Y^{C,F,M,PP}$	$Y^{C,F,M,PP}$	$Y^{CC,FF,MM,PP}$
India					$Y^{C,F,M}$	$Y^{C,F,M}$	$Y^{C,F,M}$
Indonesia					N	N	$Y^{CC,FF,MM}$
Iran	N	N	N	N	$Y^{CC,FF,M}$	$Y^{CC,FF,M}$	$Y^{CC,FF,M}$
Iraq					$Y^{CC,FF}$	$Y^{CC,FF,M}$	$Y^{CC,FF,M}$
Ireland				N	$Y^{C,F,M}$	$Y^{CC,F,M}$	$Y^{CC,FF,MM}$
Israel					$Y^{CC,FF,MM}$	$Y^{CC,FF}$	$Y^{CC,FF,MM.P}$
Italy	$Y^{CC,FF,MM}$	$Y^{CC,FF}$	$Y^{CC,FF}$	$Y^{CC,FF}$	$Y^{CC,FF,PP}$	$Y^{CC,FF,P}$	$Y^{CC,FF,MM.P}$
Japan	N	N	Y^{CC}	Y	Y	Y	$Y^{CC,FF,MM,PP}$
Kuwait						$Y^{CC,F,M}$	$Y^{CC,FF,M,SS}$
Libya						$Y^{CC,FF,MM}$	$Y^{CC,FF,M}$
Malaysia						R—UK	$Y^{CC,FF,MM}$
Mexico	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{C,FF,MM}$	$Y^{C,FF,M}$	$Y^{C,FF,MM}$	$Y^{CC,FF,MM.P}$
Morocco						$Y^{CC,FF,M}$	$Y^{CC,FF,M,SS}$
Myanmar					R—India	N	N
Netherlands	$Y^{CC,FF,MM,b}$	N	N	$Y^{CC,FF,MM}$	$Y^{C,F,M}$	$Y^{C,F,M,P}$	$Y^{CC,FF,MM.PP}$
New Zealand				$Y^{C,F,M}$	$Y^{C,F,M}$	$Y^{CC,F,M,P}$	$Y^{CC,FF,MM,PP,SS}$
Nigeria						$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$
Norway	$Y^{CC,FF,MM}$	$Y^{CC,FF}$	$Y^{CC,F,M}$	$Y^{C,F,M}$	$Y^{C,F,M}$	$Y^{CC,FF,M}$	$Y^{CC,FF,M}$
Pakistan					$Y^{C,F,M}$	$Y^{C,FF}$	$Y^{CC,FF,M}$
Peru	N	$Y^{CC,FF}$	$Y^{CC,FF}$	$Y^{CC,FF}$	$Y^{CC,FF,M}$	$Y^{CC,FF}$	$Y^{CC,FF,M}$
Philippines					$Y^{CC,FF,MM}$	$Y^{CC,FF}$	$Y^{C,FF,M}$
Poland				$Y^{C,F,M}$	$Y^{C,F,M}$	$Y^{C,F,M}$	$Y^{CC,FF,M,PP}$
Portugal	$Y^{CC,FF,MM}$	Y^{FF}	$Y^{C,FF,M}$	$Y^{C,FF,M}$	$Y^{C,F,M}$	$Y^{C,F,M}$	$Y^{CC,FF,MM}$
Romania		N	N	Y^{CC}	$Y^{CC,F,M}$	Y	$Y^{CC,FF,MM}$
Russia	$Y^{CC,FF,MM,c}$	$Y^{CC,FF,MM,c}$	$Y^{C,F,c}$	N	$Y^{C,F}$	$Y^{C,F,M}$	$Y^{CC,FF,MM,P}$
Saudi Arabia				N	N	N	$Y^{CC,FF,MM}$

Singapore						R—UK	$Y^{CC,FF,MM}$
South Africa				$Y^{CC,FF,MM}$	$Y^{C,FF,M}$	Y^{CC}	$Y^{CC,FF,MM,P}$
South Korea	N	N	N		$Y^{CC,FF}$	$Y^{CC,FF,P}$	$Y^{CC,FF,MM,PP}$
Spain	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF}$	$Y^{F,M}$	$Y^{C,F,M}$	$Y^{C,F,M}$	$Y^{C,FF,M,P}$
Sweden	$Y^{CC,FF,MM}$	$Y^{CC,FF}$	$Y^{CC,F,M}$	$Y^{CC,F,M}$	$Y^{C,F,M}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$
Switzerland	N	N	Y	$Y^{C,M}$	$Y^{C,M,d}$	Y^{C}	$Y^{CC,FF,MM,PP}$
Syria					$Y^{CC,FF,M}$	$Y^{CC,FF,M}$	$Y^{CC,FF,M}$
Taiwan					$Y^{C,F}$	Y^{C}	$Y^{CC,F,M,P,S}$
Thailand	N	N	N	N	N	N	$Y^{CC,FF,MM}$
Turkey	N	N	$Y^{CC,FF,e}$	$Y^{CC,FF}$	$Y^{CC,FF,M}$	$Y^{CC,FF,M}$	$Y^{CC,FF,M}$
Ukraine							$Y^{CC,FF,MM}$
United Arab Emirates						N	$Y^{CC,FF,M}$
United Kingdom	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,F,M}$	$Y^{CC,F,M,P}$	$Y^{CC,FF,MM,P}$
United States	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM}$	$Y^{CC,FF,MM,P}$	$Y^{CC,FF,MM,P}$	$Y^{CC,FF,MM,PP,SS}$
Venezuela	N	N	$Y^{CC,FF}$	$Y^{CC,FF}$	$Y^{CC,FF,P}$	$Y^{CC,M}$	$Y^{CC,FF,M}$

