Do Treaties Encourage Technology Transfer? Evidence from the Paris Convention

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May 19, 2011

Abstract

An important goal of international treaties such as the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement is to encourage technology transfer across countries. There is, however, only limited evidence that treaties encourage technology transfer. This paper uses the U.S. accession to the Paris Convention in 1887—four years after the treaty was originally established—to examine the effects of treaty rights on patenting by foreign nationals. The U.S. accession strengthened U.S. patent rights for nationals from countries that had signed the treaty before the United States, but had no effect on nationals from other countries. An analysis of 86,000 U.S. patents between 1865 and 1914 indicates that nationals from the original member countries increased their patenting activity in the United States by more than 40 percent after U.S. accession compared with nationals from other countries. Importantly, the effects of the treaty were strongest for nationals from countries with high pre-treaty levels of development and education, that were most able to respond to stronger property rights.

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1 Introduction

An important goal of intellectual property rights treaties is to encourage technology transfer across countries. There is, however, no empirical evidence to date that international treaties accomplish this goal. This paper uses the U.S. accession to the Paris Convention in 1887 as an empirical setting to measure the effect of treaties on technology transfer. Our analysis of more than 86,000 U.S. patents by foreign inventors indicate that stronger intellectual property rights as a result of the Paris Convention encouraged technology transfer into the United States. Effects were particularly strong for countries with high pre-treaty levels of education and GDP per capita, where inventors were in a better position to take advantage of stronger patent rights. Moreover, industries that were more dependent on patent protection were more responsive to the treaty.

Technology transfer has been shown to stimulate innovation and growth (e.g., Eaton and Kortum 1996, Coe and Helpman 1995, Coe, Helpman, and Hoffmaister 2008, Keller 2000), and reforms that strengthen intellectual property rights domestically attract technology transfer from abroad (Branstetter, Fisman, and Foley 2006). Theoretical analyses, however, indicate that independently, countries create inefficiently weak patent laws, and treaties that strengthen the rights of foreign inventors and encourage technology transfer can therefore improve overall welfare (Scotchmer 2004). To date, however, there is no empirical evidence on the effects of such treaties on technology transfer.

Empirical tests have been frustrated by the fact that the decision to enter a treaty may be endogenous. Countries are more likely to form intellectual property agreements with countries where they expect to patent more extensively. Moreover, patent harmonization policies are typically implemented as part of a broader set of reforms that strengthen patents for both domestic and foreign inventors.

The U.S. accession to the Paris Convention allows us to circumvent these problems because it was unanticipated, and we can examine its effects on inventors from countries that became treaty members *before* the United States. Specifically, to estimate the effects of the treaty on technology transfer we compare changes after 1887 in U.S. patents by inventors from member countries with changes in U.S. patents by inventors from other countries. These data indicate that the treaty increased technology transfer by a minimum of 45 percentage points. The effect is especially strong for countries within the Commonwealth that, among other things, share a common language with the United States.

It is also important to consider differences in the capacity to respond to stronger patent rights. For example, countries with higher levels of education and development experienced a stronger increase in pharmaceutical patenting in response to reforms of domestic patent laws (Qian 2007). The historical setting of the Paris Convention is particularly well-suited to evaluating the interaction between patent rights and development, because it imposed a uniform change in patent rights on a group of countries with large differences in economic development. Our analysis indicates that levels of development played a decisive role in determining the response to the treaty. Countries with high levels of education and GDP per capita responded to strengthened patent rights by increasing technology transfer by 125 percentage points (education) and 65 percentage points (GDP per capita) more than countries with low levels of education and GDP per capita.

In addition, industries differ in their need for patent protection (Mansfield 1981; Levin et al. 1987; Cohen, Nelson, and Walsh 2000), and therefore respond differently to changes in patent laws. For example, in industries that face higher imitation risk, firms are more sensitive to the strength of patent laws (Bilir 2011). In the 19th century, manufacturing machinery was particularly sensitive to imitation and inventors depended strongly on patents, while other industries, such as the chemical industry, did not need patents (Moser forthcoming). Our results indicate that patenting in manufacturing machinery was indeed more responsive to the treaty than was patenting in chemicals.

The rest of the paper proceeds as follows. In section 2, we describe the historical background and legal content of the Paris Convention, as well as the impact of U.S. accession to the treaty on the rights of foreign inventors from member countries. After describing the data in section 3, we outline the estimation approach that will be used to test whether the Paris Convention impacted technology transfer in section 4. Sections 5 and 6 present the empirical results and robustness checks, respectively. Section 7 concludes.

2 Historical Background

2.1 The Paris Convention of 1883

Prior to the Paris Convention, the complexity and diversity of local patent laws made it nearly impossible for inventors to obtain patent protection in multiple countries.[1] In addition to local working requirements, many countries required fees to maintain a patent. Countries imposed limitations on what could be patented, and many refused patent grants

[1] Penrose (1951), pp. 42.

for any invention previously disclosed to the public—including cases where the prior disclosure was a patent in another country.[2] It was also standard to impose legal dependence among patents filed in multiple countries for the same invention, and even U.S. patent law held that the duration of patent protection was capped by the expiration date of any prior foreign patent.[3] World's fairs including the 1851 Crystal Palace Exhibition, the 1873 International Vienna Exposition, and the 1878 Paris Exposition served both as catalysts and occasions during which to address these issues and the possibility of collectively moving toward internationally harmonized patent rights.[4]

Formal discussions about the international coordination of patent laws began at the Vienna Congress, which took place just after the Vienna Exposition.[5] Attended by 158 representing 13 countries and chaired by German-born William Siemens of Britain, four distinctly pro-patent resolutions were adopted. The first and second declared inventors' natural right to intellectual property protection, and established a set of principles upon which patent laws should be based. These principles included prior examination and the complete removal of mandatory working requirements. The third resolution expressed that "the necessity of reform is evident, and it is of pressing moment that Governments should endeavor to bring about an international understanding upon patent protection as soon as possible." Finally, the fourth resolution created a permanent executive committee that would oversee progress toward the developing a more formal agreement.[6]

The issue was taken up again just after the Paris Exposition. The conference was attended by nearly 500 representing eleven governments. Many attendees sought full uniformity among members' national patent laws, although debates revealed fundamental disagreements over the content of a uniform patent law.[7] Provisions for mandatory examinations of all patent

[2] Limitations on patentability often prevented drugs and medicines, food, and chemicals from receiving protection. Whitman (1871).

[3] Report of Commissioners (1898).

[4] Penrose (1951), pp. 102; Ladas (1975), pp. 59-60; Whitman (1871), pp. 61. See also "The Vienna World's Fair," *The New York Times*, 26 Aug. 1872; "Proposed Patent Treaty with Austria to Protect American Inventors at the Vienna Exposition," *The New York Times*, 18 Nov. 1872; "Vienna Exhibition-More Space Wanted by American Exhibitors," *The New York Times*, 2 Apr. 1873.

[5] Report of Commissioners (1898); Dutfield (2003), pp. 55; Ladas (1975), pp. 59-60.

[6] Ladas (1975), pp. 60. Interestingly, full harmonization was an expressed goal of the treaty that was scaled back after debates revealed that broad agreement on patent laws would be difficult to achieve, Ladas (1975) pp. 61. See also Dutfield (2003), pp. 55 and Penrose (1951), pp. 46-47.

[7] According to the Congress president and French minister of agriculture and commerce, M. Tesserenc de Bort, "Industrial property will never be truly protected until there prevail everywhere simple, uniform, and definite regulations, forming between the nations a kind of conventional plan, a sort of mutual insurance against the infringer and the counterfeiter," Report of Commissioners, 1898. See also Penrose (1951), pp. 49-53.

applications and for compulsory licensing were also contentious, although participants agreed that national treatment for foreign patentees should be included.[8] The resulting 1878 draft had a substantially more modest aim than the complete uniformity previously proposed—in order to achieve wide acceptance, the drafters acknowledged ideological differences across countries, proposing a treaty that would sidestep topics of disagreement.[9] In response to the draft treaty, governments reconvened in Paris twice, first to informally adopt it 1880, and later to officially sign the treaty in 1883.

On March 20, 1883, eleven countries became official members of the Paris Convention for the Protection of Industrial Property of 1883, which would take effect between them on July 7, 1884. These first official members were Belgium, Brazil, El Salvador, France, Guatemala, Italy, the Netherlands, Portugal, Serbia, Spain, and Switzerland. Ecuador, Tunisia, and the United Kingdom also joined the treaty prior to its initial enforcement in 1884. Other countries gradually followed: Norway and Sweden joined in 1885, the United States in 1887, the Dominican Republic in 1890, Denmark in 1894, Japan in 1899, and Mexico and Germany both joined in 1903. Today, 173 countries adhere to the Paris Convention, which has remained the dominant framework for international intellectual property negotiations for well over a century.[10] Its continued relevance is evident in the inclusion of thirteen of its articles in the TRIPS agreement.[11]

The key provisions of the Paris Convention are national treatment, the right of priority, and the independence of patents.[12] Within treaty membership, countries committed to extend the same patent privileges to foreign inventors as were granted to domestic inventors (national treatment). More importantly, members guaranteed any inventor from a member state the right of priority. After filing the first patent application, the inventor would have a *priority period* of six months during which to apply for patents in other member countries without forfeiting the originality of the invention or worse, having it patented by a competitor (the right of priority).[13] This priority rule was a central benefit of the Convention, because it enabled inventors to seek patent protection in multiple countries without being constrained to literally submit all applications simultaneously. The Convention eventually

[8] Dutfield (2003), pp. 56.

