Cross-Border Property Rights and the Globalization of Innovation: Online Appendix

Bo Bian, Jean-Marie Meier, Ting Xu[34]

Appendix: Sample Construction, Validation of Measures and Additional Robustness

A Appendix: Sample Construction

The key underlying database is PATSTAT Global (2018 Autumn Edition, version 5.12) complied by EPO. The most recent data catalog can be found from EPO's website.[35] This 2022 Autumn Edition (version 5.20) follows the 2018 Autumn Edition. The database structure and variable definitions are the same.

The following raw data tables are used in constructing the measures (see Page 25 of the Data Catalog for a logical model diagram for these tables):

- TLS201_APPLN: This basic table provides information on patent application identifiers, filing authority, filing date, granted or not, family ID, and the number of applicants and inventors.

- TLS206_PERSON: This table contains the data on applicants and inventors such as the person identifiers, person name, the address, and the country of residence. Persons are the legal or physical persons (applicants and inventors) that have a relation with the patent granting procedure.

- TLS_207_PERS_APPLN: This linkage table connects table TLS201_APPLN and

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[35]EPO (2022): Data Catalog PATSTAT Global, `https://documents.epo.org/projects/babylon/eponot.nsf/0/9BB068EEB37E80BCC125878200565B60/$File/data_catalog_global_v5.20_en.pdf`, last accessed December 1, 2022.

table TLS206_PERSON through patent identifiers and person identifiers.

- TLS209_APPLN_IPC: This table provides international technology classification for each patent.

- TLS211_PAT_PUBLN: This linkage table connects patent publications to patent applications. Citations of patents are based on publication identifiers rather than application identifiers. This table is thus used to back out citation relationship between different patent application identifiers.

- TLS212_CITATION: This table records citations from patent publications to documents which are regarded as relevant for the patent procedure.

We start with all the patents in TLS201_APPLN with application year between 1980 and 2016. We drop patents with missing filing date and impute missing information in country codes and technology classification based on subsequent filings within the same patent family (de Rassenfosse and Seliger, 2021). We keep only patent-to-patent citations (some patents also cite non-patent literature such as scientific publications, technical standards, conference proceedings, etc.).

We then define patent-level indicators for globalized innovation based on the following criteria:

- Adoption: Patents with its priority traced to another country, i.e., the filing office country is different from the applicant's country.

- Citation: Patents that cite at least one foreign patent, based on the applicant country of the citing and cited patents.

- Transfer: Patents where the applicant and inventors are from different countries.

- Co-invention: Patents where the inventors are from different countries.

- Co-application: Patents where the applicants are from different countries.

We next define source country and host country for each patent. The country variable is from TLS206_PERSON. This table contains identifying information on applicants and inventors, such as their name, country of residence, and address if available.

Table 1 summarizes the definition of source and host countries in our various measures. Note that adoption is the only measure for which we used the country of the patent office (as the host country). Importantly, in adoption, the source country is still based on the applicant country. In all other measures, countries are based on either the applicant country (for citation, co-application, and transfer) or the inventor country (for co-invention and transfer). As such, countries without patent offices will never be adopters, but they can be the knowledge-exporting country. Most countries in our sample do have a patent office. The raw PATSTAT Global data contains over 100 million patents from 196 patent offices. In our main sample, there are 150 countries and 133 patent offices, including offices (e.g., EPO) that cover multiple countries.

Patents with information missing for either country are dropped. In this way patent offices for which PATSTAT Global has complete coverage mechanically become more important in the data construction process, alleviating some of the measurement concerns about heterogeneous patenting standards and data coverage. In the end, we aggregate patent-level measures to country-pair-application-year level. We create a strictly balanced panel and fill in with zeros if there are no interactions between the source and host country in a given year.

PATSTAT Global aims to cover all the patents from each patent office. National and supranational patent authorities supply data to EPO on a regular basis. The coverage table shows 100% percent coverage for many countries, especially in recent years, for the country variable we rely on.[36] For globally important patent offices, such as EPO or USPTO, the 100% coverage rate has been consistent since the late 1970s. We use patents filed through these patent offices to construct alternative measures. For example, in row 12 of Figure A.6, we show that our results are robust to restricting to patents from the top 4 patent offices (EPO, USPTO, JPO, and WIPO).

[36] EPO (2018): "Mapping data completeness of PATSTAT Global and INPADOC data," December 19, https://forums.epo.org/mapping-data-completeness-of-patstat-global-and-inpadoc-data-tls231-7984 (last accessed December 1, 2022).

B Appendix: Validation and Further Robustness of the Adoption Measure

1. Validation of Adoption using Medical Drug Launches. Our adoption measure seeks to capture the adoption by country H (host country) of an existing technology that originates from country S (source country). By adoption, we mean that the technology is commercialized (i.e., a product based on this innovation is being sold) in a country that did not develop the technology. In the above definition, country H is the user of the technology and is where the technology is commercialized. Country S developed this technology and is where the patent applicant is based. This measure originates from Archibugi and Michie (1995) and has been used in Eaton and Kortum (1999), Lanjouw and Mody (1996), and Dechezleprêtre et al. (2011) to capture the adoption/exploitation of existing knowledge. For example, Archibugi and Michie (1995) argue that: "One way of measuring the international exploitation of innovation is to consider how firms protect them legally through patents in foreign markets. Firms undertake the cost and effort involved in extending a patent abroad if they expect to be compensated by either trading the disembodied invention or exporting products which embody it."