Notes:

C = Chemical patents allowed under certain conditions.
CC = Chemical patents allowed.
F = Food patents allowed under certain conditions.
FF = Food patents allowed.
M = Medicinal patents allowed under certain conditions.
MM = Medicinal patents allowed.
P = Plant patents allowed under certain conditions.
PP = Plant patents allowed.
S = Software patents allowed under certain conditions.
SS = Software patents allowed.

a = Patents only awarded to foreign applicants; no domestic patents.
b = No railroad-related patents.
c = No weapons-related patents.
d = No textile process patents.
e = No electricity-related patents

Table 2. The length of patent protection. The sample consists of the sixty largest countries (by gross domestic product) at the end of 1997, observed at 25-year intervals from 1850 to 1999. The table denotes the duration of a patent award to a domestic entity carried to full term (not including any extension granted at the discretion of government officials). Observations where the country was not an independent entity are filled in; those where the country did not have a patent system are shaded.

	1850	*1875*	*1900*	*1925*	*1950*	*1975*	*1999*
Algeria						20 ap[a]	20 ap[a]
Argentina		15 aw	15 aw	15 aw	15 aw	15 aw	20 ap
Australia				16 ap***	16 ap**	16 ap**	20 ap
Austria	15 aw	15	15 pub	15 pub	18 pub	18 pub	20 ap
Bangladesh						16 prior**	16 prior**
Belgium	15	20 ap	20 ap	20 ap	20 ap	20 ap	20 ap
Brazil	5***	5***	15 aw	15 aw	15 aw*	15 ap	20 ap
Canada		15	18 aw	18 aw	17 aw	17 aw	20 ap
Chile	10 work***	10 work***	10 work**	10 aw**	15 aw*	15 aw*	15 aw
China							20 ap
Columbia	20	20	20 aw	50 aw	20 aw	12 aw	15 ap
Czech Republic				15 pub	15 pub	15 ap	20 ap
Denmark		5**	15 aw	15 aw	17 ap	17 ap	20 ap
Egypt						15 ap*,P[10]	15 ap*,P[10]
Finland				15 aw	20 ap	17 ap	20 ap
France	15 aw	15 ap	15 ap	15 ap	20 ap	20 ap	20 ap[P27]
Germany	15 aw	15	15 ap	18 ap	18 ap	18 ap	20 ap[P25]
Greece				15 ap	15 ap	15 ap	20 ap
Hungary				15 ap	20 ap	20 ap	20 ap
India					16 ap**	14 prior[P7],b	14 aw[P7],b
Indonesia							14 ap*
Iran					20 ap	20 ap	20 ap
Iraq					15 ap	15 ap	15 ap
Ireland					16 ap**	16 ap**	20 ap
Israel					16 ap	20 ap	20 ap
Italy	5**	15 ap	15 ap	15 ap	15 ap	15 ap	20 ap[P38]
Japan			15 aw	15 pub**	15 pub**	15 pub[c]	20 ap[P25]
Kuwait						15 ap*,P[10]	15 ap*,P[10]
Libya						15 ap*,P[10]	15 ap*,P[10]
Malaysia							15 aw[c]
Mexico	10 work***	10 work***	20 aw*	20 aw*	15 ap	15 ap	20 ap
Morocco						20 ap	20 ap
Myanmar							
Netherlands	15			15 aw	18 aw	20 ap	20 ap[P25]
New Zealand				16 ap***	16 ap**	16 ap**	20 ap**
Nigeria						20 ap	20 ap
Norway	15 aw***	3***	15 ap	17 ap	17 ap	17 ap	20 ap
Pakistan					16 ap**	16 prior**	16 prior
Peru		10	10 aw	10 aw**	10 aw*	15 aw	20 ap
Philippines					17 aw	17 aw	17 aw
Poland				15 aw	15 ap	15 ap	20 ap
Portugal	15	15 aw*	15 aw	15 aw	15 aw	15 aw	20 ap
Romania				15 ap	15 ap	15 ap	20 ap
Russia	10 aw	10 aw	15 aw		15 ap	15 ap	20 ap
Saudi Arabia							20 aw
Singapore							20 ap
South Africa				14 ap***	14 ap***	16 ap**	20 ap*

