# Cross-Border Institutions and the Globalization of Innovation*

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**Abstract**

We identify strong cross-border institutions as a driver for the globalization of innovation. Using 67 million patents from over 100 patent offices, we introduce novel measures of innovation diffusion and collaboration. Exploiting staggered bilateral investment treaties as shocks to cross-border property rights and contract enforcement, we show that signatory countries increase technology adoption and sourcing from each other; they also increase R&D collaborations. These interactions result in technological convergence. The effects are particularly strong for process innovation, and for countries that are technological laggards or have weak domestic institutions. The mobility of financial and human capital are the key channels.

**Keywords**: Innovation, technology diffusion, globalization, cross-border 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 resources (Wuchty et al., 2007; Bloom et al., 2013). Solutions to many important issues today, such as cancer and climate change, require technological coordination or collaboration at the global level (Cantner and Rake, 2014; Rubio, 2017). In a frictionless world, the production and diffusion of innovation should not be bounded by geography. Yet only a small fraction of innovation activities happen across country borders (Jaffe et al., 1993; Feldman and Kogler, 2010). These globalized innovations, however, often generate larger impacts than local innovations, and are instrumental in helping developing countries catch up to the technological frontier (Keller, 2004; Kerr and Kerr, 2018). Consequently, policy makers are increasingly seeking ways to promote the globalization of innovation.[1]

One important challenge to such efforts is weak cross-border institutions, in particular institutions surrounding property rights and contract enforcement. When contracting happens across countries, there is often a legal vacuum regarding its enforcement. This problem is particularly acute for innovation activities, which, due to high uncertainty and intangibility, often rely on complex contracts that are difficult to enforce (Acemoglu et al., 2007). Furthermore, global innovation requires sharing and combining of inputs (e.g., financial and human capital) from multiple countries, which benefits from strong property rights protection. Strong cross-border institutions can therefore facilitate the globalization of innovation by reducing contracting frictions and increasing the mobility of innovation inputs across countries.

Testing the above hypothesis faces two challenges. First, shocks to cross-border institutions are difficult to obtain. Most changes in institutions happen within a country, rather than at the international level; they are also often slow and infrequent. We overcome this by exploiting bilateral investment treaties (BITs) as shocks to cross-border institutions, in par-

[1] See World Economic Forum, OECD, and World Intellectual Property Organization (accessed March 23, 2020).

ticular cross-border property rights and contract enforcement. These treaties provide legal protection for foreign investments between signatory countries, irrespective of their domestic institutions. Since 1959, more than 2,500 pairs of countries have signed BITs. The bilateral and staggered nature of these treaties gives us rich variation for identification, and allows a difference-in-differences design with an extensive set of fixed effects.

Second, it is hard to consistently measure innovation production and diffusion across a large number of countries. The existing literature often relies on aggregate variables such as R&D and productivity or patent data from a single patent office. We leverage 67 million patents from 105 patent offices worldwide to develop novel, patent-level measures of the globalization of innovation, which we then aggregate to a country-pair-year-level panel. Our measures capture the three stages of innovation globalization (Archibugi and Michie, 1995): the *adoption* of existing foreign knowledge, the *sourcing* of foreign knowledge in producing innovation, and international *collaboration* in producing innovation. These measures provide some of the first insights into the network and dynamics of global innovation across countries and technologies.

We begin by documenting that globalized innovation—patents that have priority rights abroad,[2] cite foreign patents, or involve foreign inventors or applicants—has increased dramatically over the past four decades. Moreover, these innovations are more impactful than local innovations, as evidenced by their higher number of future citations and higher private value (Kogan et al., 2017). Within a country, the amount of globalized innovation positively predicts future domestic innovation and GDP. This holds even within the same technology class, suggesting positive local spillovers.

We then exploit the staggered signing of BITs to show that stronger cross-border institutions have a large positive effect on the globalization of innovation. After signing a BIT, the two signatory countries adopt and source more innovations from each other, increase

[2] A priority right is triggered by the first filing of a patent application. It allows the claimant to file subsequent patent applications in other countries for the same invention, effective as of the first application's filing date. The sequence of applications with the same priority right captures the adoption of the same invention across different countries.

their collaborations in patenting, and start to converge in the directions of their innovation. These effects are economically large, amounting to increases of 20%–40% relative to the pre-treatment averages, and happen at both the intensive and extensive margins. These results highlight the important role of cross-border institutions in shaping the geographic boundaries of innovation. Our findings suggest that BITs can be a useful policy tool to promote the globalization of innovation.

To understand which countries and technologies benefit the most from strong cross-border institutions, we examine the cross-sectional heterogeneities of our results. We find that BITs have a larger effect on the globalization of innovation when the host (knowledge-importing) country is less technologically advanced than the source (knowledge-exporting) country, consistent with the scope of learning being higher for such country pairs. We also find stronger results when the host country has weaker domestic institutions than the source country. In these cases, the improvement in cross-border institutions is larger. Lastly, we show that our results are stronger for process innovation than for product innovation. Compared with product innovation, process innovation captures more disembodied knowledge, knowledge that cannot be easily reverse-engineered from final products. The diffusion of such knowledge therefore relies more on in-person interactions and the physical exchange of capital (Akcigit et al., 2018; Hovhannisyan and Keller, 2019), both of which are facilitated by BITs.

Next, we examine the channels underlying our results. We first show that the signing of BITs increases the formation of organizational vehicles that facilitate contracting on innovation, that is, strategic alliances and joint ventures—in particular those involving technology transfer and licensing. We also find increased cross-border investments by venture capital firms, which have been shown to increase technology exchange among their portfolio companies (González-Uribe, 2020). We then document that BITs significantly increase the mobility of financial and human capital—two key innovation inputs—between signatory countries. After the signing of a BIT, foreign direct investment (FDI) between the two countries increases by 10%, and international air travel by 30%. These results are consistent with localized, in-person interactions being critical to knowledge diffusion (Akcigit et al., 2018; Hovhannisyan and Keller, 2019).

Our identification strategy relies on the assumption that the timing of a BIT for a given country pair is exogenous to the countries' technological interactions. Consistent with this assumption, the law literature documents that the signing of BITs is often driven by political or diplomatic motivations, and often reflects the bureaucrats' poor understanding of these treaties (Chilton, 2015; Bonnitcha et al., 2017). Nevertheless, we take multiple approaches to address remaining identification concerns.

First, to address potential endogeneity concerns, we exploit the granularity of our sample and include an extensive set of fixed effects. We include country-year fixed effects for both the host and source countries. This ensures that our results are not driven by unobserved country-specific shocks, such as changing economic, political, or technological conditions. We also include country-pair fixed effects to absorb time-invariant heterogeneity across country pairs, such as two countries' distances in geography, culture, or institutions. These fixed effects greatly limit the set of confounders that can plausibly explain our findings.

Second, we use a dynamic difference-in-differences model to verify the parallel trends assumption. We find that treated and control country pairs exhibit similar trends in various innovation outcomes before the signing of BITs, and that the increases in outcomes only show up after the signing of BITs.

Third, we show that our estimated effects increase with treatment intensity. As mentioned earlier, BITs have larger impacts on globalized innovation when the host country has weaker domestic institutions than the source country; for these country-pairs, the improvement in cross-border institutions, hence the treatment intensity, is larger. We also exploit variation in treatment intensity within a BIT over time. Specifically, we use a natural experiment from an arbitration ruling that strengthened the legal protection offered by BITs signed before 2000. In January 2000, for the first time, the ruling of *Maffezini v. Spain* allowed investors to invoke the most favored nation (MFN) provision to gain access to better legal remedies in other BITs already signed by a host country (Jones, 2018). We find that the treatment effect of BITs signed before 2000 increases significantly after this ruling. These results suggest that our main findings are driven by variation in cross-border institutions, rather than other confounding shocks that may correlate with BITs.

Lastly, we demonstrate that our estimated treatment effects exhibit high stability when we gradually add a large number of country-pair-year-level controls (e.g., trade, the degree of economic integration, or other treaties) or add region-pair-year fixed effects. This suggests that bias from omitted variables is probably limited.

We conduct a number of robustness tests. One concern is that, by allowing foreign investors to better enforce intellectual property rights, stronger cross-border institutions may motivate "patenting" but not necessarily innovation. We show that our treatment effects remain strong for technology classes that rely little on secrecy to protect innovation, suggesting that the results are driven not by changing patenting rates but by actual increases in innovation. Relatedly, one may be concerned that BITs motivate patent offices from less developed countries to tighten up patenting standards. To address this, we show that our results are similar when restricting to patents from top patent offices. Next, to make sure that our findings are not driven by data peculiarities, we conduct 1,000 placebo tests that randomly assign BITs to placebo partner countries. We find that our true estimates are significantly larger than the placebo estimates. Lastly, our results are robust to including small countries or focusing on large countries.

We conclude with a back-of-the-envelope calculation of the effects of BITs at the country level. If a country moved from the $25^{\text{th}}$ to the $75^{\text{th}}$ percentile in the number of BITs signed, through the effect on globalized innovation, domestic innovation and GDP would increase by 5% and 1.8%, respectively. The benefits prevail not only for developing countries, but also for the most highly developed countries. This underlines the importance of BITs in driving R&D and economic growth.

Our paper contributes to the literature on technology transfer and diffusion. Prior work has documented the role of FDI (Aitken and Harrison, 1999; Javorcik, 2004; Keller and Yeaple, 2009), intellectual property rights (Branstetter et al., 2006; Cockburn et al., 2016), financial development (Comin and Nanda, 2019), and geography (Comin et al., 2012; Hovhannisyan and Keller, 2019) in the diffusion of technologies (see Keller (2004) for a survey). Our paper differs from these studies in three important ways. First, while most of this literature focuses on the transfer of existing knowledge, our paper predominantly examines the creation of new knowledge and the collaborations therein. Second, the literature frequently relies on aggregate country-level R&D and total factor productivity to measure technology diffusion. We leverage granular patenting data to measure technology adoption, sourcing, and collaboration at the country-pair level. Third, we document important heterogeneities in technology diffusion across product and process innovation.

We also add to a growing literature on globalization and knowledge production. Several studies have highlighted the importance of immigration and ethnic diversity for innovation (Kerr, 2008; Kerr and Lincoln, 2010; Bernstein et al., 2018). Others examine international collaboration in knowledge production (Griffith et al., 2006; Iaria et al., 2018; Kerr and Kerr, 2018). Our paper contributes to this literature by showing that strong cross-border institutions are an important driver for the globalization of innovation. BITs can therefore be an effective policy tool to help less developed countries catch up to the global technological frontier.

This paper joins a recent strand of papers that introduce new measures to quantify the impact and direction of technological progress. Kogan et al. (2017) measure the private value of innovation using stock market response to patent announcements, while Kelly et al. (2019) measure scientific significance using textual analysis of patent documents. Krieger et al. (2020) develop drug novelty measures using molecular dissimilarity from prior drugs. Bena and Simintzi (2019) differentiate product innovation from process innovation. We add to this literature by introducing novel measures of innovation diffusion and collaboration across a large number of countries, which we call "globalized innovation".

Lastly, we contribute to the nascent literature on *international* law and finance. Prior papers have investigated the impact of international law on country-level financial integration (Kalemli-Ozcan et al., 2010), business cycle synchronization (Kalemli-Ozcan et al., 2013), stock market liquidity (Christensen et al., 2016), firms' investment and financing decisions (Meier, 2019), and resource reallocation (Bian, 2019). Related to our paper, Bhagwat et al. (2019) document that cross-border mergers and acquisitions roughly double when two countries sign a BIT.[3] We contribute to this literature by identifying and quantifying the impact of cross-border institutions on the diffusion and production of global innovation.

# 2 Measuring the Globalization of Innovation

We use patent data to construct micro-based measures of the globalization of innovation. Our data is from PATSTAT Global, a worldwide patent database that provides detailed bibliographical information on over 100 million patent applications in more than 100 patent offices. The largest patent offices (based on the number of patent applications) in PATSTAT Global are Japan Patent Office (JPO) (20.9%), State Intellectual Property Office of China (17.8%), U.S. Patent and Trademark Office (USPTO) (15.9%), German Patent and Trademark Office (7.3%), Korean Intellectual Property Office (4.2%), European Patent Office (EPO) (3.8%), UK Intellectual Property Office (3.8%), and World Intellectual Property Organization (WIPO) (3.7%). Figure 1a shows an upward trend in the number of patent applications across patent offices in the past four decades. The total annual number of patent applications across all offices increases from one million in 1980 to four million in 2016. The comprehensive and global nature of this database is crucial to consistently measuring the globalization of innovation across a large number of countries.

Following the taxonomy in Archibugi and Michie (1995), we measure three dimensions of cross-border technological interactions, in order of increasing depth: (1) the *adoption* of existing foreign knowledge, (2) the *sourcing* of foreign technology in producing new knowl-

[3]Since prior work has documented a negative effect of M&A on innovation (e.g., Seru (2014) and Cunningham et al. (2019)), the results in our paper cannot be inferred from the results in Bhagwat et al. (2019).

edge, and (3) direct *collaboration* in producing new knowledge. We first identify patents that capture these interactions, which we define as globalized patents. We then aggregate these patent-level measures to a country-pair-year-level data set. For some of our subsequent analyses, we also extend these measures to the country-pair-technology class level.