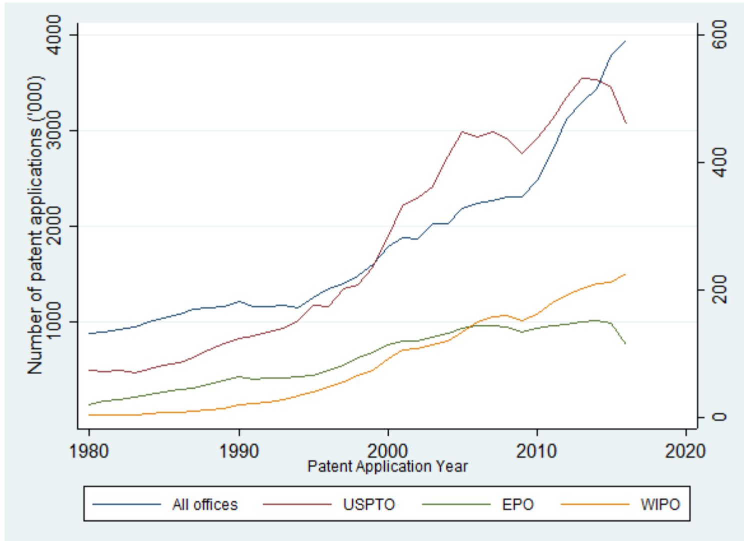
We use medical drug launch data to validate our priority-based adoption measure. Our drug launch data come from Cortellis, a commercial database that tracks the development and commercialization of the near universe of drugs around the world. For each drug, Cortellis identifies the originator company, whose country we use as the drug's originating country. Cortellis also tracks the launch of the same drug (or drug-indication) in each foreign country, the launch date, as well as the associated distributing company. Drugs in our data originate from 61 countries and diffuse to 213 countries and territories. Cortellis also links drugs to patents, making it the ideal data to validate our adoption measure. The drug Tocilizumab provides an example of how duplicate patent filings of the same priority can trace drug diffusion. Tocilizumab, marketed under the common brand

Actemra, is an intravenous drug treating rheumatoid arthritis originated by the Japanese company Chugai Pharmaceutical in 2009. Panel A of Table A.8 presents the dates this drug was launched in 13 different countries from 2009 to 2016, as well as the associated duplicate patent filing date in that country. We can see that although there can be a time difference between patent filing and drug launch, the two series of events largely track each other across countries.

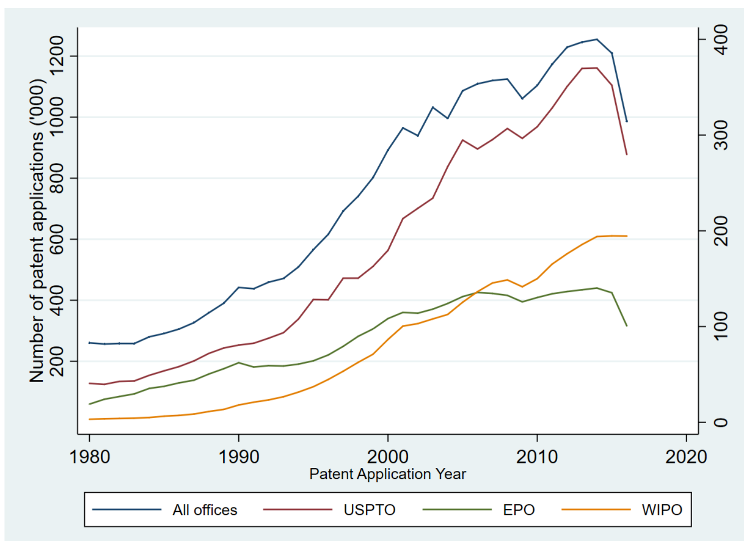
We conduct more systematic validations in Panels B and C of Table A.8. Panel B validates the extensive margin of adoption. The sample is at the drug-adoption-country level. We find that filing a duplicate patent for a drug in a country increases the probability of selling the drug in that country by 6.2 times. Conversely, launching a drug in a country increases the probability of a duplicate patent filing in that country by 3.5 times. These results hold both in the overall cross-section, as well as within a drug across countries. For the intensive margin, we examine whether the timing of drug launch correlates with the timing of duplicate patent filing, conditional on both happening. If the timing of duplicate patent filing is purely random or highly strategic/preemptive, we should see little correlation in timing between the two. Panel C correlates a country's sequence number in the adoption of a drug with its sequence number in duplicate patent filings of that drug. Moving up one spot earlier in duplicate patent filing is associated with a 0.16 earlier adoption spot; moving up one spot earlier in adoption is associated with a 0.43 earlier duplicate patent filing spot. These numbers are 0.1 and 0.24 respectively within-drug across countries. Overall, these results show that patent priority contains important information on the adoption of innovation across countries.

2. Additional Validation of the Adoption Measure. In some cases, companies can strategically file a patent in multiple patent offices simultaneously or within a short period of time. This typically happens in initial filings and could result in the first filing country being different from the applicant's country. In our data, the vast majority of patent families (85%) have an initial filing in the same country as the applicant's country. We use the applicant's country instead of the first filing country as the source country in defining our adoption measure; we also drop the small number of filings before the applicant-country filing (i.e., we only consider those after the applicant-country filing as adoption). To further alleviate concerns regarding preemptive filings, we conduct robustness tests using two alternative versions of the adoption measure. First, we define adoption using the 85% of patent families whose initial filing is in the same country as the applicant. Second, we drop the initial cluster of filings when tracing adoption, where the initial cluster is defined as filings within 1, 6, or 12 months of the first filing. The idea is that this initial cluster of filings are more likely to be strategic or preemptive relative to the ones that that occurred later. The results are reported in rows 18-21 of Figure A.6a and are similar to our main results.