South Korea					17 aw**	12 pub[d]	20 ap[P[25]]
Spain	15 aw	15 aw	20 aw	20 aw	20 aw	20 aw	20 ap
Sweden	15 aw***	3***	15 ap	15 ap	17 ap	17 ap	20 ap[P[25]]
Switzerland			15 ap	15 ap[P[10]]	15 ap[P[10],C[10]]	18 ap	20 ap
Syria					15 ap	15 ap	15 ap
Taiwan					15 ap	15 ap	20 ap[P[25]]
Thailand							20 ap
Turkey			15 ap	15 ap	15 ap	15 ap	20 ap
Ukraine							20 ap
United Arab Emirates							15 ap
United Kingdom	14***	14 ap***	14 ap***	16 ap**	16 ap**	16 ap**	20 ap
United States	14 aw**	17 aw	17 aw	17 aw	17 aw	17 aw	20 ap[P[25],e]
Venezuela			15 aw	15 aw	10 aw	10 aw	15 ap

Notes:

ap = Date of patent application.
aw = Date of patent award.
pub = Date of patent publication.
prior = Date of original ("priority") patent application.
work = Date at which patent is first worked in a given country (or end of compulsory working period).

* = Extension of patents are possible for up to five years.
** = Extension of patents is possible for more than 5, but 10 or less years.
*** = Extension of patent for more than 10 or an indefinite period is possible.
C = Chemical patents may be of a different length. Bracketed number indicates maximum possible length.
P = Pharmaceutical patents may be of a different length. Bracketed number indicates maximum possible length.

a = Patents only awarded to foreign applicants; no domestic patents.
b = Pharmaceutical awards cannot exceed lesser of seven years from the application date or five years from the award date.
c = Patents cannot last for more than 20 years from application date.
d = Patents cannot last for more than 15 years from application date.
e = Extensions also possible for patents delayed by interference procedures.

In some cases, nineteenth-century patent laws were ambiguous as to whether the award initiated with the application or award date. This reflected the fact that the gap between these two was typically very short.

Table 3. The cost of patent protection. The sample consists of the sixty largest countries (by gross domestic product) at the end of 1997, observed at 25-year intervals from 1850 to 1999. The table denotes the fee charged a domestic patentee for a patent award carried to full term (not including any extension granted at the discretion of government officials), expressed in 1998 U.S. dollars. (All payments are discounted at the ten-year U.S. Treasury yield or a proxy therefor.) Observations where the country was not an independent entity are filled in; those where the country did not have a patent system are shaded.

	1850	*1875*	*1900*	*1925*	*1950*	*1975*	*1999*
Algeria						NA	78[a]
Argentina		4704	6493	3205	226	144	2657
Australia				530	552	944	2774
Austria	3284	4665	11671	1403	2848	2523	5867
Bangladesh						NA	208
Belgium	4836	3185	5887	1242	2811	875	1398
Brazil	894	688	21070	2292	290	100	6657
Canada		719	1036	336	276	230	2067
Chile	941	711	6999	439	214	47	132
China							3371
Columbia	8234	5997	4117	10318	NA	NA	1204
Czech Republic				1888	437	673	2278
Denmark		143	8280	2393	2426	1808	4951
Egypt						240	67
Finland				382	3101	1489	4544
France	4189	3125	4933	1443	1711	1066	3597
Germany	37	19	22694	14076	5938	4367	6803
Greece				1782	616	169	2728
Hungary				272	1344	2451	2835
India					1355	194	206
Indonesia							1940
Iran					NA	205	0[b]
Iraq					NA	NA	NA
Ireland					2050	569	3541
Israel					1364	384	1377
Italy	857	2665	4341	1824	1024	412	3456
Japan			2356	1155	484	505	15150
Kuwait						NA	43
Libya						NA	NA
Malaysia							933
Mexico	6314	4632	2709	2132	223	194	1473
Morocco						NA	4401
Myanmar							
Netherlands	5352			4187	2410	7065	6062
New Zealand				564	582	243	874
Nigeria						NA	NA
Norway	0[b]	168	2682	1830	1277	2004	4300
Pakistan					1876	162	25
Peru		14711	8118	4072	NA	112	NA
Philippines					NA	280	24
Poland				2735	842	270	2569
Portugal	66	862	692	234	139	13	1517
Romania				6057	NA	917	3976
Russia	5433	4675	18941		4271	868	5280
Saudi Arabia							2762

Singapore							2963
South Africa				906	565	205	22
South Korea					NA	NA	4757
Spain	6234	4601	21954	2989	474	90	2840
Sweden	0[b]	0[b]	3218	4266	2934	2023	2720
Switzerland			4235	1846	1626	2753	5111
Syria					NA	NA	383
Taiwan					NA	NA	2155
Thailand							5662
Turkey			2283	733	865	1324	2768
Ukraine							2992
United Arab Emirates							NA
United Kingdom	37237	10195	6612	4025	1631	1052	3787
United States	618	546	720	386	343	442	5840
Venezuela			2389	2227	NA	400	NA

Notes:

NA = No data on patent fees are available.

