International Legal Institutions and the Globalization of Innovation*

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Abstract

We study how innovation goes global in response to the establishment of strong international legal institutions that reduce cross-border contracting frictions. We construct novel measures of the globalization of innovation at the country-pair level using 70 million patents from more than 100 patent offices. Exploiting the staggered signing of Bilateral Investment Treaties (BITs), we find that stronger international legal institutions increase a country's technology adoption and sourcing from its BIT partner country and the R&D collaborations between them, resulting in the convergence of the directions of their innovations. The results are particularly strong for countries with weak domestic institutions, for technological laggards, and for process innovation. Increases in the mobility of financial and human capital appear to be the key mechanisms.

Keywords: Innovation, technology diffusion, globalization, international legal institutions, bilateral investment treaties

JEL classification: F21, F23, F61, G18, K33, O31, O32, O33

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1 Introduction

Innovation is characterized by positive spillovers and the pooling of diverse talents.[1] Solutions to many important issues today require technological coordination and collaboration at the global level. In a frictionless world, the production and diffusion of innovation should not be bounded by geography. Yet only a small fraction of innovative activities happen across country borders (Jaffe et al. (1993), Keller (2002)). These globalized innovations, however, often generate larger impacts than local innovations, and are instrumental in developing countries' catching up to the technological frontier (Keller (2004), Kerr and Kerr (2018)). What constrains the geographic boundaries of innovation? Will the removal of these constraints lead to greater innovation collaborations and spillovers among countries? If so, what type of countries or technologies benefit the most?

In this paper, we focus on an important constraint arising from weak international legal institutions. We hypothesize that strong international legal institutions can facilitate the globalization of innovation. First, strong international legal institutions facilitate cross-border contracting on innovation. Due to high uncertainty and low tangibility, innovative activities often require complex contracts. These contracts are difficult to enforce, especially in countries with weak legal institutions. Second, strong international legal institutions facilitate the movement of capital across countries, which further induces the movement of human capital. Prior studies show that physical and human capital are important inputs to innovation, and that their mobility is important to the spillover of knowledge. Therefore, improvements in international legal institutions can expand the geographic boundaries of innovation by reducing contracting frictions and increasing the mobility of innovation inputs.

Empirically testing the above hypothesis faces two challenges. First, shocks to international legal institutions are difficult to come by. Most variations in legal institutions happen within a country, and are often slow and infrequent. We overcome this by using the signing of Bilateral Investment Treaties (BITs) as shocks to international legal institutions. These treaties provide legal protection for foreign investments between signatory countries, irrespective of their domestic institutions. Since 1959, more than 2,000 pairs of countries have signed BITs. The staggered

[1] Hewlett et al. (2013) discuss how diversity can drive innovation. Kerr and Kerr (2018) investigate the impact of inventor team composition on new knowledge creation.

and bilateral nature of these treaties give us rich variations and allow us to include an extensive set of fixed effects. Second, it is hard to observe and consistently measure the globalization of innovation across a large number of countries. The most commonly used patent data from the U.S. Patent and Trademark Office (USPTO) do not provide comprehensive, global coverage. To address this, we leverage 70 million patents from more than 100 patent offices worldwide to construct novel measures of the globalization of innovation at the country-pair-year level. We measure the adoption, sourcing, and collaboration of innovation between any two countries. These measures, combined with BITs, allow us to use a difference-in-differences strategy to examine the effect of international legal institutions on the globalization of innovation.

We begin by documenting that the share of globalized patents — patents that have been adopted abroad, cite foreign patents, or involve foreign inventors or applicants — have increased dramatically in the past four decades. Moreover, these patents are more influential than local patents, as evidenced in their higher number of forward citations. Our main finding is that BITs have a large and positive effect on the globalization of innovation across all our measures. After the signing of a BIT, the two signatory countries adopt and source more innovations from each other, increase their collaboration in patenting and co-ownership of patents, and start to converge in the directions of their innovative activities. These effects are economically large, amounting to 20%–40% increases relative to the pretreatment means, and happen both at the intensive and extensive margin (i.e., the initiation of any collaboration or cross-pollination between two countries). These results suggest that the lack of strong international legal institutions severely constrains the optimal boundaries of the production and diffusion of innovation. BITs are therefore an important policy tool to promote the globalization of innovation.

Our identification strategy relies on the assumption that the timing of BITs for a given country pair is exogenous. Consistent with this assumption, the law literature documents that the signing of BITs is often driven by political or diplomatic reasons (Chilton (2015); Bonnitcha et al. (2017)). Nevertheless, we take multiple approaches to address remaining concerns that the timing of BITs may be endogenous to the economic conditions of the signing countries.

First, we include a rich set of fixed effects and controls. We include country-year fixed effects for both the host (knowledge-importing) countries and the source (knowledge-exporting) countries.

This ensures that our results are not explained by country-specific shocks, such as changing economic, political, institutional, or financial conditions. We also include country-pair fixed effects to absorb time-invariant country-pair-level heterogeneities, such as two countries' geographic, cultural, or linguistic distances. We further control for time-varying country-pair-level variables such as trade volume, currency agreements, and various measures of their economic integration. This alleviates the concern that shocks to bilateral economic relationships between two countries explain our results.

Second, we use a dynamic difference-in-differences model to verify that treated and control country pairs exhibit parallel trends in innovation outcomes before the signing of BITs, and that the effect only shows up after the signing of BITs. Third, we show that our results are concentrated in country pairs where the knowledge-importing country has worse domestic institutions than the knowledge-exporting country. In these cases, the room for improvement in legal institutions, hence the degree of treatment, is larger. Lastly, we exploit a natural experiment from a landmark arbitration ruling to further strengthen identification. The ruling of *Maffezini v. Spain* in January 2000 significantly increased the impact of BITs on international legal protection by allowing investors for the first time to invoke the most favored nation (MFN) provision to gain access to better legal remedies in another BIT already signed by the host country (Jones (2018)). We find that BITs signed before 2000 have a significantly larger impact on our innovation outcomes in the years after the ruling than the years before it.

We document two cross-sectional heterogeneity results that are consistent with the economics of innovation diffusion. We find that our results are stronger when the knowledge-importing country is less technologically advanced than the knowledge-exporting country, consistent with the scope of learning and technological spillover being higher among such country pairs. We also find that our results are stronger for process innovation than for product innovation. This is in line with the process innovation capturing more disembodied knowledge than product innovation. Since disembodied knowledge cannot be reverse-engineered from products and relies more on in-person interactions and physical capital exchanges for dissemination (Keller (2004), Akcigit et al. (2018), Hovhannisyan and Keller (2019)), this result suggests that BITs are particularly effective in diffusing disembodied knowledge through the movement of physical and human capital.

We then examine the mechanisms underlying our main results. We show that foreign direct investments (FDI) play a key role in explaining our findings. We find that the signing of BITs increases the formation of strategic alliances between the signatory countries by 20%, and the formation of joint ventures by 30%. In addition, Bhagwat et al. (2019) document that BITs significantly increase the volume of cross-border mergers and acquisitions between the signatory countries. We also find that international travel between signatory countries increases by 30% after the signing of BITs. This is consistent with the movement of physical capital inducing the movement of human capital due to the complementary between capital and high-skilled labor. Such in-person interactions are especially important for innovations that require disembodied knowledge (such as process innovations) and may also facilitate collaborations in R&D activities (Hovhannisyan and Keller (2019)).

This paper contributes to the literature on institutions (North (1990), Hall and Jones (1999), Acemoglu et al. (2001), Acemoglu et al. (2002), and Acemoglu et al. (2005)) and law and finance (La Porta et al. (1997) and La Porta et al. (1998)). In particular, the paper contributes to the nascent literature on *international* law and finance. Prior papers in this literature have investigated the impact of international law and regulations on country-level financial integration (Kalemli-Ozcan et al. (2010)), stock market liquidity (Christensen et al. (2016)), business cycle synchronization (Kalemli-Ozcan et al. (2013)), firms' investment and financing decisions (Meier (2019)), and resource reallocation (Bian (2019)). Related to our paper, Bhagwat et al. (2019) studies the effect of BITs on mergers and acquisitions. We contribute to this literature by identifying and quantifying the impact of international legal institutions on the globalization of innovation.

Our paper also contributes to the literature on technology transfer and diffusion. Prior work has documented the role of FDI (Aitken and Harrison (1999), Keller and Yeaple (2009), Javorcik (2004), Haskel et al. (2007), Blalock and Gertler (2008)), intellectual property rights (Branstetter et al. (2006)), patent regulation (Cockburn et al. (2016)), joint ventures (Jiang et al. (2018)), financial development (Comin and Nanda (2019)), geography (Comin et al. (2012), Keller (2002)), and technology sourcing (Griffith et al. (2006)) in the diffusion and spillover of technologies (see Saggi (2002) and Keller (2004) for surveys). Our paper differs from these studies in several ways. First, while most of this literature focuses on the adoption and transfer of existing knowledge, our paper predominantly examines the creation of new knowledge and the collaborations therein. Second, prior work in this literature frequently relies on aggregate country-level R&D or total factor productivity to study technology diffusion. We leverage micro-level patenting data to measure technological adoption, sourcing, and collaboration at the bilateral level. We also differentiate between different types of technologies (i.e., product vs. process innovations), which is new to the innovation literature (Eswaran and Gallini (1996), Bena and Simintzi (2019)).

Last, we add to the literature on the determinants of country-level innovation activities. Prior literature has examined the roles of immigration (Moser et al. (2014), Doran and Yoon (2018)), institutions (Donges et al. (2019)), financial development (Hsu et al. (2014)), access to foreign knowledge (Iaria et al. (2018)), and international business travel (Hovhannisyan and Keller (2019)) on *country-level* innovation activities. However, few paper have studied what determines *cross-country* innovations and the globalization of innovation. Our paper adds to this literature by documenting the role of international legal institutions in promoting cross-country technological exchange and collaborations.

2 Measuring the Globalization of Innovation

We use patent data to measure the globalization of innovation. Our data come from PATSTAT Global, a worldwide patenting database maintained by the European Patent Office (EPO). PATSTAT Global provides detailed bibliographical information on over 100 million patents applied in more than 100 patent offices around the world. The largest (based on the number of patents) patent offices in PATSTAT Global include Japan Patent Office (JPO) (20.9%), State Intellectual Property Office of China (SIPO) (17.8%), U.S. Patent and Trademark Office (USPTO) (15.9%), German Patent and Trademark Office (GPTO) (7.3%), Korean Intellectual Property Office (KIPO) (4.2%), European Patent Office (EPO) (3.8%), UK Intellectual Property Office (3.8%), and World Intellectual Property Organization (WIPO) (3.7%). Figure 1 shows an overall increasing trend in the number of patents applied in different patent offices in the past four decades. The total number of patent applications in all offices increased from one million in 1980 to four million in 2016. The comprehensive and global nature of this database is critical to our international setting.

We construct novel measures of the globalization of innovation that capture the interactions in patenting activities across countries. We classify these measures into three categories, corresponding to increasing depth of knowledge exchange involved in these interactions. The first category captures the straightforward adoption of foreign technology. The second category involves technology sourcing from foreign countries through patent citations and patent transfers. The third category measures collaboration in developing new technology between different countries. Except for the third category (collaboration), all measures are directional, from the knowledge-exporting country (country A) to the knowledge-importing country (country B).

In the first category, we use patent priority records to extract information on the adoption of the same technology in different countries over time. A priority right is triggered by the first filing of an application for a patent. The priority right allows the claimant to file a subsequent application in another country for the same invention, effective as of the same date as the first application. Given that patenting in a particular country is a signal of adopting or commercializing a technology in that country, the sequence of applications therefore captures the timing of adoption of the underlying technology across different countries. For example, Figure A.1 shows that a medical device for drug delivery was originally patented by Bayer in Germany in 2002. It was then patented in many other countries from 2003 to 2017. We count the number of patents that have their priority rights in country A and are subsequently patented in country B to construct a country-pair-year-level measure. In this way, this measure captures the number of inventions from country A that are later adopted in country B. Figure 2b plots the share of patents that have subsequent foreign adoptions from 1980 to 2016. This share increased steadily until the mid-2000s, reaching over 40%, and then declined due to the fact that the diffusion process takes time. Figure 2b also compares the forward citations received by patents that are applied in multiple countries versus those applied in just one country. The globally adopted patents are considerably more valuable, receiving approximately twice the number of citations compared to “local” patents.

In the second category, we first measure technology sourcing by patent citations. Specifically, we count the number of patents in country B that cites country A’s patents. Figure A.2a provides an example. It shows that a USPTO patent owned by the Chinese company Huawei cites 13 patents, whose assignees are from 6 foreign countries. Figure 2c shows that the fraction of patents that cite foreign patents is increasing over time, and that such patents tend to be of higher quality as measured by higher numbers of forward citations. We then measure a country's sourcing of innovation from a foreign country's inventors. Specifically, we count the number of patents whose inventors are in country A but whose applicants or assignees are in country B. This measure reflects the extent to which country B sources innovation from country A through patent transfers. Figure A.2b provides such an example, where a patent invented by a team of UK inventors is assigned to Microsoft in the United States. Figure 2d shows a similar trend as in Figure 2b in the share of patents that are transferred from local inventors to foreign companies.

In the third category, we measure the collaboration in patenting between two countries. We count the number of patents whose inventors are in both country A and country B (co-inventions), as well as the number of patents whose applicants are in both country A and country B (co-applications). Figures A.3a and A.3b provide examples of such patents. Figure 2e shows that the fraction of patents that are co-invented by multiple countries has been increasing over time, although the increase stalled or reversed after the financial crisis of 2008. Further, internationally co-invented patents receive more forward citations than other patents. Figure 2f shows similar patterns for internationally co-applied patents.

Lastly, we also measure the technological proximity between two countries. We use the cosine similarity between country A's and country B's patent portfolios. This measure reflects the extent to which country B's innovations are converging toward country A's. We look at both the flow and stock of country A's patents, since learning takes place with a lag. Figure A.4 shows that the average technological proximity between countries has been steadily increasing over the past four decades.

Our final patent-level sample is from 1980 to 2016 and covers more than 70 million patents. Panel A of Table 1 provides summary statistics at the patent level on the different categories of innovation measures. Over our sample period, 34% of patents have priority in a foreign country, 18% of patents cite foreign patents, 4% of patents are sourced from foreign inventors, 2% of patents are co-invented by inventors from different countries, and 1% of patents involve applicants from different countries. Together, these globalized patents (i.e., patents that fall into at least one of the five categories) constitute 41% of all patents worldwide, and they have significantly higher impacts than local patents, as suggested by their substantially higher numbers of forward citations (16.1

vs. 1.9).