Figure A.1: Number of Patent Applications Over Time



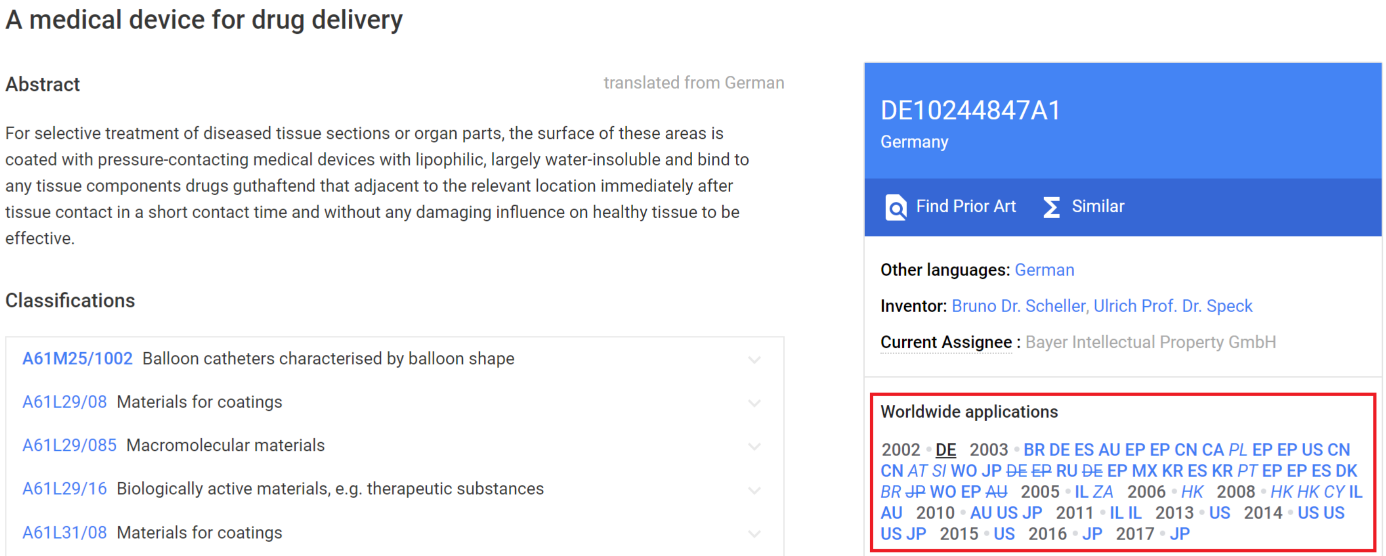
(a) All Patents



(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 A.1a includes all patents while Figure A.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.

Figure A.2: Example — Adoption Measured with Patent Priority

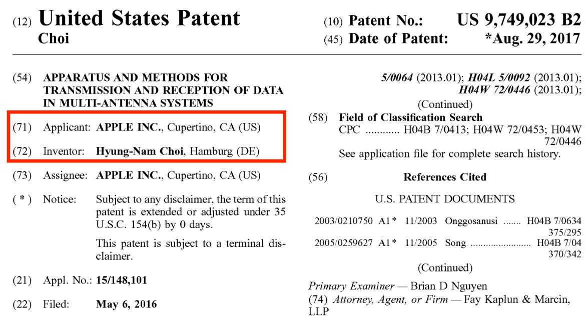


This figure shows an example of patent priority, based on which we measure technology adoption. A priority right is triggered by the first filing of an application for a patent. The priority right allows the claimant to file a subsequent application in another country for the same invention effective 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.3: Example — Sourcing from Foreign Knowledge

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

(a) Citation of Foreign Knowledge


(12) **United States Patent**
Choi

(10) **Patent No.: US 9,749,023 B2**
(45) **Date of Patent: *Aug. 29, 2017**

(54) **APPARATUS AND METHODS FOR TRANSMISSION AND RECEPTION OF DATA IN MULTI-ANTENNA SYSTEMS**

(71) Applicant: **APPLE INC.**, Cupertino, CA (US)

(72) Inventor: **Hyung-Nam Choi**, Hamburg (DE)

(73) Assignee: **APPLE INC.**, Cupertino, CA (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.: **15/148,101**

(22) Filed: **May 6, 2016**

5/0064 (2013.01); ***H04L 5/0092*** (2013.01); ***H04W 72/0446*** (2013.01);

(Continued)

(58) **Field of Classification Search**
CPC H04B 7/0413; H04W 72/0453; H04W 72/0446
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2003/0210750 A1* 11/2003 Onggosanusi H04B 7/0634 375/295
2005/0259627 A1* 11/2005 Song H04B 7/04 370/342

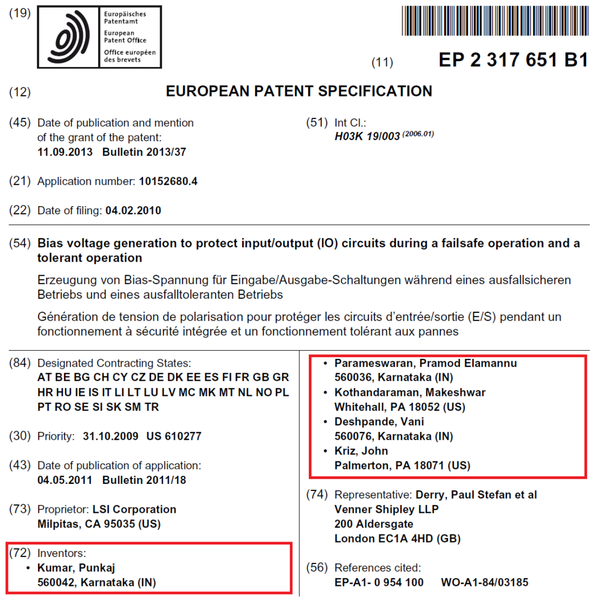
(Continued)

Primary Examiner — Brian D Nguyen
(74) *Attorney, Agent, or Firm* — Fay Kaplun & Marcin, LLP

(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 "Apparatus and methods for transmission and reception of data in multi-antenna systems," is transferred from an inventor in Germany to the assignee (or applicant) in the United States, Apple Inc.