[a]Fee is only for foreign applicants; no domestic patents.
[b]Fee is only a nominal tax or publication costs (for domestic patentees only, in the case of Iran).

In making the computations, for 1950 and afterwards, it is assumed that awards occur two years after the application date (one year after publication date). For 1900 and 1925, it is assumed awards occur one year after the application date (and publication date). For 1850 and 1875, it is assumed awards occur only a nominal period after application.

Table 4. Limitations on patent protection. The sample consists of the sixty largest countries (by gross domestic product) at the end of 1997, observed at 25-year intervals from 1850 to 1999. The table denotes the "working" period: the number of years after the award when the patent may be licensed to third parties by the government or revoked if not employed in a given country. (Extensions for extraordinary circumstances may be provided, but are not reported.) The footnotes denote other important limitations on patent protection. Observations where the country was not an independent entity are filled in; those where the country did not have a patent system are shaded.

	1850	*1875*	*1900*	*1925*	*1950*	*1975*	*1999*
Algeria						$3^{CL,PU}$	$3^{CL,PU}$
Argentina		2	2	2	2	2^{CL}	2^{CL}
Australia				$4^{CL,R}$	3^{CL}	3^{CL}	3^{CL}
Austria	1^{D}	$1^{D,PU}$	$3^{CL,PU}$	3^{CL}	3^{CL}	$3^{CL,PU,R}$	3^{PU}
Bangladesh						$4^{CL,R}$	4^{CL}
Belgium	2	1	1^{a}	1	1	1	$3^{CL,PU}$
Brazil	2	2	$3^{CL,R}$	3^{R}	2^{R}	$3^{CL,R}$	3^{CL}
Canada		$3^{CLs,PU}$	$2^{CLs,PU}$	2^{CLs}	3^{CL}	$3^{CL,PU}$	3^{PU}
Chile	Discr.	Discr.	Discr.	1	None	None	None
China							$3^{CL,PU}$
Columbia	1	1	1	1	None	$3^{CL,R}$	3^{CL}
Czech Republic				3^{CL}	$3^{CL,R}$	$3^{CL,PU}$	$None^{PU}$
Denmark		1^{PU}	3^{PU}	3	3^{CL}	$3^{CL,PU}$	$3^{CL,PU}$
Egypt						$3^{CL,PU,R}$	$3^{CL,PU,R}$
Finland				3	3^{CL}	$3^{CL,PU}$	$3^{CL,PU}$
France	2	2	2	2	3^{CLs}	$3^{CL,PU}$	$3^{CL,PU}$
Germany	0.5^{PU}	0.5^{PU}	$3^{CL,PU,R}$	$3^{CL,R}$	3^{CL}	$Immed.^{CL,PU}$	$Immed.^{CL,PU}$
Greece				3^{CL}	3^{CL}	$3^{CL,PU}$	$3^{CL,PU}$
Hungary				$3^{CL,R}$	3^{CL}	$3^{CL,PU}$	$None^{CL,PU}$
India					3^{CL}	$3^{CL,R}$	3^{CL}
Indonesia							5^{PU}
Iran					5	5	5
Iraq					2	$3^{CL,R}$	3^{CL}
Ireland					$3^{CL,R}$	3^{CL}	3^{CL}
Israel					3^{CL}	$3^{CL,PU}$	$3^{CL,PU}$
Italy	1	2	2	2	3^{R}	$3^{CL,R}$	$3^{CL,PU}$
Japan			$3^{CL,R}$	3^{CL}	3^{CL}	$3^{CL,PU}$	$3^{CL,PU}$
Kuwait						$3^{CL,PU,R}$	$3^{CL,PU}$
Libya						3	$3^{CL,PU,b}$
Malaysia							3^{PU}
Mexico	None	None	$None^{PU}$	3	3	$3^{PU,R}$	3^{PU}
Morocco						3	3^{b}
Myanmar							
Netherlands	2			5^{CL}	3^{CL}	$3^{CL,PU}$	$3^{CL,PU}$
New Zealand				$4^{CL,R}$	$3^{CL,R}$	3^{CL}	3^{CL}
Nigeria						$3^{CL,PU}$	$3^{CL,PU}$
Norway	2^{D}	1^{D}	$3^{CL,D,PU}$	3^{CL}	3^{CL}	$3^{CL,PU}$	$3^{CL,PU}$
Pakistan					4	$4^{CL,R}$	$4^{CL,R}$
Peru		2	2	2	2	2^{CL}	3^{CL}
Philippines					3^{CL}	3^{CL}	2^{CL}
Poland				3	$3^{CL,R}$	$3^{CL,R,PU}$	$3^{CL,PU}$
Portugal	$7.5^{CL,R}$	$1^{CL,R}$	$2^{CL,R}$	$2^{CL,R}$	$3^{CL,R}$	$3^{CL,R}$	$3^{CL,c}$
Romania				$4^{D,R}$	4^{CL}	$3^{CL,PU}$	$3^{CL,PU}$
Russia	2.5	2.5	5		$3^{CL,R}$	$None^{CL,PU,R}$	$3^{CL,PU}$
Saudi Arabia							2^{PU}