The sample used for most of our regression analyses is at the country-pair-year level. Due to the directional nature of our innovation globalization measures, each country pair appears twice, with one country as the knowledge-importing country and the other as the knowledge-exporting country, and vice versa. The raw sample contains 205 countries and 41,820 (205 $\times$ 204) country pairs. We restrict to countries with at least 50 patents over our sample period. This yields a sample of 826,950 country-pair years covering 150 countries from 1980 to 2016 (see Panel B of Table 1), which we use as the baseline sample in our analyses. In a given year, an average country pair has 13.5 patent applications that have priory in the partner country (of which 4.4 are granted), 17.1 patent applications that cite the partner country's patents, 2 patent applications that are sourced from inventors in the partner country, 2.5 co-invented patents, and 1 co-applied patent. The relative low value is due to averaging across more than 20,000 country pairs and 37 years, many of which have no such globalized patents.

3 Bilateral Investment Treaties

To generate variation in international legal institutions, we exploit the establishments of Bilateral Investment Treaties (BITs) at the country-pair level. A BIT is one of the most ubiquitous policy tools used by countries to attract foreign investment. More than 3,200 BITs have been signed since 1959, with 2,321 BITs currently in force (UNCTAD (2018)).

The types of investments covered by BITs are very broad, covering practically all assets owned or controlled by a foreign investor and extending well beyond FDI, the typically perceived purpose of BITs. Most treaties refer to "every kind of asset," followed by an open-ended list including tangible property, debt and equity (including minority portfolio investments), contractual rights, intellectual property rights, and concession contracts. BITs also cover a broad range of foreign investors, including both individuals (natural persons) and juridical entities (legal persons). Most treaties cover investments made both before and after the treaty entered into force.

BITs are commonly employed to overcome the fundamental problem that when a national of one country invests in another country, legal frictions inhibit the enforcement of contracts across borders. Given the lack of a supranational judicial system, basic international law requires investors to rely solely on the host country's law. Host countries may change laws after an investment is made. Anticipating this, firms rationally either withhold investment or only invest if the terms are quite favorable. This leads to a time-inconsistency problem, as host countries cannot commit to not expropriate. International law contains no generally accepted rules for dealing with investment disputes, and lacks a binding mechanism to resolve disputes between an investor and the host country.

BITs protect foreign investment from adverse actions by the host government typically through the following mechanisms. First, agreements guarantee that investments made by individuals and corporations from the other country will be treated fairly and equitably. Second, the agreements limit expropriation of investment, and provide for compensation when expropriation does take place. Third, the agreements provide investors the right to transfer their property out of the foreign state freely. Fourth, the agreements place restrictions on trade-distorting performance requirements—like local content requirements or export quotas. Fifth, BITs tend to allow for the management team of the investor's choosing, without regard to local residency or nationality requirements. Lastly, if the terms of the BIT have been violated and the national courts of the foreign country do not provide redress, the agreements authorize investors to force the foreign state to participate in binding arbitration. Taken together, these provisions give assurances to foreign investors that investments made in the economy of a treaty partner will be provided with legal protection.

Scholars from law and political economy have documented that the signings of BITs are often driven by political or bureaucratic reasons. Chilton (2015) shows that the United States has used BITs as a foreign policy tool to improve relationships with strategically important countries in the developing world. Consistent with this, he finds that investment considerations do not explain the pattern of US BIT formation, but that political considerations do. Reviewing existing studies on investment treaties, Bonnitcha et al. (2017) conclude that developed countries largely promoted investment treaties for bureaucratic and political reasons, and not as a reponse to lobbying by investors or corporations. In some cases, the treaties are used to avoid diplomatic entanglements. Bonnitcha et al. (2017) further document that, due to lack of expertise, many developing countries hastened into BITs with little consideration of the implications of these agreements. The negotiations of investment treaties in these countries rarely involve legal experts, and are often delegated to mid-level bureaucrats, many of whom have misunderstandings about the treaties.[2] Therefore, the timing of BITs can be viewed as largely exogenous to the economic relationship between signatory countries.

We obtain our bilateral investment treaties data from the Investment Policy Hub of the United Nations Conference on Trade and Development (UNCTAD). This database provides detailed information on 2,913 BITs, including the signing countries, sign date, and enforcement date. There is substantial variation in the type of countries signing these treaties, as well as the timing of these treaties. Figure 3 shows the distribution of these treaties by sign year from 1960 to 2018. A large amount of treaties were signed between 1990 and 2010. Following the prior literature, we will use the sign year as the year of treatment, as these treaties can be retroactively applied to years before force date but after sign date. In our main sample, 12% of country-pair years have a BIT in effect.

Figure 4 illustrates the cross-sectional relationship between the number of partner countries a country has for its innovative activity, and the number of partner countries a country has signed BITs with in the year 2016. The fitted line shows an almost one-to-one relationship between these two variables. Figure 5 shows this relationship in the time-series for four individual countries: China, Russia, Korea, and Germany. We again observe a strong positive correlation between the number of partner countries a country has for its innovative activity, and the number of partner countries with which it has signed BITs. Although many other factors can drive these positive correlations, these graphs suggest that good legal protections for foreign investments may play an important role in a country's globalization of its innovation activities.

[2]For example, officials of South Africa incorrectly assumed the treaties contained only broad statements of policy principles, and failed to realize that the provisions potentially gave foreign investors protections over and beyond those enshrined in the South African constitution. In the Czech Republic, a former negotiator recalls that the staff involved "really didn't know that the treaties had any bite in practice...They were neither aware of the costs or the fact that it could lead to arbitration." A Mexican representative says that "many here in Latin American thought it was harmless to sign these treaties, no one had an idea what they mean...They just signed them off within a few days of hours...There was no legal review, control, or scrutiny of the content...No one cared until the dispute came" (Skovgaard Poulsen (2014); Poulsen (2015)).

4 Empirical Strategy

Our primary empirical strategy exploits the staggered signing of BITs as shocks to legal institutions governing contracting environment between different pairs of countries. The specification is a difference-in-differences. The bilateral and staggered nature of BITs offers us rich variations. First, not all countries have signed BITs within our sample period, which allows us to compare countries that have signed BITs with those that never have. Second, for countries that have signed BITs, they do so at different points in time, and with different partner countries. This allows us to use a rich set of fixed effects to absorb potential confounding factors. We estimate the following two specifications at the country-pair-year level:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\kappa_t} + \beta BIT_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t} \quad (1)$$

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t} \quad (2)$$

In both equations, the dependent variable $Y_{ij,t}$ is a measure of the globalization of innovation as described in Section 2 and varies at the level of country i, country j, and year t, where country i is the knowledge-exporting county and country j is the knowledge-importing country. To facilitate interpretation, we construct $Y_{ij,t}$ by scaling the number of globalized patents between country i and j in each category by the total number of such patents generated by country j with all partner countries. We then multiply this number by 100 for ease of displaying the coefficients. $Y_{ij,t}$ can therefore be interpreted as the percentage share of knowledge imported from country i by country j. As such, the mean of our dependent variables in our main sample is always 0.671%.[3] $\boldsymbol{\gamma_{ij}}$ is a set of fixed effects that absorbs time-invariant country-pair-specific factors, such as their distance in geography, culture, language, and genetics. $BIT_{ij,t}$ is the variable of interest — a dummy variable indicating whether a bilateral investment treaty is in place for the country-pair i and j in year t. In robustness tests, we also include a set of country-pair-year-level control variables, $X_{ij,t}$, which includes trade volume, currency agreement, the presence of Bilateral Labor Agreements (BLA), and a measure of the extent of economic integration between the two countries.

[3] Our main sample contains 150 countries, meaning each country has 149 potential partner countries. The mean of of our dependent variable, partner country share, is then calculated as $1/149 \times 100\% = 0.671\%$.

In equation (1), we additionally control for year fixed effects κ_t that absorb global macroeconomic shocks. In equation (2), we use a tighter set of fixed effects, $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, to absorb country-specific shocks at the country-year level for both the knowledge-importing country and the knowledge-exporting country. This specification therefore rules out the explanatory power of any time-varying country-specific factors, such as a country's institution, economic condition, financial development, political condition, or technological advancement. It also absorbs a country's general tendency to participate in the international market. Standard errors are robust and clustered at the country-pair level.[4]

5 Main Results

5.1 Baseline Results

To examine the effect of international legal institutions on the globalization of innovation, we start by analyzing the effect of BITs on patent priority, a measure of cross-border technology adoption. As described in Section 2, our priority measure captures the amount of inventions originating in country A that are subsequently patented, and thus adopted, in country B. Table 2 presents the results. The dependent variable is constructed using patent applications in columns (1) and (4), and using granted patents in columns (2) and (5). Instead of equally weighting all granted patents as in columns (2) and (5), the granted patents are weighted by their forward citations in columns (3) and (6). Across all dependent variables, we see a strong effect of the signing of BITs on patent priority, regardless of the set of fixed effects used. The estimated effect is economically large. For instance, in column (4), the signing of a BIT between two countries increases the share of patent applications with priority from the partner country by 0.133%, which is a 20% increase relative to a mean of the dependent variable of 0.671%.

We then move from technology adoption to the creation of new knowledge. In Table 3, we study the effect of BITs on technology sourcing from foreign countries. Panel A studies sourcing through patent citations. In columns (1) and (4), the dependent variable is based on the number of times a country's patents cite a particular partner country's patents. The dependent variable in columns

[4]Our results are robust to double-clustering by both the knowledge-importing country and the knowledge-exporting country. See Table A.4.

(2) and (5) (columns (3) and (6)) is based on the number of patent applications (granted patents) that cite a particular partner country's patents. Throughout all columns, we find a significant and large effect of BITs on international cross-citations. For instance, in column (4), the introduction of a BIT between two countries increases the share of their cross-citations by 0.209%, which is a 31.1% increase relative to a mean of the dependent variable of 0.671%.

Panel B of Table 3 studies a more direct type of sourcing — the transfer of patents from inventors in a partner country to companies in a host country. The columns are defined analogously as in Panel A. Across all specifications, we observe a strong effect of the signing of BITs on the cross-border transfer of technology. In column (4), for instance, the introduction of a BIT between two countries increases patent transfers by 0.169%, which is a 25.2% increase relative to a mean of the dependent variable of 0.671%.

We next investigate the effect of international legal institutions on countries' collaborations in innovation. We start with international co-inventions (Panel A of Table 4), which measures the collaboration between inventors from two different countries in creating new knowledge. The columns are defined analogously as in Table 2. We find that across all specifications, the signing of BITs between two countries significant increases their co-inventions. In column (4), for instance, the introduction of a BIT increases international co-inventions by 0.268%, which is a 40% increase relative to the mean of the dependent variable. Panel B examines co-applications, which measures the joint ownership of new knowledge between the two countries. We find a similarly strong effect of BITs on the extent of co-applications between the two signatory countries. For instance, in column (4), the introduction of a BIT between two countries increases their co-applications of patents by 0.218%, which is a 32.5% increase relative to a mean of the dependent variable of 0.671%.

Finally, we examine whether the above-observed interactions in patenting between two countries lead to the convergence in their technology space. As discussed in Section 2, we measure technological proximity using the cosine similarity between two countries' patent portfolios. Because this variable is not based on patent count and has a value between 0 and 1, it is not scaled into partner country share. Table 5 presents the results. We follow the International Patent Classification (IPC) by WIPO, and define technology class at the patent class level in columns (1) to (3), and at the patent subclass level in columns (4) through (6). In columns (1) and (4), the yearly flows of new patent applications are used for both countries. In columns (2) and (5) (columns (3) and (6)), the technology-exporting country's portfolio is a 3-year (10-year) stock of patents while the technology-importing country's portfolio is the 1-year flow of new patent applications. Regardless of the measure we use, we find a strong effect of the signing of a BIT on two countries' technological convergence, with a magnitude of 3% to 10% relative to the mean.

Overall, the above results suggest that stronger international legal institutions induced by BITs facilitate the diffusion and collaboration of frontier technology across countries, which further leads to the convergence in the directions of their technological developments.

5.2 Further Identification from *Maffezini v. Spain*

To further strengthen identification, we exploit a natural experiment arising from an arbitration decision, *Maffezini v. Spain*, issued in January of 2000 (Jones, 2018). This arbitration decision was the first to allow an investor to invoke the most favored nation (MFN) protection in its treaty to gain access to better legal remedies in other active BITs signed by the host country. Specifically, prior to *Maffezini v. Spain*, it was generally understood by policymakers that MFN treatment in the context of investment treaties was limited in scope to similar commercial policies like taxes, subsidies, and regulatory takings, and did not extend to legal remedies like access to arbitration. After *Maffezini v. Spain*, investors entitled to MFN treatment now had legal precedent for invoking any legal remedy in any active investment treaty signed by the host country, rather than relying exclusively on the legal remedies in the treaty with the investor's home country.[5] Thus protected investors now have access to better legal protections. Given that most BITs contain an MFN provision (98.2%), the ruling significantly increased the impact of BITs on international legal protection, even within a BIT across time. This natural experiment addresses the concern about the endogenous timing of BITs since it exploits an unexpected arbitration decision that is unrelated to the timing of BITs

[5] A more detailed description of the case can be found in Jones (2018). In 1997 an Argentine investor, Emilio Agustin Maffezini, led an arbitration claim at the ICSID against Spain under the Argentina-Spain BIT signed in 1991. According to the BIT, Maffezini was required to first fully litigate his claim in Spanish Courts before a claim could be brought before an arbitration tribunal (local remedy first). Maffezini cited two facts. First, Spain had signed a BIT with Chile that did not include the local remedy first condition. Second, the Argentina-Spain BIT included MFN protection. Maffezini then argued that the MFN protection in the Argentina-Spain BIT allowed him to invoke the better legal remedy in the Chile-Spain BIT to avoid litigating first in Spanish courts. Argentina argued that access to different procedural remedies did not constitute treatment" by a host economy under MFN and so MFN could not be used to circumvent the domestic court requirement. In its 2000 decision, the panel of three arbitrators unanimously agreed with Maffezini, thus allowing the claim to move forward.

signed before the decision.

To exploit this shock to the legal protections offered by BITs, we restrict our sample to country pairs that signed BITs before 2000, the year of the *Maffezini v. Spain* ruling, and country pairs that never signed BITs. We interact *BIT* with a dummy, *Post 2000*, indicating years of and after 2000. This allows us to test whether BITs signed before *Maffezini v. Spain* have a stronger treatment effect in years after *Maffezini v. Spain* than in years before it. Table 6 presents the results. Consistent with our conjecture, we find that BITs signed before 2000 have a significantly stronger impact on our innovation outcomes after 2000 than before 2000, except for the adoption measure. These results suggest that it is the legal protections offered by BITs that drive our main results, rather than confounding economic factors that correlate with the timing of BITs.