Figure A.4: 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**

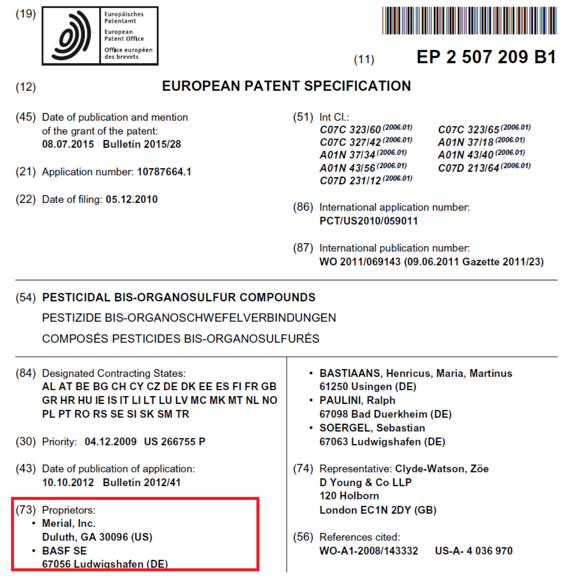
(73) Proprietor: **LSI Corporation Milpitas, CA 95035 (US)**

(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

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

(30) Priority: **04.12.2009 US 266755 P**

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

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

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

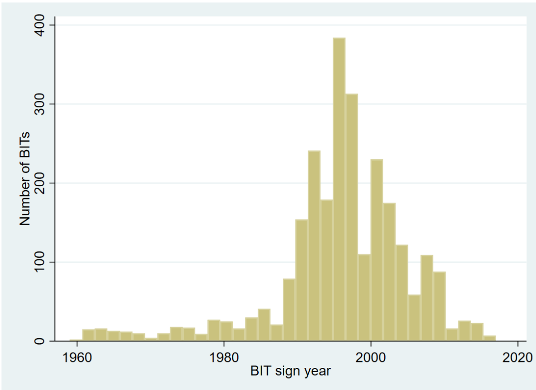
(74) Representative: **Clyde-Watson, Zöe D Young & Co LLP 120 Holborn London EC1N 2DY (GB)**

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

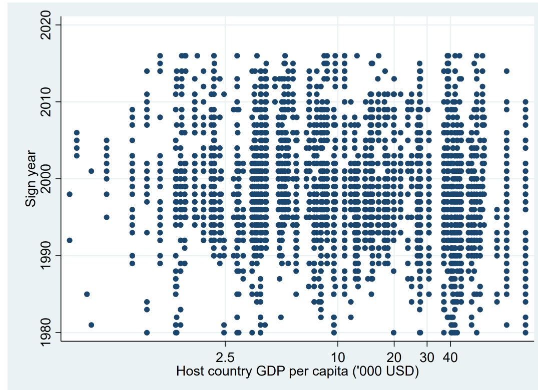
(b) Co-Application

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.5: Distribution of BITs across Time