[9] Penrose (1951), pp. 55.

[10] Hovenkamp, et al (2008), pp. 40-44.

[11] The Paris Convention has been revised several times since its inception. It was revised in Brussels (1900), Washington (1911), The Hague (1925), London (1934), Lisbon (1958), and Stockholm (1967).

[12] Manual of Industrial Property Conventions (1978).

[13] The priority period was extended to 12 months when the treaty was revised in Brussels in 1900. Manual of Industrial Property Conventions (1978).

also imposed legal independence across patents, so that the revocation or expiration of a patent in one country could no longer impact the validity of existing patents for the same technology in another country (independence of patents).[14,15]

2.2 U.S. Accession to the Paris Convention in 1887

The United States did not immediately join the Paris Convention in 1883, despite being active in deliberations leading up to the agreement. Historical accounts suggest the delay was due to sentiments that U.S. inventors had little to gain from membership, because U.S. patent laws were already egalitarian relative to those of other countries, and the treaty imposed no minimum standards for patent protection on members.[16] However, the nation reversed its decision four years later, officially joining the patent treaty on May 30, 1887. U.S. accession to the Paris Convention forms the basis of our natural experiment, because this event improved patent rights for inventors from existing treaty members, but had no effect on inventors from non-members.

In many respects, U.S. patent laws were already aligned with the Paris Convention at the time of U.S. accession.[17,18] Member-country inventors benefited from U.S. accession primarily through the partial harmonization of international patent applications created by the right of priority. Receiving a patent in the United States no longer threatened the validity of pending applications for the same invention in other countries, provided that the applica-

[14]In addition, the treaty forbade revocation of patents solely due to importation from a member nation into the patent-granting country, yet otherwise allowed nations to establish separate local working requirements.

[15]For additional background and details on the events leading up to the Paris Convention, see Penrose (1951), Ladas (1975), Whitman (1871), Report of Commissioners (1898), and Dutfield (2003).

[16]See Dutfield (2003), pp. 57; Manual of Industrial Property Conventions (1978); Report of Commissioners, 1898; and "Rejecting the Trademark Treaty," *New York Times*, 14 June 1884. Although U.S. accession may have been loosely anticipated (Ladas 1975, pp. 227), a comprehensive search of Senate documents uncovers no evidence that the precise date was revealed prior to the March 1887 announcement.

[17]See Report of Commissioners, 1898 and Revised Statutes SEC. 4887 (1897) and SEC. 4887 (1870). Foreign inventors were already entitled to comparable patent protection as that provided to U.S. citizens, for example, and the United States already had its own prior disclosure rule which was more generous than the Convention's priority rule in its time allowance. But this rule did not grant an inventor the right to exclude third parties from patenting the invention, as the Paris Convention did. This provided another subtle benefit to inventors when the United States officially aligned its laws with this provision in 1903. See Ladas (1975), pp. 498 for further discussion.

[18]See discussion in Report of Commissioners, 1898. See also Ladas (1975), and judicial opinions in Hennebique Const. Co. v. Myers 172 Fed. 869 (1909); Cameron Septic Tank Co. v. Knoxville, 227 US 39 (1913), Rousseau v. Brown, 104 O.G. 1120 (1903). There is also a record of diplomatic correspondence over whether the treaty had yet taken effect in the United States: See Ladas (1975), pp. 217, Cameron Septic Tank Co. v. Knoxville, 227 US 39 (1913).

tions were filed within the priority period.[19] This made it substantially easier for inventors from member states to obtain patent protection in multiple foreign markets including the United States, as subsequent applications were treated as if filed simultaneously.[20]

A second, key benefit was that patents were no longer able to be revoked due to importation of the patented product, as was the case in France at the time.[21] This was an important motivation for U.S. accession to the treaty, as substantial efficiency gains could be achieved if production could be localized rather than spread across countries, particularly in knowledge-intensive sectors.[22] Finally, inventors benefited from an exclusive right to obtain patents in member countries within the priority period.

3 Data and Descriptive Statistics

3.1 U.S. Patents by Foreign Nationals, 1865–1914

We introduce a dataset that identifies the country of origin and patent class for U.S. patents granted during 1865–1914, based on historical records from the United States Patent and Trademark Office (USPTO). With automated scripts, we obtain the number, main class, and any subclasses or secondary classifications available for each U.S. patent granted between 1865 and 1914. We then search the full text of each patent to determine its country of origin.

Two full-text search methods are implemented to identify countries of origin. Our first method relies on the specific syntax by which U.S. patents during our sample period record inventors' identities. The inventor's name and country of origin appear in the patent heading as follows: "[inventor's name] of ... [country of origin]." Searching for appropriate word combinations using the Google Patents database, we identify countries of origin without systematically miscategorizing patents that include country names elsewhere in the document. Using this method, we search the full text of over a million U.S. patents, and identify approximately 86,000 patents as originating in one of our sample countries.

Our second method is a "hand-check:" we download the full text of each patent and

[19] Report of Commissioners, 1898. Also, inventors wishing to serve the US market would likely prefer to file the US patent first, so as to escape from the conditional expiration date rule in S4887 and thereby enjoy the full 17-year patent term according to the Revised statutes. See Whitman (1871), pp. 10.

[20] This was thought to be a benefit more likely to apply to foreign than domestic inventors, see Bate Refrigerating Co. v. Sulzberger.

[21] Rules relating to importation of goods prior to patent application are in Article 5 of the Paris Convention, Manual of Industrial Property Conventions (1978).

[22] CIS Senate Executive Documents and Reports, Jan 20, 1885, CIS-NO 48-2-14 MFICHE 1299.

search for all country names and U.S. states that may appear in the document. Each patent is then evaluated individually by hand to identify the country of origin based on this search information and the patent document. We categorize 13,000 patents by hand for the ten patent classes with the highest volumes of foreign-origin U.S. patents in 1886, the year prior to U.S. accession to the patent treaty.[23] Summary statistics appear in Table 2. We find an overall correlation of approximately 82% between the two measures, with time series correlations ranging between 90% and 99% within each class. The similarity of the two measures is evident in Figures 1 and 2. Figure 1 plots both series over time, aggregated across all sample countries and the ten classes, while figure 2 splits the sample into a) original treaty members and b) other countries. These graphs reveal that both the algorithm-based and hand-checked measures capture similar variation over time in U.S. patenting by foreign nationals, and importantly, that there do not appear to be systematic differences in the two measures between original treaty members and other countries.[24]

Countries included in our dataset are those legally affected by the U.S. decision to join the Paris Convention in 1887 and a broad sample of counties that joined the Convention later. Original Paris Convention members are: Belgium, Brazil, Britain, Ecuador, El Salvador, France, Guatemala, Italy, the Netherlands, Norway, Portugal, Serbia, Spain, Sweden, Switzerland, and Tunisia [Table 1]. Each of these countries had signed the Paris Convention before 1887, thus the treaty went into immediate effect between these countries and the United States in 1887 (except Ecuador, which left the treaty in 1886). Control countries are those that had not joined the treaty by 1887: Argentina, Australia, Austria, Canada, China, Demark, Finland, Germany, Ireland, Japan, Mexico, and New Zealand.[25] More than 90 percent of U.S. patents by foreign inventors are granted to individuals from one of these countries.

Finally, the data provide detailed information on the sectoral composition of U.S. patents by foreign nationals. Each patent is classified into one of approximately 350 patent classes, distinct technology areas ranging from “Buckles, buttons, clasps, etc.” (class 24) to “Motors:

[23]The top-ten patent classes, as ranked by U.S. patents granted to foreign nationals in 1886, are (in numerical order) 19, 24, 84, 112, 122, 126, 137, 280, 423, and 426.

[24]One noteworthy feature of these graphs is the systematic undercounting of the algorithm-based method in early sample years. This may be due to the image quality of older patents, which interferes with the translation from image to searchable text. Because this measurement error appears to be symmetric across countries, year fixed effects should absorb the average difference in search accuracy over time.

[25]El Salvador and Guatemala withdrew from the treaty soon after the United States joined, thus we place these countries in the control sample. Records indicate that New Zealand and Ireland, on the other hand, were effectively original treaty members because of Britain, though each later re-joined the treaty once fully independent.

expansible chamber type" (class 91) to "Firearms" (class 42). Our empirical analysis will use this class-level information to determine whether responsiveness to the Paris Convention varied significantly across sectors.

3.2 Education and GDP per Capita, 1880

To capture variation across countries in levels of education and GDP per capita, we use available measures from Lindert (1994) and Lindert (2004). Education is specifically defined to be the share of children between five and 14 years of age that are enrolled in primary school, by country, in 1880. These rates range widely, from a low of ten percent in Finland to a high of ninety percent in Australia. Enrollment data are available for: Argentina, Australia, Belgium, Brazil, Britain, Canada, Denmark, Finland, France, Germany, Guatemala, Ireland, Italy, Japan, Mexico, the Netherlands, New Zealand, Norway, Portugal, Serbia, Spain, Sweden, and Switzerland. We also test for the effects of education using secondary school and university enrollment as alternative measures (Lindert, 2004). GDP per capita in 1880 is available for the same set of countries. Summary statistics appear in Table 2, which includes a comparison in all measures between original treaty members and other countries.

4 Empirical Framework

We use the U.S. accession to the Paris Convention in 1887 to examine whether improved patent rights associated with treaty membership encourage international technology transfer. Specifically, we make use of the fact that U.S. accession to the treaty immediately strengthened the patent rights of inventors from existing member countries, but left unchanged the rights of inventors from non-member countries. Our empirical approach thus compares changes in U.S. patenting by foreign nationals from both member and non-member countries before and after U.S. accession to the treaty.