Singapore							4[CLs,PU]
South Africa				2[CL]	3[CLs]	3[CL]	3[CL,PU]
South Korea					3	3	3[CL,PU]
Spain	1	1[D]	2[D]	3	3	3	3[CL,PU]
Sweden	2[D]	2	3[PU,R]	3[R]	3[CL,R]	3[CL,PU]	3[CL,PU]
Switzerland			Immed.[PU,R]	3[CL]	3[CL]	3[CL,PU]	3[CL,PU]
Syria					3	2	2
Taiwan					3	3	4[CL,PU]
Thailand							3[CL,PU]
Turkey			2[D]	2	2	2	2[PU]
Ukraine							3
United Arab Emirates							2[PU]
United Kingdom	None	None	None[CL]	4[CL,R]	3[CL]	3[CL]	3[CL,PU]
United States	1.5[d]	None	None	None	None	None	None
Venezuela			2	2	2	2	3

Notes:

Discr. = Government can set working period at its discretion.
Immed. = Awardee must begin working patent immediately after award.
None = No compulsory working period.

CL= Government can demand compulsory licensing of patents for reasons other than non-working.
CLs= Compulsory licensing provisions only for some industries (typically pharmaceuticals).
D = Damages in patent infringement cases are limited to a fixed amount.
PU = Prior users of a patented technology cannot be sued for infringement.
R = Government can revoke patents for reasons other than non-working and failure to comply with compulsory licensing order.

a = Calculated from date first worked abroad.
b = Working can be in any country, any Paris Convention country, or in the country of origin.
c = Working can be in any European Community country.
d = Applies to foreign patentees only.

No data other than working requirements is reported for Libya, South Korea, and Taiwan in 1975. No data on prior user rights is reported for any country in 1925 and 1950 and Bangladesh and Ukraine in any year.

Table 5. Impact of a change in patent policy on patenting activity. The sample consists of 177 changes in patent policy between 1852 and 1998 in the sixty largest countries (by gross domestic product) at the end of 1997. Panel A displays the change in the number of unadjusted patent applications filed from two years before the event to two 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. In Panels B and C, these changes are shown net of equal-weighted and value-weighted indexes of patenting in the ten nations with the longest time series of application data. Underneath each adjusted change, the absolute t-statistic of the difference of the change from zero is displayed. Panel D presents t-tests of the null hypothesis that the effects of patent policy changes are the same for domestic and foreign patentees. In all tests, each observation is weighted by the inverse of its standard deviation of the annual change in patenting from twenty to five years before the policy change.

Panel A: Unadjusted Changes in Patenting Around Policy Changes

	Domestic Entities Patenting in Country	*Foreign Patenting in Country*	*Residents' Patenting in United Kingdom*
Positive Patent Policy Changes	+2424	+8662	-27
Ambiguous/Negative Changes	+529	+1401	+210
Positive Changes Involving Coverage or Scope	+2233	+9739	-63
Positive Changes Involving Patent Duration	+2399	+10957	-80
Positive Changes Involving Working Periods	-1081	+3191	-34

Panel B: Changes in Patenting Around Policy Changes, Adjusted by Equal-Weighted Index

	Domestic Entities Patenting in Country	*Foreign Patenting in Country*	*Residents' Patenting in United Kingdom*
Positive Patent Policy Changes	-1617	+4979	-101
	*[1.86]	**[2.41]	***[4.61]
Ambiguous/Negative Changes	-525	+390	-217
	[0.34]	[1.28]	***[3.19]
Positive Changes Involving Coverage or Scope	+1915	+7704	-98
	[1.03]	**[2.58]	***[5.13]
Positive Changes Involving Patent Duration	-4714	+5699	-190
	**[2.22]	*[1.84]	***[4.68]
Positive Changes Involving Working Periods	-1239	+2772	-27
	*[1.84]	[1.31]	[1.33]

Panel C: Changes in Patenting Around Policy Changes, Adjusted by Value-Weighted Index

	Domestic Entities Patenting in Country	*Foreign Patenting in Country*	*Residents' Patenting in United Kingdom*
Positive Patent Policy Changes	-932	+5617	-100
	*[1.69]	***[2.85]	***[4.52]
Ambiguous/Negative Changes	-408	+501	-137
	[0.07]	[1.65]	**[2.40]
Positive Changes Involving Coverage or Scope	+1781	+7963	-111
	[0.94]	**[2.57]	***[5.12]
Positive Changes Involving Patent Duration	-3347	+6690	-186
	**[2.14]	**[2.36]	***[4.63]
Positive Changes Involving Working Periods	-1289	+2809	-27
	*[1.89]	[1.27]	[1.29]

Panel D: Test Statistic, Equality of Changes in Patenting by Domestic and Foreign Entities

	With Equal-Weighted Index	*With Value-Weighted Index*
Positive Patent Policy Changes	***2.96	***3.23
Ambiguous/Negative Changes	1.12	1.17

Positive Changes Involving Coverage or Scope	**1.99	**2.07
Positive Changes Involving Patent Duration	***2.86	***3.17
Positive Changes Involving Working Periods	1.74	1.72
Positive Changes, Controlling for Type of Change, Other Events, Population, and Discrimination	**2.56	***2.81

* = Significant at the 10% confidence level; ** = significant at the 5% confidence level; *** = significant at the 1% confidence level.