To measure the adoption of existing foreign knowledge, we use patent priority records to extract information on the adoption of the same invention in different countries over time. A priority right is triggered by the first filing of a patent application. It allows the claimant to file a subsequent patent application in another country for the same invention, effective as of the filing date of the first application. Given that patenting in a particular country signals the adoption or commercialization of an invention in that country, the sequence of applications therefore captures the timing of adoption of the same invention 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, then patented in many other countries between 2003 and 2017.[4] We aggregate this measure to the country-pair-year level by counting the number of patents in country H that have priority rights traced back to country S, thus capturing country H's adoption of technologies from country S. (We use country S to refer to the source country and country H to refer the host country.)

We then measure the sourcing of foreign technology in producing new knowledge. We first measure technology sourcing through patent citations. Specifically, we count the number of patents in country H that cite country S'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 six foreign countries. Next, we measure a country's direct sourcing of innovation—the transfer of technology from foreign inventors to companies in a host country. We count the number of patents whose inventors are in country S but whose applicants or assignees are in country H. This measure reflects the extent to which country H sources innovation from country S through technology transfers. Figure A.2b provides an example,

[4] A country can show up multiple times in a patent priority sequence due to changes to the same underlying invention. Our measure only counts the first time a country shows up in a patent priority sequence.

where a patent invented by a team of UK inventors is assigned to Microsoft in the US.

Our third group of measures focuses on cross-border collaboration in innovation. We count the number of patents whose inventors come from both country S and country H (co-inventions), as well as the number of patents whose applicants are in both country S and country H (co-applications). Figures A.3a and A.3b provide examples.

Lastly, we measure the technological proximity between two countries. We compute the cosine similarity between country S's and country H's shares of patents in different technology classes. Since learning takes place gradually, we focus on country H's patent flow and country S's patent flow as well as patent stock (3-year or 10-year). This measure reflects the extent to which country H's innovations are converging toward country S's.

Our innovation globalization measures have several appealing features. First, they are micro-based. Unlike prior literature that relies mainly on country-level aggregates such as R&D and TFP to measure technology spillovers, our measures are constructed from patent-level data. Second, our measures can be flexibly extended to different levels of granularity. Because each patent has an exact date (application or issuance), an exact geographic location (inventor's or assignee's), and can be assigned to different levels of technology classes, our measures allow different levels of aggregation along the dimensions of time, geography, and technology space. This offers researchers insights into the granular network of technology diffusion and its dynamics at the high-frequency level. Lastly, though not conducted in this paper, our globalized patents can be matched to firms, which allows the study of the role of firms in the globalization of innovation.

# 3 Descriptive Statistics

## 3.1 The Importance of Globalized Innovation

How important are globalized innovations? Panel A of Table 1 provides summary statistics of our patent-level sample, which covers all patents in PATSTAT Global from 1980 to 2016 with no missing country information—a total of 67 million patents. In our sample, 34% of patents have priority in a foreign country, 18% cite foreign patents, 4% are sourced from foreign inventors, 2% are co-invented by inventors from different countries, and 1% involve applicants from different countries. Together, these globalized patents (i.e., patents captured by at least one of the five measures) constitute 41% of all patents worldwide.[5] Figure 1b shows a dramatic increase in globalized patents in the past four decades. Such a pattern holds across different patent offices. In Figure 2, we further confirm an overall upward trend in the share of globalized patents across different innovation globalization measures.[6]

To understand the value of globalized patents, we compare the forward citations received by globalized patents with those received by local patents in Figure 2. Figures 2b to 2f focus on patents captured by each of the globalization measures described above, while Figure 2a examines patents captured by any of these measures. Across all figures, we see that globalized patents have significantly higher impact than local patents, receiving two to three times the number of citations compared to local patents. Panel A of Table 1 confirms this finding. Panel A of Table 2 further compares the private value of globalized versus local patents, using the patent-level stock market response measure from Kogan et al. (2017). For this analysis, we focus on patents issued to US public firms by USPTO. We find that globalized patents have significantly higher private value than local patents, with an average additional USD 6.3 million per patent.

We then examine the social value of globalized innovation by studying its potential positive spillover effect on domestic innovation and the local economy. Panel B of Table 2 presents the relationship between a country's number of local patents and the lagged number of globalized patents at the country-year-technology class level. The granularity of our data allows us to control for a rich set of fixed effects, including country-year fixed effects, country-class fixed effects, and class-year fixed effects. We find a significantly positive relationship between

[5]Our globalization measures are not mutually exclusive.

[6]The slight decline towards the sample end is explained by the time lag in patent publications, which tends to be longer for globalized patents, and a recent trend of deglobalization (James, 2018). The sharp decline in co-applications in 2013 is due to an increase in application fees for international applications at USPTO in 2013. All our results are robust to ending our sample period in 2012.

globalized and future domestic innovations across all globalization measures, with an elasticity of 0.08 to 0.16. Panel C of Table 2 examines the relationship between a country's GDP and its lagged number of globalized patents at the country-year level, controlling for country fixed effects and year fixed effects. We find a significantly positive correlation for almost all measures. Although these results are not causal, they suggest that the value of globalized innovation probably goes beyond the globalized patents themselves—it potentially benefits a country's domestic innovation and overall economy through positive spillovers.

### 3.2 Regression Sample

The sample for most of our regression analyses is a country-pair-year panel. Except for the collaboration measures, all measures are directional, from the source country (country S) to the host country (country H), implying that each country pair appears twice, with one country as the source country and the other as the host country, and vice versa. Our raw sample contains 205 countries and 41,820 (205 $\times$ 204) country pairs. We restrict our baseline sample 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. Panel B of Table 1 provides country-pair-year level summary statistics. In a given year, an average country pair has 13.5 patent applications that have priority in the partner country (of which 8.2 are granted), 32.1 patent applications that cite the partner country's patents, 3.8 patent applications sourced from inventors in the partner country, 4.7 co-invented patents, and 1.5 co-applied patents. The relatively low values are due to averaging across all possible country-pair years, many of which have no innovation interactions.

## 4 Bilateral Investment Treaties

To generate variation in cross-border institutions, we exploit the signing of bilateral investment treaties (BITs) at the country-pair level. BITs are one of the most ubiquitous policy tools used by countries to protect foreign investment. More than 2,900 BITs have been signed since 1959, with 2,321 BITs in force as of 2018 (UNCTAD, 2018).

BITs are commonly employed to overcome the fundamental problem that when a national of one country invests in another country, legal frictions inhibit contract enforcement across borders. Given the lack of a supranational judicial system, investors have to rely solely on the host country's judicial system. Host countries may change laws after an investment is made, enforce laws poorly, or even expropriate foreign investors. 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 investors and host countries. Hence, cross-border institutions surrounding investments are generally weak in the absence of BITs.

BITs protect foreign investment from adverse actions by the host government through the following mechanisms: First, BITs guarantee that investments made by individuals and firms from the other country will be treated fairly and equitably. Second, the agreements limit expropriation of investors and provide for compensation when expropriation does occur. Third, BITs give investors the right to transfer their property out of the foreign state freely. Fourth, the agreements place restrictions on trade-distorting performance requirements, such as local content requirements or export quotas. Fifth, BITs often allow investors to choose their own management team, without regard to residency or nationality requirements. Lastly, and most importantly, if the terms of a BIT have been violated, investors can force the foreign state to participate in binding international arbitration, often without having to go through local courts first.[7] Taken together, these provisions give foreign investors assurances that investments made in a partner country will be provided with enforceable protection.

The types of investments protected by BITs are very broad, covering practically all assets owned or controlled by a foreign investor. Most treaties refer to "every kind of asset," followed by an open-ended list including tangible property, debt and equity (including portfolio

[7]These international arbitrations are overseen by an independent international tribunal, such as the International Center for Settlement of Investment Disputes (ICSID).

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 a treaty enters into force. Overall, the signing of a BIT between two countries can be viewed as a positive shock to cross-border property rights protection and contract enforcement.

Law and political economy scholars have documented that the motivation for BITs is often political or bureaucratic. Chilton (2015) shows that the United States has used BITs as a foreign policy tool to improve relationships with countries that provide political benefits. Consistent with this, he finds that investment considerations do not explain the pattern of U.S. BIT formations, while political considerations do. Reviewing existing studies on investment treaties, Bonnitcha et al. (2017) conclude that developed countries have largely promoted BITs for bureaucratic and political reasons, not as a response to lobbying by investors or corporations. Bonnitcha et al. further document that, due to a lack of expertise, many developing countries have rushed into BITs with little consideration of their implications. The negotiation of BITs in these countries has rarely involved legal experts, and has often been delegated to mid-level bureaucrats, many of whom had misunderstandings about the treaties.[8] This explains why many developing countries with no commercial ties have signed a BIT. Overall, the majority of BITs seem to have been signed for reasons unrelated to technological interactions between the signatory countries. Nevertheless, our empirical tests are designed to address remaining concerns about the potential endogeneity of BITs.

We obtain BIT 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, signing date, and enforcement date. Following

[8]For example, South African officials incorrectly assumed that the treaties contained only broad statements of policy principles, and failed to realize that the provisions gave foreign investors protections over and above those in the local legal system. 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 or hours...There was no legal review, control, or scrutiny of the content...No one cared until the dispute came" (Poulsen, 2014, 2015).

the prior literature (Chilton, 2015; Bhagwat et al., 2019), we use the signing year as the year of treatment, as these treaties can be retroactively applied to investments made before the enforcement date. In our main sample, 12% of country-pair years have a BIT in effect.

There is substantial variation in the timing of BITs, as well as in the type of countries signing them. Figure 3a shows the distribution of these treaties by signing year from 1960 to 2018. A large number of treaties were signed between 1990 and 2010. However, within a host country, the timing of these treaties is much more even (Figure 3b). There is great dispersion in the level of economic development and the geography of countries signing BITs, as shown in Figures A.4 and A.5. These heterogeneities allow us to estimate results applicable to a broad set of countries, and to investigate what type of countries benefit the most from BITs.

Figure 4a illustrates, for the year 2016, the cross-sectional relationship between the number of innovation partner countries and the number of BIT partner countries a country has. The fitted line shows a strong positive correlation between the two variables. Figure 4b examines this relationship in the time-series for China, Russia, Korea, and Germany. We again observe a strong positive correlation between a country's number of innovation partner countries and its number of BIT partner countries. Although many other factors can drive these correlations, these figures suggest that the presence of strong cross-border institutions may play an important role in the globalization of a country's innovation activities.

# 5 Empirical Strategy

Our primary empirical strategy exploits the staggered signing of BITs as shocks to legal institutions governing the enforcement of contracts and property rights between different country pairs. We use a difference-in-differences research design. The bilateral and staggered nature of BITs offers us rich variation. First, we can 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:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\kappa_t} + \beta BIT_{ij,t} + \varepsilon_{ij,t} \quad (1)$$

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \varepsilon_{ij,t} \quad (2)$$

In both equations, the dependent variable $Y_{ij,t}$ is a measure of the globalization of innovation as described in Section 2. It varies at the level of country $i$, country $j$, and year $t$, where country $i$ is the source (knowledge-exporting) country and country $j$ is the host (knowledge-importing) country. To facilitate interpretation, we construct $Y_{ij,t}$ by scaling the number of globalized patents between countries $i$ and $j$ with the total number of such patents generated by country $j$ with all its partner countries. We then multiply this number by 100 for ease of reporting the coefficients. $Y_{ij,t}$ can therefore be interpreted as the percentage share of knowledge imported from country $i$ by country $j$. The advantage of using this share as an outcome variable is that it facilitates comparison across countries and measures. As such, the mean of dependent variables in our main sample is always 0.671%. (Our main sample contains 150 countries, meaning each country has 149 potential partners. The mean of our dependent variable, partner country share, is then calculated as $1/149 \times 100\% = 0.671\%$.) $\boldsymbol{\gamma_{ij}}$ is a set of fixed effects that absorbs time-invariant country-pair-specific factors, such as two countries' distance in geography, culture, or institutions. $BIT_{ij,t}$ is the variable of interest—a dummy variable indicating whether a BIT is in place between countries $i$ and $j$ in year $t$.

In equation (1), we additionally control for year fixed effects $\kappa_t$ 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 host and the source countries. This specification rules out any time-varying country-specific factors in explaining our results, such as a country's institution or technological advancement. It also absorbs a country's general time-varying tendency to participate in the global economy. Standard errors are robust and clustered at the country-pair level. We also show robustness to double-clustering standard errors by both the host and the source countries (Table A.1).

# 6 Main Results

## 6.1 Baseline Results

To examine the effect of cross-border institutions on the globalization of innovation, we start by analyzing the effect of BITs on cross-border technology adoption. As described in Section 2, our adoption measure captures the amount of inventions originating in country S that are subsequently patented, and thus adopted, in country H. Table 3 presents the results. Columns (1) to (3) use the specification in equation (1), and columns (4) to (6) use the specification in equation (2). The dependent variable is based on patent applications in columns (1) and (4), and on granted patents in columns (2) and (5). Instead of equal 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 find a strong effect of BITs on the adoption of foreign innovation, regardless of the set of fixed effects used. The estimated effect is economically large and statistically significant at the 1% level. For instance, in column (4), the signing of a BIT between two countries increases the share of patents adopted from the partner country by 0.13%, which is a 19.8% increase relative to a mean of 0.671%.

We then move from the adoption of existing knowledge to the creation of new knowledge. In Table 4, we study how BITs affect technology sourcing from abroad. 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 partner country's patents. The dependent variable in columns (2) and (5) (columns (3) and (6)) is based on the number of patent applications (granted patents) that cite a partner country's patents. Throughout all columns, we find a statistically significant and large effect of BITs on international cross-citations. In column (5), for example, the introduction of a BIT between two countries increases their cross-citation shares by 0.259%, which is a 38.6% increase relative to a mean of 0.671%.