4.1 Baseline

As a first step, we compare the number of U.S. patents by inventors from existing member countries with those by other foreign inventors using a simple difference-in-differences test. Our baseline estimating equation is

$$Patents_{it} = \beta \cdot Member_i \times Post\ 1887_t + \eta_i + \eta_t + \eta_i \times t + \epsilon_{it}, \quad (1)$$

where $Patents_{it}$ is the log of U.S. patents by foreign nationals from country i in year t, $Member_i$ is an indicator equal to one if country i joined the Paris Convention prior to 1887, and $Post\ 1887_t$ is an indicator equal to one after U.S. accession to the treaty ($t \geq 1887$). The coefficient β captures the impact of the Paris Convention on technology transfer to the United States under the identifying assumption that trends in U.S. patenting would have been similar across members and non-members, had the United States not signed the Paris Convention in 1887. Regression controls in (1) include country fixed effects η_i, year fixed effects η_t, and country-specific time trends $\eta_i \times t$. The error term ϵ_{it} combines any omitted factors that affect patterns of foreign patenting in the United States. Errors are clustered by country in all reported results.

4.2 Pre-Treaty Education and GDP per Capita

An important component of our empirical tests considers the influence of pre-existing development levels as a determinant of countries' sensitivity to strengthened U.S. patent rights. Analyses of modern data for the pharmaceutical industry, for example, have shown that patenting is more responsive to strengthened intellectual property rights in countries with higher levels of education and GDP per capita (Qian 2007). We extend our baseline approach to allow variation across countries in the capacity to respond to benefits of the Paris Convention, as determined by development levels at the time of U.S. accession. To do this, we estimate the following equation

$$\begin{aligned} Patents_{it} &= \beta \cdot Member_i \times Post\ 1887_t \\ &\quad + \gamma \cdot Member_i \times Post\ 1887_t \times Education_i + \eta_i + \eta_t + \eta_i \times t + \epsilon_{it}, \end{aligned} \tag{2}$$

where $Education_i$ is an 1880 measure of the primary-school education rate in country i, and all other variables are defined as in (1). The combined effect $\beta + \gamma \cdot Education_i$ reflects the estimated impact of the Paris Convention on technology transfer from a country with a pre-treaty education rate $Education_i$. We perform an analogous regression that uses GDP per Capita in place of education in (2). In either case, a positive differential effect γ would indicate that, as in Qian (2007), relatively developed countries are more responsive to strengthened patent rights than are less-developed countries.

4.3 Differences Across Industries

Because the Paris Convention may not affect technology transfer equally across sectors, we next implement regressions that evaluate differences across sectors in responsiveness to strengthened patent rights, controlling for other differences across sectors by patent class.

We first identify patent classes related to the manufacturing or chemical industries. Manufacturing sectors include Tools (81), Motors (91), Machine Elements (74), and Metal Working (29).[26] Chemical sectors include: Bleaching and Dyeing (8), Chemistry of Carbon Compounds (260), Drug, Bio-Effecting and Body-Treating Compositions (424), and Distillation (203).[27] Defining Mnf_j as a dummy equal to 1 if class j corresponds to the manufacturing industry, and $DrugChem_j$ as a dummy equal to 1 if class j corresponds to the chemical industry, we then allow estimates of β and γ to differ across these industry groups as follows

$$\begin{aligned} Patents_{ijt} = {} & \beta_0 \cdot Member_i \times Post\ 1887_t + \beta_1 \cdot Member_i \times Post\ 1887_t \times Mnf_j \\ & + \beta_2 \cdot Member_i \times Post\ 1887_t \times DrugChem_j \\ & + \gamma_0 \cdot Member_i \times Post\ 1887_t \times Education_i \\ & + \gamma_1 \cdot Member_i \times Post\ 1887_t \times Education_i \times Mnf_j \\ & + \gamma_2 \cdot Member_i \times Post\ 1887_t \times Education_i \times DrugChem_j \\ & + \delta_1 \cdot Mnf_j \times Education_i + \delta_2 \cdot DrugChem_j \times Education_i \\ & + \eta_i + \eta_j + \eta_t + \eta_i \times t + \epsilon_{it}. \end{aligned} \tag{3}$$

In (3), $Patents_{ijt}$ is the log of U.S. patents by sector-j inventors from country i in year t, η_j is a patent-class fixed effect, and all other variables are defined as above and in (1).

4.4 Robustness Checks

We extend the baseline approach described in equations (1)–(2) in several ways. First, to better control for the influence over time of pre-accession differences across countries, we add interactions between country characteristics common to country groups, G_i, and a full set

[26] The complete list is as follows: Textiles (87, 26, 19, 68, 38, 66, 28, 57, 139, 112), Wood manufacturing (142, 217, 144), Tools (483, 173, 82, 901, 492), Motors and Pumps (418, 415, 464, 91, 185), Metal Working (72, 164, 228, 76, 148, 29, 266, 74).

[27] The complete list is as follows: Bleaching and dyeing (8), Chemistry (422, 260, 585, 423, 436, 204, 429, 71, 518, 435, 530, 23), Cleaning compositions and other agents (510, 516, 588, 504), Distillation (202, 203, 201), Drugs (424, 514), Synthetic resins (520-528), Perfume (512), Mineral Oils (208), Electrolysis (205), and Organic Compounds (532-570).

of year dummies as follows

$$\begin{aligned} Patents_{it} &= \beta \cdot Member_i \times Post\ 1887_t + \gamma \cdot Member_i \times Post\ 1887_t \times Development_i \\ &+ \sum_t \delta_t' G_i \times \eta_t + \eta_i + \eta_t + \eta_i \times t + \epsilon_{it}, \end{aligned} \tag{4}$$

so that the coefficients δ_t reflect differences over time in patenting across countries with different group or region characteristics, where groups are continental Europe, the British Commonwealth, or other. As a second variant, equation (5) below adds interactions between an indicator for original treaty members and year dummies for the five years preceding U.S. accession in 1887. These interactions control for any differential trends in U.S. patenting between members and non-members of the Convention prior to U.S. accession, which may reflect unobserved differences in innovative capacity or benefits of treaty membership

$$Patents_{it} = \beta \cdot Member_i \times Post\ 1887_t + \sum_{t=1882}^{1886} \delta_t \cdot Member_i \times \eta_t + \eta_i + \eta_t + \eta_i \times t + \epsilon_{it}. \tag{5}$$

In (5), the coefficients δ_t capture pre-accession differences between members and non-members in U.S. patenting. We explore the empirical results using (5) and all previous specifications in section 5. Finally, we evaluate the results of a flexible estimation approach that allows the effect of treaty membership to vary non-parametrically over time. To do this, we estimate variants of (1) and (2) that include interactions between an full set of year dummies and a) an indicator for original treaty membership, and b) the interaction between the original membership indicator and country i's 1880 education level or GDP per capita. This allows us to investigate the dynamics of the Paris Convention's impact on patenting. The resulting coefficients appear in Figures 3 and 4 and are described in section 6.

5 Main Results

5.1 Baseline

The first set of empirical results examines the impact of U.S. accession to the Paris Convention on patenting in the United States by foreign nationals. In Table 3, we present estimates of equation (1) and two related specifications. The first column includes only country and year fixed effects, and in this regression, the β estimate suggests that the Paris Convention had little impact on technology transfer into the United States. This changes after adding country-specific linear time trends (column 2) and country-specific quadratic trends (column 3), revealing the importance of controlling for differences across countries in underlying patenting trends unrelated to the Paris Convention. In particular, the estimates suggest that U.S. accession to the treaty increased U.S. patenting by foreign inventors by a minimum of 45 percentage points. Column 4 presents estimates using a limited sample of countries: those that either a) joined the Convention before the United States, or b) joined outside the sample period (i.e. after 1914). Because many of our control countries chose to become treaty members after the United States, this approach takes into account that including these observations may lead us to understate the impact of the treaty. The estimates suggest a somewhat larger impact of approximately 60 percentage points within this sample.

5.2 Interactions with Education and GDP per Capita

The next set of results uses cross-country differences in development levels, which reflect differences in the capacity to respond to strengthened patent rights, to further isolate the effect of the Paris Convention on technology transfer to the United States. Table 4 presents estimates of equation (2) to evaluate the influence of primary-school education rates prior to U.S. accession on responsiveness to treaty rights. This country-level measure is from Lindert (2004) and is defined to be the share of children between the ages of five and 14 that were enrolled in primary school in 1880. Across all specifications, the results show that the Paris Convention had a positive effect on U.S. patenting by foreign nationals, and that this effect is increasing in countries' existing primary education rates. The differential effect of education γ is positive and highly significant across all specifications. These estimates suggest that on average, countries with 1880 education rates in the 75th percentile increased patenting by at least 110 percentage points more than countries near the 25th-percentile of the education rate distribution. Similarly, countries with above-median education rates in 1880 increased U.S. patenting by 125 percentage points more than below-median countries. These estimates also suggest that countries with high pre-existing education rates are responsible for the full response to strengthened U.S. patent rights.[28]

[28]Additional estimates based on secondary school and university enrollment appear in Table A6, and indicate that secondary education is also able to explain a significant share of cross-country variation in responsiveness to the Paris Convention. In particular, the estimates in column 3 suggest that countries with 1880 secondary education rates in the 75th percentile increased patenting by approximately 35 percentage points more than countries near the 25th-percentile of the distribution. University enrollment, on the other

Table 5 presents a symmetric analysis based on per-capita income differences across countries. Estimation is again based on equation (2), with $Education_i$ replaced by country i's GDP per capita in 1880. The pattern of results in Table 5 is qualitatively similar to that in Table 4: relatively developed countries are significantly more responsive to the Paris Convention's benefits than are less-developed countries. Comparing countries at the 75th and 25th percentiles of the GDP per capita distribution, wealthier countries increased patenting by approximately 45 percentage points, and above-median countries increased patenting by 65 percentage points more than other countries. Taken together, the results in Tables 4 and 5 suggest the strong influence of cross-country development differences on responsiveness to intellectual property rights, and also indicate that education rates are a particularly potent determinant of responsiveness.