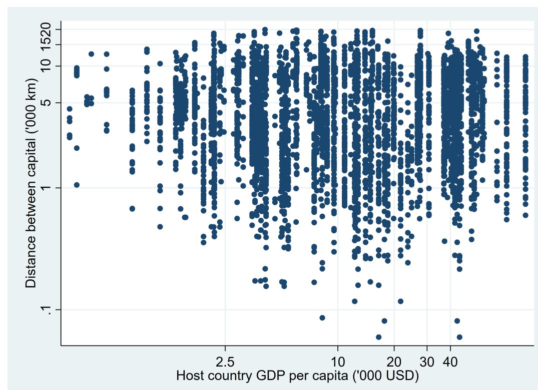


(a) Number of New BITs Signed over Time



(b) Timing of BITs by GDP Per Capita

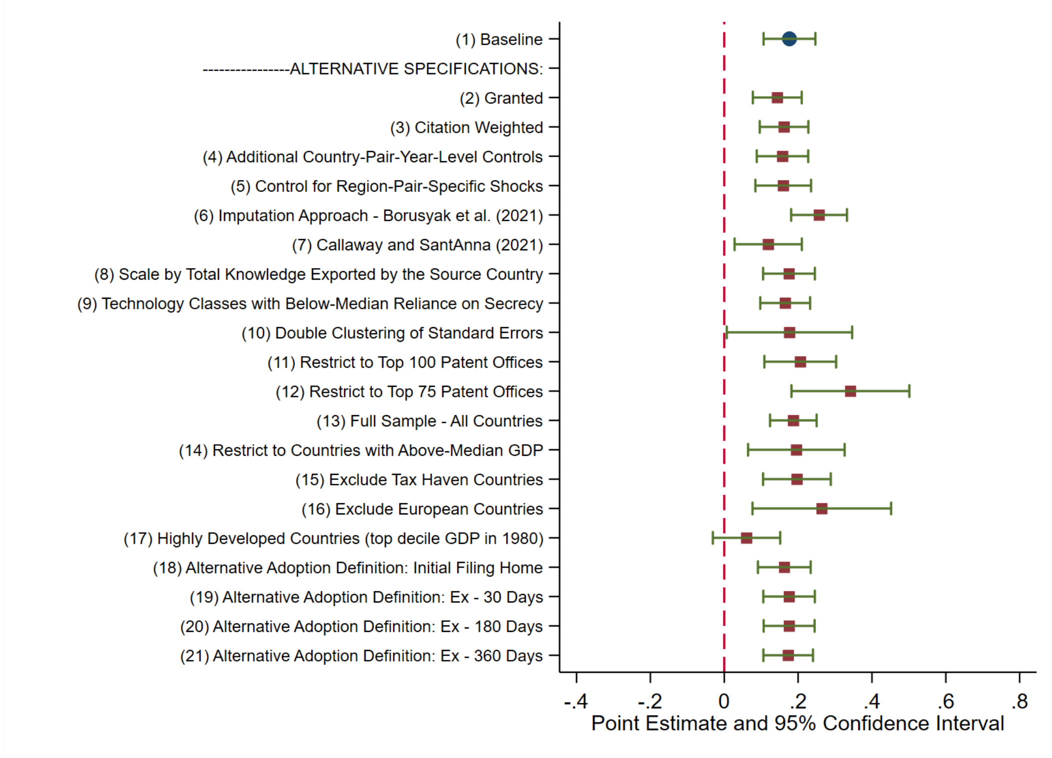
(c) GDP per Capita of Signing Countries



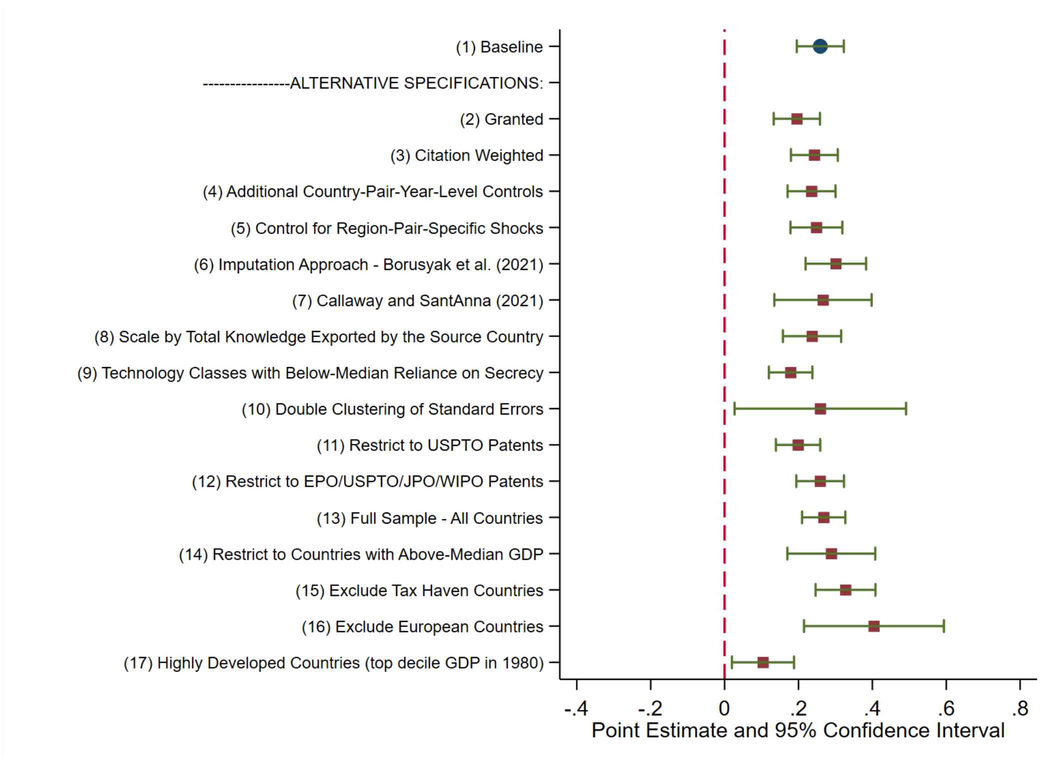
(d) Geographic Distance by GDP Per Capita

Figure A.5a shows the number of newly signed bilateral investment treaties by signing year. Figure A.5b plots the distribution of BITs according to the GDP per capita of the host country (x axis) and the sign year (y axis). Figure A.5c plots the distribution of BITs according to the GDP per capita of the host country (x axis) and the source country (y axis). Figure A.5d 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: Robustness Estimates