5.3 Extensive Margin

An important question is whether our results are only driven by the intensive margin of there being more globalized innovations or the extensive margin of globalized R&D efforts being initiated. We investigate this in Table A.1, where the dependent variables are indicators of whether the prior outcome variables are positive or zero within a country-pair year. We find a large and statistically significant positive effect of BITs on the occurrence of any globalized innovation between two countries across all measures. This suggests that the extensive margin plays an import role in driving our main results, and that BITs prompt countries with no prior innovation ties to initiate interactions.

5.4 Dynamics

A key identifying assumption of our difference-in-differences design is the parallel trends between our treatment and control groups. Although such an assumption is ultimately untestable, we provide strong supporting evidence in Figure 6, where we estimate a dynamic difference-in-differences model. As shown in Figure 6a, there is no pre-trend in the adoption measure between treated and control country pairs. The increase in the outcome variable only starts after the treatment (i.e., the signing of BITs). Similar patterns can be observed in Figure 6b and Figure 6c, where we study the other two categories of measures — sourcing and collaboration. This lends support to the validity of our research design.

5.5 Robustness

5.5.1 Additional Controls

In this section, we provide additional evidence on the robustness of our main results. One potential concern is that the results could be driven by other changes that take place at the country-pair level, such as increased economic integration between two countries. To address this, Table A.2 includes additional control variables. Specifically, in Panel A, we add country-pair-year level measure of the degree of economic integration. This categorical variable takes values of 1 through 6, representing different degrees of integration between two countries: no agreement, a preferential trade agreement, a free trade agreement, a customs union, a common market, or an economic union.[6] We also add indicators for exchange rate agreement: both pegged, both floating, with the base group being one pegged and one floating.[7] We also add indicators for the presence of Bilateral Labor Agreements (BLA).[8] To alleviate the concern that the results may be driven by international trade between two countries rather than changes in cross-border institutions, we also control for the amount of trade between two countries.[9] Panel A of Table A.2 presents the results including the above controls. The results remain largely the same.

Another concern is that the timing of BITs may correlate with improved geopolitical relationships or economic ties between different regions of countries. To address this, we add region-pair-year fixed effects to abosorb such region-pair specific shocks. We follow the definitions of UNCTAD and define five regions: Africa, Americas, Asia, Europe, and Oceania. The results remain very similar, as shown in Panel B of Table A.2.

[6] For detailed definitions, see https://kellogg.nd.edu/nsf-kellogg-institute-data-base-economic-integration-agreements.

[7] Data on currency regimes are from Ilzetzki et al. (2011).

[8] Data on bilateral labor agreements (BLA) are from Chilton and Posner (2018). See also https://www.law.uchicago.edu/bilateral-labor-agreements-dataset.

[9] Data is from UN Comtrade.

5.5.2 Alternative Samples

One may be concerned that dropping countries with little patenting activities may bias our estimation. Therefore, we rerun all the regressions using the full sample, which includes all 205 countries. Results are reported in Panel A of Table A.3, and are similar to those obtained from the main sample.

Another concern is that our results might be driven by small countries. We address this by focusing on a subsample of larger countries with above-median GDP. Panel B of Table A.3 reproduces our main analyses restricting to the 75 countries with above-median GDP in 1979. The results remain similar.

5.5.3 Placebo Tests

Another potential concern is that our results may be spurious due to certain data structures. For example, it is possible that some patent offices may have a better coverage of patent data over time. Another possibility is that the error terms in our panel data may have correlation structures unaccounted for by clustering at the country-pair level or double-clustering at the source country-year and host country-year level. To address these concerns, we conduct placebo tests by randomly assigning the signing of BITs across country-pair years. We run 1,000 such placebo regressions for each of our outcome variables, and plot the distributions of the estimated coefficients in Figure A.5. We find that the coefficients in our main results are substantially above the empirical distributions of the placebo coefficients. This suggests that our main results are not mechanically driven by spurious data structures.

5.6 Cross-Sectional Heterogeneity

In this section, we examine the cross-sectional heterogeneities of our results. We investigate whether BITs differentially impact the globalization of innovation for country pairs with different characteristics or for different types of technologies. The tests in this section serve two purposes: to tighten identification by exploiting variation in treatment intensity across country pairs, and to understand what types of countries and technologies benefit the most from stronger international legal institutions.

5.6.1 Distance in Legal Institutions

We first examine the variation in the strength of legal protections offered by BITs. Prior literature shows that BITs are most beneficial when the host country has weaker institutions than the source country. In these cases, the risk of expropriating foreign investors is the highest. Such country pairs would therefore benefit the most from the signing of BITs. If our main findings are indeed driven by BITs improving cross-country legal institutions, we should expect our results to be stronger when the host (i.e., knowledge-importing) country has relatively weaker institutions than the source (i.e., knowledge-exporting) country, as such country pairs would receive higher treatment intensity.

To test this, we construct a variable capturing the distance in the rule of law between the knowledge-exporting country and the knowledge-importing country, using data on the rule of law from the Worldwide Governance Indicators (WGI) project.[10] We then interact this distance measure with the BIT indicator in Equation (2). Table 7 presents the results. Consistent with our conjecture, we find a positive and highly significant coefficient on the interaction term for most dependent variables. This suggests that countries with a weaker rule of law experience a stronger increase in R&D interactions with a BIT partner country when the partner country has a stronger rule of law.

5.6.2 Distance in Technological Development

We then study whether countries' levels of technological development affect the strength of the treatment effect from signing BITs. We hypothesize that countries that are less technologically advanced have more to gain from its BIT partner country through learning and spillovers, especially when the partner country is more technologically advanced. Our main results should therefore be stronger when there is a larger distance in technological development between the knowledge-exporting country and knowledge-importing country.

To test this, we interact the BIT indicator with the distance in ex-ante technological devel-

[10] For a detailed description and discussion of the data, see Kaufmann et al. (2009).

opment between the two countries. Specifically, we measure the difference in patenting amounts between the knowledge-exporting and the knowledge-importing countries in the years before 1980. Table 8 presents the interaction results. Consistent with our conjecture, we find that the coefficient on the interaction term between BITs and technological distance is positive and statistically significant for all outcome variables. This indicates that countries that are technological laggards benefit from signing a BIT, especially if the BIT partner country is technologically more advanced. Improvements in international legal institutions induced by BITs can therefore play an important role in developing countries' catching up to the technological frontier.

5.6.3 Process vs. Product Innovation

Finally, we investigate whether the strength of the treatment effect depends on the nature of the innovation. In particular, we are interested in the distinction between product and process innovation. Consider, for example, Apple's iPhone. If another company wants to imitate the iPhone's designs or features (product innovation), it can reverse-engineer it by disassembling an iPhone and studying its parts. In contrast, the technologies used in the production of an iPhone (process innovation) is harder to copy, because it involves tacit, disembodied knowledge that can not be easily reverse-engineered from the final product. The diffusion of process innovation therefore requires more in-person interactions and the exchange of production factors, as opposed to simple trading of products. Because BITs encourage direct investments and the exchange of financial and human capital (we provide evidence on this in Section 6), they can be especially beneficial for the diffusion of process innovation. To this end, we expect our main results to be stronger for process innovation than for product innovation.

We leverage technology-class-level data and classify technology classes by the fraction of process versus product innovation in each class. The process innovation share data come from Bena and Simintzi (2019). Table A.6 shows the top 10 technology classes with the most process innovations and the top 10 technology classes with the most product innovations. We first present our technology class-level results graphically in Figure 7. The x axis represents the share of process innovation for each technology class (IPC class, three digit level). The y axis represents the magnitude of the treatment effect of BITs. The graphs show a positive correlation between the share of process innovation and the estimated treatment effect of BITs across technological classes. This holds true for all measures of the globalization of innovation, including adoption, sourcing, and collaboration.

We also provide statistical evidence in Table 9. Different from previous regressions, which are at the country-pair-year level, this regression is at the country-pair-technology-class level. The granularity of this panel allows us to add high-dimensional fixed effects, including country-pair $\times$ technology class fixed effects, country-pair $\times$ year fixed effects, and country $\times$ year $\times$ technology class fixed effects. By adding country-pair $\times$ year fixed effects, we can absorb any shock to a country pair, including the signing of a BIT (hence the BIT indicator is absorbed). The key variable of interest is the interaction between the BIT indicator and the share of process innovation. Consistent with the evidence in Figure 7, the coefficient on this interaction term is positive and significant for most specifications. This suggests that BITs are particularly effective in globalizing process innovation, which contains more disembodied and tacit knowledge.

6 Mechanisms

In this section, we explore the mechanisms underlying our results.

6.1 Bilateral Investment Treaties and Foreign Direct Investment

An implicit assumption of our research design is that once a BIT has been signed by two countries, there will be an increase in foreign direct investment (FDI) between the two countries, which will support the globalization of innovation. This assumption is supported by the evidence in Alfaro et al. (2008), which documents that differences in institutions across countries are the leading explanation as to why more capital is not flowing from rich to poor countries. We therefore investigate whether the flow of FDI between two countries increases if they have signed a BIT. We obtain bilateral inward and outward FDI data from OECD. This data is available for OECD countries and all their FDI partner countries. We follow the specifications used in our main analysis. As shown in Table 10, after the signing of BITs, the flow of FDI between the two signatory countries increases by approximately 10%. Consistent with our results, Bhagwat et al. (2019) document that cross-border mergers and acquisitions between two countries roughly doubles after the signing of a BIT between them. Prior literature also shows that foreign subsidiaries of multinational companies (MNC) are important in facilitating technological transfer and collaboration (Almeida (1996), Branstetter et al. (2006)). In addition to M&A, we examine the establishment of joint ventures and strategic alliances in the following section.

6.2 Joint Ventures, Strategic Alliances, and Venture Capital Investments

Prior literature documents that joint ventures and strategic alliances are two important organizational vehicles through which companies contract and collaborate on innovative activities (Müller and Schnitzer (2006), Gomes-Casseres et al. (2006), Li et al. (2019), Fitzgerald (2018), Jiang et al. (2018)). Unlike mergers and acquisitions, joint ventures are independent subsidiaries jointly owned by two companies for specific collaborative purposes. Strategic alliances are a nexus of contracts that surround participating firms, and can be considered as a collaborative form that lies between the boundaries of a single firm and market transactions (Robinson (2008)). Due to their collaborative nature, these two organizational forms are particularly sensitive to the legal institutions (Roy and Oliver (2009)) of the participating countries. We hypothesize that the formation of international joint ventures and strategic alliances between BIT signatory countries is an important channel through which BITs promote technological collaborations and spillovers.

González-Uribe (2019) and Lindsey (2008) show that venture capital firms can facilitate technological exchange and collaboration among their portfolio companies. Startups sharing the same VC are more likely to cite or purchase each others' patents, exchange inventors, form strategic alliances, or enter into mergers and acquisitions. This happens through VCs' role as information intermediary and monitor. We therefore hypothesize that cross-country VC investments is another channel through which BITs increase the globalization of innovation.

We obtain alliance and joint venture data from Thomson Financial's SDC Database on Joint Ventures and Strategic Alliances. The SDC Joint Venture and Strategic Alliance database has a global coverage of alliances and joint ventures participated by companies from more than 220 countries. We restrict to the sample period of 1990 to 2016, as the coverage of deals is spotty before 1990. We obtain 88,707 international strategic alliance and joint venture deals, out of which 9,160 involve technology transfer or licensing. We collapse these deals to the country-pair-year level by participants' countries and deal announcement year, and create a measure of the share of deals among partner countries for a given host country-year. We obtain VC investments data from Thomson Financial's VentureXpert Database. This database also has a global coverage, containing investments by VCs from 120 countries in portfolio companies from 171 countries. We use the sample period of 1980 to 2016, when VentureXpert has reasonable coverage. We obtain 696,961 investments at the portfolio company-investor-round level. We then collapse this investment-level data to the country-pair-year level, and compute the number of investments (both inward and outward) between two countries in a given year. The dependent variable is again scaled into partner country share.

Table 11 presents the results. We find that the signing of a BIT significantly increases the formation of strategic alliances between the two signatory countries by 20%, the formation of joint ventures by 31%, and the formation of alliances or joint ventures that involve technology transfer or licensing by 17%. BITs also significantly increase the volume of VC investments between the signatory countries by 19%. These results suggest that, in response to reduced cross-border contracting frictions, companies set up more collaborative vehicles that facilitate the transfer and joint production of knowledge; there is also greater cross-border flow of startup financing, inducing technological exchange between the source and the invested country.

6.3 In-Person Interactions

The production and diffusion of innovation entail a process that combines new ideas from different sources — different fields, industries, or countries. Ideas often occur randomly and result from individuals interacting with and learning from each other (Akcigit et al. (2018)). Further, technological knowledge often contains noncodifiable elements that make it tacit. Face-to-face meetings are therefore important for the transfer of knowledge (Polanyi (1966), Hovhannisyan and Keller (2019)). If better international legal institutions attract foreign investments, we should also expect more frequent movement of human capital across country borders, especially skilled labor such as R&D personnel and business managers who complement physical capital. In this section, we study whether in-person interactions can be an underlying mechanism for our main results.

To this end, we exploit data on international air travelers. We use the "Traffic by Flight

Stage" (TFS) data set from the International Civil Aviation Organization (ICAO).[11] This data set provides annual traffic on-board aircraft on individual flight stages of international scheduled services, and includes information on the number of flights operated, the actual traffic (passengers, freight, and mail) carried and the available seats or freight volume offered. The data set further contains information on country names, which we use to collapse the data into a country-pair-year panel from 1990 to 2016. We create a measure of the shares of air travels from partner countries to a particular host country in a given year. We then merge this panel with the timing of BITs and apply the specifications in our main analysis.

Table 12 presents the results. In Panel A, we find that the signing of a BIT significantly increases the number of passengers flying between the signatory countries by about 30%, as shown in column (1). We find similar results in columns (2) and (3), where the dependent variables are based on the total distance traveled by revenue passengers, and the available seat miles supplied by airlines, respectively. In columns (4) and (5), we examine the number of unique routes and the total number of flights operated between any two countries. We find a similar 30% increase in the variety and frequency of air travels between the BIT signatory countries. These results suggest that, following the signing of BITs and increased bilateral investment activities between the two signatory countries, there are more frequent movements of human capital and therefore more in-person interactions between countries. This can contribute crucially to the cross-country exchange of ideas and the creation of new knowledge.