5.3 Differences Across Industries: Manufacturing vs. Chemicals

A benefit of measuring technology transfer with patent data is that we are able to discern the sectoral composition of these transfers at a highly disaggregated level. Each patent in our dataset is categorized by three-digit patent class and one or more additional three-digit subclasses, providing an unusually detailed view, for this period in history, of technology transfer into the United States. The estimation approach in equation (3) makes use of this technology classification to examine how the effects described above differ across industries. The results are presented in Table 3.

Table 6 reveals differences between the manfacturing and chemical sectors in sensitivity to improved patent protection. Columns 1 and 2 indicates that patenting increased significantly more in manufacturing than in the chemical industry or other sectors; the magnitude of the differential effect depends on the estimation approach. Estimates of equation (3), which include interactions with 1880 education and GDP per capita, appear in columns 3–6. These also suggest evidence that the differential impact of the treaty, determined by pre-existing development levels, of strengthened patent protection was larger in manufacturing than in other industries.

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hand, does not appear to explain the variation in the data.

6 Robustness Checks

We perform a series of robustness checks to evaluate the stability of our main results. These appear in Tables 7 and 8. First, we control flexibly for differential trends in patenting across major country groups by estimating equation (4). This specification includes controls that absorb any differences in U.S. patenting over time between Europe, the Commonwealth, and other countries in recognition that there may have been general differences in the extent of industrialization across these groups during the sample period. We next estimate equation (5), which flexibly controls for differences between original treaty members and non-members in patenting trends prior to U.S. accession. To address the possibility that our results may be strongly influenced by countries with high U.S. patent volumes, we also exclude from our sample Britain, Germany, Austria, and Ireland; by a significant margin, these four countries were the top U.S. patent recipients in 1886, just prior to U.S. accession to the Paris Convention. In addition, because Commonwealth countries are responsible for a large share of the response to the Paris Convention [Table A7], we exclude all Commonwealth countries: Britain, Australia, New Zealand, Canada, and Ireland. Finally, we exclude all zeros in the dependent variable. We find qualitatively similar results under each of these alternative specifications.

We also include four additional sets of robustness checks in the appendix. In the first set, which appears in Table A1, we limit the sample of countries to those that either a) joined the Paris Convention prior to 1887, or b) joined after 1914. Under this specification, countries such as Germany, which joined in 1903, are excluded. This is in recognition of the fact that Germany's treaty membership late in our sample period may lead us to understate the effect of the treaty. Table A2 presents a comparison of results using our main measure of technology transfer and the hand-constructed measure. These results reveal somewhat smaller, but still highly significant, effects using the hand-constructed measure. In a separate set of tests [Table A4] we evaluate estimates from Tables 3–5 using a sample that omits observations with zero patents. In Table A5, we report incidence rate ratios from the re-estimation of results in Tables 3–5 using Poisson regressions, and find similar results under this and each of the previous sets of robustness checks.

6.1 Time-Varying Effects

To evaluate the time profile of the Paris Convention's impact on patenting, we estimate specifications that allow coefficients to vary over time. Figure 3 plots the coefficients resulting from an equation similar to (1) that includes separate interactions between a full set of year dummies and $Member_i$, which indicates whether country i was an original treaty member. The results suggest high rates of U.S. patenting by foreign inventors during the late 1880's, with a peak effect in 1893. There also appears to be a sharp upward shift beginning in 1889, less than two years after the U.S. accession to the Paris Convention. However, patenting appears to have risen sharply at earlier points, for example at 1874 and 1880, well before the Paris Convention was established.

Figure 4 illustrates the results of a similar estimation exercise in which time-varying coefficients are able to differ across countries according to pre-existing development levels. In both the upper panel (education) and lower panel (GDP per capita), it is evident that development levels prior to U.S. accession explain significant differences in patenting trends. Countries with high levels of development appear to increase U.S. patenting after 1887, while countries with low levels of development do not. These figures again suggest that relatively developed countries increased U.S. patenting prior to 1887 as well, beginning around 1878–1880, underscoring the importance of robustness checks that control for differences across countries in pre-existing trends.

7 Conclusion

This paper has used the U.S. accession to the Paris Convention in 1887, four years after the treaty was originally established, as an empirical setting to examine the effects of international treaties on technology transfer. U.S. accession to the treaty strengthened patent rights in the United States for nationals from countries that had signed the treaty before 1887, but had no effect on patent rights for nationals from other countries. Data on 86,000 U.S. patents between 1865 and 1914 indicate that the number of patent grants per year increased by 45 percentage points for nationals from member countries after the U.S. accession to the treaty, compared with nationals from other countries.

The data also show that domestic conditions in the originating countries are a crucial determinant of the response to treaty rights. Countries with higher levels of education, measured by primary school enrollment, experience a 125 percent stronger increase in patenting compared with other countries. These results also hold for secondary-school enrollment, and equivalent regressions using variation in GDP per capita yield comparable results. An explanation for these findings is that countries with higher levels of education and economic development have more potential to invent and transfer technologies in response to strengthened protection for their ideas.

A complementary set of results suggest that treaties may also affect the industrial composition of technology transfer. Specifically, the effects of the treaty were stronger in manufacturing machinery than in the chemical industry. During the 19th-century, innovations in manufacturing machinery depended on patent protection because they were easy to reverse-engineer, while innovations in chemicals could be protected by secrecy and did not need patents (Moser, forthcoming). Today, innovations in chemicals and pharmaceuticals are among the most dependent on patent protection, thus contemporary treaties such as TRIPS may have their strongest effects in those industries.