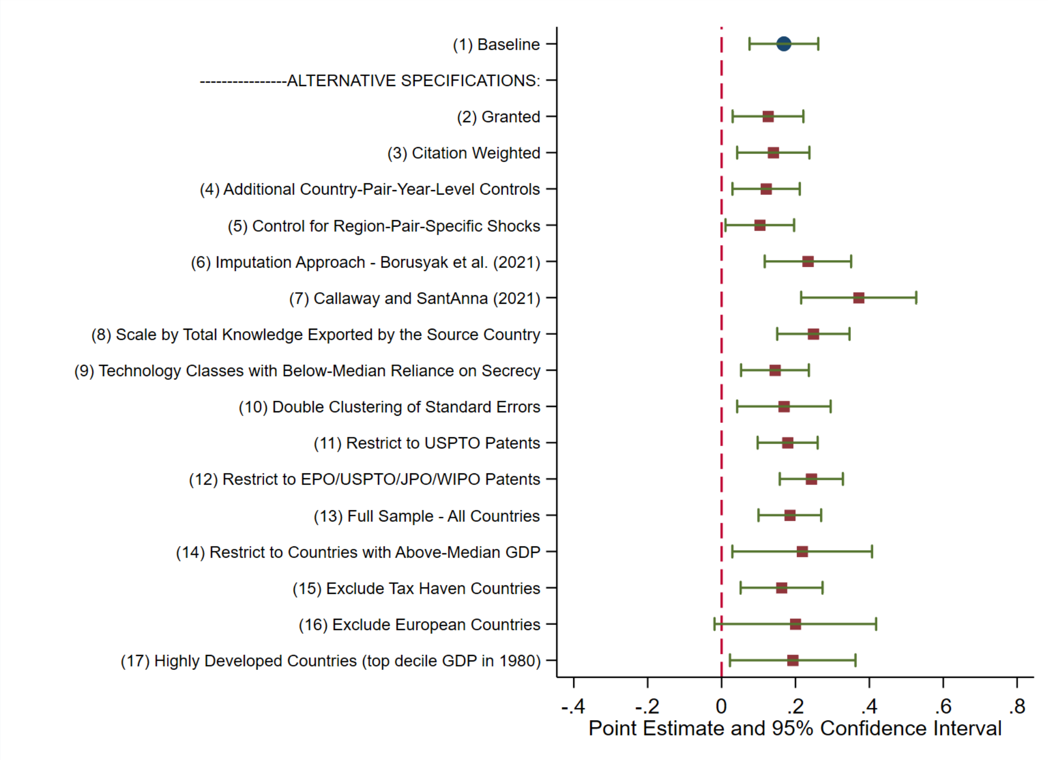


(a) Adoption

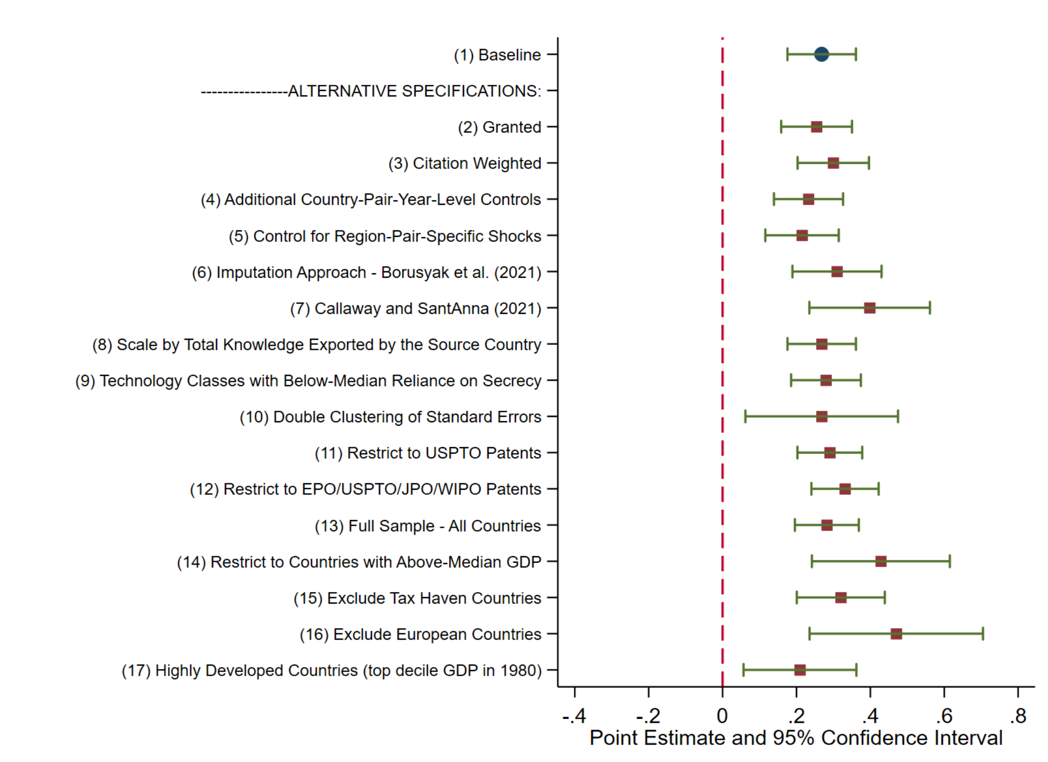


(b) Sourcing: Citation

Figure A.6: Robustness Estimates (Continued)