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

Next, we investigate the effect of cross-border institutions on countries' collaborations in producing innovation. We start with international co-inventions (Panel A of Table 5), which measures collaboration between inventors from two countries. The columns are defined analogously to Table 3. Across all specifications, the signing of a BIT between two countries significantly increases their co-inventions. In column (4), the introduction of a BIT increases cross-border co-inventions by 0.268%, which is a 39.9% increase relative to the mean. Panel B examines co-applications, which measures the joint ownership of new knowledge between two countries. We find a similarly strong effect of BITs on the extent of co-applications between signatory countries. For instance, in column (4), the signing of a BIT between two countries increases their patent co-applications by 0.218%, which is a 32.5% increase relative to the mean.

Finally, we examine whether these increased interactions lead to the convergence of countries in the technology space. As discussed in Section 2, we measure technological proximity as the cosine similarity between two countries' patenting weights across technology classes. Because this variable has a value between 0 and 1, it is not scaled as partner country share. Table 6 presents the results. We follow the International Patent Classification (IPC) and define technology class at the patent class level (3-digit IPC) in columns (1) to (3), and at the patent subclass level (4-digit IPC) in columns (4) through (6). Columns (1) and (4) use yearly flows of new patent applications for both countries. Columns (2) and (5) (columns (3) and (6)) focus on the proximity between the host country's patent flow and the source country's 3-year (or 10-year) patent stock. Regardless of the measure used, we find a strong effect of BITs on signatory countries' technological convergence—an increase of 3% to 10% relative to the mean.

Taken together, the above results suggest that stronger cross-border institutions induced by BITs facilitate innovation diffusion and collaboration between countries, leading to the convergence in the directions of their technological changes.

### 6.2 Extensive Margin

An important question is whether our results are driven by the deepening of existing technological interactions (the intensive margin), or by the initiation of new interactions (the extensive margin). We investigate this in Table A.2, where the dependent variables are indicators of whether the prior outcome variables are positive or zero within a country-pair year. For brevity, we focus on outcome variables based on patent application counts. We find a large and statistically significant effect of BITs on the incidence of any innovation interactions between two countries for all measures except co-application. This suggests that the extensive margin plays an important role in driving our main results, and that BITs prompt countries with no prior innovation ties to initiate such interactions.

### 6.3 Dynamics

A key assumption of our difference-in-differences design is parallel trends between our treatment and control country pairs before treatment. We provide strong evidence supporting this assumption in Figure 5, where we estimate a dynamic difference-in-differences model. As shown in Figure 5a, there is no pre-trend in the adoption measure between treated and control country pairs. The increase in adoption only starts after the treatment (i.e., the signing of BITs). Similar patterns can be observed in Figures 5b and 5c, which focus on technology sourcing and collaboration. These results support the validity of our research design.

### 6.4 Further Identification Tests

Our baseline identification relies on a difference-in-differences design with a rich set of fixed effects. Although the dynamic difference-in-differences results support the parallel trends assumption, there could still be the concern that unobserved country-pair-year-level factors drive our results. To address this, we first exploit variation in treatment intensity of the effect of BITs on cross-border institutions, both across BITs and within a BIT over time. If we find that the treatment effects increase with treatment intensity, this provides assurance that our results are driven not by confounding shocks, but by shocks to institutions induced by BITs. Further, within-BIT variation in treatment intensity addresses the concern that BITs may be endogenously timed. Second, we add a large number of country-pair-year-level controls to our main specification. If our estimates exhibit high stability across specifications with different controls, this suggests that bias from omitted variables is probably limited.

**A. Cross-BIT Variation in Treatment Intensity: Domestic Institutions.** We first exploit variation in treatment intensity across BITs. The prior literature documents that BITs matter the most when the host country has weaker institutions than the source country (Bonnitcha et al., 2017). In these cases, the risk of expropriating foreign investors is particularly pronounced. Such country pairs would therefore benefit more from BITs. If our main findings are indeed driven by BITs improving cross-border institutions rather than other confounding shocks, we should expect our results to be stronger when the host country has weaker institutions than the source country, as such country pairs would receive higher treatment intensity than an average country pair.

To test this heterogeneity, we construct a variable capturing the distance in the rule of law between the source country and the host country, using data on the rule of law from the Worldwide Governance Indicators project (Kaufmann et al., 2009). We then interact this measure with the BIT indicator in Equation (2). For brevity, we focus on the version of outcome variables based on patent applications. 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 relative to the BIT partner country experience a stronger increase in R&D interactions with the partner country.

**B. Within-BIT Variation in Treatment Intensity: *Maffezini v. Spain.*** One may argue that variation in treatment intensity across BITs may correlate with unobserved country-pair-level trends that affect countries' technological interactions. Further, BITs may be endogenously timed based on expected benefits from innovation globalization. To address this, we exploit a natural experiment that shocks the treatment intensity of existing BITs within a treaty across time. Our natural experiment is an arbitration ruling, *Maffezini v. Spain*, issued in January 2000 (Jones, 2018). This arbitration decision was the first to allow an investor to invoke the most favored nation (MFN) provision in a BIT to access better legal remedies in other active BITs signed by the same host country. Prior to *Maffezini v. Spain*, it was generally understood that the MFN provision in the context of investment treaties was limited in scope to similar commercial policies like taxes, subsidies, and regulatory issues, and did not extend to legal remedies like access to arbitration. *Maffezini v. Spain* gave investors entitled to MFN provision legal precedent for invoking any legal remedy in any active treaty signed by the host country, rather than relying exclusively on the legal remedies in the treaty with the investor's home country.[9] Thus, investors gained access to better legal protections after the ruling. Given that most BITs contain an MFN provision (98.2%), the ruling significantly increased the impact of BITs on cross-border 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 exogenous to the timing of BITs signed before the decision.

To exploit this shock to 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-ruling*,

[9] In 1997 the Argentine investor Maffezini led an arbitration claim at the ICSID against Spain under the Argentina-Spain BIT. According to the BIT, Maffezini was required to fully litigate his claim in the 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 the Spanish courts. Spain 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 2000, an ICSID panel of three arbitrators unanimously agreed with Maffezini, allowing the claim to move forward. For more details see Jones (2018).

indicating the years of and after 2000. This allows us to test whether BITs signed before *Maffezini v. Spain* have a stronger treatment effect in the years after *Maffezini v. Spain* than in the years before it. Table 8 presents the results. Consistent with our conjecture, we find that pre-2000 BITs have a significantly stronger impact on our innovation outcomes after 2000 than before 2000, except for the adoption measure.[10] In conclusion, these results suggest that it is the legal protections offered by BITs that drive our main results, rather than confounding factors that correlate with the timing of BITs.

**C. Mitigating Omitted Variable Concerns: Additional Controls.** To further address the concern that our results are driven by other changes at the country-pair level, such as increased economic integration or exchange rate fluctuations, we include additional control variables. In Panel A of Table A.3, we add a country-pair-year level measure of economic integration. This categorical variable takes values of 1 through 6, representing different degrees of integration between two countries.[11] We also add indicators for currency regimes (Ilzetzki et al., 2019) and a set of indicator variables for capital account openness (Chinn and Ito, 2006). Further, we control for the presence of bilateral labor agreements, bilateral tax treaties, and tax information exchange agreements.[12] To alleviate the concern that the results are driven by international trade, we also control for the amount of trade between two countries (data from UN Comtrade). Panel A of Table A.3 presents the main results including the above controls. The results remain very similar to those reported in Tables 3 to 5.

One might also be concerned that the signing of BITs coincides with countries joining international treaties regarding intellectual property. Panel B of Table A.3 additionally controls for countries' membership of the Patent Cooperation Treaty, the Patent Law Treaty, and the World Intellectual Property Organization (WIPO). Since the World Trade Organi-

[10]A likely explanation is that the adoption of existing knowledge places less stringent requirements on cross-border institutions than new knowledge creation through sourcing and collaboration.

[11]For details, see NSF-Kellogg Institute Data Base on Economic Integration Agreements.

[12]Data on bilateral labor agreements are from Chilton and Posner (2018). Data on bilateral tax treaties and tax information exchange agreements are from the Exchange of Information Database.

zation (WTO) also has some rules on the protection of intellectual property, we also control for WTO membership. Again, the results remain highly similar.

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 absorb 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 C of Table A.3.

Overall, the stability of our coefficients across specifications with different controls suggests that potential bias from omitted variables is probably limited.

## 6.5 Robustness

**A. Changes in the Incentives to File Patents: Reliance on Secrecy.** One potential concern is that by allowing foreign investors to better enforce intellectual property rights, stronger cross-border institutions motivate "patenting" but not necessarily innovation. To address this concern, we use data from an annual innovation survey in Germany (Crass et al., 2019) that asks firms to report their reliance on secrecy to protect innovations. This data is available at the industry level, which we map to 3-digit IPC technology classes. If the above concern is valid, one should see a weaker treatment effect for industries less reliant on secrecy, since the room to substitute secrecy with "patenting" is smaller. In Table A.4, the treatment effect remains similar for technology classes with a below median reliance on secrecy, suggesting that our results are driven not by changes in the patenting rate, but by actual increases in innovation.

**B. Changes in Patenting Standards: Restricting to Top Patent Offices.** Another related concern is that BITs may correlate with some patent offices tightening their patenting standards, especially in less developed countries. For example, a developing country's patent office may tighten its examinations of prior art and enforcement of patent citations, especially when such patents build on knowledge from BIT partner countries. Such patenting standard changes could affect our globalization measures, even when underlying innovation activities do not change. To address this possibility, we reconstruct our globalization measures, restricting to patents from a single patent office, or from the top patent offices whose patenting standards have always been the highest and are therefore unlikely to be changed by BITs. Table A.5 presents these results. Panel A repeats our main analysis using only patents applied through EPO, while Panel B restricts to patents applied through the top four patent offices: EPO, USPTO, JPO, and WIPO. In both panels, our results remain similar.

**C. Alternative Samples.** One may be concerned that dropping countries with little patenting activity may bias our estimation. We rerun all analyses using the full sample, which includes all 205 countries. Results are reported in Panel A of Table A.6, and are similar to those for the main sample. To address the possibility that our results are driven by small countries with limited economic activity, we also restrict our analyses to a subsample of large countries with above-median GDP before our sample period. Panel B of Table A.6 reproduces our main regressions on this subsample. The results remain similar. Panel C of Table A.6 further shows that our results are robust to excluding all European countries, which have more integrated economies and may be less affected by the signing of BITs.

**D. Placebo Tests.** Another potential concern is that our results may be spurious due to data issues. For example, some patent offices may have 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 and host country level. To address these concerns, we conduct a placebo test that randomly assigns BITs to partner countries while keeping each country's number of BITs and their timing fixed. We run 1,000 such placebo regressions for each of our outcome variables, and plot the distributions of the estimated coefficients in Figure A.6. 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 driven by peculiarities of the underlying data.

# 7 Cross-Sectional Heterogeneity

Next, we examine which countries or technologies benefit the most from strong cross-border institutions.

## 7.1 Distance in Technological Development

We first examine whether countries' levels of technological development affect the treatment effects from signing BITs. On one hand, countries that are less technologically advanced than their BIT partner countries have more to gain through learning and spillovers. On the other hand, larger technology gaps may make it harder for countries to collaborate in innovation.

To test this, we interact the BIT indicator with the distance in ex-ante technological development between the two countries in a pair. Specifically, we measure the lagged difference in the number of patents between the host and the source countries. Panel A of Table 9 presents the results. We find that the coefficient on the interaction term is positive and statistically significant for all outcome variables, including the collaboration outcomes. This indicates that countries that are technological laggards benefit particularly from signing a BIT with a technological leader. Improvements in cross-border institutions induced by BITs can therefore play an important role in helping developing countries catch up to the technological frontier.

## 7.2 Process vs. Product Innovation

Next, we investigate whether the effects of BITs depend on the nature of the innovation. In particular, we distinguish between process and product innovation. Process innovation concerns a method or process of producing a product, while product innovation refers to product designs and features. Consider, for example, Apple's iPhone. If another company wants to imitate the iPhone's designs or features (product innovation), it can reverse-engineer them by disassembling an iPhone and studying its parts. In contrast, the technologies used in the production of an iPhone (process innovation) are harder to copy, as it involves tacit, disembodied knowledge that cannot be easily reverse-engineered from the product. The diffusion of process innovation therefore relies more on in-person interactions and the exchange of production factors, as opposed to simple trading of products. Because BITs encourage the direct exchange of financial and human capital (we provide evidence on this in Section 8), they can be especially effective in diffusing process innovation.

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

Panel B of Table 9 provides the regression results. The analysis is at the country-pair-technology-class level. The granularity of this analysis allows us to add even tighter 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 absorb any remaining unobserved shocks to a country pair (the BIT indicator is thus absorbed). Consistent with Figure 6, the coefficient on the interaction between BIT and process innovation share is positive and significant for most specifications. This suggests that BITs are particularly effective in diffusing process innovation, which contains more disembodied knowledge than product innovation.

# 8 Channels

We continue by exploring the channels underlying our results. Theories on innovation and knowledge diffusion highlight the importance of local interactions between agents with diverse knowledge and backgrounds (Buera and Oberfield, 2020). We examine two types of such interactions: organizational vehicles that facilitate innovation collaborations, and the movement of capital and talents across countries.

## 8.1 Joint Ventures, Strategic Alliances, and Venture Capital

Joint ventures and strategic alliances are two important organizational vehicles through which companies contract and collaborate on innovative activities (Gomes-Casseres et al., 2006; Müller and Schnitzer, 2006). Due to their collaborative nature, these two organizational forms are particularly sensitive to the legal institutions of the participating countries (Roy and Oliver, 2009). We hypothesize that the formation of international joint ventures and strategic alliances between BIT signatory countries are an important channel through which BITs promote the globalization of innovation.