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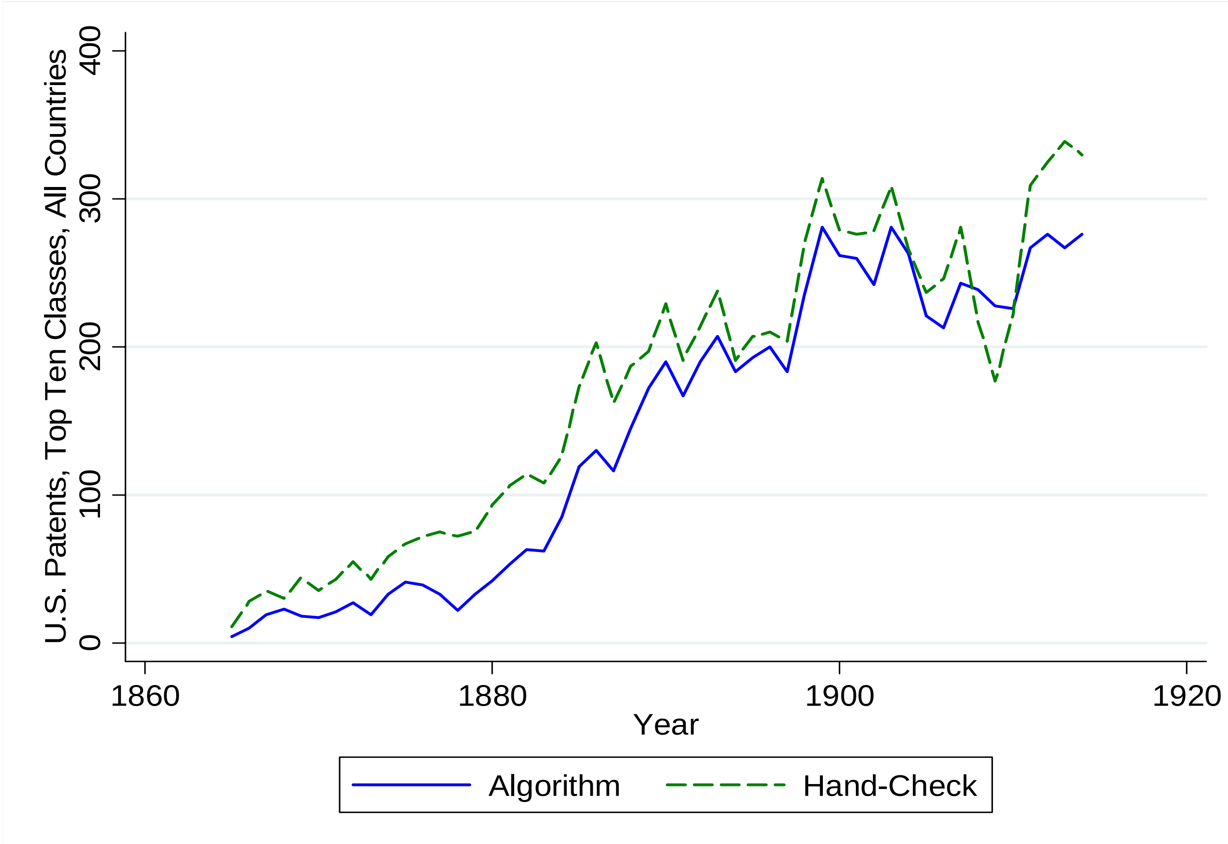
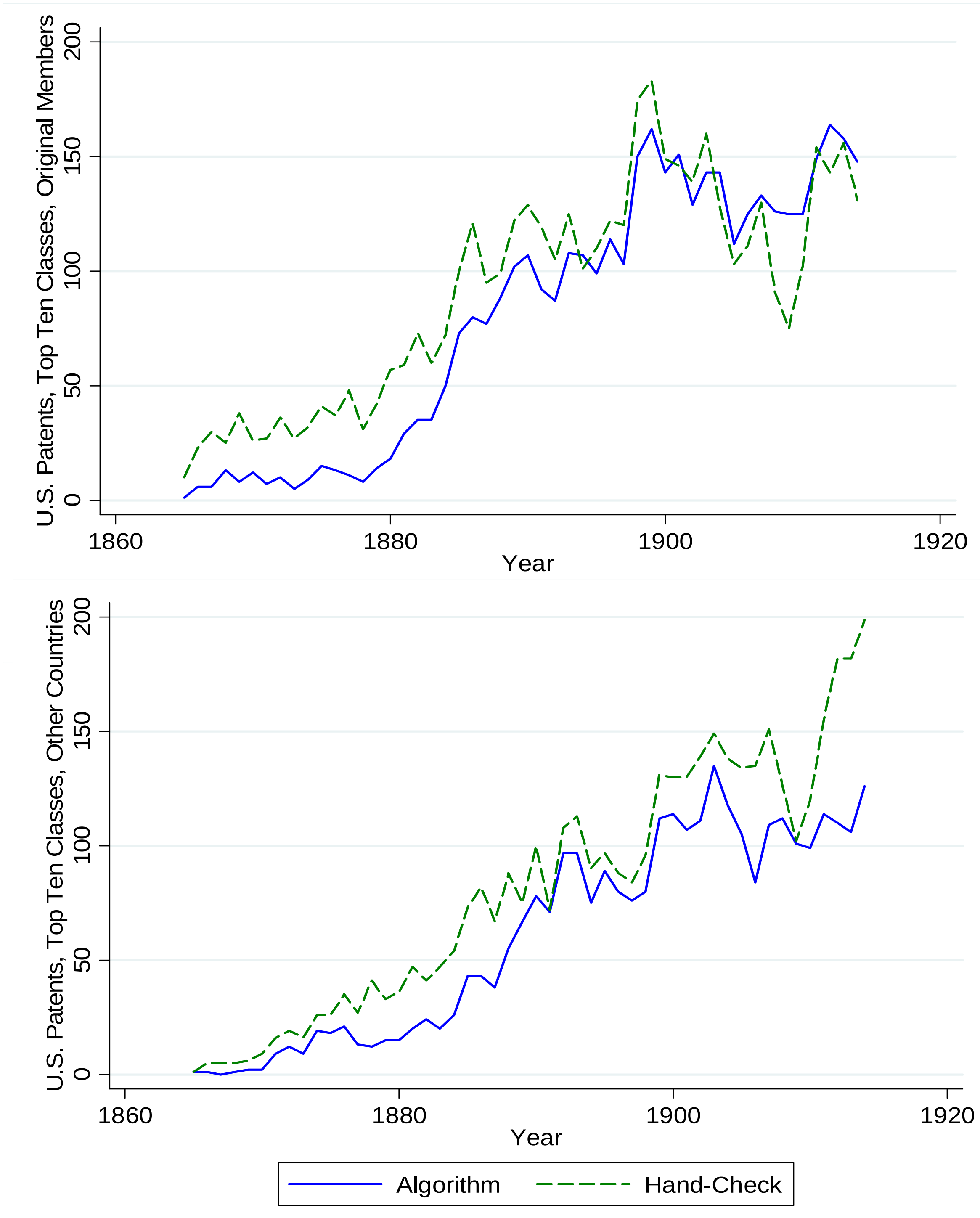
Figure 1: Hand Check vs. Algorithm - All Countries, Top Ten Patent Classes



Notes: This figure plots the number of U.S. patents by foreign nationals in the top ten patent classes during 1865-1914, as obtained using two distinct patent search methodologies. The solid line is based on the Google Patents search engine, while the dashed line is based on a hand-constructed method for identifying inventors' countries of origin.

Figure 2: Hand Check vs. Algorithm, Top Ten Patent Classes by Group

Original treaty members (upper panel); Other countries (lower panel)

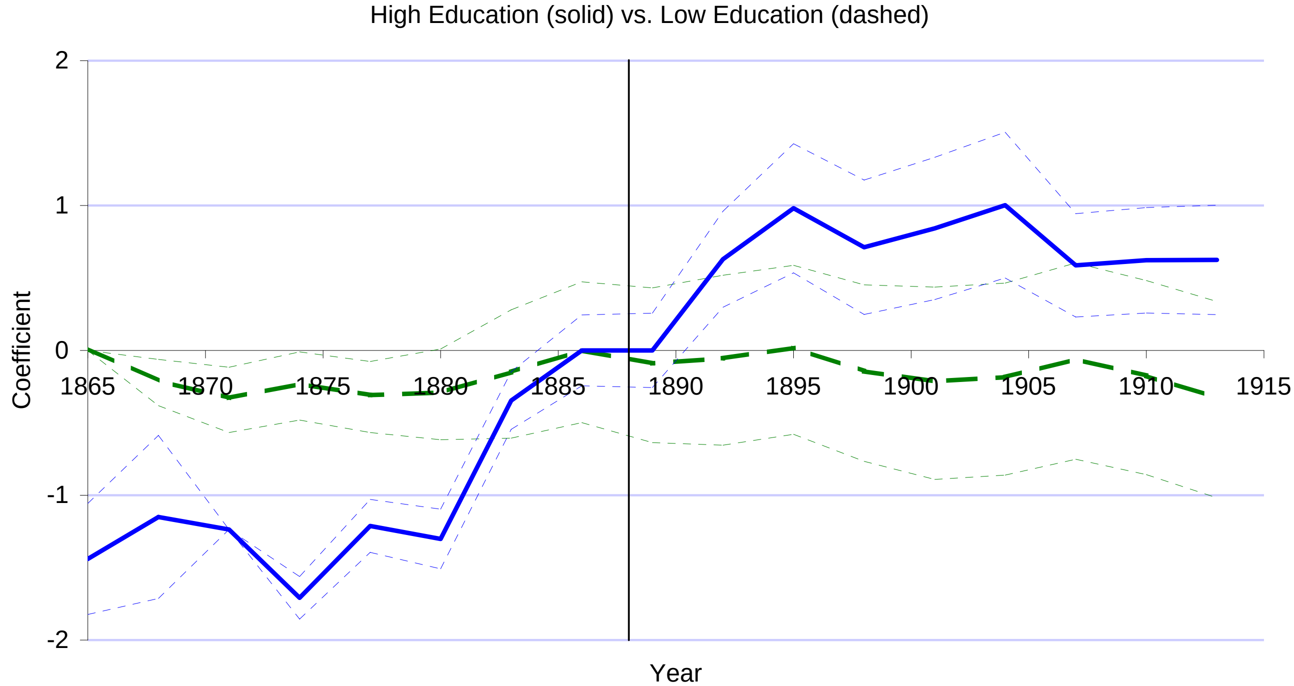


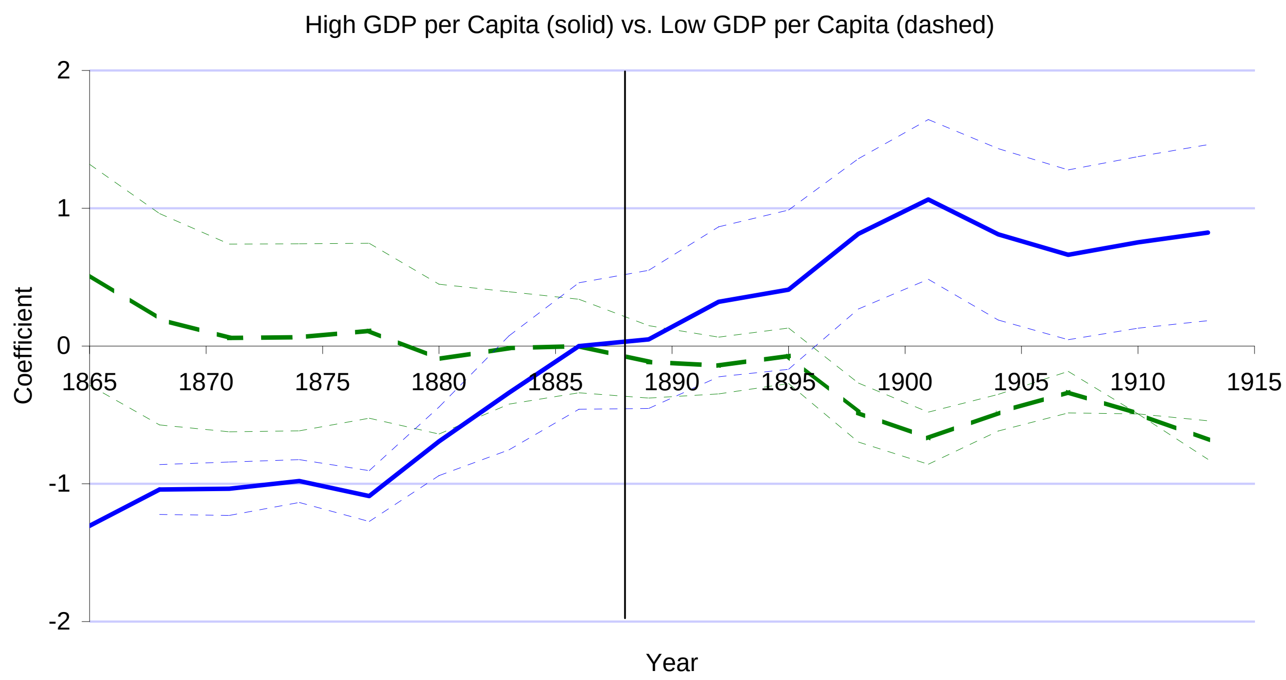
Notes: This figure plots the number of U.S. patents by foreign nationals in the top ten patent classes during 1865-1914, as obtained using two distinct patent search methodologies. The solid line is based on the Google Patents search engine, while the dashed line is based on a hand-constructed method for identifying inventors' countries of origin. The upper panel corresponds to original members of the Paris Convention, while the series for other countries appear in the lower panel.