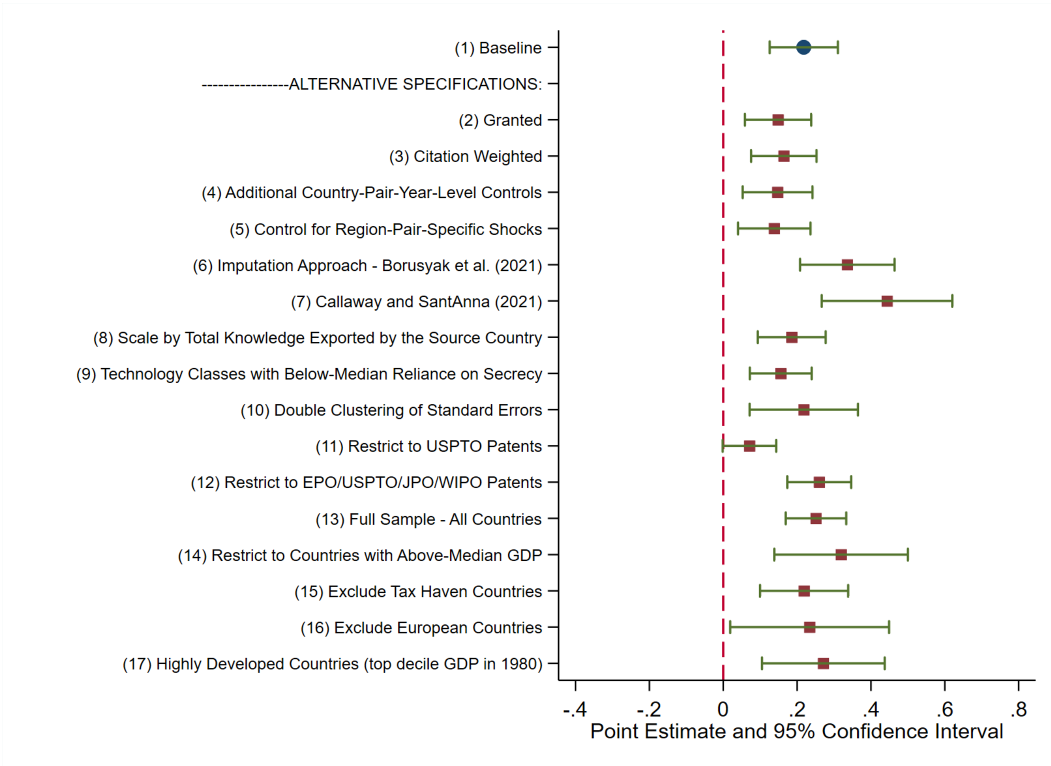


(c) Sourcing: Transfer



(d) Collaboration: Co-Invention

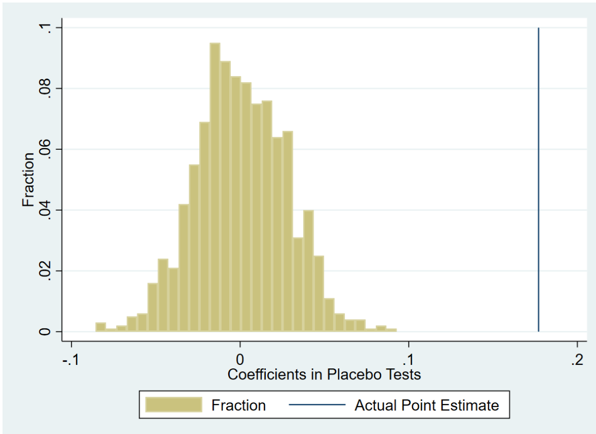
Figure A.6: Robustness Estimates (Continued)



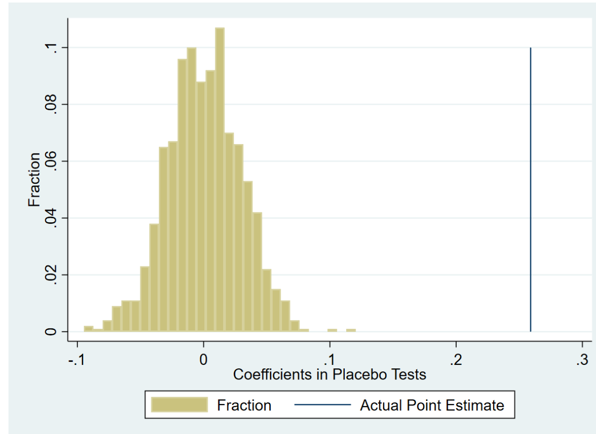
(e) Collaboration: Co-Application

This figure summarizes the robustness of our main results to various specifications and alternative samples. In each figure, the top row represents our baseline estimate from Table VI.A. The remaining rows correspond to various robustness tests. Row 2 (3) used granted patents (citation-weighted patents) to construct our innovation outcomes. Row 4 adds country-pair-year-level controls, including 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, tax information exchange agreements, Patent Cooperation Treaty, Patent Law Treaty, membership of the World Intellectual Property Organization, and membership of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). Row 5 controls for region-pair-specific shocks by adding Region-pair $\times$ Year fixed effects. We follow the definitions of UNCTAD and define five regions: Africa, Americas, Asia, Europe, and Oceania. Row 6 addresses staggered DID bias using the imputation approach from Borusyak et al. (2024). Row 7 addresses staggered DID bias using the alternative estimator from Callaway and Sant'Anna (2021). Row 8 uses dependent variables scaled by total knowledge exported by the source country (i.e., the total amount between country i (the source country) and all partner countries). Row 9 restricts to patents in technology classes (IPC 3-digit) with below-median reliance on secrecy. Row 10 shows estimates using standard errors double clustered by both the source and the host country. Row 11 (12) of panel (a) restricts to countries with the top 75 (100) patent offices based on total number of patents filed through each office. Row 11 (12) of panels (b) to (e) restricts to patents applied through USPTO (EPO, USPTO, JPO and WIPO) when defining the sourcing and collaboration variables. Rows 13 uses the full sample of 205 countries. Row 14 restricts to above-median GDP countries (75 countries). Row 13 excludes tax haven countries (35 countries excluded). Row 16 excludes European countries (43 countries excluded). Row 17 restricts to the most highly developed countries, measured as those with top decile GDP in 1980. In FigureA.6a, rows 18-21 provide additional robustness on our adoption measure. Row 18 defines adoption using the 85% of patent families whose initial filing is in the same country as the applicant. Rows 19-21 drop the initial cluster of filings within a patent family when defining adoption, where initial cluster is defined as filings within 30, 180, or 360 days of the initial filing, respectively.

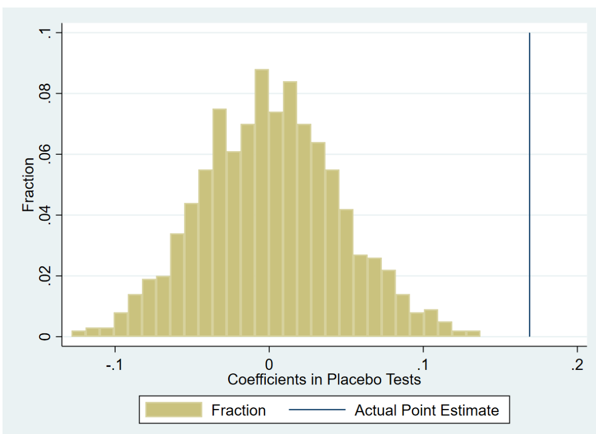
Figure A.7: True Estimate vs. Placebo Estimates