Panel B examines whether technologically leading countries play a particularly strong role in the increase in air travel. To this end, we interact the treatment in Panel A with a dummy indicating air traffic to or from one of the top 50 countries by patent count. The results show that BITs mainly increase air travels to and from innovative countries, suggesting that international movement of innovative human capital is likely an important channel behind our main results.

To further shed light on the role of in-person interations in explaining our main results, we examine the role of language. Prior literature shows that sharing the same language greatly facilitates interpersonal interactions and hence the diffusion of knowledge (Keller (2002)). We therefore examine whether the effect of BITs on the globalization of innovation is stronger for country-pairs

[11]Same data is used in Campante and Yanagizawa-Drott (2017).

that share a common language. Table A.7 presents the results, where we interact our treatment with $Common\ language_{i,j}$, a dummy indicating that at least 9% of the population in each dyad country speaks the same language. We find that sharing a common language significantly increases the impact of BITs on cross-country patent transfer, co-invention, and co-application, but has no effect on cross-country citation or adoption of existing knowledge. To the extent that the former three outcomes require in-person communications and interaction while the latter two do not, these results corroborate the importance of in-person interactions in explaining our results.

7 Conclusion

This paper studies how innovation goes global in response to the establishment of strong international legal institutions that reduce cross-border contracting frictions. We construct novel measures of the globalization of innovation at the country-pair level using 70 million patents from more than 100 patent offices. These measures capture the adoption of foreign technologies, technology sourcing through patent citations and transfers, and collaboration among inventors and firms from different countries. These "globalized innovations" are highly influential and receive significantly more forward citations than local innovation. We use these measures to investigate whether bilateral investment treaties (BITs), a tool to improve international legal institutions, promote cross-country collaboration in the production and diffusion of new knowledge. We find that BITs increase a country's adoption and sourcing of technology from its BIT partner country and the R&D collaborations between them, resulting in the convergence of the directions of their innovations. Moreover, the results are particularly strong for countries with weak domestic institutions, for technological laggards, and for process innovation. Shedding light on the mechanisms, we find that BITs increase the mobility of financial and human capital across countries. After the signing of a BIT, there is an increase in FDI. Companies set up more collaborative vehicles, such as joint ventures and strategic alliances, to facilitate the transfer and joint production of new knowledge, and international air travel increases between the BIT signatory countries. Taken together, this paper illustrates the instrumental role of international legal institutions on investments in extending the geographic boundaries of innovation.

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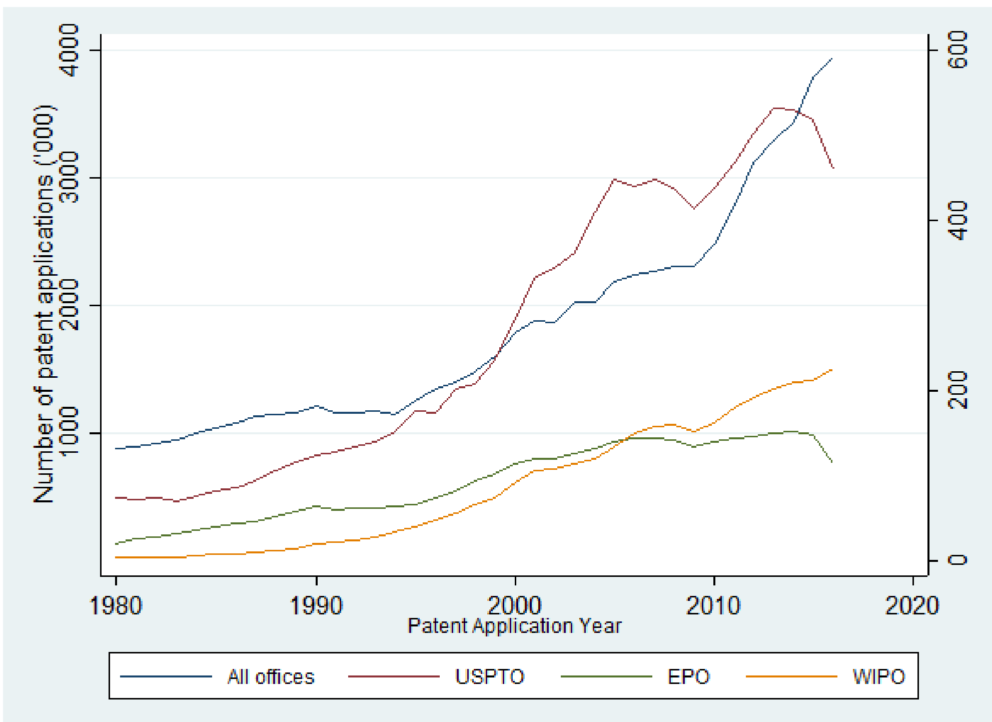
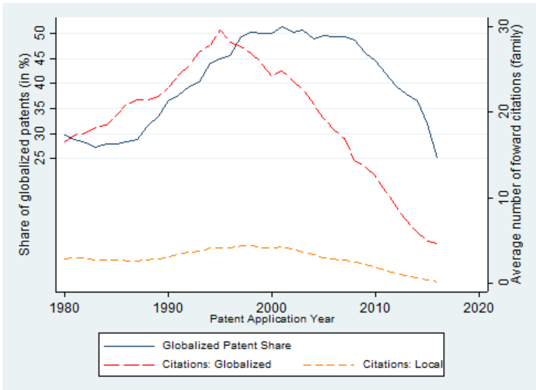
Figure 1: Number of Patent Applications Over Time

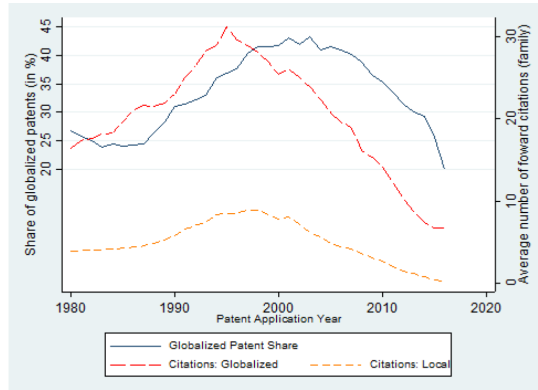


This figure shows the number of patent applications (in thousands) received by different patent offices over time (USPTO: United States Patent and Trademark Office, EPO: European Patent Office, WIPO: World Intellectual Property Organization). Patent counts from all offices use the left y axis, while patent counts from individual patent offices use the right y axis.

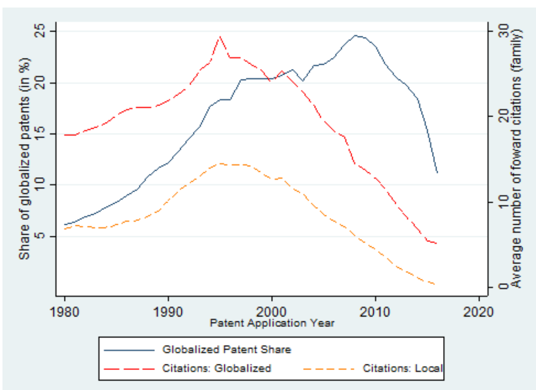
Figure 2: Globalized vs. Local Patents



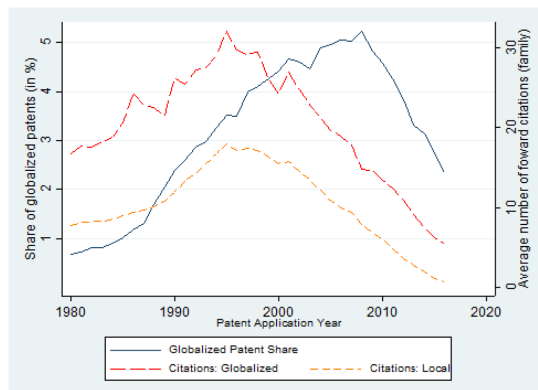
(a) Any type



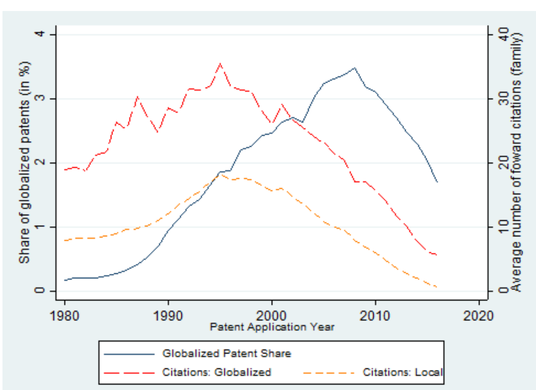
(b) Adoption



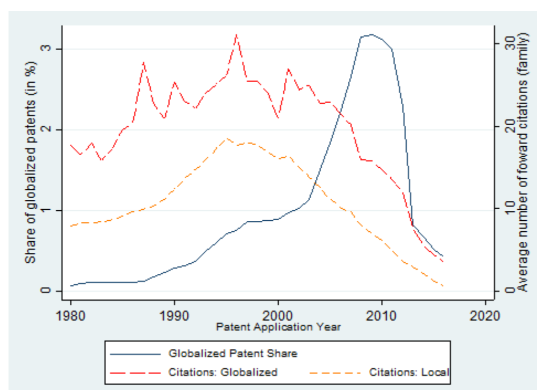
(c) Sourcing: Citation



(d) Sourcing: Transfer



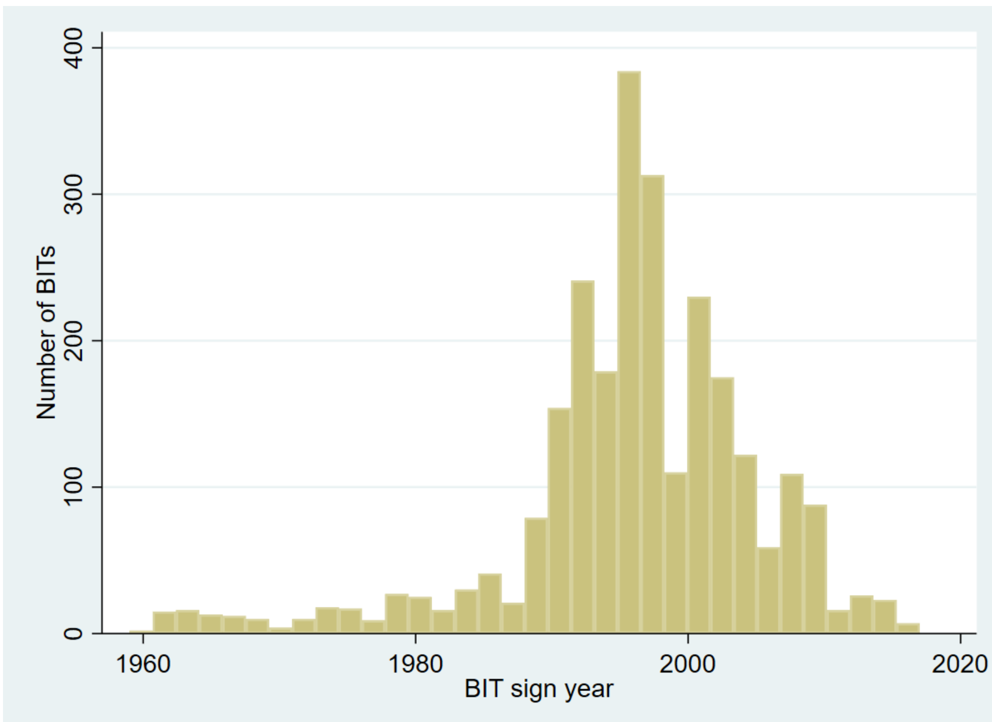
(e) Collaboration: Co-invention



(f) Collaboration: Co-application

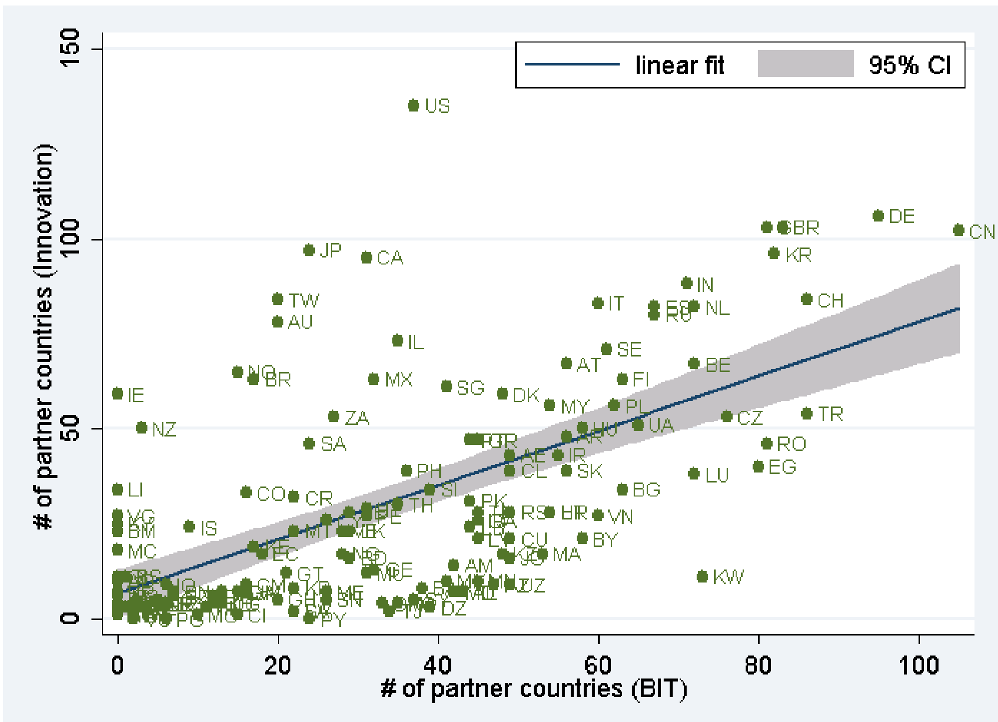
These figures show the share of globalized patents in percentage over time and compares the forward citations received by globalized vs. local patents. Globalized patents are patents involving foreign adoption (Figure 2b), citation of foreign patents (Figure 2c), transfer from foreign inventors (Figure 2d), collaboration with foreign inventors (Figure 2e), or collaboration with foreign applicants (Figure 2f), or any of the above interactions (Figure 2a).

Figure 3: Number of New Bilateral Investment Treaties over Time



This figure shows the distribution of the number of newly signed Bilateral Investment Treaties by sign year.