González-Uribe (2020) shows that venture capital (VC) firms, through their roles as information intermediaries and monitors, facilitate technological exchange among their portfolio companies. Startups sharing the same VC are more likely to cite or purchase each other's patents, exchange inventors, form strategic alliances, or enter into mergers and acquisitions. We therefore hypothesize that cross-border VC investments are another channel through which BITs increase the globalization of innovation.

We obtain alliance, joint venture, and VC investment data from the SDC Platinum Database, which has global coverage of deals from more than 200 countries. We obtain about 148,000 international strategic alliance and joint venture deals from 1990 to 2016 and 143,000 international VC investments from 1980 to 2016.[13] We collapse these deals to the country-pair-year level and create measures of the share of deals among partner countries for a given host-country-year.

Panel A of Table 10 presents the results. The signing of a BIT significantly increases the formation of strategic alliances between firms from the two signatory countries by 20%, the formation of joint ventures by 31%, and the formation of alliances or joint ventures that

[13]The coverage of alliances and joint ventures in SDC Platinum is sparse before 1990.

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 investment vehicles that facilitate the transfer and joint production of knowledge. There is also a greater cross-border flow of startup financing, inducing technological exchange between the source and the destination country.

## 8.2 Foreign Direct Investments

Moreover, BITs may indirectly increase the globalization of innovation by increasing the mobility of innovation inputs, such as financial and human capital, across countries. We first hypothesize that increased FDI could be an important channel. Alfaro et al. (2008) document that differences in institutions explain FDI flows between countries. To shed light on this channel, we examine whether the flow of FDI between two countries increases after the signing of a BIT. We obtain bilateral inward and outward FDI data from the 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 Panel B of Table 10, after the signing of a BIT, the flow of FDI between the two countries increases by approximately 10%.[14]

## 8.3 In-Person Interactions

Another important channel is the mobility of human capital and the resulting interactions between R&D personnel. The production of innovation entails a process that combines new ideas from different fields and regions. 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, tacit elements that require face-to-face meetings to transfer (Polanyi, 1966; Hovhannisyan and Keller, 2019). If stronger cross-border institutions attract foreign investments, we should also see more frequent movement of human capital across country borders, especially skilled labor that complements physical capital.

[14]Prior studies have found mixed evidence on the effect of BITs on FDI (Bonnitcha et al., 2017), in part due to the difficulty of measuring FDI (Coppola et al., 2020). Further, few of these studies use a difference-in-differences design on a large panel of countries.

To test the effect of BITs on the movement of human capital, we exploit data on international air travel. We use the Traffic by Flight Stage data set from the International Civil Aviation Organization. This data provides annual on-board traffic of individual flight stages of international services from 1990 to 2016. We collapse this data set to the country-pair-year level and create a measure of the shares of air travel from partner countries to a particular host country in a given year.

Panel C of Table 10 presents the results. The signing of a BIT increases the number of passengers flying between the signatory countries by about 30% (see column (1)). We find similar results in columns (2) to (5), where the dependent variables are based on the total distance traveled by passengers, the available seat miles supplied by airlines, the number of unique routes, and the number of flights between any two countries, respectively. These results suggest that, following the signing of BITs, there are more movements of people and therefore more in-person interactions between countries. This contributes to the cross-border exchange of ideas and the creation of new knowledge.[15]

Table A.8 examines whether technologically leading countries play a particularly important 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 innovative 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 probably an important channel behind our main results.

To further shed light on the role of in-person interactions, we examine the role of language. Sharing the same language greatly increases interpersonal interactions and the diffusion of knowledge (Keller, 2002). We therefore examine whether the effect of BITs on the globalization of innovation is stronger for country pairs that share a common language. Table A.9 presents the results, where we interact our treatment with $Common\ language_{i,j}$, a dummy indicating that at least 9% of the population in a country pair speak the same language

[15] Figure A.7 illustrates, both in the cross-section and in the time-series, a positive relationship between a country's number of innovation partner countries and its number of direct flight countries.

(Mayer and Zignago, 2011). We find that sharing a common language significantly increases the impact of BITs on cross-border patent transfer, co-invention, and co-application, but has no effect on cross-border citation or adoption of existing knowledge. To the extent that the former three outcomes rely more on in-person communications than the latter two, these results corroborate the importance of in-person interactions in explaining our findings.

# 9 Policy Implications

Economists have long agreed on the far-reaching benefits of globalization. Yet in recent years, the world has witnessed a backlash against globalization, including the US-China trade war, "Brexit", and more closely related to our paper, the cancellation of BITs by some countries.[16] We investigate what would happen if countries embraced bilateral agreements and globalization. We conduct a back-of-the-envelope calculation of the effects of BITs at the country level. If a country moved from the 25$^{\text{th}}$ to the 75$^{\text{th}}$ percentile in the number of BITs signed, through the effect on globalized innovation, domestic innovation and GDP would increase by 5% and 1.8%, respectively.[17] This underlines the importance of strong cross-border institutions in driving R&D and economic growth.

Skeptics may argue that the globalization of innovation, while benefiting developing countries, has no or even a negative effect on developed countries such as the US. Intellectual property theft and forced technology transfer are two major concerns for advanced economies. To assess the merits of such arguments, we rerun our analyses of the effect of BITs on globalized innovation, domestic innovation, and GDP by restricting the sample to countries that have GDP per capita in the highest decile in 1980. Despite the substantially smaller sample and therefore lower statistical power, we find that BITs are associated with increases in

[16]For example, India terminated 57 BITs and put on notice the remaining 25 BITs in 2016. South Africa, Indonesia, Venezuela, Bolivia, and Ecuador have also terminated many of their BITs. (accessed September 21, 2020)

[17]To illustrate the calculation, we use citation as an example. We start by taking the coefficient in column (5), Panel A of Table 4. Signing BITs with 41 more countries would increase sourcing through citation by $(0.259/0.571) \times (41/150) = 10.6\%$. We multiply this number by the coefficient in column (2), Panel B of Table 2. The increase in domestic innovation due to the increase in sourcing through citation is thus $0.157 \times 10.6\% = 1.7\%$. We can similarly calculate the increase in GDP based on Panel C of Table 2, as well as the increases due to other forms of globalized innovation.

globalized innovation, domestic innovation, and GDP, even for the most highly developed countries (see Table A.10). As suggested by Branstetter et al. (2018), these countries benefit mostly through tapping foreign human capital and R&D collaborations.

Lastly, an often overlooked advantage of BITs is that they are incremental and targeted, and are thus relatively easy to implement. Other policy tools may also promote innovation, but require more fundamental changes (e.g. structural reforms of domestic institutions) and are thus often forcefully opposed by vested interests.

# 10 Conclusion

Using novel measures of innovation diffusion and collaboration across a large number of countries, this paper documents a dramatic increase in the globalization of innovation in the past four decades. We show that globalized innovations are more impactful than local innovations, and that these innovations are sensitive to cross-border institutions.

We exploit the staggered signings of bilateral investment treaties (BITs) as shocks to cross-border contract enforcement and property rights. We find that countries significantly increase their technological interactions after signing a BIT: they adopt and source more technologies from each other and collaborate more in innovation, resulting in technological convergence. Countries with weak domestic institutions and technology laggards benefit the most from strong cross-border institutions, as does process innovation as opposed to product innovation. Shedding light on the channels, we find that BITs significantly increase the mobility of financial and human capital across countries. Our paper illustrates the instrumental role of strong cross-border institutions in expanding the geographic boundaries of innovation. Improving the institutional environment for foreign investors may be an important policy tool to promote technological spillover at the global level.

An avenue for future research could be to use our measures of innovation diffusion and collaboration to study the firm-level dynamics of the globalization of innovation. An interesting question for such a firm-level analysis is how the globalization of innovation impacts the reallocation of capital and employment across countries or within a country across firms. Furthermore, one could investigate the role of multinational corporations and supply-chain relationships in the globalization of innovation.

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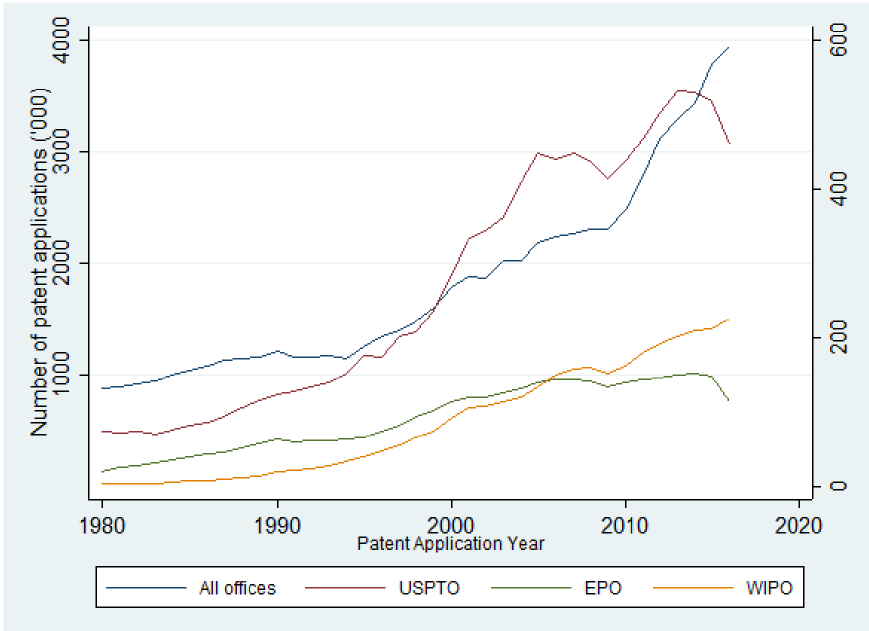
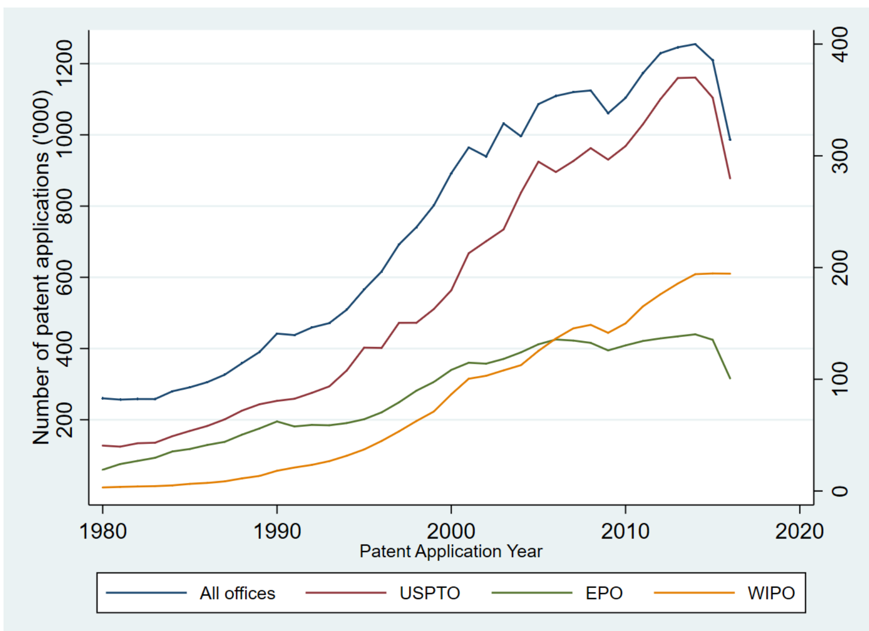
**Figure 1:** Number of Patent Applications Over Time



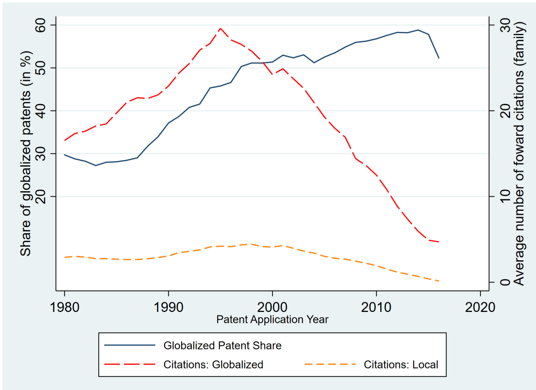

**(a)** all patents



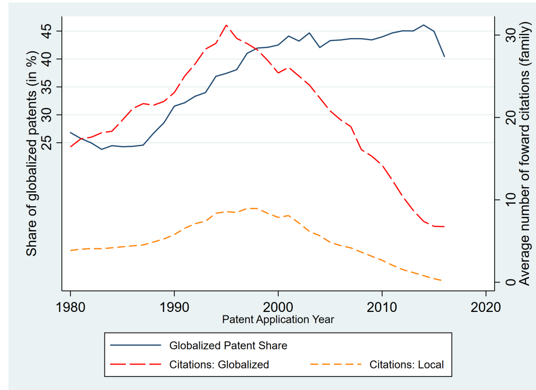

**(b)** globalized patents

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 1a includes all patents while Figure 1b focuses on globalized patents, which are patents involving foreign adoption, citation of foreign patents, transfer from foreign inventors, collaboration with foreign inventors, or collaboration with foreign applicants, or any of the above interactions.