Table 6. Weighted least squares regression analyses of patenting by domestic entities in nations undergoing patent policy changes. The sample consists of 177 changes in patent policy between 1852 and 1998 in the sixty largest countries (by gross domestic product) at the end of 1997. The dependent variable is the change in the number of patent applications filed by domestic entities in the country undergoing the policy change from two years prior to the policy change to two years afterwards, net of either a value-weighted (VW) or equal-weighted (EW) index of patenting in the ten nations with the longest time series of application data. The independent variables are dummy variables denoting whether the policy change entailed an unambiguous increase in protection and the aspects of patent policy that the change covered, variables denoting whether during the period the country began or ended a conflict on its territory or expanded or contracted its territory (with the former instance being coded as +1, the latter as –1, and all others as zero), the number of patent applications by domestic entities two years before the policy change, and the population of the nation at the time of the change. In addition, the various regressions include dummy variables denoting whether the country had a particularly strong or weak patent policy before the change, the nation's per capita gross domestic policy relative to the leading nation at the time, and the interaction of these measures with the dummy variable indicating an increase in patent protection. Each observation is weighted by the inverse of the standard deviation of the annual change in domestic patent applications from twenty to five years before the policy change. Absolute t-statistics in parentheses.

	Dependent Variable: Change in Domestic Patent Applications Net of			
	VW Index	*EW Index*	*VW Index*	*EW Index*
Positive Patent Policy Change?	1862.87 [0.76]	2361.31 [0.82]	2727.11 [1.32]	2887.20 [0.59]
Strong Protection Prior to Change?	-1079.46 [0.30]	-717.08 [0.17]		
Weak Protection Prior to Change?			-2018.17 [0.12]	
GDP as Percent of Leading Nation				4630.29 [0.63]
Strong Protection * Positive Change	1657.97 [0.42]	1230.48 [0.27]		
Weak Protection * Positive Change			-611.87 [0.04]	
Relative GDP * Positive Change				-615.17 [0.08]
Change Involving Coverage or Scope?	1153.91 [0.63]	1311.54 [0.61]	1423.43 [0.80]	1861.75 [0.88]
Change Involving Duration?	-373.71 [0.21]	-566.56 [0.27]	-746.30 [0.41]	-387.44 [0.19]
Change Involving Cost?	1979.52 [0.59]	1872.51 [0.48]	1580.56 [0.48]	1226.20 [0.32]
Change Involving Working Periods?	1485.56 [0.53]	1620.48 [0.50]	1473.81 [0.53]	1758.43 [0.54]
Inception of Conflict?	-1639.60 [0.41]	-1523.63 [0.33]	-1999.77 [0.51]	-2125.00 [0.46]
Change in Territory?	-1231.93 [0.36]	-934.01 [0.23]	-1215.29 [0.35]	322.75 [0.08]
Applications Two Years before Event	***-0.23 [16.53]	***-0.31 [18.95]	***-0.24 [16.65]	***-0.32 [18.64]
Population of Nation	***25.20 [3.05]	***26.56 [2.74]	***26.46 [3.22]	***30.19 [2.94]
Constant	-1449.71 [0.43]	-1500.72 [0.38]	-1756.58 [0.60]	-4797.64 [0.88]
Number of Observations	132	132	132	132
F-Statistic	27.83	36.82	28.05	37.29
p-Value	0.000	0.000	0.000	0.000
Adjusted R^2	0.69	0.75	0.69	0.75

* = Significant at the 10% confidence level; ** = significant at the 5% confidence level; *** = significant at the 1% confidence level.

Table 7. Weighted least squares regression analyses of patenting by residents of the countries that underwent patent policy changes in Great Britain around the time of the changes. The sample consists of 177 changes in patent policy between 1852 and 1998 in the sixty largest countries (by gross domestic product) at the end of 1997. 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 afterwards, net of either of a value-weighted (VW) or equal-weighted (EW) index of patenting in the ten nations with the longest time series of application data. The independent variables are dummy variables denoting whether the policy change entailed an unambiguous increase in protection and the aspects of patent policy that the change covered, variables denoting whether during the period the country began or ended a conflict on its territory or expanded or contracted its territory (with the former instance being coded as +1, the latter as –1, and all others as zero), the number of patent applications by domestic entities in Great Britain two years before the policy change, and the population of the nation at the time of the change. In addition, the various regressions include dummy variables denoting whether the country had a particularly strong or weak patent policy before the change, the nation's per capita gross domestic policy relative to the leading nation at the time, and the interaction of these measures with the dummy variable indicating an increase in patent protection. Each observation is weighted by the inverse of the standard deviation of the annual change in patent applications in Great Britain from twenty to five years before the policy change. Absolute t-statistics in parentheses.