Figure 4: Number of Partner Countries for Innovation vs. for Bilateral Investment Treaties

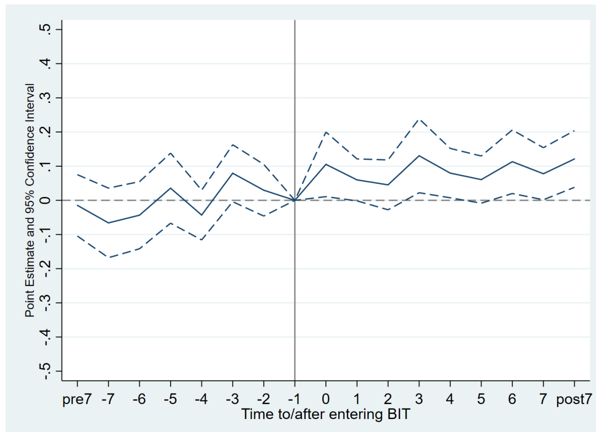


This figure plots the number of partner countries a country has for its innovation activities against the number of partner countries a country has signed Bilateral Investment Treaties with by the end of 2016.

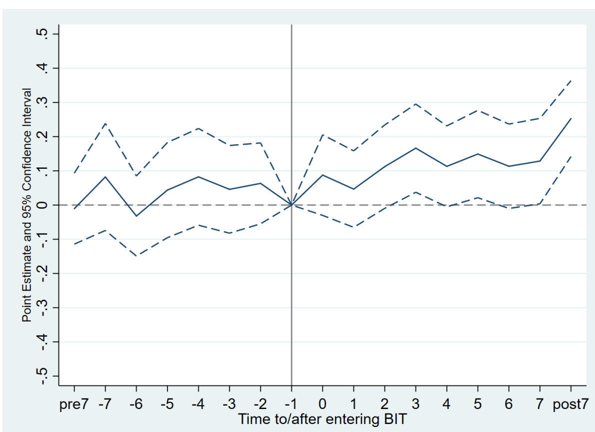
Figure 5: Partner Countries for Innovation vs. Partner Countries for Bilateral Investment Treaties

This figure plots, within a country over time, the number of partner countries a country has for its innovation activities against the number of partner countries a country has signed Bilateral Investment Treaties with for the following four countries: China, Russia, Korea, and Germany.

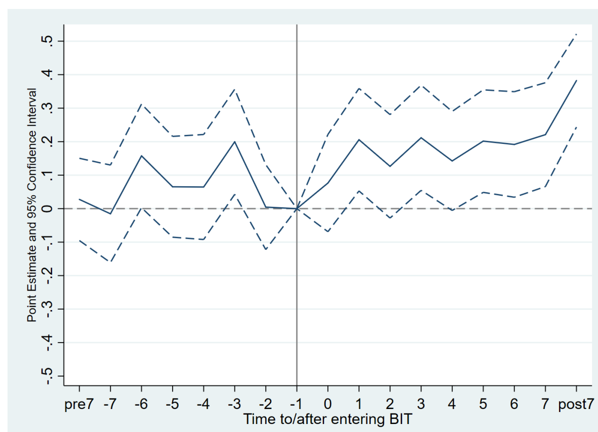
Figure 6: Dynamic Effects



(a) Adoption



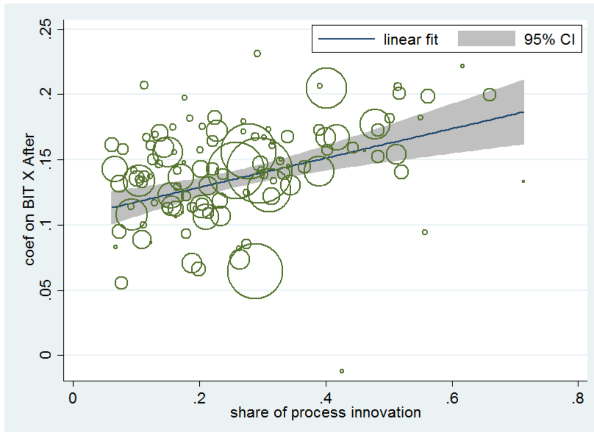
(b) Sourcing



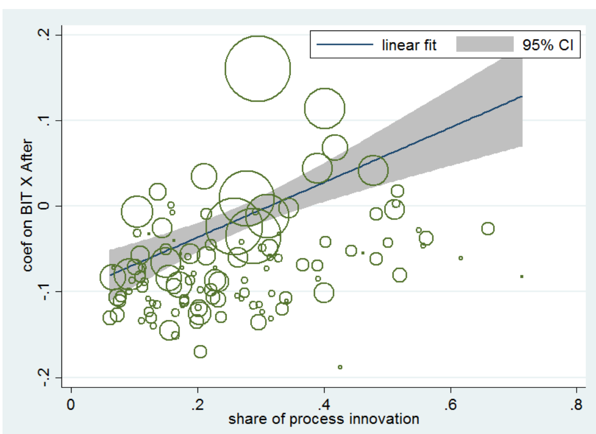
(c) Collaboration

Figure 6a shows the dynamic effect of Bilateral Investment Treaties on the adoption of partner countries' technology around the year of signing. Figure 6b shows the dynamic effect of Bilateral Investment Treaties on technology sourcing from partner countries around the year of signing. Figure 6c shows the dynamic effect of Bilateral Investment Treaties on collaboration in patenting with partner countries around the year of signing.

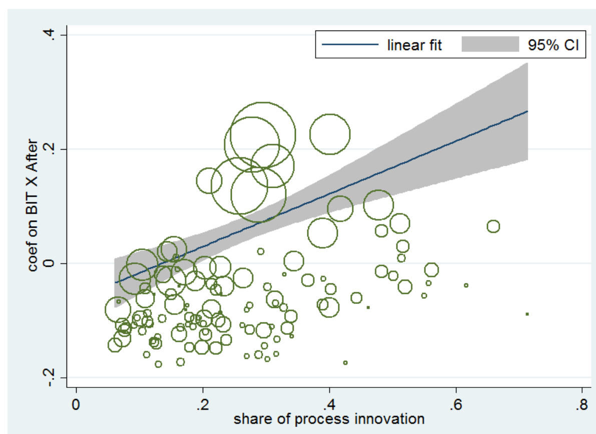
Figure 7: Process vs. Product Innovation



(a) Adoption



(b) Sourcing



(c) Collaboration

This figure illustrates the heterogeneous treatment effects for technology classes with different fractions of process vs. product innovation. The x axis shows the share of process innovation for each technology class (IPC 3-digit class). The y axis shows the magnitude of the treatment effect (i.e., the estimated coefficient on BIT). The fitted line shows the linear relationship between the two variables across technology classes. The size of the bubble indicates the number of patents in each technology class. Figure 7a shows the effects of BITs on the adoption of foreign technology. Figure 7b shows the effects of BITs on technology transfer from foreign inventors. Figure 7c shows the effects of BITs on international co-invention.

Table 1: Summary Statistics

Panel A: Patent level

Globalization variable	Globalized # (%) of obs	Globalized Citations (family)	Globalized Citations (individual)	Local # (%) of obs	Local Citations (family)	Local Citations (individual)
Adoption	22,406,295 (33.5%)	17.2	3.33	44,533,388 (66.5%)	2.91	2.94
Foreign citation	11,906,129 (17.8%)	15.0	10.1	55,033,554 (82.2%)	6.11	1.55
Transfer	2,336,952 (3.5%)	16.3	6.65	64,602,731 (96.5%)	7.37	2.94
Co-invention	1,446,950 (2.2%)	17.1	5.63	65,492,733 (97.8%)	7.47	3.01
Co-application	816,647 (1.2%)	14.7	7.53	66,123,036 (98.8%)	7.6	3.01
Any of the above	27,251,029 (40.7%)	16.1	5.18	39,688,654 (59.3%)	1.9	1.62
Total	66,939,683	7.68	3.07			

Panel B: Country-pair-year level

Variables	Full Sample # of obs	Full Sample Applied	Full Sample Granted	Restricted Sample # of obs	Restricted Sample Applied	Restricted Sample Granted
Adoption	1,547,340	7.2	4.4	826,950	13.5	8.23
Foreign citation	1,547,340	17.1	11.4	826,950	32.1	21.4
Transfer	1,547,340	2.01	1.1	826,950	3.77	2.06
Co-invention	1,547,340	2.49	1.27	826,950	4.66	2.38
Co-application	1,547,340	0.805	0.396	826,950	1.51	0.74
Number of countries		205			150	
Number of country pairs		41,820			22,350	

Panel A reports the number and the share of globalized vs. local patents for each measure of innovation globalization. Panel A also compares the number of forward citations received by globalized vs. local patent patents or patent families. Panel B presents the mean number of applied and granted patents for each globalization measure at the country-pair-year level. The full sample includes all countries and the restricted sample excludes countries with little innovations (below 50 patents). Among the five globalization measures, adoption, foreign citation, and transfer are directional while co-invention and co-application are dyadic (i.e. non-directional).

Table 2: Impact of Bilateral Investment Treaties on the Adoption of Partner Countries' Technology

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries					
	application	grant	citation-w	application	grant	citation-w
BIT	0.185***	0.146***	0.148***	0.133***	0.097***	0.120***
	[0.028]	[0.027]	[0.028]	[0.033]	[0.034]	[0.031]
Year FE	YES	YES	YES	Absorbed	Absorbed	Absorbed
Country × Year FE	NO	NO	NO	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES	YES
Obs	826,950	826,950	826,950	826,950	826,950	826,950
Adj. R-sq	0.621	0.604	0.593	0.631	0.609	0.599

The table examines how Bilateral Investment Treaties affect the adoption of partner countries' technology. The unit of observation is a country-pair year. The coefficients in columns (1) to (3) are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\kappa_t} + \beta BIT_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

The coefficients in columns (4) to (6) are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

where i indexes the knowledge-importing country, j indexes the knowledge-exporting country, and t indexes year. Country-pair and year fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$ and $\boldsymbol{\kappa_t}$. Country × year fixed effects for knowledge-exporting and knowledge-importing countries are indicated by $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, respectively. $BIT_{ij,t}$ is an indicator that equals one if country i and country j have an active Bilateral Investment Treaty in year t and zero otherwise. All dependent variables are scaled by the total amount between country j and all partner countries. The dependent variable in columns (1) and (4) (columns (2) and (5)) is based on the number of patent applications (granted patents) in country j whose priority traces back to country i. The dependent variable in columns (3) and (6) is based on the citation-weighted number of granted patents in country j whose priority traces back to country i. The sample period is 1980 to 2016. Robust standard errors clustered at the country-pair level are reported in brackets. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 3: Impact of Bilateral Investment Treaties on Technology Sourcing from Partner Countries

Panel A: Citation of foreign knowledge

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries					
	citation	application	grant	citation	application	grant
BIT	0.246***	0.295***	0.253***	0.243***	0.259***	0.196***
	[0.040]	[0.033]	[0.030]	[0.032]	[0.032]	[0.032]
Year FE	YES	YES	YES	Absorbed	Absorbed	Absorbed
Country × Year FE	NO	NO	NO	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES	YES
Obs	826,950	826,950	826,950	826,950	826,950	826,950
Adj. R-sq	0.637	0.510	0.486	0.663	0.522	0.495

Panel B: Transfer of foreign knowledge

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries					
	application	grant	citation-w	application	grant	citation-w
BIT	0.253***	0.229***	0.243***	0.169***	0.126**	0.140***
	[0.045]	[0.045]	[0.048]	[0.047]	[0.049]	[0.050]
Year FE	YES	YES	YES	Absorbed	Absorbed	Absorbed
Country × Year FE	NO	NO	NO	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES	YES
Obs	826,950	826,950	826,950	826,950	826,950	826,950
Adj. R-sq	0.356	0.357	0.334	0.373	0.375	0.356

The table examines how Bilateral Investment Treaties affect technology sourcing from partner countries through patent citations (Panel A) and patent transfers (Panel B). The unit of observation is a country-pair year. The coefficients in columns (1) through (3) are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\kappa_t} + \beta BIT_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

The coefficients in columns (4) through (6) are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

where i indexes the knowledge-importing country, j indexes the knowledge-exporting country, and t indexes year. Country-pair and year fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$ and $\boldsymbol{\kappa_t}$. Country × year fixed effects for knowledge-exporting and knowledge-importing countries are indicated by $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, respectively. $BIT_{ij,t}$ is an indicator that equals one if country i and country j have an active Bilateral Investment Treaty in year t and zero otherwise. All dependent variables are scaled by the total amount between country j and all partner countries. In Panel A, the dependent variable in columns (1) and (4) is based on the number of times country j's patents cite country i's patents. The dependent variable in columns (2) and (5) (columns (3) and (6)) is based on the number of patent applications (granted patents) in country j that cite country i's patents. In Panel B, the dependent variable in columns (1) and (4) (columns (2) and (5)) is based on the number of patent applications (granted patents) in country j that are transferred from inventors in country i. The dependent variable in columns (3) and (6) is based on the citation-weighted number of granted patents in country j that are transferred from inventors in country i. The sample is from 1980 to 2016 in all columns. Robust standard errors clustered at the country-pair level are reported in brackets. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 4: The Impact of Bilateral Investment Treaties on Innovation Collaboration

Panel A: Co-invention

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries					
	application	grant	citation-w	application	grant	citation-w
BIT	0.333***	0.355***	0.392***	0.268***	0.254***	0.300***
	[0.047]	[0.048]	[0.051]	[0.047]	[0.049]	[0.049]
Year FE	YES	YES	YES	Absorbed	Absorbed	Absorbed
Country × Year FE	NO	NO	NO	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES	YES
Obs	826,950	826,950	826,950	826,950	826,950	826,950
Adj. R-sq	0.437	0.430	0.404	0.450	0.440	0.419

Panel B: Co-application

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries					
	application	grant	citation-w	application	grant	citation-w
BIT	0.333***	0.259***	0.248***	0.218***	0.148***	0.164***
	[0.044]	[0.040]	[0.041]	[0.047]	[0.046]	[0.045]
Year FE	YES	YES	YES	Absorbed	Absorbed	Absorbed
Country × Year FE	NO	NO	NO	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES	YES
Obs	826,950	826,950	826,950	826,950	826,950	826,950
Adj. R-sq	0.248	0.232	0.215	0.280	0.263	0.248

The table shows how Bilateral Investment Treaties affect international collaboration in patenting (co-invention and co-application). The unit of observation is a country-pair year. The coefficients in columns (1) to (3) are obtained by estimating the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\kappa_t} + \beta BIT_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