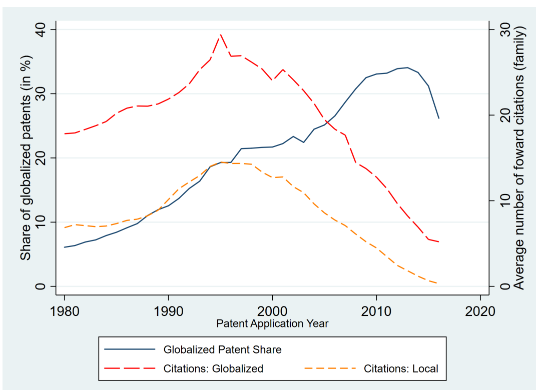
**Figure 2:** Globalized vs. Local Patents



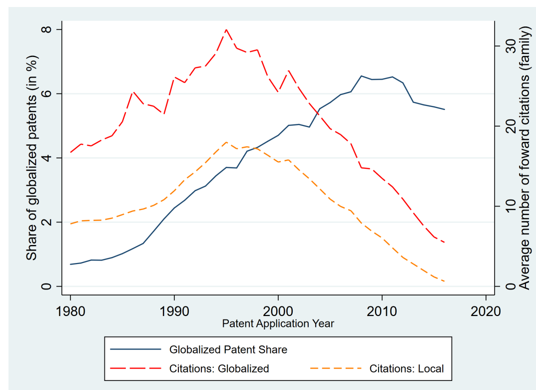

**(a)** Any type



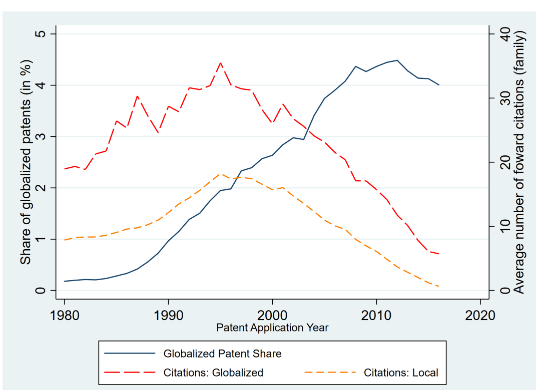

**(b)** Adoption



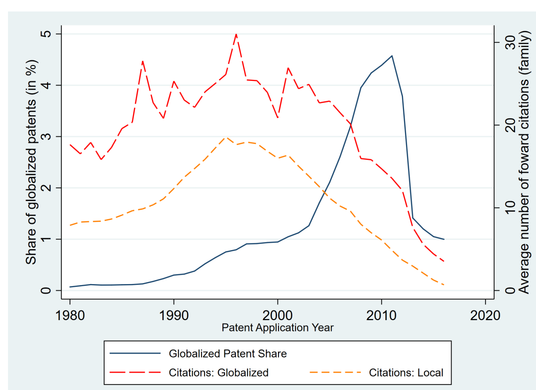

**(c)** Sourcing: Citation




**(d)** Sourcing: Transfer



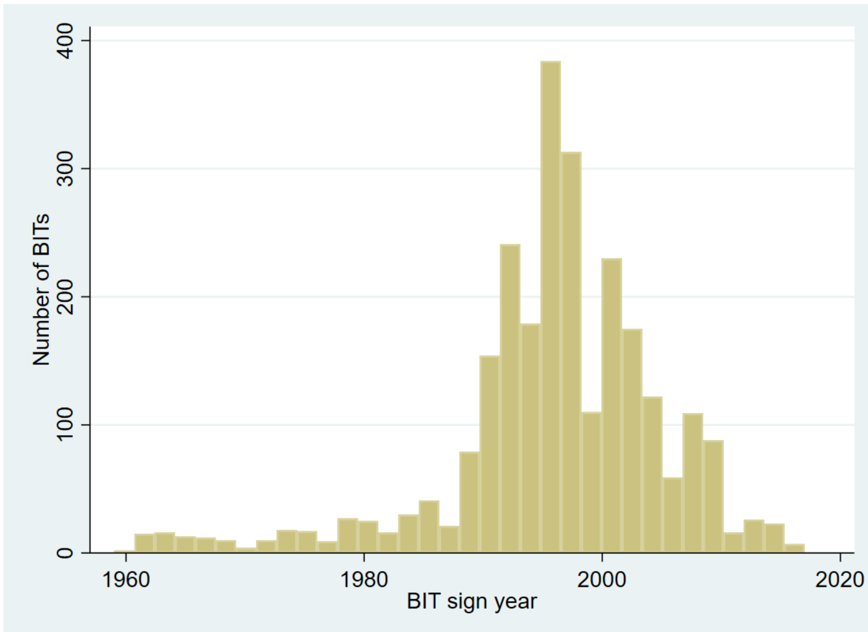

**(e)** Collaboration: Co-invention



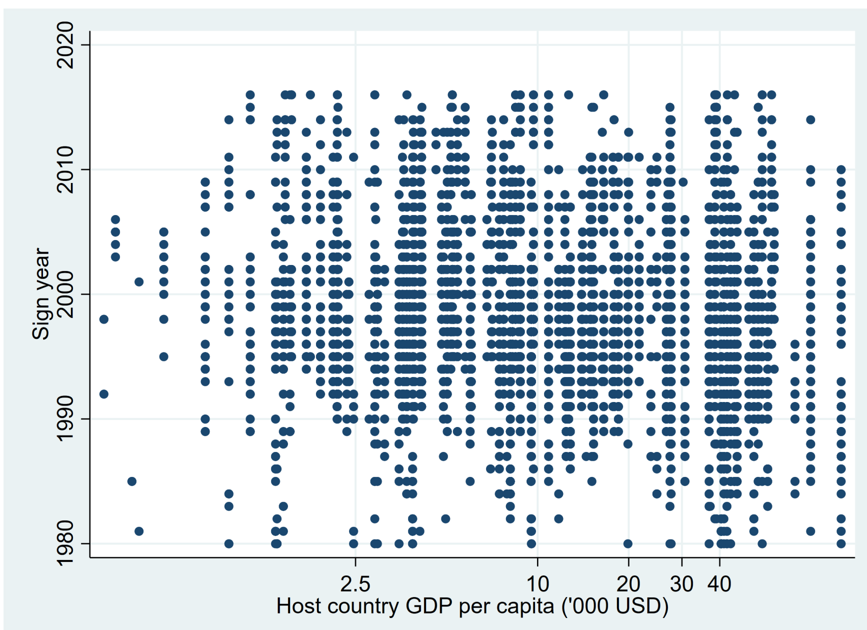

**(f)** Collaboration: Co-application

These figures show the share of globalized patents over time (solid line, left y-axis) and compare the forward citations received by globalized vs. local patents (dotted lines, right y-axis). 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). In each figure, local patents refer to all other patents that do not have the respective globalization feature.

**Figure 3:** Distribution of BITs across Time



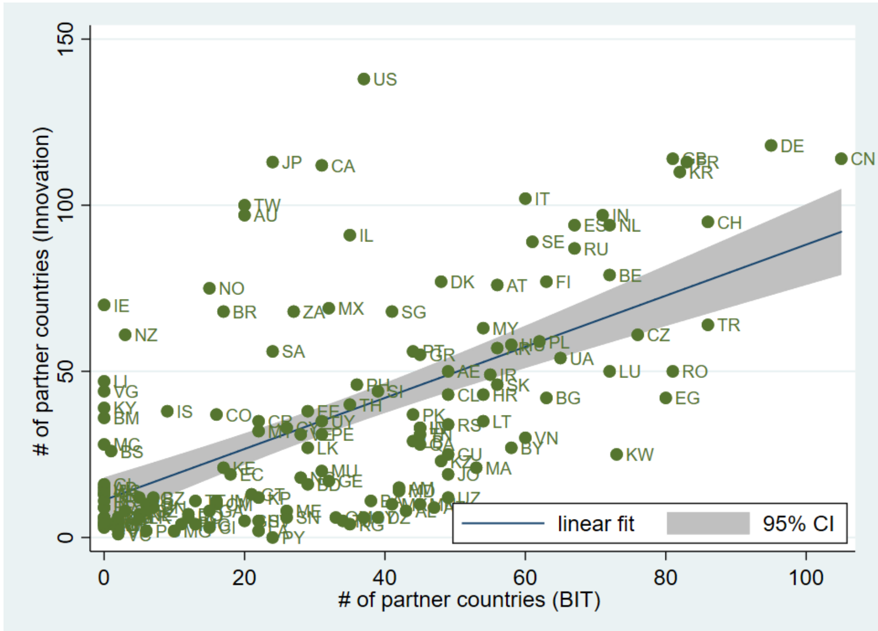

**(a)** Number of New BITs Signed over Time



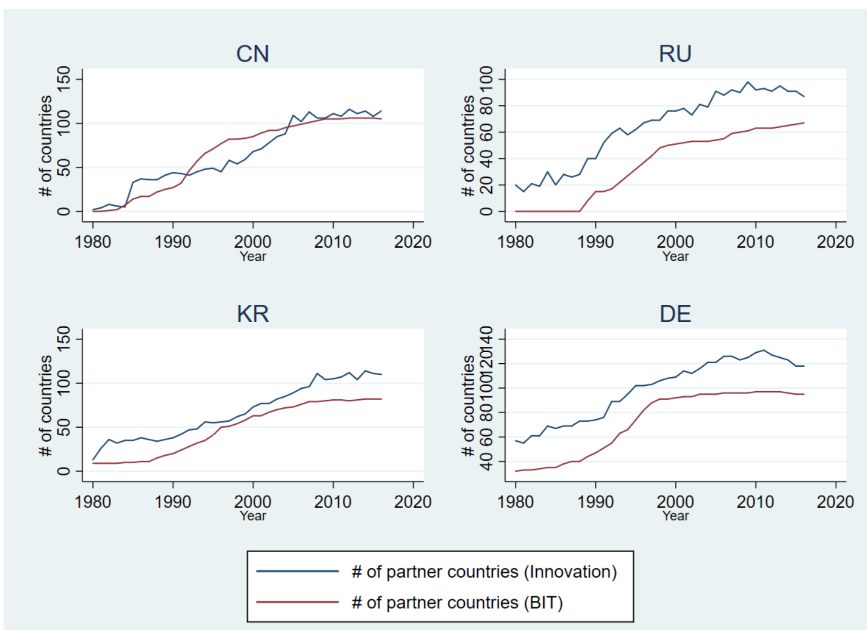

**(b)** Within-country Timing of BITs by GDP per capita

Figure 3a shows the number of newly signed bilateral investment treaties by signing year. Figure 3b plots the distribution of BITs according to the GDP per capita of the host country (x axis) and the sign year (y axis). Each dot represents one treaty.

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



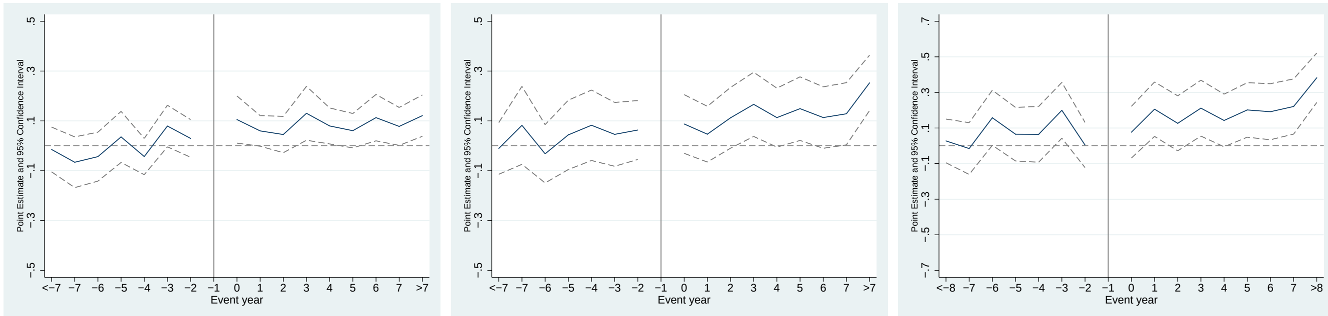

**(a)** Cross-section




**(b)** Time-series

Figure 4a plots for the year 2016 the number of partner countries a country has for its innovation activities against the number of partner countries with which a country has signed bilateral investment treaties. Figure 4b plots for China, Russia, Korea, and Germany, within a country over time, the number of partner countries a country has for its innovation activities against the number of partner countries with which a country has signed bilateral investment treaties.

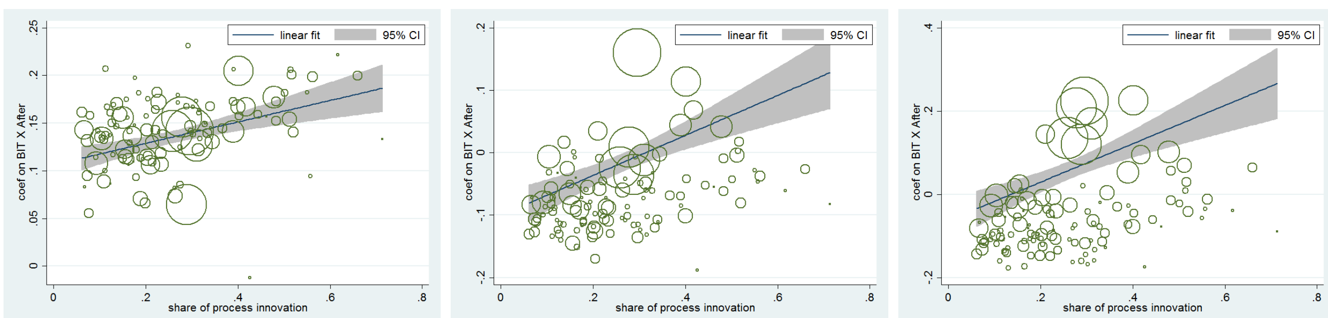
**Figure 5:** Dynamic Effects




**(a)** Adoption **(b)** Sourcing **(c)** Collaboration

Figure 5a shows the dynamic effect of bilateral investment treaties on the adoption of partner countries' technology around the year of signing. Figure 5b shows the dynamic effect of bilateral investment treaties on technology sourcing from partner countries around the year of signing. Figure 5c shows the dynamic effect of bilateral investment treaties on collaboration in patenting with partner countries around the year of signing.