Figure 3: Time-varying Coefficients

Notes: This figure plots estimated coefficients from a flexible estimation equation in which the effect of the Paris Convention is able to vary non-parametrically across years. These coefficients are plotted over time with standard errors, and the smoothed line is sixth-degree polynomical trend line. The dependent variable is the log of U.S. patents by foreign nationals and the data span 1865-1914.

Figure 4: Time-varying coefficients - Education and GDP per Capita





Notes: These figures plot estimated coefficients from a flexible estimation equation in which the effect of the Paris Convention is able to vary non-parametrically over time in three-year bins. This specification allows the effect of Paris Convention membership to vary at differential rates for countries with high or low levels of development in 1880 as indicated above each graph. The dependent variable is the log of U.S. patents by foreign nationals and the data span 1865-1914.

Table 1: List of Sample Countries and Accession Dates

Country	Initial Accession Year
Original Signatories:	
Belgium	1883
Brazil	1883
France	1883
Italy	1883
The Netherlands	1883
Portugal	1883
Serbia	1883
Spain	1883
Switzerland	1883
Great Britain	1884
Ireland	1884
Tunisia	1884
Norway	1885
Sweden	1885
Other Countries:	
El Salvador	1883
Guatemala	1883
Ecuador	1884
Denmark	1894
Japan	1899
Germany	1903
Mexico	1903
Australia	1907
Austria	1909
Finland	1921
Canada	1925
New Zealand	1931
Argentina	1967
China	1985

Notes: Original signatories were members of the Paris Convention prior to U.S. accession in 1887. Australia (1925) and Ireland (1925) each re-joined the treaty once fully independent of the British Empire; New Zealand joined as a Commonwealth country at around the time of U.S. accession and also later re-joined in 1931. Ecuador, El Salvador, and Guatemala were original signatories, but each withdrew from the treaty shortly after accession. Source: Manual of Industrial Property Conventions (1978).

Table 2: Summary Statistics

Variable	Mean	Standard Deviation	Min	Max
Full Sample:				
U.S. Patents by Foreign Nationals, per country and year	62.0	159	0	1160
U.S. Patents by Foreign Nationals, per country, year, and class	.131	.684	0	39
U.S. Patents by Foreign Nationals, per country and year				
Algorithm – top ten classes	.808	1.15	0	4.44
U.S. Patents by Foreign Nationals, per country and year				
Hand-check - top ten classes	.726	1.21	0	4.89
Education – Enrollment in Primary School, 1880				
Students age 5-14 in school, per 1000	441	234	68	882
Log GDP per Capita, 1880	7.02	.575	5.78	8.03
Original Treaty Members:				
U.S. Patents by Foreign Nationals, per country and year	68.5	170	0	1160
U.S. Patents by Foreign Nationals, per country, year, and class	.143	.677	0	23
U.S. Patents by Foreign Nationals, per country and year				
Algorithm – top ten classes	.917	1.18	0	4.29
U.S. Patents by Foreign Nationals, per country and year				
Hand-check - top ten classes	.793	1.22	0	4.86
Education – Enrollment in Primary School, 1880				
Students age 5-14 in school, per 1000	453	189	70	705
Log GDP per Capita, 1880	7.04	.567	5.78	7.62
Other Countries:				
U.S. Patents by Foreign Nationals, per country and year	54.5	146	0	976
U.S. Patents by Foreign Nationals, per country, year, and class	.135	.754	0	39
U.S. Patents by Foreign Nationals, per country and year				
Algorithm – top ten classes	.729	1.18	0	4.44
U.S. Patents by Foreign Nationals, per country and year				
Hand-check - top ten classes	.820	1.29	0	4.89
Education – Enrollment in Primary School, 1880				
Students age 5-14 in school, per 1000	424	284	68	882
Log GDP per Capita, 1880	6.98	.584	6.17	8.03
Number of Country-Year Observations	1400			
Number of Country-Year-Class Observations	517050			

Notes: Data on U.S. patent grants are from United States Patent and Trademark Office records (www.uspto.gov), and demographic variables are from Lindert (1994, 2004). Full-text patents were accessed through the Google Patents database: http://www.google.com/patents. For the top ten patent classes, two methodologies were used: a) an algorithm-based search using the Google Patents search engine; and b) a hand-check with patents individually matched to countries of origin.

Table 3: The Paris Convention and Foreign Patenting in the United States

Dependent variable:	Log(U.S. patents by foreign nationals)			
	Full Sample	Full Sample	Full Sample	Excl. countries that joined after the U.S.
	(1)	(2)	(3)	(4)
Member x Post	0.583	0.431**	0.379**	0.468**
	(0.411)	(0.193)	(0.165)	(0.172)
Year Fixed Effects	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y
Country-Specific Linear Trends	N	Y	Y	Y
Country-Specific Quadratic Trends	N	N	Y	Y
R-squared	0.873	0.952	0.961	0.962
N	1400	1400	1400	1000

* p<0.10, ** p<0.05, *** p<0.01; Standard errors clustered at the country level

Notes: This table reports least-squares of equation (1). The sample period is 1865–1914. Estimates in column 4 exclude countries that joined the Paris Convention after 1887 but before 1914. The dependent variable is the log of one plus the number of United States patent grants to foreign nationals by country and year. The results are qualitatively similar when we exclude zeros [Table A4] and use Poisson estimation [Table A5]. The Member variable is an indicator equal to one for original members of the Paris Convention; Post is an indicator equal to one after U.S. accession in 1887.

Table 4: Education and the Impact of the Paris Convention

Dependent variable:	Log(U.S. patents by foreign nationals)					
	(1)	(2)	(3)	(4)	(5)	(6)
Member x Post	-1.063**	-0.527*	-0.477*	0.278	0.219	0.187
	(0.433)	(0.285)	(0.255)	(0.423)	(0.195)	(0.162)
Member x Post x Education	3.675***	2.185***	1.889***			
	(0.609)	(0.498)	(0.460)			
Member x Post x High Education				1.448***	0.910***	0.822***
				(0.344)	(0.274)	(0.264)
Year Fixed Effects	Y	Y	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y	Y	Y
Country-Specific Linear Trends	N	Y	Y	N	Y	Y
Country-Specific Quadratic Trends	N	N	Y	N	N	Y
R-squared	0.901	0.941	0.95	0.884	0.954	0.962
N	950	950	950	1400	1400	1400

* p<0.10, ** p<0.05, *** p<0.01; Standard errors clustered at the country level

Notes: This table reports least-squares estimates of equation (2). The sample period is 1865–1914. The dependent variable is the log of one plus the number of United States patents granted to foreign inventors by country and year. The results are qualitatively similar when we exclude zeros [Table A4] and use Poisson estimation [Table A5]. The Member variable is an indicator equal to one for original members of the Paris Convention; Post is an indicator equal to one after U.S. accession in 1887. Education is the share of children between the ages of 5 and 14 enrolled in primary school in 1880, by country (Lindert 2004). High Education indicates countries with above-median rates of primary education; because this is available for a larger group of countries than is Education, the sample size is larger in Columns 5-8 than in Columns 1-4. Estimates based on secondary education and university enrollment appear in Table A6.

Table 5: Per-capita Income and the Paris Convention

Dependent variable:	Log(U.S. patents by foreign nationals)					
	(1)	(2)	(3)	(4)	(5)	(6)
Member x Post	-6.856***	-3.353***	-2.959***	-0.269	0.075	0.071
	(1.621)	(0.882)	(0.832)	(0.553)	(0.219)	(0.175)
Member x Post x GDP per Capita	1.060***	0.543***	0.475***			
	(0.224)	(0.122)	(0.115)			
Member x Post x High GDP per Capita				1.408***	0.577**	0.500**
				(0.490)	(0.252)	(0.213)
Year Fixed Effects	Y	Y	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y	Y	Y
Country-Specific Linear Trends	N	Y	Y	N	Y	Y
Country-Specific Quadratic Trends	N	N	Y	N	N	Y
R-squared	0.896	0.94	0.95	0.889	0.953	0.962
N	950	950	950	1400	1400	1400

* p<0.10, ** p<0.05, *** p<0.01; Standard errors clustered at the country level

Notes: This table reports least-squares estimates of equation (2). The sample period is 1865–1914. The dependent variable is the log of one plus the number of United States patents granted to foreign inventors by country and year. The results are qualitatively similar when we exclude zeros [Table A4] and use Poisson estimation [Table A5]. The Member variable is an indicator equal to one for original members of the Paris Convention; Post is an indicator equal to one after U.S. accession in 1887. GDP per Capita is the log of per-capita GDP in 1880, by country (Lindert 1994). High GDP per Capita indicates countries with above-median per-capita incomes; because this is available for a larger group of countries than is GDP per Capita, the sample size is larger in Columns 5-8 than in Columns 1-4.