	Dependent Variable: Change in U.K. Patent Applications Net of			
	VW Index	*EW Index*	*VW Index*	*EW Index*
Positive Patent Policy Change?	165.94 [0.87]	***598.53 [3.24]	19.13 [0.11]	-333.42 [0.88]
Strong Protection Prior to Change?	-249.34 [0.96]	86.93 [0.35]		
Weak Protection Prior to Change?			273.22 [0.32]	
GDP as Percent of Leading Nation				***-1561.76 [2.92]
Strong Protection * Positive Change	**-602.57 [1.99]	***-980.07 [3.34]		
Weak Protection * Positive Change			-133.66 [0.14]	
Relative GDP * Positive Change				**1292.27 [2.15]
Change Involving Coverage or Scope?	50.74 [0.37]	216.92 [1.65]	32.63 [0.22]	61.80 [0.42]
Change Involving Duration?	-199.37 [1.41]	-79.30 [0.58]	-171.04 [1.06]	-135.68 [0.91]
Change Involving Cost?	***1014.88 [4.42]	***1137.36 [5.12]	***1059.91 [4.24]	***1252.63 [5.26]
Change Involving Working Periods?	*-335.37 [1.78]	-192.88 [1.06]	-249.62 [1.22]	-117.16 [0.61]
Inception of Conflict?	-10.97 [0.04]	-332.82 [1.09]	80.75 [0.24]	-118.82 [0.36]
Change in Territory?	***-1058.54 [3.37]	130.20 [0.43]	***-1042.61 [3.03]	-118.22 [0.35]
Applications Two Years before Event	***-0.12 [11.63]	***-0.13 [13.14]	***-0.12 [10.13]	***-0.12 [10.03]
Population of Nation	0.07 [0.07]	0.27 [0.29]	-0.14 [0.14]	-0.96 [0.94]
Constant	21.18 [0.09]	-523.10 [2.21]	-117.27 [0.50]	428.65 [1.10]
Number of Observations	159	159	159	159
F-Statistic	17.10	23.14	12.06	18.08
p-Value	0.000	0.000	0.000	0.000
Adjusted R^2	0.53	0.61	0.44	0.54

* = Significant at the 10% confidence level; ** = significant at the 5% confidence level; *** = significant at the 1% confidence level.

Table 8. Cross-tabulation of national characteristics and patent policy. The sample consists of the sixty largest countries (by gross domestic product) at the end of 1997, observed at 25-year intervals from 1850 to 1999. Panel A of the table indicates for each group the percentage of observations which had a patent system and the mean of the duration (in years from time of application) of patents granted to domestic applicants, the net present value of the fee charged a domestic patentee for a patent carried to full term (in 1998 U.S. dollars), and the "working" period (the number of years after the award when the patent may be licensed to third parties by the government or revoked if not employed, typically in a given country). Observations are divided by the level of the country's per capita gross domestic product (expressed as a fraction of the country with the highest GDP in that year), whether the effective head of the nation was elected, whether the national legislature was rated as effective, whether the national legislature was elected, and the family of origin of the country's commercial legal code. Panel B presents the p-value of tests of the significance of these differences, based either on a chi-squared test (the existence of a patent system) or t-tests (all other variables).

	Patent System	*Award Duration*	*Award Cost*	*Working Period*
Panel A: Mean of Different Groups				
Relative Gross Domestic Product:				
Top Quartile	92.5%	17.1	4516	4.3
Second Quartile	97.0%	16.5	2353	3.0
Third Quartile	89.6%	16.9	2576	4.2
Bottom Quartile	83.6%	16.6	1603	3.7
Effective Head Selection:				
Direct Election	98.0%	17.8	2677	5.4
Indirect Election	93.8%	17.0	2942	3.5
Not Elected	65.0%	15.2	3287	2.8
Legislative Effectiveness:				
Effective	94.2%	17.0	3007	3.8
Ineffective	81.0%	16.3	3075	3.4
No Legislature	43.6%	14.9	1709	3.3
Legislative Selection:				
Elected	92.1%	17.0	2987	3.7
Not Elected or No Legislature	50.9%	14.6	2804	3.1
Legal Family:				
English	83.6%	17.2	2296	5.3
French	86.1%	16.5	2881	3.2
German	91.7%	16.8	4594	2.5
Scandinavian	96.0%	15.5	2372	2.7
Communist	77.3%	17.7	2211	5.8
Other	27.3%	12.0	9683	3.3
Panel B: p-Values, Tests of Equality of Means				
Above Median GDP vs. Below	0.000	0.575	0.087	0.727
Effective Head Elected vs. Not Elected	0.000	0.001	0.551	0.034
Effective Legislature vs. Not	0.000	0.077	0.830	0.397
Legislative Elected vs. Not	0.000	0.006	0.868	0.388
English Family vs. All Others	0.869	0.227	0.219	0.001
Civil Law Families vs. All Others	0.006	0.216	0.405	0.000
Communist Family vs. All Others	0.352	0.273	0.469	0.019
Other Family vs. All Others	0.000	0.055	0.006	0.877