**Figure 6:** 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 6a shows the effects of BITs on the adoption of foreign technology. Figure 6b shows the effects of BITs on technology transfer from foreign inventors. Figure 6c shows the effects of BITs on international co-invention.

**Table 1:** Summary Statistics

Panel A: Patent level

| Globalization measures | Globalized | | | Local | | |
|---|---|---|---|---|---|---|
| | # (%) of obs | Citations (family) | Citations (individual) | # (%) of obs | Citations (family) | Citations (individual) |
| Adoption | 22,406,295 (33.5%) | 17.2 | 3.3 | 44,533,388 (66.5%) | 2.9 | 2.9 |
| Foreign citation | 11,906,129 (17.8%) | 15.0 | 10.1 | 55,033,554 (82.2%) | 6.1 | 1.6 |
| Transfer | 2,336,952 (3.5%) | 16.3 | 6.7 | 64,602,731 (96.5%) | 7.4 | 2.9 |
| Co-invention | 1,446,950 (2.2%) | 17.1 | 5.6 | 65,492,733 (97.8%) | 7.5 | 3.0 |
| Co-application | 816,647 (1.2%) | 14.7 | 7.5 | 66,123,036 (98.8%) | 7.6 | 3.0 |
| Any of the above | 27,251,029 (40.7%) | 16.1 | 5.2 | | | |
| None of the above | | | | 39,688,654 (59.3%) | 1.9 | 1.6 |
| Total | 66,939,683 | 7.7 | 3.1 | | | |

Panel B: Country-pair-year level

| Globalization measures | Full Sample | | | Restricted Sample | | |
|---|---|---|---|---|---|---|
| | # of obs | Applied | Granted | # of obs | Applied | Granted |
| Adoption | 1,547,340 | 7.2 | 4.4 | 826,950 | 13.5 | 8.2 |
| Foreign citation | 1,547,340 | 17.1 | 11.4 | 826,950 | 32.1 | 21.4 |
| Transfer | 1,547,340 | 2.0 | 1.1 | 826,950 | 3.8 | 2.1 |
| Co-invention | 1,547,340 | 2.5 | 1.3 | 826,950 | 4.7 | 2.4 |
| Co-application | 1,547,340 | 0.8 | 0.4 | 826,950 | 1.5 | 0.7 |
| 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 patent applications 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 few innovations (below 50 patents). Among the five globalization measures, adoption, foreign citation, and transfer are directional while co-invention and co-application are non-directional.

**Table 2:** The Value of Globalized Innovation

Panel A: Private Value of Globalized vs Local Patents

| Globalization measures | Globalized | | | Local | | | Diff |
|---|---|---|---|---|---|---|---|
| | Mean | Median | SD | Mean | Median | SD | |
| Adoption | 41.77 | 13.68 | 100.91 | 31.07 | 11.69 | 83.50 | 10.70*** |
| Foreign citation | 33.80 | 12.45 | 88.29 | 31.89 | 10.89 | 85.35 | 1.91*** |
| Transfer | 39.11 | 13.96 | 94.61 | 32.66 | 11.84 | 86.70 | 6.45*** |
| Co-invention | 45.43 | 13.00 | 104.11 | 32.79 | 12.05 | 86.71 | 12.64*** |
| Co-application | 60.93 | 25.99 | 120.77 | 33.38 | 12.05 | 87.93 | 27.54*** |
| Any of the above | 35.02 | 12.72 | 90.57 | | | | |
| None of the above | | | | 28.74 | 10.20 | 79.58 | 6.28*** |

Panel B: Correlation with Future Domestic Innovation

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Dep. Var. | ln (# of domestic patents) | | | | |
| ln (lagged # globalized patents) | 0.150*** | 0.157*** | 0.114*** | 0.080*** | 0.100*** |
| | [0.020] | [0.014] | [0.012] | [0.011] | [0.013] |
| Globalized patents measured by | adoption | citation | transfer | co-invention | co-application |
| Country × Year FE | YES | YES | YES | YES | YES |
| Country × Class FE | YES | YES | YES | YES | YES |
| Class × Year FE | YES | YES | YES | YES | YES |
| Obs | 606,900 | 606,900 | 606,900 | 606,900 | 606,900 |
| Adj. R-sq | 0.939 | 0.939 | 0.938 | 0.938 | 0.938 |

Panel C: Correlation with Future GDP

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Dep. Var. | ln (GDP) | | | | |
| ln (lagged # globalized patents) | 0.003 | 0.057*** | 0.050*** | 0.058*** | 0.028* |
| | [0.012] | [0.018] | [0.017] | [0.018] | [0.015] |
| Globalized patents measured by | adoption | citation | transfer | co-invention | co-application |
| Country FE | YES | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES | YES |
| Obs | 4,230 | 4,230 | 4,230 | 4,230 | 4,230 |
| Adj. R-sq | 0.993 | 0.993 | 0.993 | 0.993 | 0.993 |

Panel A compares the private economic value of globalized versus local patents using the patent-level stock market response measure from Kogan et al. (2017). The sample is based on patents granted to U.S. public firms by USPTO. Patent values are in millions of dollars (nominal). Panels B and C examine the relationship between a country's lagged number of globalized patents and its number of domestic patents, respectively. Panel B is at the country-year-technology class level, controlling for country-year fixed effects, country-class fixed effects, and class-year fixed effects. Panel C is at the country-year level, controlling for country fixed effects and year fixed effects. All samples are from 1980 to 2016. Robust standard errors clustered at the country level are reported in brackets. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

**Table 3:** Impact of BITs 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:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\kappa_t} + \beta BIT_{ij,t} + \varepsilon_{ij,t}$$

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

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \varepsilon_{ij,t}$$

where $i$ indexes the host country, $j$ indexes the source 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 source and host 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. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

**Table 4:** Impact of BITs 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:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\kappa_t} + \beta BIT_{ij,t} + \varepsilon_{ij,t}$$

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

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \varepsilon_{ij,t}$$

where $i$ indexes the host country, $j$ indexes the source 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 source and host 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. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

**Table 5:** The Impact of BITs 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:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\kappa_t} + \beta BIT_{ij,t} + \varepsilon_{ij,t}$$

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

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \varepsilon_{ij,t}$$

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. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

**Table 6:** The Impact of BITs 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:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \varepsilon_{ij,t}$$

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 (4) to (6) measure proximity at the 4-digit IPC subclass level. In columns (1) and (4), the cosine similarity is between country $i$'s and country $j$'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. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

**Table 7:** Cross-BIT Variation in Treatment Intensity: 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:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \kappa BIT_{ij,t} \times Institution\_diff_{ij} + \varepsilon_{ij,t}$$

where $i$ indexes the host country, $j$ indexes the source country, and $t$ indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for source and host 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. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

**Table 8:** Within-BIT Variation in Treatment Intensity: Shock from *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-ruling | -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 arbitration 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:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \kappa BIT_{ij,t} \times Post - ruling_t + \varepsilon_{ij,t}$$

where $i$ indexes the host country, $j$ indexes the source country, and $t$ indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for source and host 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. $Post - ruling$ 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. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

**Table 9:** Cross-sectional Heterogeneity

Panel A: 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 |

Panel B: 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 |

Panel A 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:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \kappa BIT_{ij,t} \times Tech\_diff_{ij,t-1} + \varepsilon_{ij,t}$$

Panel B 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:

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

where $i$ and $j$ index country, $c$ indexes technology class (3-digit IPC class), and $t$ indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for source and host countries are indicated by $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$, respectively. 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. $Tech\_diff_{ij,t-1}$ is the difference between country $i$ and country $j$'s technological development as measured by the lagged number of patent applications. $Process\_Share_c$ denotes the share of process innovation in each technology class (Bena and Simintzi, 2019). In Panel A, all dependent variables are scaled by the total amount between country $j$ and all partner countries. In Panel B, 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). The sample is from 1980 to 2016 in all columns. Robust standard errors clustered at the country-pair level are reported in brackets. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

## Table 10: Channels

### Panel A: 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 |

### Panel B: 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 |

### Panel C: International Travel

| | (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 |

The table provides evidence on the channels underlying the main results. It shows how bilateral investment treaties affect the number/volume of partnerships and VC investments (Panel A), foreign direct investment (Panel B), and international travel (Panel C) between two countries in a country pair. The unit of observation is a country-pair year. The coefficients are estimated from the following specification:

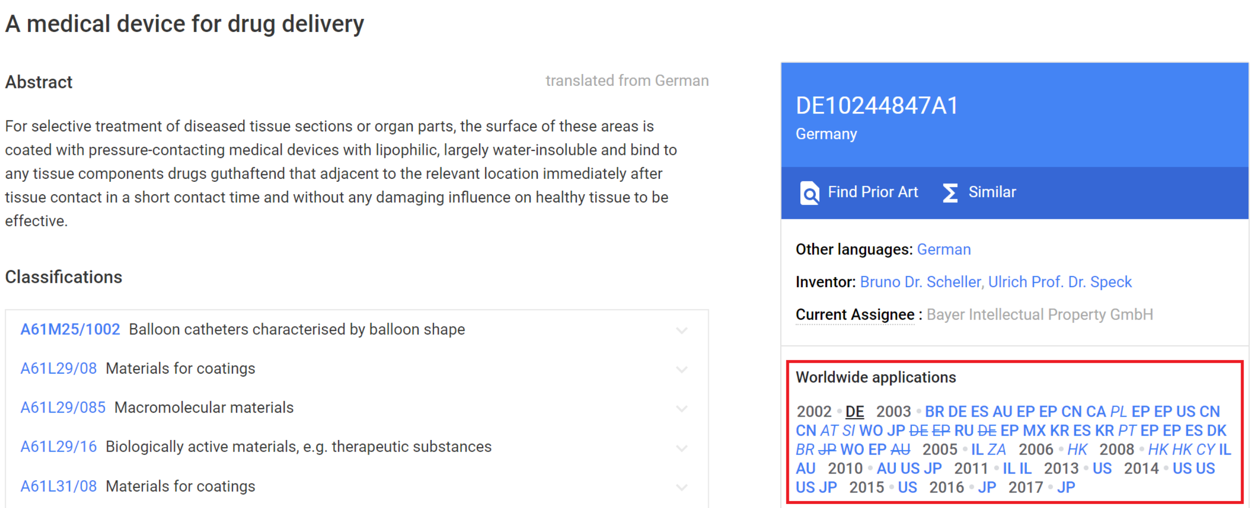
$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \varepsilon_{ij,t}$$

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 $\boldsymbol{\delta_{j,t}}$. $BIT_{ij,t}$ 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 Panels A and C. In Panel A, the dependent variable in columns (1) to (4) measures the number of joint ventures, strategic alliances, technology transfer- or licensing-induced joint ventures or strategic alliances, and VC investments between country $i$ and country $j$. The sample is from 1990 to 2016 in columns (1) to (3), and is from 1980 to 2016 in column (4). In Panel B, the dependent variable in all columns is the logarithm of annual FDI flow from country $i$ to country $j$. Country-pair-year-level controls include variables described in Panel A of Table A.3. Columns (1) and (3) use the full OECD sample and columns (2) and (4) exclude countries with zero or little patenting activities. The sample is from 1985 to 2016 in all columns. In Panel C, 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. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

# For Online Publication:

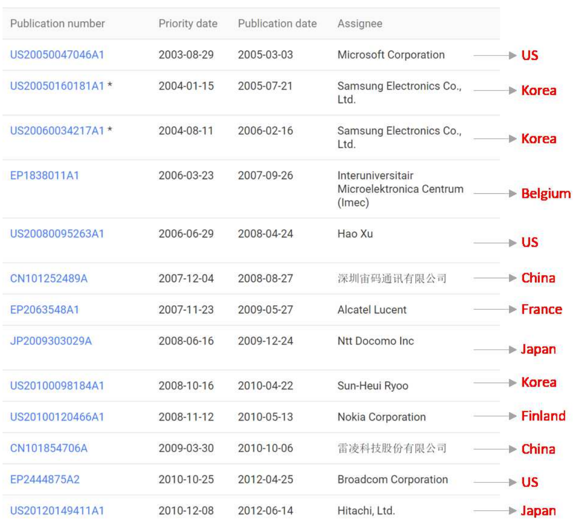
# Internet Appendix to "Cross-Border Institutions and the Globalization of Innovation"

**Figure A.1:** Example — Adoption Measured from Patent Priority



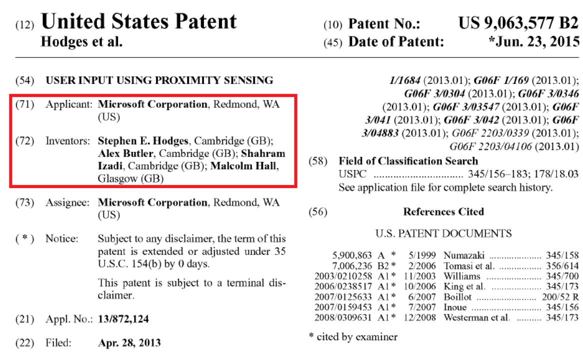

This figure shows an example of patent priority, based on which we measure technology adoption. A priority right is triggered by the first filing of an application for a patent. The priority right allows the claimant to file a subsequent application in another country for the same invention effective 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 | 深圳宙码通讯有限公司 | → 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**
**Hodges et al.**