The coefficients in columns (4) to (6) are obtained by estimating the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

where i and j index country, and t indexes year. Country-pair and year fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$ and $\boldsymbol{\kappa_t}$. Country × year fixed effects are indicated by $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, respectively. $BIT_{ij,t}$ is an indicator that equals one if country i and country j have an active Bilateral Investment Treaty in year t and zero otherwise. All dependent variables are scaled by the total amount between country j and all partner countries. In Panel A (Panel B), the dependent variable in columns (1) and (4) (columns (2) and (5)) is based on the number of patent applications (granted patents) involving inventors (applicants) from both country j and country i. The dependent variable in columns (3) and (6) is based on the citation-weighted number of granted patents involving inventors (applicants) from both country j and country i. The sample is from 1980 to 2016 in all columns. Robust standard errors clustered at the country-pair level are reported in brackets. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 5: The Impact of Bilateral Investment Treaties on Technology Convergence

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	Proximity: overlap in technology area					
	Class			Subclass		
	flow-flow	3yr stock-flow	10yr stock-flow	flow-flow	3yr stock-flow	10yr stock-flow
BIT	0.009***	0.006***	0.005***	0.012***	0.011***	0.012***
	[0.002]	[0.002]	[0.002]	[0.001]	[0.001]	[0.001]
Country × Year FE	YES	YES	YES	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES	YES
Obs	826,950	826,950	826,950	826,950	826,950	826,950
Adj. R-sq	0.809	0.825	0.853	0.794	0.808	0.832

The table shows how Bilateral Investment Treaties affect the overlap in technology classes between countries. The unit of observation is a country-pair year. The coefficients are obtained by estimating the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

where i and j index country, and t indexes year. Country-pair and year fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$ and $\boldsymbol{\kappa_t}$. Country × year fixed effects are indicated by $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, respectively. $BIT_{ij,t}$ is an indicator that equals one if country i and country j have an active Bilateral Investment Treaty in year t and zero otherwise. Proximity is measured by the cosine similarity between country i and country j's patenting weights across technology classes. Columns (1) to (3) measure proximity at the 3-digit IPC class level. Columns (1) to (3) measure proximity at the 4-digit IPC subclass level. In columns (1) and (4), the consine similarity is between country i's and country i's 1-year flows of patent applications. In columns (2) and (5) (columns (3) and (6)), the cosine similarity is between country i's 3-year (10-year) patent stock and country j's 1-year patent flow. The sample is from 1980 to 2016 in all columns. Robust standard errors clustered at the country-pair level are reported in brackets. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 6: The Impact of Pre-2000 Bilateral Investment Treaties before and after *Maffezini v. Spain*

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries				
	adoption	citation	transfer	co-invention	co-application
BIT	0.186***	0.247***	-0.093	0.167**	0.016
	[0.051]	[0.054]	[0.080]	[0.076]	[0.081]
BIT × Post 2000	-0.010	0.152***	0.513***	0.268***	0.425***
	[0.051]	[0.048]	[0.082]	[0.075]	[0.092]
Country × Year FE	YES	YES	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES
Obs	768,046	768,046	768,046	768,046	768,046
Adj. R-sq	0.634	0.529	0.380	0.458	0.284

The table shows the differential impacts of pre-2000 Bilateral Investment Treaties before and after the ruling decision of *Maffezini v. Spain* in January, 2000. The sample excludes country-pairs that signed BITs in or after 2000. The unit of observation is a country-pair year. The coefficients are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \kappa BIT_{ij,t} \times Post\ 2000_t + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

where i indexes the knowledge-importing country, j indexes the knowledge-exporting country, and t indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for knowledge-exporting and knowledge-importing countries are indicated by $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, respectively. $BIT_{ij,t}$ is an indicator that equals one if country i and country j have an active Bilateral Investment Treaty in year t and zero otherwise. $Post\ 2000_t$ indicates calendar years of or after 2000. All dependent variables are scaled by the total amount between country j and all partner countries. The dependent variables are based on the number of patent applications in country j with the following globalization characteristics: adoption (priority traces back to country i), citation (cite country i's patents), transfer from country i's inventors, co-invention (co-invent with country i's inventors), and co-application (co-apply with country i's applicants). The sample period is 1980 to 2016 in all columns. Robust standard errors clustered at the country-pair level are reported in brackets. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 7: Cross-sectional Heterogeneity: Distance in Institutions

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries				
	adoption	citation	transfer	co-invention	co-application
BIT	0.127***	0.272***	0.177***	0.271***	0.221***
	[0.034]	[0.033]	[0.048]	[0.048]	[0.049]
BIT × Institution_diff	0.113***	0.172***	0.052	0.180***	0.112**
	[0.026]	[0.038]	[0.044]	[0.046]	[0.045]
Country × Year FE	YES	YES	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES
Obs	699,522	699,522	699,522	699,522	699,522
Adj. R-sq	0.631	0.533	0.387	0.466	0.287

The table shows how Bilateral Investment Treaties differentially affect the globalization of innovation for country-pairs that are more distant in their institutional environments as measured by rule of law. Country-level rule of law data come from the Worldwide Governance Indicators. The unit of observation is a country-pair year. The coefficients are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \kappa BIT_{ij,t} \times Institution\_diff_{ij} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

where i indexes the knowledge-importing country, j indexes the knowledge-exporting country, and t indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for knowledge-exporting and knowledge-importing countries are indicated by $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, respectively. $BIT_{ij,t}$ is an indicator that equals one if country i and country j have an active Bilateral Investment Treaty in year t and zero otherwise. $Institution\_diff_{ij}$ is country i's rule of law score minus country j's rule of law score. All dependent variables are scaled by the total amount between country j and all partner countries. The dependent variables are based on the number of patent applications in country j with the following globalization characteristics: adoption (priority traces back to country i), citation (cite country i's patents), transfer from country i's inventors, co-invention (co-invent with country i's inventors), and co-application (co-apply with country i's applicants). The sample is from 1980 to 2016 in all columns. Robust standard errors clustered at the country-pair level are reported in brackets. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 8: Cross-sectional Heterogeneity: Distance in Technological Development

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries				
	adoption	citation	transfer	co-invention	co-application
BIT	0.133***	0.252***	0.166***	0.265***	0.213***
	[0.033]	[0.031]	[0.047]	[0.047]	[0.047]
BIT × Tech_diff	0.086**	0.201***	0.210**	0.248***	0.167*
	[0.039]	[0.073]	[0.082]	[0.081]	[0.086]
Country × Year FE	YES	YES	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES
Obs	826,950	826,950	826,950	826,950	826,950
Adj. R-sq	0.631	0.525	0.374	0.450	0.281

The table shows how Bilateral Investment Treaties differentially affect the globalization of innovation for country-pairs that have different distances in their technological development levels. The unit of observation is a country-pair year. The coefficients are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \kappa BIT_{ij,t} \times Tech\_diff_{ij,t-1} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

where i indexes the knowledge-importing country, j indexes the knowledge-exporting country, and t indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for knowledge-exporting and knowledge-importing countries are indicated by $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, respectively. $BIT_{ij,t}$ is an indicator that equals one if country i and country j have an active Bilateral Investment Treaty in year t and zero otherwise. $Tech\_diff_{ij,t-1}$ is the difference between country i and country j's technological development as measured by the lagged number of patent applications. The dependent variables are based on the number of patent applications in country j with the following globalization characteristics: adoption (priority traces back to country i), citation (cite country i's patents), transfer from country i's inventors, co-invention (co-invent with country i's inventors), and co-application (co-apply with country i's applicants). The sample is from 1980 to 2016 in all columns. Robust standard errors clustered at the country-pair level are reported in brackets. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 9: Cross-sectional Heterogeneity: Process vs. Product Innovation

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	$Y_{ijc,t}/\sum_j Y_{ijc,t}$: share among all partner countries				
	adoption	citation	transfer	co-invention	co-application
BIT × Process Share	0.045**	0.039***	0.067***	0.098***	0.027
	[0.020]	[0.014]	[0.020]	[0.021]	[0.019]
Country × Year × Class FE	YES	YES	YES	YES	YES
Country-pair FE × Class FE	YES	YES	YES	YES	YES
Country-pair FE × Year FE	YES	YES	YES	YES	YES
Obs	81,845,700	81,845,700	81,845,700	81,845,700	81,845,700
Adj. R-sq	0.387	0.345	0.237	0.260	0.212

The table shows how Bilateral Investment Treaties differentially affect the globalization of process versus product innovation. The unit of observation is a country-pair-technology-class-year. The coefficients are estimated from the following specification:

$$Y_{ijc,t} = \boldsymbol{\gamma_{ijc}} + \boldsymbol{\alpha_{ij,t}} + \boldsymbol{\delta_{ic,t}} + \boldsymbol{\vartheta_{jc,t}} + \kappa BIT_{ij,t} \times ProcessShare_c + \varepsilon_{ijc,t}$$

where i, j index country, c indexes technology class (3-digit IPC class), and t indexes year. Country-pair × class fixed effects are indicated by $\boldsymbol{\gamma_{ijc}}$. Country-pair × year fixed effects are indicated by $\boldsymbol{\alpha_{ij,t}}$. Country × year × class fixed effects are indicated by $\boldsymbol{\delta_{ic,t}}$ and $\boldsymbol{\vartheta_{jc,t}}$. $BIT_{ij,t}$ is an indicator that equals one if country i and country j have an active Bilateral Investment Treaty in year t and zero otherwise. $Share_c$ denotes the share of process innovation in each technology class (data from Bena and Simintzi (2019)). All dependent variables are scaled by the total amount for class c between country j and all partner countries. The dependent variables are based on the number of patent applications in country j with the following globalization characteristics: adoption (priority traces back to country i), citation (cite country i's patents), transfer from country i's inventors, co-invention (co-invent with country i's inventors), and co-application (co-apply with country i's applicants). Robust standard errors clustered at the country-pair level are reported in brackets. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 10: The Impact of Bilateral Investment Treaties on Foreign Direct Investment

	(1)	(2)	(3)	(4)
Dep. Var.	ln (FDI)			
BIT	0.108**	0.109**	0.094**	0.094**
	[0.045]	[0.046]	[0.045]	[0.046]
Sample	Full	Restricted	Full	Restricted
Controls	NO	NO	YES	YES
Country × Year FE	YES	YES	YES	YES
Country-pair FE	YES	YES	YES	YES
Obs	154,544	121,533	154,544	121,533
Adj. R-sq	0.608	0.598	0.608	0.599

The table shows how Bilateral Investment Treaties affect foreign direct investment. Annual FDI data come from OECD. The unit of observation is a country-pair year. The coefficients are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

where i indexes the source country, j indexes the destination country, and t indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for the source and destination countries are indicated by $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, respectively. $BIT_{ij,t}$ is an indicator that equals one if country i and country j have an active Bilateral Investment Treaty in year t and zero otherwise. The dependent variable in all columns is the logarithm of annual FDI flow from country j and country i. Country-pair-year-level controls include economic integration (no agreement, preferential trade agreement, free trade agreement, customs union, common market, or economic union), exchange rate arrangement (both pegged, both floating), Bilateral Labor Agreements (BLA), and trade volume. The sample is from 1985 to 2016 in all columns. Columns (1) and (3) use the full OCED sample and columns (2) and (4) exclude countries with zero or little patenting activities. Robust standard errors clustered at the country-pair level are reported in brackets. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 11: The Impact of Bilateral Investment Treaties on Joint Ventures, Strategic Alliances, and VC Investments

	(1)	(2)	(3)	(4)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries			
	joint venture	strategic alliance	tech transfer and licensing	vc investments
BIT	0.211***	0.135***	0.116***	0.130***
	[0.048]	[0.038]	[0.032]	[0.050]
Country × Year FE	YES	YES	YES	YES
Country-pair FE	YES	YES	YES	YES
Obs	603,450	603,450	603,450	826,950
Adj. R-sq	0.191	0.283	0.275	0.394

The table shows how Bilateral Investment Treaties affect the number of partnerships (joint ventures or strategic alliances) as well as the volume of VC investments between two countries in a country pair. The unit of observation is a country-pair year. The coefficients are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

where i indexes the source country, j indexes the destination country, and t indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for the source and destination countries are indicated by $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, respectively. $BIT_{ij,t}$ is an indicator that equals one if country i and country j have an active Bilateral Investment Treaty in year t and zero otherwise. All dependent variables are scaled by the total amount between country j and all partner countries. The dependent variable in column (1) (column (2)) measures the number of joint ventures (strategic alliances) between country i and j. The dependent variable in column (3) measures the number of joint ventures or strategic alliances involving technology transfer or licensing. The dependent variable in column (4) measures the number of VC investments (both inward and outward) between two countries. The sample is from 1990 to 2016 in columns (1) to (3), and is from 1980 to 2016 in column (4). Robust standard errors clustered at the country-pair level are reported in brackets. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 12: The Impact of Bilateral Investment Treaties on International Travel

Panel A: Baseline

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries				
	passengers	rpk	ask	routes	flights
BIT	0.200***	0.195***	0.195***	0.185***	0.201***
	[0.061]	[0.068]	[0.066]	[0.047]	[0.058]
Country × Year FE	YES	YES	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES
Obs	603,450	603,450	603,450	603,450	603,450
Adj. R-sq	0.688	0.672	0.668	0.592	0.685

Panel B: Differential effects for innovation-active countries

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries				
	passengers	rpk	ask	routes	flights
BIT	0.006	-0.040	-0.043	0.053	0.068
	[0.078]	[0.082]	[0.083]	[0.070]	[0.083]
BIT × Top 50	0.274***	0.333***	0.337***	0.187**	0.188**
	[0.087]	[0.092]	[0.091]	[0.080]	[0.090]
Country × Year FE	YES	YES	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES
Obs	603,450	603,450	603,450	603,450	603,450
Adj. R-sq	0.688	0.672	0.668	0.592	0.685

The table shows how Bilateral Investment Treaties affect international travels between two countries in a country pair. The unit of observation is a country-pair year. Panel A estimates the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

Panel B estimates the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \kappa BIT_{ij,t} \times Top50_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

where i indexes the source country, j indexes the destination country, and t indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for the source and destination countries are indicated by $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, respectively. $BIT_{ij,t}$ is an indicator that equals one if country i and country j have an active Bilateral Investment Treaty in year t and zero otherwise. $Top50_{ij,t}$ equals one if either the destination or the origin country belongs to a top 50 patenting country. All dependent variables are scaled by the total amount between country j and all partner countries. The dependent variable in columns (1) to (5) measures the number of passengers, revenue-passenger-kilometer (rpk), available-seat-kilometer (ask), number of routes, and number of flights from country i to j. The sample is from 1990 to 2016 in all columns. Robust standard errors clustered at the country-pair level are reported in brackets. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Figure A.1: Example — Patent Priority (A Measure of Adoption)

A medical device for drug delivery

Abstract translated from German

For selective treatment of diseased tissue sections or organ parts, the surface of these areas is coated with pressure-contacting medical devices with lipophilic, largely water-insoluble and bind to any tissue components drugs guthaftend that adjacent to the relevant location immediately after tissue contact in a short contact time and without any damaging influence on healthy tissue to be effective.