Notes:

The "patent system" tabulations include countries that automatically recognize patents granted by another nation as having patent protection; these observations are omitted from all other tabulations. The patent duration and patent fee calculations do not include any provisions for extensions by the government due to extraordinary circumstances. In making the calculations, for 1950 and afterwards, it is assumed that awards occur two years after the application date (one year after publication date). For 1900 and 1925, it is assumed awards occur one year after the application date (and publication date). For 1850 and 1875, it is

assumed awards occur only a nominal period after application. All payments are discounted at the ten-year U.S. Treasury yield or a proxy therefor back to the application date. The working period is computed from the award date. It does not include any provisions for extensions due to extraordinary circumstances. Countries with no working provisions are recorded as having a working period that extends for the life of the patent; those where the working period is set at the government's discretion as having a working period of zero years.

Table 9. Instrumental variable regression analyses of patenting by residents of nations undergoing patent policy changes domestically and in Great Britain. The sample consists of 177 changes in patent policy between 1852 and 1998 in the sixty largest countries (by gross domestic product) at the end of 1997. The dependent variable is the change in the number of patent applications filed by residents of the nation undergoing the policy change domestically and in Great Britain from two years prior to the policy change to two years afterwards, net of a equal-weighted index of patenting in the ten nations with the longest time series of application data. The independent variables are dummy variables denoting whether the policy change entailed an unambiguous increase in protection and the aspects of patent policy that the change covered, variables denoting whether during the period the country began or ended a conflict on its territory or expanded or contracted its territory (with the former instance being coded as +1, the latter as –1, and all others as zero), the number of patent applications by domestic entities in Great Britain two years before the policy change, and the population of the nation at the time of the change. In addition, the various regressions include dummy variables denoting whether the country had a particularly strong patent policy before the change, the nation's per capita gross domestic policy relative to the leading nation at the time, and the interaction of these measures with the dummy variable indicating an increase in patent protection. A dummy variable denoting that the policy change took place in the ten years following the signing of the Paris Convention of 1883 and the preliminary version of the TRIPs agreement of 1993 is used as instrument for the measure of positive patent policy changes. Each observation is weighted by the inverse of the standard deviation of the annual change in patent applications domestically and in Great Britain from twenty to five years before the policy change. Absolute t-statistics in parentheses.

	Dependent Variable: Change in Patent Applications, Net of Equal-Weighted Index			
	Domestic Applications		Applications in Great Britain	
Positive Patent Policy Change?	-7243.45 [0.37]	6075.96 [0.19]	***7737.47 [3.00]	-3342.62 [0.87]
Strong Protection Prior to Change?	-3062.68 [0.16]		**4546.50 [2.28]	
GDP as Percent of Leading Nation		15135.62 [0.57]		**-9152.71 [2.48]
Strong Protection * Positive Change	1621.90 [0.07]		**-6671.86 [2.48]	
Relative GDP * Positive Change		-18925.80 [0.49]		**10667.92 [2.06]
Change Involving Coverage or Scope?	202.25 [0.07]	1569.60 [0.56]	**1137.27 [2.15]	-115.15 [0.31]
Change Involving Duration?	-1912.28 [0.86]	-926.64 [0.39]	133.54 [0.29]	-529.23 [1.50]
Change Involving Cost?	-2480.94 [0.44]	-1792.07 [0.28]	**2655.75 [2.12]	**2128.94 [2.56]
Change Involving Working Periods?	-5693.91 [0.58]	-4964.26 [0.77]	**3322.78 [2.26]	1438.40 [1.57]
Inception of Conflict?	-104.44 [0.02]	-627.54 [0.11]	*-2221.32 [1.79]	-202.12 [0.23]
Change in Territory?	1875.57 [0.29]	4339.82 [0.66]	-1380.91 [1.17]	**-2111.38 [2.14]
Applications Two Years before Event	***-0.24 [9.49]	***-0.24 [9.84]	-0.12 [3.52]	***-0.08 [2.79]
Population of Nation	22.52 [1.41]	30.62 [1.64]	3.45 [1.08]	-4.12 [1.55]
Constant	8720.00 [0.47]	-3886.16 [0.16]	***-7283.29 [2.94]	2883.99 [1.01]
Number of Observations	132	132	159	159
F-Statistic	11.29	11.34	3.08	5.34
p-Value	0.000	0.000	0.001	0.000

* = Significant at the 10% confidence level; ** = significant at the 5% confidence level; *** = significant at the 1% confidence level.