(10) **Patent No.:** **US 9,063,577 B2**
(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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| 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 application, titled "Method and Wi-Fi device for setting communications mode," is from 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 "User input using proximity sensing," is transferred from inventors in the U.K. to the U.S. assignee (or applicant), 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

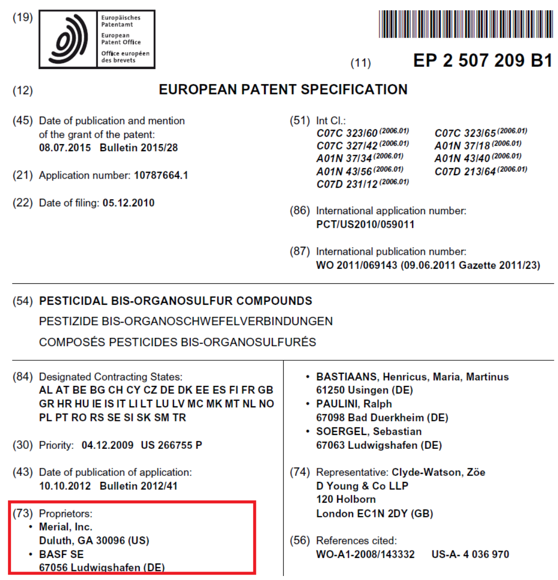
(73) Proprietor: LSI Corporation Milpitas, CA 95035 (US)

(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-invention


(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

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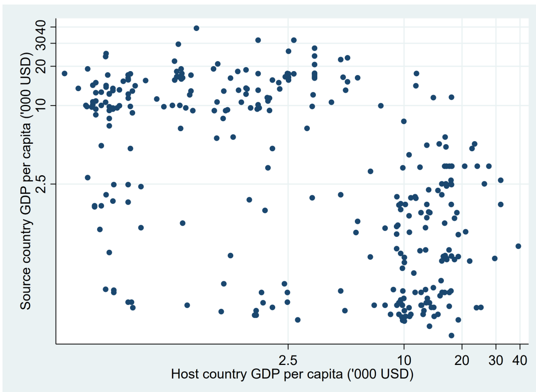
(56) References cited: WO-A1-2008/143332 US-A- 4 036 970

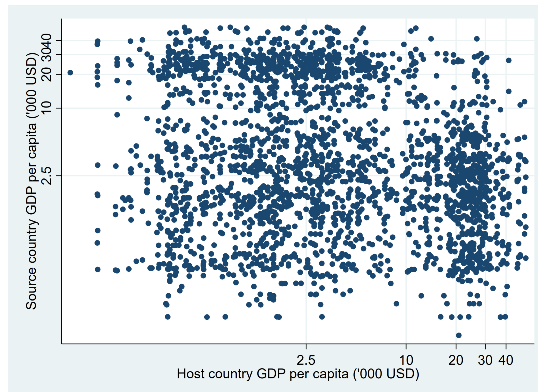
**(b)** Co-application

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.

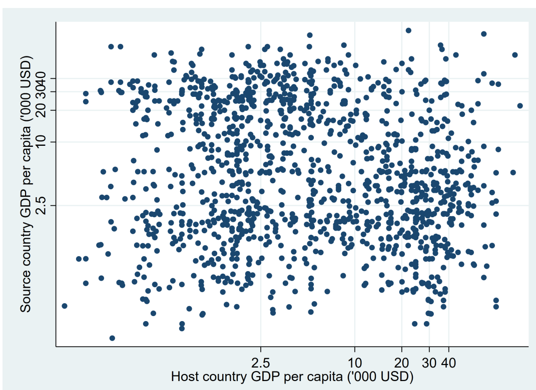
**Figure A.4:** Distribution of BITs: GDP per capita



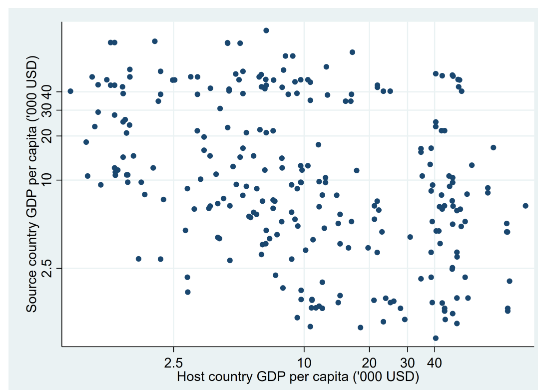

**(a)** Newly signed BITs: 1980-1989



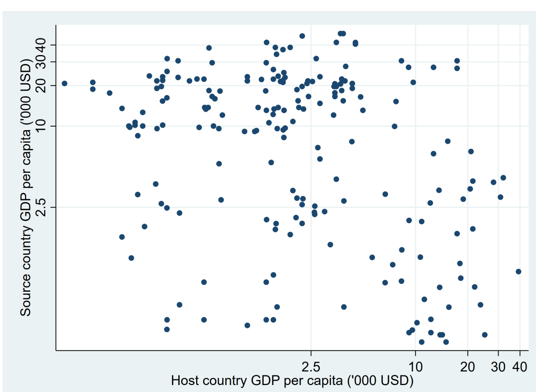

**(b)** Newly signed BITs: 1990-1999




**(c)** Newly signed BITs: 2000-2009




**(d)** Newly signed BITs: 2010-2016

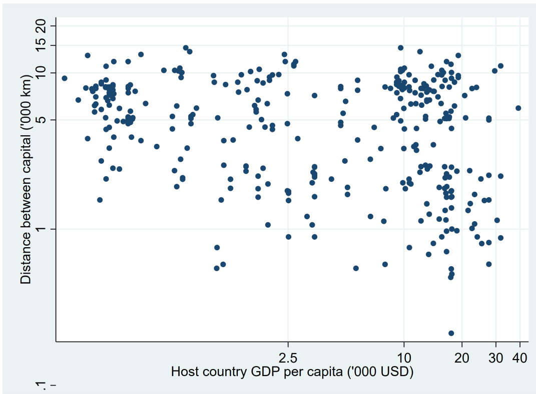



**(e)** First three BITs

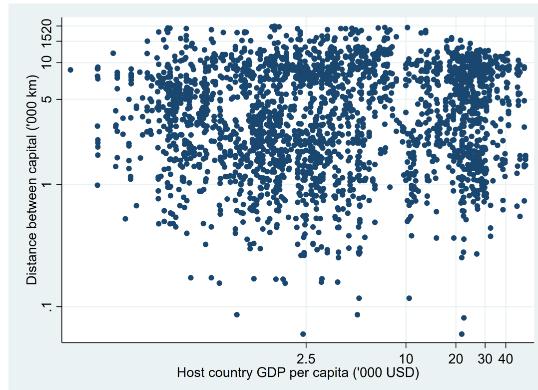

**(f)** All active BITs by 2016

This figure plots the distribution of BITs according to the GDP per capita of the host country (x axis) and the source country (y axis). Each dot represents one treaty.

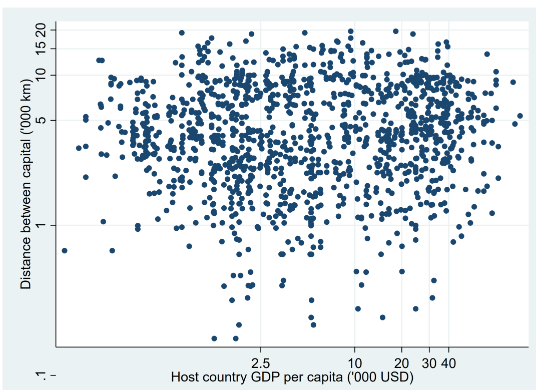
**Figure A.5:** Distribution of BITs: Geographical Distance



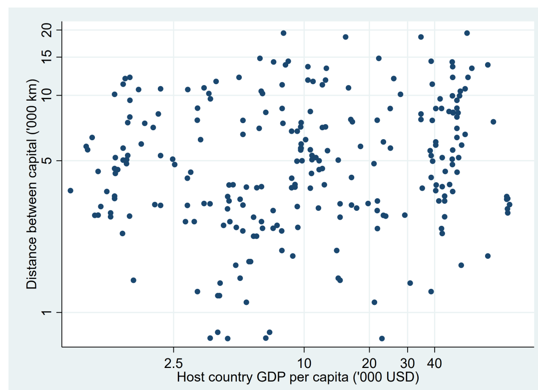

**(a)** Newly signed BITs: 1980-1989



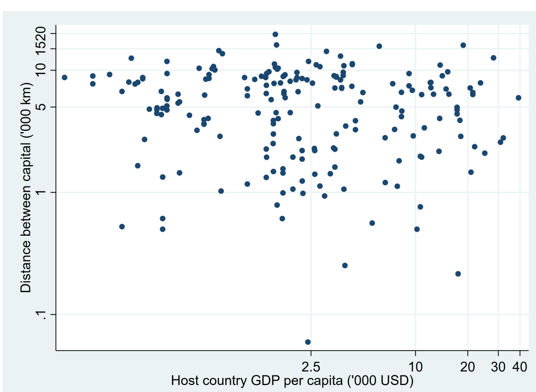

**(b)** Newly signed BITs: 1990-1999



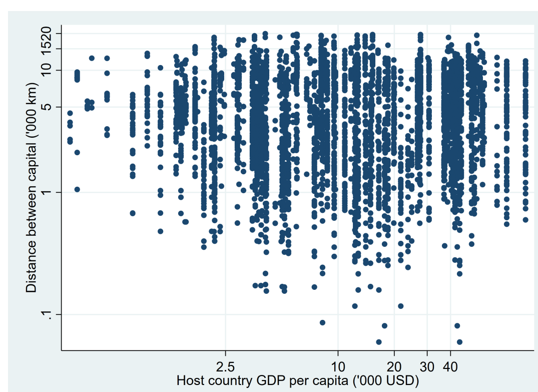

**(c)** Newly signed BITs: 2000-2009




**(d)** Newly signed BITs: 2010-2016



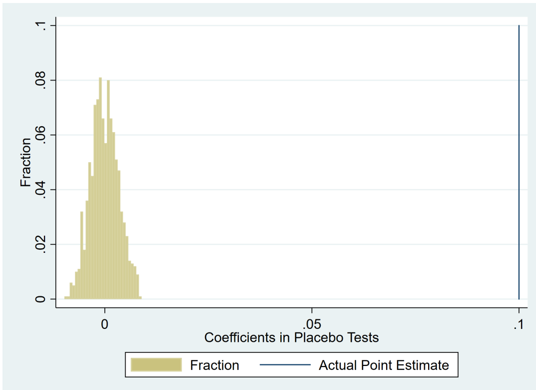

**(e)** First three BITs



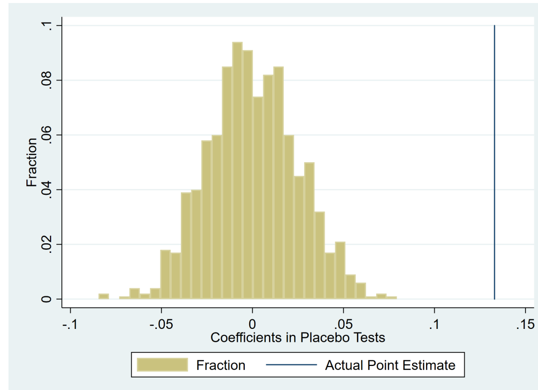

**(f)** All active BITs by 2016

This figure plots the distribution of BITs according to the GDP per capita of the host country (x axis) and the geographical distance between the host and source country's capitals (y axis). Each dot represents one treaty.