Table 6: The Impact of the Paris Convention on the Composition of Patenting, Class-level Results

Dependent variable:	Log(U.S. patents by foreign nationals)					
	OLS (1)	Poisson (3)	OLS (3)	Poisson (4)	OLS (5)	Poisson (6)
Treaty	0.0169	0.995	-.0693	1.16	-0.775	8.68***
	(0.059)	(0.025)	(.423)	(0.147)	(0.470)	(4.90)
Treaty x Manufacturing	0.031*	1.43***	.0245	0.804**	-0.182	14.7***
	(0.015)	(0.020)	(.020)	(0.081)	(0.148)	(12.9)
Treaty x Chemicals	-0.0413	0.475***	-0.120	1.55***	0.429	73.4***
	(0.031)	(0.022)	(.020)	(0.196)	(0.389)	(77.8)
Treaty x Education Rate			.0002	1.00***		
			(.0001)	(0.000)		
Treaty x Education x Manufacturing			0.009	1.98***		
			(0.053)	(0.343)		
Treaty x Education x Chemicals			-.0545	0.883		
			(.0570)	(0.205)		
Treaty x GDP per Capita					0.116	0.796***
					(0.072)	(0.060)
Treaty x GDPpc x Manufacturing					0.0301	0.699***
					(0.229)	(0.084)
Treaty x GDPpc x Chemicals					-0.152	0.602***
					(0.157)	(0.088)
Country Fixed Effects	Y	Y	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y	Y	Y
R-squared	0.246	--	0.297	--	0.198	--
N	517050	440450	344700	344700	344700	344700

* p<0.10, ** p<0.05, *** p<0.01; OLS Standard errors clustered at the country level

Notes: This table reports OLS estimates and incidence rate ratios from Poisson estimation of equation (3). The sample period is 1865–1914. The dependent variable is the log of one plus the number of U.S. patents granted to foreign inventors by country, year, and patent class (OLS) or the number of patents granted to foreign inventors by country, year, and patent class (Poisson). The Member variable is an indicator equal to one for original members of the Paris Convention; Post is an indicator equal to one after U.S. accession in 1887. Manufacturing indicates patent classes corresponding to the manfucaturing sector; Chemicals indicates patent classes corresponding to the chemical (including pharmaceutical) industry. Education Rate (Education) is the share of children between the ages of 5 and 14 enrolled in primary school in 1880, and GDP per Capita (GDPpc) is the log of per-capita GDP in 1880, both by country (Lindert 1994). Coefficients on additional pairwise interactions in equation (3) have been suppressed to conserve space but are available upon request.

Table 7: Robustness Checks - Education

Dependent variable:	Log(U.S. patents by foreign nationals)					
	Baseline	Include year dummies x region effects	Include original signatory pre-trends	Exclude top-patenting countries	Exclude Commonwealth	Exclude zeros
	(1)	(2)	(3)	(4)	(5)	(6)
Member x Post	-0.477*	-0.292	-0.161	-0.442	-0.316	-0.730**
	(0.255)	(0.349)	(0.364)	(0.273)	(0.264)	(0.344)
Member x Post x Education Rate	1.889***	1.730**	1.810***	1.804***	1.811**	2.231***
	(0.460)	(0.719)	(0.450)	(0.487)	(0.655)	(0.480)
Year Fixed Effects	Y	Y	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y	Y	Y
Country-Specific Linear Trends	Y	Y	Y	Y	Y	Y
Country-Specific Quadratic Trends	Y	Y	Y	Y	Y	Y
R-squared	0.950	0.942	0.951	0.942	0.941	0.936
N	950	950	950	850	750	726

* p<0.10, ** p<0.05, *** p<0.01; Standard errors clustered at the country level

Notes: This table reports least-squares estimates of equations (2), (4), and (5). The sample period is 1865–1914. The dependent variable in Columns 1--5 is the log of one plus the number of United States patents granted to foreign inventors by country and year. In Column 6, the dependent variable is the log of the number of U.S. patents granted to foreign inventors by country and year, and thus this regression excludes all zeros. The Member variable is an indicator equal to one for original members of the Paris Convention; Post is an indicator equal to one after U.S. accession in 1887. Education Rate is the share of children between the ages of 5 and 14 enrolled in primary school in 1880, by country (Lindert 2004). Column 2 adds year dummies interacted with region dummmies to the baseline equation. Column 3 adds interactions between an indicator for original Paris Convention members and year dummies for 1882 - 1886, to flexibly control for common trends in U.S. patenting prior to U.S. accession. Column 4 excludes the top-patenting countries in 1887: Britain, Germany, Austria, and Ireland. Column 5 drops all countries in the Commonwealth (Britain, Ireland, Canada, Australia, and New Zealand) and column 6 drops observations with zero patents.

Table 8: Robustness Checks - Income per Capita

Dependent variable:	Log(U.S. patents by foreign nationals)					
	Baseline	Include year dummies x region effects	Include original signatory pre-trends	Exclude top-patenting countries	Exclude Commonwealth	Exclude zeros
	(1)	(2)	(3)	(4)	(5)	(6)
Member x Post	-2.959***	-1.709	-2.501**	-2.724**	-2.455**	-3.698**
	(0.832)	(1.261)	(0.889)	(0.960)	(1.111)	(1.673)
Member x Post x GDP per Capita	0.475***	0.310*	0.451***	0.443***	0.419**	0.569**
	(0.115)	(0.177)	(0.114)	(0.136)	(0.173)	(0.226)
Year Fixed Effects	Y	Y	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y	Y	Y
Country-Specific Linear Trends	Y	Y	Y	Y	Y	Y
Country-Specific Quadratic Trends	Y	Y	Y	Y	Y	Y
R-squared	0.950	0.941	0.950	0.942	0.941	0.935
N	950	950	950	850	750	726

* p<0.10, ** p<0.05, *** p<0.01; Standard errors clustered at the country level

Notes: This table reports least-squares estimates of equations (2), (4), and (5). The sample period is 1865–1914. The dependent variable in Columns 1--5 is the log of one plus the number of United States patents granted to foreign inventors by country, year, and patent class. In Column 6, the dependent variable is the log of the number of U.S. patents granted to foreign inventors by country and year, and thus this regression excludes all zeros. The Member variable is an indicator equal to one for original members of the Paris Convention; Post is an indicator equal to one after U.S. accession in 1887. GDP per Capita is the log of per-capita GDP in 1880, by country (Lindert 1994). Column 2 adds year dummies interacted with region dummmies to the baseline equation. Column 3 adds interactions between an indicator for original Paris Convention members and year dummies for 1882 - 1886, to flexibly control for common trends in U.S. patenting prior to U.S. accession. Column 4 excludes the top-patenting countries in 1887: Britain, Germany, Austria, and Ireland. Column 5 drops all countries in the Commonwealth (Britain, Ireland, Canada, Australia, and New Zealand) and column 6 drops all observations with zero patents.

Table A1: The Impact of the Paris Convention - Limited Sample

Dependent variable:	Log(U.S. patents by foreign nationals)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Member x Post	0.468**	0.422**	0.422**	-0.341	0.335**	-2.699**	0.199
	(0.172)	(0.186)	(0.186)	(0.248)	(0.145)	(0.898)	(0.164)
Member x Post x Commonwealth		0.320					
		(0.236)					
Member x Post x Commonwealth excl. Britain			0.091				
			-0.157				
Member x Post x Britain			0.549***				
			(0.157)				
Member x Post x Education				1.892***			
				-0.603			
Member x Post x High Education					0.926**		
					(0.373)		
Member x Post x GDP per Capita						0.455***	
						-0.136	
Member x Post x High GDP per Capita							0.470*
							(0.233)
Year Fixed Effects	Y	Y	Y	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y	Y	Y	Y
Country-Specific Linear Trends	Y	Y	Y	Y	Y	Y	Y
Country-Specific Quadratic Trends	Y	Y	Y	Y	Y	Y	Y
R-squared	0.962	0.962	0.962	0.951	0.963	0.951	0.962
N	1000	1000	1000	650	1000	650	1000

* p<0.10, ** p<0.05, *** p<0.01; Standard errors clustered at the country level

Notes: This table reports least-squares estimates of equations (1) and (2). The sample period is 1865–1914, and the estimates are based on a limited group of countries: those that were either a) original treaty members, or b) did not join the treaty until after 1914. The dependent variable is the log of one plus the number of United States patents granted to foreign inventors by country and year, though the results are qualitatively similar when we exclude zeros. The Member variable is an indicator equal to one for original members of the Paris Convention; Post is an indicator equal to one after U.S. accession in 1887. Commonwealth, Commonwealth excl Britain, Britain, Education, High Education, GDP per Capita, and High GDP per Capita are as defined in previous tables.