Classifications

A61M25/1002 Balloon catheters characterised by balloon shape
A61L29/08 Materials for coatings
A61L29/085 Macromolecular materials
A61L29/16 Biologically active materials, e.g. therapeutic substances
A61L31/08 Materials for coatings

DE10244847A1
Germany

Find Prior Art   Similar

Other languages: German

Inventor: Bruno Dr. Scheller, Ulrich Prof. Dr. Speck

Current Assignee : Bayer Intellectual Property GmbH

Worldwide applications

2002 • DE 2003 • BR DE ES AU EP EP CN CA *PL* EP EP US CN CN *AT* *SI* WO JP ~~DE~~ ~~EP~~ RU ~~DE~~ EP MX KR ES KR *PT* EP EP ES DK *BR* ~~JP~~ WO EP ~~AU~~ 2005 • IL *ZA* 2006 • *HK* 2008 • *HK* *HK* *CY* IL AU 2010 • AU US JP 2011 • IL IL 2013 • US 2014 • US US US JP 2015 • US 2016 • JP 2017 • JP

This figure shows an example of patent priority, based on which we measure technology adoption. A priority right is triggered by the first filing of an application for a patent. The priority right allows the claimant to file a subsequent application in another country for the same invention effective as of the filing date of the first application. The sequence of applications captures the timing of adoption of the same technology across different countries. In this example, the German pharmaceutical company Bayer patented a medical invention initially in 2002 in Germany, and later filed subsequent patents for the same invention in other countries (patent offices).

Figure A.2: Example — Sourcing from Foreign Knowledge

Publication number	Priority date	Publication date	Assignee	
US20050047046A1	2003-08-29	2005-03-03	Microsoft Corporation	US
US20050160181A1 *	2004-01-15	2005-07-21	Samsung Electronics Co., Ltd.	Korea
US20060034217A1 *	2004-08-11	2006-02-16	Samsung Electronics Co., Ltd.	Korea
EP1838011A1	2006-03-23	2007-09-26	Interuniversitair Microelektronica Centrum (Imec)	Belgium
US20080095263A1	2006-06-29	2008-04-24	Hao Xu	US
CN101252489A	2007-12-04	2008-08-27	深圳市码通讯有限公司	China
EP2063548A1	2007-11-23	2009-05-27	Alcatel Lucent	France
JP2009303029A	2008-06-16	2009-12-24	Ntt Docomo Inc	Japan
US20100098184A1	2008-10-16	2010-04-22	Sun-Heui Ryoo	Korea
US20100120466A1	2008-11-12	2010-05-13	Nokia Corporation	Finland
CN101854706A	2009-03-30	2010-10-06	雷凌科技股份有限公司	China
EP2444875A2	2010-10-25	2012-04-25	Broadcom Corporation	US
US20120149411A1	2010-12-08	2012-06-14	Hitachi, Ltd.	Japan

(a) Citation of Foreign Knowledge

(12) **United States Patent** (10) **Patent No.: US 9,063,577 B2**
Hodges et al. (45) **Date of Patent: *Jun. 23, 2015**

(54) USER INPUT USING PROXIMITY SENSING

(71) Applicant: **Microsoft Corporation**, Redmond, WA (US)

(72) Inventors: **Stephen E. Hodges**, Cambridge (GB); **Alex Butler**, Cambridge (GB); **Shahram Izadi**, Cambridge (GB); **Malcolm Hall**, Glasgow (GB)

(73) Assignee: **Microsoft Corporation**, Redmond, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/872,124**

(22) Filed: **Apr. 28, 2013**

1/1684 (2013.01); ***G06F 1/169*** (2013.01); ***G06F 3/0304*** (2013.01); ***G06F 3/0346*** (2013.01); ***G06F 3/03547*** (2013.01); ***G06F 3/041*** (2013.01); ***G06F 3/042*** (2013.01); ***G06F 3/04883*** (2013.01); *G06F 2203/0339* (2013.01); *G06F 2203/04106* (2013.01)

(58) **Field of Classification Search**
USPC 345/156–183; 178/18.03
See application file for complete search history.

(56) **References Cited**

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7,006,236	B2 *	2/2006	Tomasi et al.	356/614
2003/0210258	A1 *	11/2003	Williams	345/700
2006/0238517	A1 *	10/2006	King et al.	345/173
2007/0125633	A1 *	6/2007	Boillot	200/52 R
2007/0159453	A1 *	7/2007	Inoue	345/156
2008/0309631	A1 *	12/2008	Westerman et al.	345/173

* cited by examiner

(b) Transfer of Foreign Knowledge

The left panel shows an example of citation of foreign knowledge. This patent, titled "Method and Wi-Fi device for setting communications mode," is applied by Huawei Device Shenzhen Co Ltd from China. It cites 13 patents from seven countries, of which six are foreign countries. The right panel shows an example of technology transfer. The patent, titled "Under input using proximity sensing," is transferred from inventors in the U.K. to the U.S. assignee (or applicatnt) Microsoft Corporation.

Figure A.3: Example — International Collaboration in Patenting

(19) Europäisches Patentamt European Patent Office Office européen des brevets

(11) EP 2 317 651 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent: 11.09.2013 Bulletin 2013/37

(51) Int Cl.: *H03K 19/003* (2006.01)

(21) Application number: 10152680.4

(22) Date of filing: 04.02.2010

(54) **Bias voltage generation to protect input/output (IO) circuits during a failsafe operation and a tolerant operation**

Erzeugung von Bias-Spannung für Eingabe/Ausgabe-Schaltungen während eines ausfallsicheren Betriebs und eines ausfalltoleranten Betriebs

Génération de tension de polarisation pour protéger les circuits d'entrée/sortie (E/S) pendant un fonctionnement à sécurité intégrée et un fonctionnement tolérant aux pannes

(84) Designated Contracting States: AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR

(30) Priority: 31.10.2009 US 610277

(43) Date of publication of application: 04.05.2011 Bulletin 2011/18

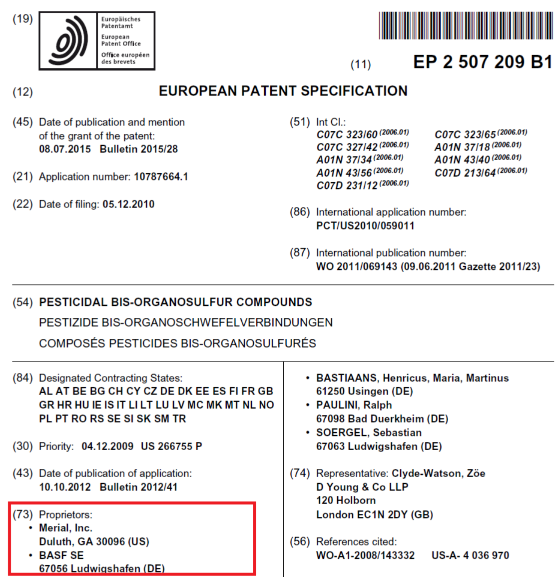
(73) Proprietor: LSI Corporation Milpitas, CA 95035 (US)

(72) Inventors:
- Kumar, Punkaj 560042, Karnataka (IN)
- Parameswaran, Pramod Elamannu 560036, Karnataka (IN)
- Kothandaraman, Makeshwar Whitehall, PA 18052 (US)
- Deshpande, Vani 560076, Karnataka (IN)
- Kriz, John Palmerton, PA 18071 (US)

(74) Representative: Derry, Paul Stefan et al Venner Shipley LLP 200 Aldersgate London EC1A 4HD (GB)

(56) References cited: EP-A1- 0 954 100 WO-A1-84/03185

(a) Co-application



(19) Europäisches Patentamt European Patent Office Office européen des brevets

(11) EP 2 507 209 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent: 08.07.2015 Bulletin 2015/28

(51) Int Cl.: *C07C 323/60* (2006.01) *C07C 323/65* (2006.01) *C07C 327/42* (2006.01) *A01N 37/18* (2006.01) *A01N 37/34* (2006.01) *A01N 43/40* (2006.01) *A01N 43/56* (2006.01) *C07D 213/64* (2006.01) *C07D 231/12* (2006.01)

(21) Application number: 10787664.1

(22) Date of filing: 05.12.2010

(86) International application number: PCT/US2010/059011

(87) International publication number: WO 2011/069143 (09.06.2011 Gazette 2011/23)

(54) PESTICIDAL BIS-ORGANOSULFUR COMPOUNDS

PESTIZIDE BIS-ORGANOSCHWEFELVERBINDUNGEN

COMPOSÉS PESTICIDES BIS-ORGANOSULFURÉS

(84) Designated Contracting States: AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: 04.12.2009 US 266755 P

(43) Date of publication of application: 10.10.2012 Bulletin 2012/41

(73) Proprietors:
- Merial, Inc. Duluth, GA 30096 (US)
- BASF SE 67056 Ludwigshafen (DE)

- BASTIAANS, Henricus, Maria, Martinus 61250 Usingen (DE)
- PAULINI, Ralph 67098 Bad Duerkheim (DE)
- SOERGEL, Sebastian 67063 Ludwigshafen (DE)

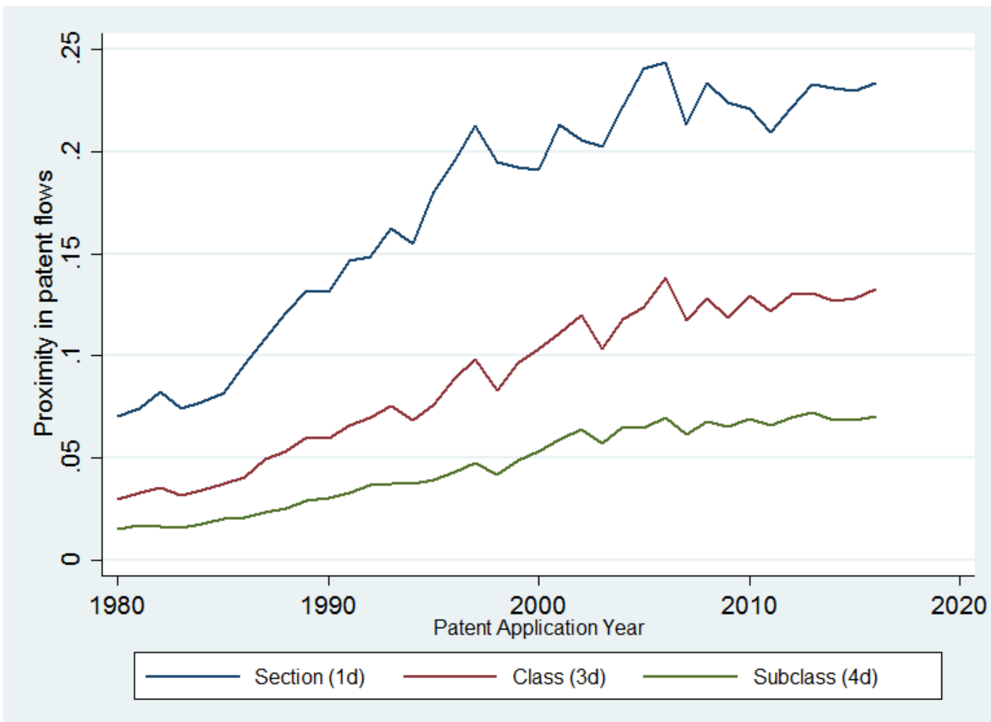
(74) Representative: Clyde-Watson, Zöe D Young & Co LLP 120 Holborn London EC1N 2DY (GB)

(56) References cited: WO-A1-2008/143332 US-A- 4 036 970

(b) Co-invention

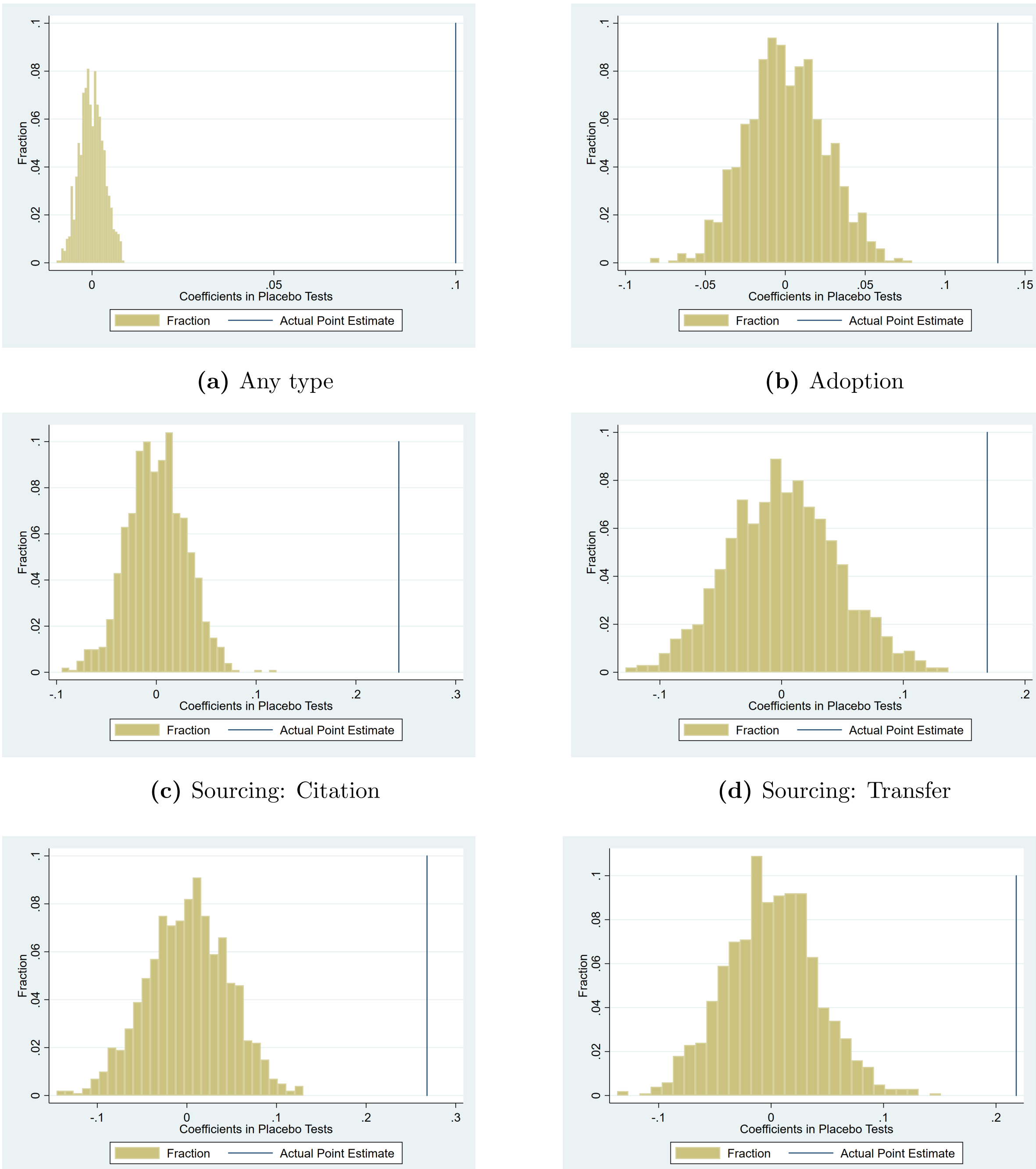
The left panel shows an example of patent co-invention, in which inventors from different countries (in this case, the United States and India) show up simultaneously on the same patent. The right panel shows an example of patent co-application, in which applicants from different countries (in this case, the United States and Germany) show up simultaneously on the same patent.