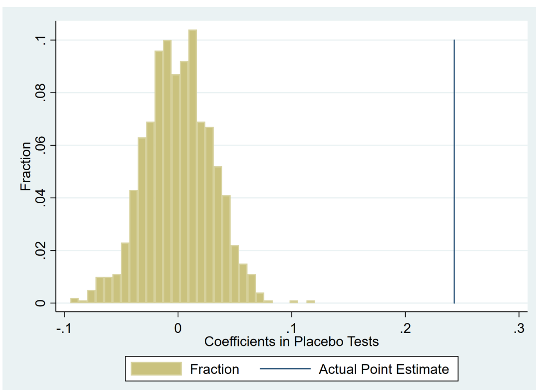
**Figure A.6:** True Estimate vs. Placebo Estimates



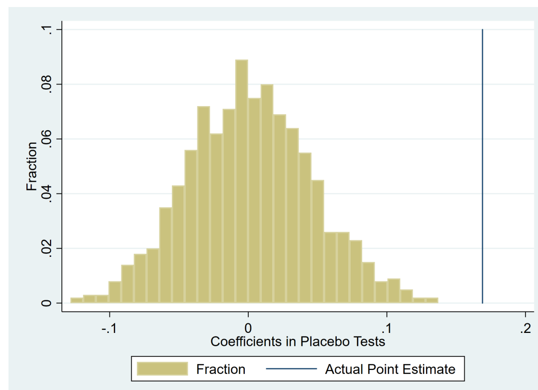

**(a)** Any type



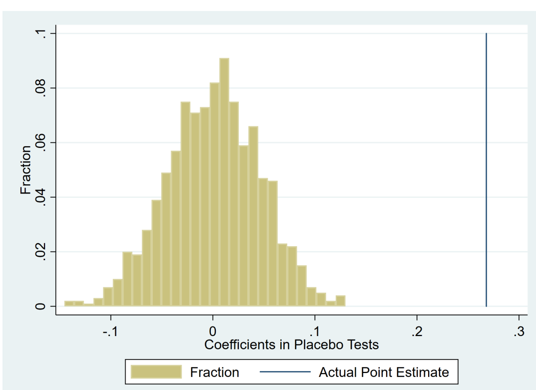

**(b)** Adoption



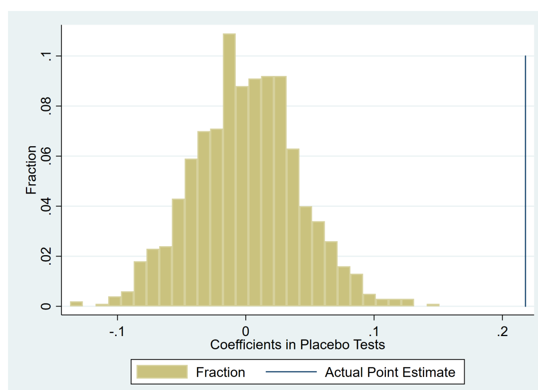

**(c)** Sourcing: Citation




**(d)** Sourcing: Transfer



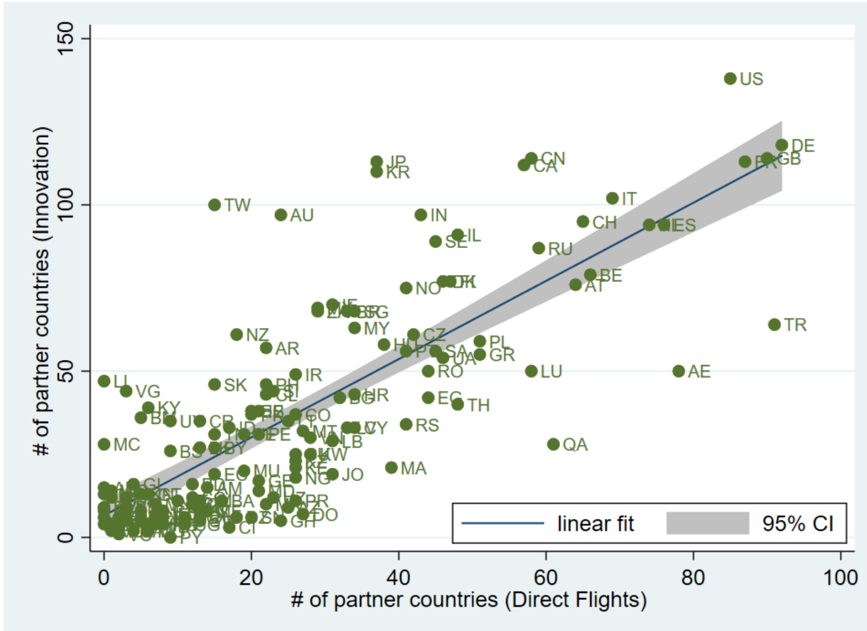

**(e)** Collaboration: Co-invention



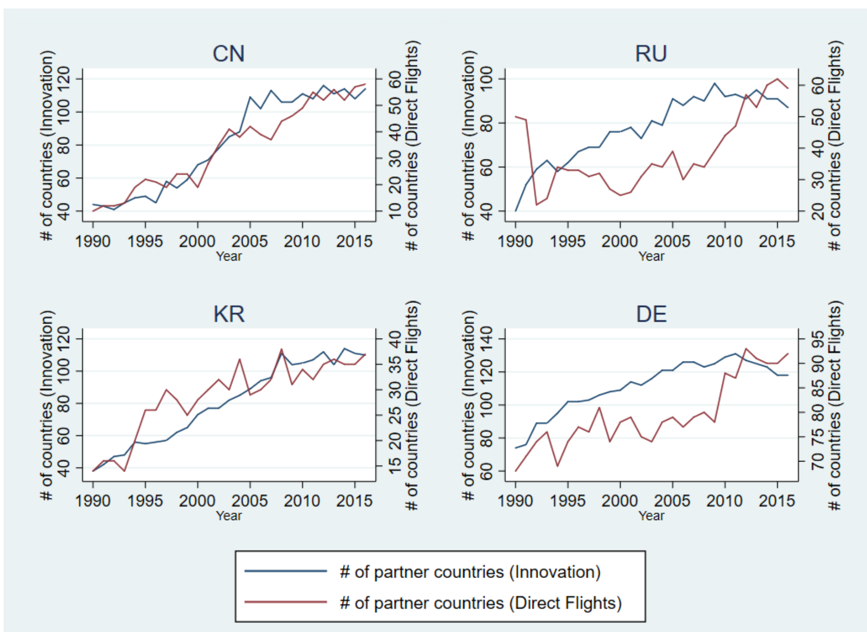

**(f)** Collaboration: Co-application

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 3.

**Figure A.7:** Number of Partner Countries for Innovation vs. for Direct Flights




**(a)** Cross-section




**(b)** Time-series

Panel A plots the number of partner countries a country has for its innovation activities against the number of partner countries a country has direct flights with by the end of 2016. Panel B plots for China, Russia, Korea, and Germany, 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 direct flights with.

**Table A.1:** 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 × 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 host and the source countries. The unit of observation is a country-pair year. The coefficients are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \varepsilon_{ij,t}$$

where $i$ indexes the host country, $j$ indexes the source country, and $t$ indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for source and host 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. ***, **, and * denote significance at the 1%, 5% and 10% levels, respectively.

**Table A.2:** 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:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \varepsilon_{ij,t}$$

where $i$ indexes the host country, $j$ indexes the source country, and $t$ indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for source and host 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. ***, **, and * denote significance at the 1%, 5% and 10% levels, respectively.

**Table A.3:** Robustness — Additional Controls

Panel A: Baseline 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: Additional Controls for IP-related Agreements

| | (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 | 0.109*** | 0.236*** | 0.121*** | 0.234*** | 0.150*** |
| | [0.032] | [0.033] | [0.046] | [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 |
| Dep. Var. Mean | 0.296 | 0.484 | 0.478 | 0.496 | 0.393 |

Panel C: 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. Panels A and B add country-pair-year-level controls. Panel A controls for trade volume, bilateral labor agreements, indicators for different degrees of economic integration, exchange rate arrangement, the degree of capital account openness of each country-pair, bilateral tax treaties, and tax information exchange agreements. Panel B additionally controls for patent cooperation treaties, patent law treaties, membership of the World Intellectual Property Organization, and membership of the World Trade Organization (WTO). Panel C 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 coefficients in Panel A and B 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 C are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \boldsymbol{\zeta_{r_i r_j,t}} + \beta BIT_{ij,t} + \varepsilon_{ij,t}$$

where $i$ indexes the host country, $j$ indexes the source 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 source and host 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. The sample is from 1980 to 2016 in all columns. Robust standard errors clustered at the country-pair level are reported in brackets. ***, **, and * denote significance at the 1%, 5% and 10% levels, respectively.

**Table A.4:** Robustness — Changes in the Incentives to File Patents: Below-median Reliance on Secrecy

| | (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 | 0.126*** | 0.179*** | 0.145*** | 0.280*** | 0.156*** |
| | [0.034] | [0.030] | [0.047] | [0.048] | [0.043] |
| 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 | 0.562 | 0.467 | 0.319 | 0.393 | 0.243 |

The table reproduces our main analyses by focusing on globalized patents in technology classes that have below-median reliance on secrecy. The unit of observation is a country-pair year. The coefficients are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \varepsilon_{ij,t}$$

where $i$ indexes the host country, $j$ indexes the source country, and $t$ indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for source and host 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. ***, **, and * denote significance at the 1%, 5% and 10% levels, respectively.

**Table A.5:** Robustness — Changes in Patenting Standards: Restricting to Top Patent Offices

Panel A: Restricting to EPO

| | (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*** | 0.148*** | 0.127*** | 0.270*** | 0.094** |
| | [0.033] | [0.026] | [0.040] | [0.041] | [0.036] |
| 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 | 0.455 | 0.278 | 0.339 | 0.233 |

Panel B: Restricting to EPO, USPTO, JPO, and WIPO

| | (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*** | 0.243*** | 0.331*** | 0.260*** |
| | [0.033] | [0.033] | [0.044] | [0.046] | [0.044] |
| 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 | 0.509 | 0.378 | 0.470 | 0.302 |

The table repeats our main analysis, restricting to patents issued by important patent offices when creating measures of the globalization of innovation. Panel A restricts to patents applied through EPO. Panel B restricts to patents applied through EPO, USPTO, JPO, and WIPO. The unit of observation is a country-pair year. The coefficients are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \varepsilon_{ij,t}$$

where $i$ indexes the host country, $j$ indexes the source country, and $t$ indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for source and host 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. ***, **, and * denote significance at the 1%, 5% and 10% levels, respectively.

**Table A.6:** 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 | citation | transfer | 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 |

Panel C: Excluding European 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 | 0.148*** | 0.404*** | 0.200* | 0.470*** | 0.234** |
| | [0.057] | [0.097] | [0.112] | [0.120] | [0.110] |
| Country × Year FE | YES | YES | YES | YES | YES |
| Country-pair FE | YES | YES | YES | YES | YES |
| Obs | 419,654 | 419,654 | 419,654 | 419,654 | 419,654 |
| Adj. R-sq | 0.745 | 0.605 | 0.445 | 0.539 | 0.397 |

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). Panel C excludes all European countries (43 countries). The unit of observation is a country-pair year. The coefficients are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \varepsilon_{ij,t}$$

where $i$ indexes the host country, $j$ indexes the source country, and $t$ indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for source and host 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. ***, **, and * denote significance at the 1%, 5% and 10% levels, respectively.

**Table A.7:** 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; Inhibiting Corrosion of Metallic Material or Incrustation in General | 0.561 |
| C05 | Fertilizers; 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 is from Bena and Simintzi (2019).

**Table A.8:** The Impact of Bilateral Investment Treaties on International Travel

*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 differently affect international travel between two countries for innovation-active versus innovation-inactive countries. The unit of observation is a country-pair year. It estimates the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \kappa BIT_{ij,t} \times Top50_{ij,t} + \varepsilon_{ij,t}$$

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 by patent count. 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. ***, **, and * denote significance at the 1%, 5% and 10% levels, respectively.

**Table A.9:** 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:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \kappa BIT_{ij,t} \times Common\ language_{i,j} + \varepsilon_{ij,t}$$

where $i$ indexes the host country, $j$ indexes the source country, and $t$ indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for source and host 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 speak 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. ***, **, and * denote significance at the 1%, 5% and 10% levels, respectively.

**Table A.10:** Impact for Highly Developed Countries

Panel A: Effect of BITs on Globalized Innovation

| | (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 | 0.042 | 0.100*** | 0.178** | 0.191*** | 0.258*** |
| | [0.040] | [0.038] | [0.074] | [0.068] | [0.077] |
| Country × Year FE | YES | YES | YES | YES | YES |
| Country-pair FE | YES | YES | YES | YES | YES |
| Obs | 93,721 | 93,721 | 93,721 | 93,721 | 93,721 |
| Adj. R-sq | 0.905 | 0.844 | 0.69 | 0.647 | 0.547 |

Panel B: Correlation with Future Innovation

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Dep. Var. | log (# of domestic patents) | | | | |
| log (lagged # globalized patents) | 0.137*** | 0.123*** | 0.076*** | 0.056*** | 0.079*** |
| | [0.031] | [0.017] | [0.013] | [0.012] | [0.012] |
| Globalized patents measured by | adoption | citation | transfer | co-invention | co-application |
| Country × Year FE | YES | YES | YES | YES | YES |
| Country × IPC3d FE | YES | YES | YES | YES | YES |
| Year × IPC3d FE | YES | YES | YES | YES | YES |
| Obs | 60,690 | 60,690 | 60,690 | 60,690 | 60,690 |
| Adj. R-sq | 0.938 | 0.938 | 0.937 | 0.937 | 0.937 |

Panel C: Correlation with Future GDP

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Dep. Var. | log (GDP) | | | | |
| log (lagged # globalized patents) | 0.013 | 0.058* | 0.042 | 0.084** | 0.026 |
| | [0.009] | [0.028] | [0.039] | [0.038] | [0.017] |
| Globalized patents measured by | adoption | citation | transfer | co-invention | co-application |
| Country FE | YES | YES | YES | YES | YES |
| Year FE | YES | YES | YES | YES | YES |
| Obs | 572 | 572 | 572 | 572 | 572 |
| Adj. R-sq | 0.998 | 0.998 | 0.998 | 0.998 | 0.998 |

This table studies how bilateral investment treaties affect the globalization of innovation (Panel A) and the value of globalized patents (Panels B and C) in developed countries that have GDP per capita in the highest decile in 1980. In Panel A, the coefficients are estimated from the following specification:

$$Y_{ij,t} = \boldsymbol{\gamma_{ij}} + \boldsymbol{\alpha_{i,t}} + \boldsymbol{\delta_{j,t}} + \beta BIT_{ij,t} + \varepsilon_{ij,t}$$

where $i$ indexes the host country, $j$ indexes the source country, and $t$ indexes year. Country-pair fixed effects are indicated by $\boldsymbol{\gamma_{ij}}$. Country × year fixed effects for source and host 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). Panels B and C examine the relationship between a country's lagged number of globalized patents and its number of domestic patents, respectively. Panel B is at the country-year-technology class level, controlling for country-year fixed effects, country-class fixed effects, and class-year fixed effects. Panel C is at the country-year level, controlling for country fixed effects and year fixed effects. The sample is from 1980 to 2016 in all columns. Robust standard errors clustered at the country-pair level are reported in brackets. ***, **, and * denote significance at the 1%, 5% and 10% levels, respectively.