Table A2: The Paris Convention and Foreign Patenting in the United States - Hand-Check vs. Algorithm

Dependent variable:	Log(U.S. patents by foreign nationals in top 10 classes)			
	Algorithm	Hand-Check	Algorithm	Hand-Check
	(1)	(2)	(3)	(4)
Member x Post	-0.707**	-0.825***	-5.102***	-2.531**
	(0.289)	(0.257)	(1.680)	(0.897)
Member x Post x Education Rate	2.187***	1.637***		
	(0.579)	(0.473)		
Member x Post x GDP per Capita			0.765***	0.322**
			(0.252)	(0.133)
Year Fixed Effects	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y
R-squared	0.791	0.876	0.793	0.888
N	900	900	900	900

* p<0.10, ** p<0.05, *** p<0.01; Standard errors clustered at the country level

Notes: This table reports least-squares estimates of equation (2). The sample period is 1865–1914. The dependent variable in Columns 1 and 3 is the log of one plus the number of U.S. patents granted to foreign inventors by country and year in the top ten patent classes, ranked by foreign patenting in 1886. The dependent variable in Columns 2 and 4 is an analogous measure but is constructed by hand. The Member variable is an indicator equal to one for original members of the Paris Convention; Post is an indicator equal to one after U.S. accession in 1887. Education Rate is the share of children between the ages of 5 and 14 enrolled in primary school in 1880, and GDP per Capita is the log of per-capita GDP in 1880, both by country (Lindert 1994).

Table A3: The Impact of the Paris Convention - New Zealand

Dependent variable:	Log(U.S. patents by foreign nationals)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Member x Post	0.308	0.262	0.262	-0.508*	0.176	-2.866***	0.039
	(0.189)	(0.201)	(0.201)	(0.262)	(0.166)	(0.881)	(0.182)
Member x Post x Commonwealth		0.320					
		(0.232)					
Member x Post x Commonwealth excl. Britain			0.091				
			-0.155				
Member x Post x Britain			0.549***				
			(0.155)				
Member x Post x Education				1.892***			
				-0.588			
Member x Post x High Education					0.926**		
					(0.367)		
Member x Post x GDP per Capita						0.455***	
						-0.132	
Member x Post x High GDP per Capita							0.470**
							(0.229)
Year Fixed Effects	Y	Y	Y	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y	Y	Y	Y
Country-Specific Linear Trends	Y	Y	Y	Y	Y	Y	Y
Country-Specific Quadratic Trends	Y	Y	Y	Y	Y	Y	Y
R-squared	0.961	0.961	0.961	0.95	0.962	0.949	0.962
N	1400	1400	1400	950	1400	950	1400

* p<0.10, ** p<0.05, *** p<0.01; Standard errors clustered at the country level

Notes: This table reports least-squares estimates of equations (1) and (2). The sample period is 1865–1914, and the estimates are based on a control group definition that includes New Zealand. Records indicate that New Zealand joined the Paris Convention as part of the Commonwealth at around the time of U.S. accession, but it is not clear whether accession was before or after 1887. Our baseline estimates place New Zealand in the group of countries affected by U.S. accession; this table takes the opposite assumption. The dependent variable is the log of one plus the number of United States patents granted to foreign inventors by country and year, though the results are qualitatively similar when we exclude zeros. The Member variable is an indicator equal to one for original members of the Paris Convention; Post is an indicator equal to one after U.S. accession in 1887. Commonwealth, Commonwealth excl Britain, Britain, Education, High Education, GDP per Capita, and High GDP per Capita are as defined in previous tables.

Table A4: The Impact of the Paris Convention - Exclude Zeros

Dependent variable:	Log(U.S. patents by foreign nationals)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Member x Post	0.467*	0.368	0.378	-0.730**	0.276	-3.698**	0.202
	(0.225)	(0.265)	(0.266)	(0.344)	(0.253)	(1.673)	(0.351)
Member x Post x Commonwealth		0.316	0.196				
		(0.238)	(0.252)				
Member x Post x Commonwealth excl. Britain			0.320*				
			-0.18				
Member x Post x Britain				2.231***			
				-0.48			
Member x Post x Education					0.645***		
					-0.205		
Member x Post x High Education						0.569**	
						(0.226)	
Member x Post x GDP per Capita							0.343
							-0.317
Member x Post x High GDP per Capita							0.470**
							(0.229)
Year Fixed Effects	Y	Y	Y	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y	Y	Y	Y
Country-Specific Linear Trends	Y	Y	Y	Y	Y	Y	Y
Country-Specific Quadratic Trends	Y	Y	Y	Y	Y	Y	Y
R-squared	0.943	0.943	0.943	0.936	0.944	0.935	0.943
N	952	952	952	726	952	726	952

* p<0.10, ** p<0.05, *** p<0.01; Standard errors clustered at the country level

Notes: This table reports least-squares estimates of equations (1) and (2). The sample period is 1865–1914. The dependent variable is the log of the number of United States patents granted to foreign inventors by country and year, thus the sample excludes all observations with zero patents. The Member variable is an indicator equal to one for original members of the Paris Convention; Post is an indicator equal to one after U.S. accession in 1887. Commonwealth, Commonwealth excl Britain, Britain, Education, High Education, GDP per Capita, and High GDP per Capita are as defined in previous tables.

Table A5: The Impact of the Paris Convention - Poisson Estimation

Dependent variable:	Log(U.S. patents by foreign nationals)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Member x Post	1.06*	0.917**	0.918**	0.296***	0.997	.218**	1.1
	(0.034)	(0.039)	(0.046)	(0.056)	(0.033)	(0.149)	(0.101)
Member x Post x Commonwealth		1.24***					
		(0.053)					
Member x Post x Commonwealth excl. Britain			1.15**				
			(.069)				
Member x Post x Britain			1.27***				
			(0.057)				
Member x Post x Education				18.0***			
				(6.14)			
Member x Post x High Education					2.07***		
					(0.163)		
Member x Post x GDP per Capita						1.29***	
						(0.118)	
Member x Post x High GDP per Capita							0.945
							(0.087)
Year Fixed Effects	Y	Y	Y	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y	Y	Y	Y
Country-Specific Linear Trends	Y	Y	Y	Y	Y	Y	Y
N	1150	1150	1150	900	1150	900	1150

* p<0.10, ** p<0.05, *** p<0.01; Standard errors clustered at the country level

Notes: This table reports Poisson estimates of equations (1) and (2). The sample period is 1865–1914. The dependent variable is the number of United States patents granted to foreign inventors by country and year. The Member variable is an indicator equal to one for original members of the Paris Convention; Post is an indicator equal to one after U.S. accession in 1887. Commonwealth, Commonwealth excl Britain, Britain, Education, High Education, GDP per Capita, and High GDP per Capita are as defined in previous tables.

Table A6: Education and the Impact of the Paris Convention - Secondary and University Enrollment

Dependent variable:	Log(U.S. patents by foreign nationals)					
	(1)	(2)	(3)	(4)	(5)	(6)
Member x Post	0.132	0.079	0.026	0.864	0.73	0.68
	(0.487)	(0.281)	(0.240)	(0.844)	(0.444)	(0.399)
Member x Post x Secondary Education	4.287**	3.625***	3.320***			
	(1.506)	(0.813)	(0.675)			
Member x Post x University				-90.531	-87.907	-101.450
				(219.317)	(106.229)	(92.208)
Year Fixed Effects	Y	Y	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y	Y	Y
Country-Specific Linear Trends	N	Y	Y	N	Y	Y
Country-Specific Quadratic Trends	N	N	Y	N	N	Y
R-squared	0.89	0.941	0.95	0.882	0.939	0.949
N	950	950	950	950	950	950

* p<0.10, ** p<0.05, *** p<0.01; Standard errors clustered at the country level

Notes: This table reports least-squares estimates of equation (2). The sample period is 1865–1914, and the estimates are based on the complete sample of countries. The dependent variable is the log of one plus the number of United States patents granted to foreign inventors by country and year. The Member variable is an indicator equal to one for original members of the Paris Convention; Post is an indicator equal to one after U.S. accession in 1887. Secondary Education is the share of children enrolled in secondary school, by country, and University is the share enrolled in graduate studies; both measures are from (Lindert 2004).

Table A7: The Paris Convention and Foreign Patenting in the United States - Commonwealth

Dependent variable:	Log(U.S. patents by foreign nationals)					
	(1)	(2)	(3)	(4)	(5)	(6)
Member x Post	0.38	0.301	0.289	0.382	0.309	0.293
	(0.447)	(0.221)	(0.194)	(0.447)	(0.221)	(0.195)
Member x Post x Commonwealth	0.968**	0.555**	0.385*			
	(0.367)	(0.235)	(0.216)			
Member x Post x Commonwealth excluding Britain				0.794**	0.398*	0.302
				(0.348)	(0.208)	(0.244)
Member x Post x Britain				1.313***	0.859***	0.549***
				(0.324)	(0.171)	(0.155)
Year Fixed Effects	Y	Y	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y	Y	Y
Country-Specific Linear Trends	N	Y	Y	N	Y	Y
Country-Specific Quadratic Trends	N	N	Y	N	N	Y
R-squared	0.878	0.953	0.962	0.878	0.953	0.962
N	1400	1400	1400	1400	1400	1400

* p<0.10, ** p<0.05, *** p<0.01; Standard errors clustered at the country level

Notes: This table reports least-squares estimates of equation (1) with separate interactions for Commonwealth countries: Australia, Britain, Canada, Ireland, and New Zealand. The sample period is 1865–1914. The dependent variable is the log of one plus the number of United States patents granted to foreign inventors by country and year. The results are qualitatively similar when we exclude zeros [Table A4] and use Poisson estimation [Table A5]. The Member variable is an indicator equal to one for original members of the Paris Convention; Post is an indicator equal to one after U.S. accession in 1887. Commonwealth indicates former members of the British Empire as listed above. Commonwealth excl. Britain indicates British Empire countries excluding Britain, and Britain is an indicator for that country.