Figure A.4: Time Trend in Technological Proximity



This figure shows the time trend in technological proximity for the average country pair. Technological proximity is measured as the cosine similarity of two countries' patenting weights across all technology classes, where a technology class is defined using either IPC section (1-digit), IPC class, (3-digit), or IPC subclass (4-digit).

Figure A.5: Histogram of placebo test coefficients



(a) Any type

(b) Adoption

(c) Sourcing: Citation

(d) Sourcing: Transfer

(e) Collaboration: Co-invention

(f) Collaboration: Co-application

This figure plots the histogram of the estimated coefficients on BITs from 1,000 placebo tests. Each placebo test keeps a country's number of BITs and their timing fixed but randomly assigns BITs to partner countries. The sample and regression specifications are the same as those in Table 2.

Table A.1: Extensive Margin

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	Dummy for positive number of patent applications				
	adoption	citation	transfer	co-invention	co-application
BIT	0.052***	0.057***	0.034***	0.075***	0.000
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Country × Year FE	YES	YES	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES
Obs	826,950	826,950	826,950	826,950	826,950
Adj. R-sq	0.681	0.646	0.577	0.589	0.54
Dep. Var. Mean	0.084	0.113	0.067	0.083	0.047

The table shows how Bilateral Investment Treaties affect the probability of globalization in innovation (extensive margin). The unit of observation is a country-pair year. The coefficients are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

where i indexes the knowledge-importing country, j indexes the knowledge-exporting country, and t indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for knowledge-exporting and knowledge-importing countries are indicated by $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, respectively. $BIT_{ij,t}$ is an indicator that equals one if country i and country j have an active Bilateral Investment Treaty in year t and zero otherwise. The dependent variables are dummies indicating whether there is a positive number of patent applications in country j with the following globalization characteristics: adoption (priority traces back to country i), citation (cite country i's patents), transfer from country i's inventors, co-invention (co-invent with country i's inventors), and co-application (co-apply with country i's applicants). The sample is from 1980 to 2016 in all columns. Robust standard errors clustered at the country-pair level are reported in brackets. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table A.2: Robustness — Additional Controls

Panel A: Add country-pair-year-level controls

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries				
	adoption	citation	transfer	co-invention	co-application
BIT	0.110***	0.242***	0.128***	0.235***	0.160***
	[0.032]	[0.033]	[0.047]	[0.048]	[0.048]
Country × Year FE	YES	YES	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES
Obs	826,950	826,950	826,950	826,950	826,950
Adj. R-sq	0.624	0.519	0.37	0.447	0.276

Panel B: Control for region-pair-specific shocks

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries				
	adoption	citation	transfer	co-invention	co-application
BIT	0.122***	0.271***	0.145***	0.242***	0.204***
	[0.036]	[0.035]	[0.049]	[0.050]	[0.050]
Country × Year FE	YES	YES	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES
Region-pair × Year FE	YES	YES	YES	YES	YES
Obs	751,322	751,322	751,322	751,322	751,322
Adj. R-sq	0.635	0.527	0.376	0.453	0.284

The table reproduces our main analyses including additional control variables. Panel A adds the following country-pair-year-level controls: economic integration (no agreement, preferential trade agreement, free trade agreement, customs union, common market, or economic union), exchange rate arrangement (both pegged, both floating), Bilateral Labor Agreements (BLA), and trade volume. Panel B controls region-pair-specific shocks by adding Region-pair × Year fixed effects. We follow the definitions of UNCTAD and define five regions: Africa, Americas, Asia, Europe, and Oceania. The unit of observation is a country-pair year. The coefficients in Panel A are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

The coefficients in Panel B are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \boldsymbol{\zeta_{r_i r_j,t}} + \beta BIT_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

where i indexes the knowledge-importing country, j indexes the knowledge-exporting country, t indexes year, and r_i and r_j index the regions of country i and country j. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for knowledge-exporting and knowledge-importing countries are indicated by $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, respectively. Region-pair × Year fixed effects are indicated by $\boldsymbol{\zeta_{r_i r_j,t}}$. $BIT_{ij,t}$ is an indicator that equals one if country i and country j have an active Bilateral Investment Treaty in year t and zero otherwise. All dependent variables are scaled by the total amount between country j and all partner countries. The dependent variables are based on the number of patent applications in country j with the following globalization characteristics: adoption (priority traces back to country i), citation (cite country i's patents), transfer from country i's inventors, co-invention (co-invent with country i's inventors), and co-application (co-apply with country i's applicants). The sample is from 1980 to 2016 in all columns. Robust standard errors clustered at the country-pair level are reported in brackets. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table A.3: Robustness — Alternative Samples

Panel A: Full sample — all countries

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries				
	adoption	citation	transfer	co-invention	co-application
BIT	0.151***	0.268***	0.185***	0.282***	0.251***
	[0.029]	[0.030]	[0.043]	[0.044]	[0.042]
Country × Year FE	YES	YES	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES
Obs	1,547,340	1,547,340	1,547,340	1,547,340	1,547,340
Adj. R-sq	0.626	0.489	0.347	0.408	0.26

Panel B: Restricting to countries with above-median GDP

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries				
	adoption	citing	sourcing	co-invention	co-application
BIT	0.134***	0.283***	0.210**	0.437***	0.303***
	[0.049]	[0.059]	[0.094]	[0.093]	[0.090]
Country × Year FE	YES	YES	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES
Obs	366,300	366,300	366,300	366,300	366,300
Adj. R-sq	0.704	0.558	0.378	0.474	0.312

The table shows how Bilateral Investment Treaties affect the globalization of innovation with alternative samples. Panel A uses the full sample that includes all countries (205 countries). Panel B restricts to countries with above median GDP in our main sample (75 countries). The unit of observation is a country-pair year. The coefficients are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

where i indexes the knowledge-importing country, j indexes the knowledge-exporting country, and t indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for knowledge-exporting and knowledge-importing countries are indicated by $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, respectively. $BIT_{ij,t}$ is an indicator that equals one if country i and country j have an active Bilateral Investment Treaty in year t and zero otherwise. All dependent variables are scaled by the total amount between country j and all partner countries. The dependent variables are based on the number of patent applications in country j with the following globalization characteristics: adoption (priority traces back to country i), citation (cite country i's patents), transfer from country i's inventors, co-invention (co-invent with country i's inventors), and co-application (co-apply with country i's applicants). The sample is from 1980 to 2016 in all columns. Robust standard errors clustered at the country-pair level are reported in brackets. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table A.4: Robustness — Double Clustering of Standard Errors

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries				
	adoption	citation	transfer	co-invention	co-application
BIT	0.133**	0.259**	0.169***	0.268**	0.218***
	[0.061]	[0.117]	[0.064]	[0.105]	[0.074]
Country $\times$ Year FE	YES	YES	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES
Obs	826,950	826,950	826,950	826,950	826,950
Adj. R-sq	0.624	0.519	0.37	0.447	0.276

The table reproduces our main analyses by double clustering standard errors by both the knowledge-importing and the knowledge-exporting countries. The unit of observation is a country-pair year. The coefficients are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

where i indexes the knowledge-importing country, j indexes the knowledge-exporting country, and t indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country $\times$ year fixed effects for knowledge-exporting and knowledge-importing countries are indicated by $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, respectively. $BIT_{ij,t}$ is an indicator that equals one if country i and country j have an active Bilateral Investment Treaty in year t and zero otherwise. All dependent variables are scaled by the total amount between country j and all partner countries. The dependent variables are based on the number of patent applications in country j with the following globalization characteristics: adoption (priority traces back to country i), citation (cite country i's patents), transfer from country i's inventors, co-invention (co-invent with country i's inventors), and co-application (co-apply with country i's applicants). The sample is from 1980 to 2016 in all columns. Robust standard errors double clustered at the country i level and country j level are reported in brackets. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table A.5: Cross-sectional Heterogeneity: Is there a differential effect for early BITs?

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries				
	adoption	citation	transfer	co-invention	co-application
BIT	0.134***	0.258***	0.142***	0.250***	0.197***
	[0.033]	[0.033]	[0.045]	[0.048]	[0.046]
BIT × Early	-0.008	0.02	0.547	0.369	0.434
	[0.171]	[0.203]	[0.364]	[0.307]	[0.316]
Country × Year FE	YES	YES	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES
Obs	826,950	826,950	826,950	826,950	826,950
Adj. R-sq	0.624	0.519	0.37	0.447	0.276

The table examines whether the first few Bilateral Investment Treaties signed by a country have a different impact on the globalization of innovation than the ones signed subsequently. Early BITs (*Early*) are the first three BITs signed by a country. The unit of observation is a country-pair year. The coefficients are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \kappa BIT_{ij,t} \times Early_{ij} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

where i indexes the knowledge-importing country, j indexes the knowledge-exporting country, and t indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for knowledge-exporting and knowledge-importing countries are indicated by $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, respectively. $BIT_{ij,t}$ is an indicator that equals one if country i and country j have an active Bilateral Investment Treaty in year t and zero otherwise. $Early_{ij}$ is an indicator equal to one if country i and country j have signed no more than three Bilateral Investment Treaties as of year t. All dependent variables are scaled by the total amount between country j and all partner countries. The dependent variables are based on the number of patent applications in country j with the following globalization characteristics: adoption (priority traces back to country i), citation (cite country i's patents), transfer from country i's inventors, co-invention (co-invent with country i's inventors), and co-application (co-apply with country i's applicants). The sample is from 1980 to 2016 in all columns. Robust standard errors double clustered at the country i level and country j level are reported in brackets. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table A.6: Process vs. Product Innovation Classes

Panel A: Top 10 Process Innovation Classes

IPC class (3 digit)	Classification	Process Share
C13	Sugar Industry	0.750
C01	Inorganic Chemistry	0.688
B09	Disposal Of Solid Waste; Reclamation Of Contaminated Soil	0.637
C10	Petroleum, Gas Or Coke Industries; Technical Gases Containing Carbon Monoxide; Fuels; Lubricants; Peat	0.598
C30	Crystal Growth	0.598
C23	Coating Metallic Material; Coating Material With Metallic Material; Chemical Surface Treatment; Diffusion Treatment Of Metallic Material; Coating By Vacuum Evaporation, By Sputtering, By Ion Implantation Or By Chemical Vapour Deposition, In General; Inhibiting Corrosion Of Metallic Material Or Incrustation In General	0.561
C05	Fertilisers; Manufacture Thereof	0.560
C22	Metallurgy; Ferrous Or Non-Ferrous Alloys; Treatment Of Alloys Or Non-Ferrous Metals	0.549
C12	Biochemistry; Beer; Spirits; Wine; Vinegar; Microbiology; Enzymology; Mutation Or Genetic Engineering	0.545
C02	Treatment Of Water, Waste Water, Sewage, Or Sludge	0.535

Panel B: Top 10 Product Innovation Classes

IPC class (3 digit)	Classification	Process Share
E05	Locks; Keys; Window Or Door Fittings; Safes	0.045
A42	Headwear	0.053
A47	Furniture; Domestic Articles Or Appliances; Coffee Mills; Spice Mills; Suction Cleaners In General	0.054
F21	Lighting	0.057
B25	Hand Tools; Portable Power-Driven Tools; Manipulators	0.062
B62	Land Vehicles For Travelling Otherwise Than On Rails	0.067
A45	Hand Or Travelling Articles	0.068
B43	Writing Or Drawing Implements; Bureau Accessories	0.081
B63	Ships Or Other Waterborne Vessels; Related Equipment	0.081
B60	Vehicles In General	0.084

The table shows the top 10 process innovation classes (Panel A) and top 10 product innovation classes (Panel B) by IPC 3 digits. Data on the share of process innovation in each technology class come from Bena and Simintzi (2019).

Table A.7: Cross-sectional Heterogeneity — Language

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	$Y_{ijt}/\sum_j Y_{ijt}$: share among all partner countries				
	adoption	citation	transfer	co-invention	co-application
BIT	0.146***	0.261***	0.043	0.162***	0.106**
	[0.038]	[0.035]	[0.048]	[0.047]	[0.050]
BIT × Common language	-0.054	-0.063	0.821***	0.707***	0.699***
	[0.074]	[0.097]	[0.190]	[0.177]	[0.163]
Country × Year FE	YES	YES	YES	YES	YES
Country-pair FE	YES	YES	YES	YES	YES
Obs	646,760	646,760	646,760	646,760	646,760
Adj. R-sq	0.637	0.530	0.374	0.458	0.285

The table shows the role of language in the impact of Bilateral Investment Treaties on the globalization of innovation. The unit of observation is a country-pair year. The coefficients are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \kappa BIT_{ij,t} \times Common\ language_{i,j} + \boldsymbol{\theta' X_{ij,t}} + \varepsilon_{ij,t}$$

where i indexes the knowledge-importing country, j indexes the knowledge-exporting country, and t indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for knowledge-exporting and knowledge-importing countries are indicated by $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, respectively. $BIT_{ij,t}$ is an indicator that equals one if country i and country j have an active Bilateral Investment Treaty in year t and zero otherwise. $Common\ language_{i,j}$ is an indicator that equals one if at least 9% of the population in each dyad country speaks the same language. The dependent variables are based on the number of patent applications in country j with the following globalization characteristics: adoption (priority traces back to country i), citation (cite country i's patents), transfer from country i's inventors, co-invention (co-invent with country i's inventors), and co-application (co-apply with country i's applicants). The sample is from 1980 to 2016 in all columns. Robust standard errors clustered at the country-pair level are reported in brackets. * indicates statistical significance at the 10% level, ** at the 5% level, and *** at the 1% level.