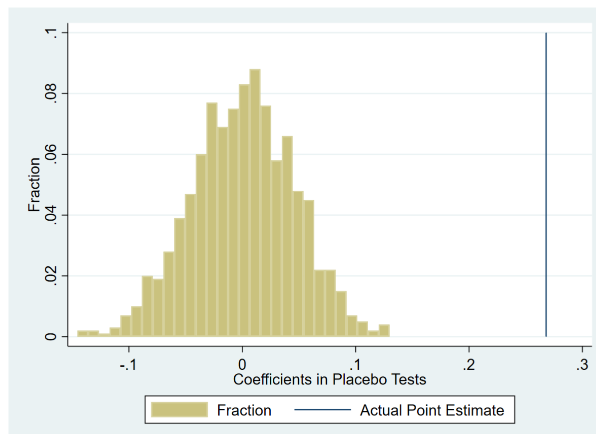
(a) Adoption



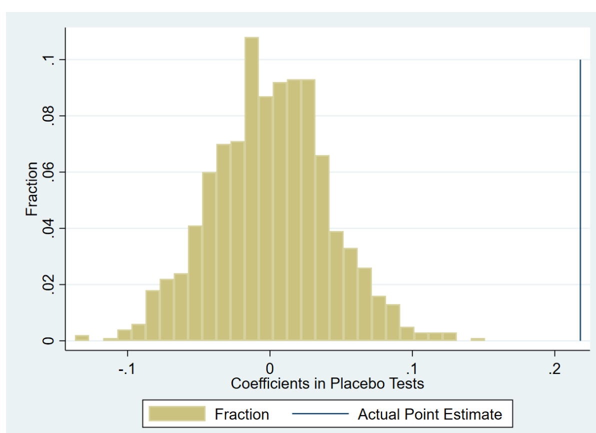
(b) Sourcing: Citation



(c) Sourcing: Transfer



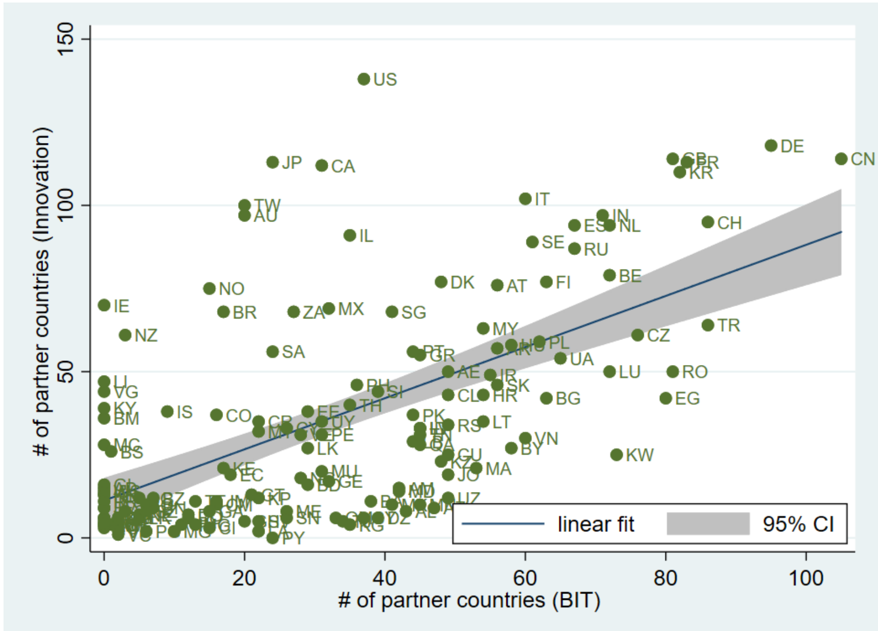
(d) Collaboration: Co-Invention



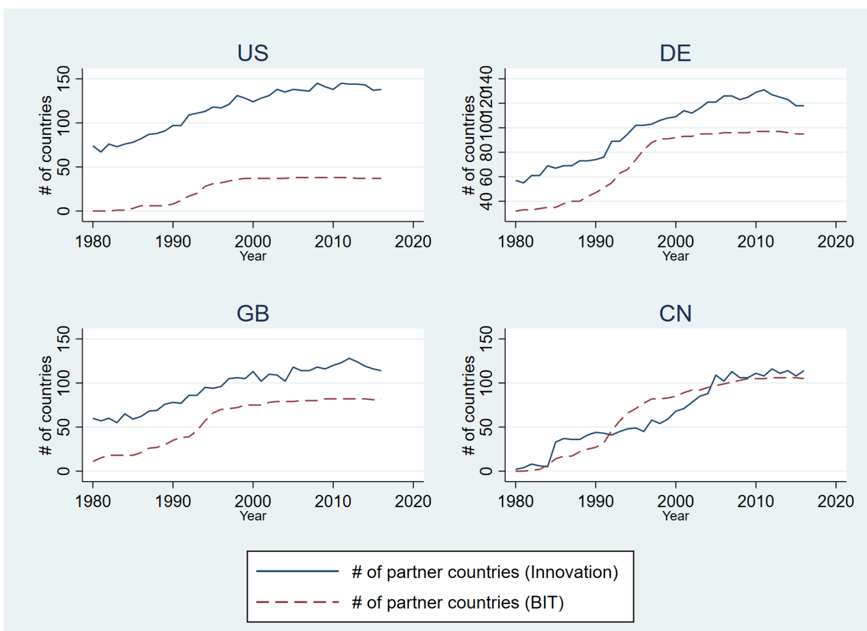
(e) Collaboration: Co-Application

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 Panel B of Table 3.

Figure A.8: Number of Partner Countries for Innovation vs. for Bilateral Investment Treaties



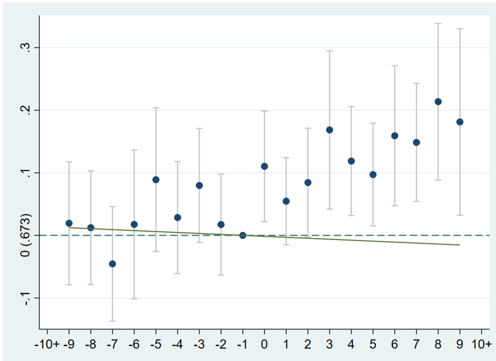
(a) Cross-Section



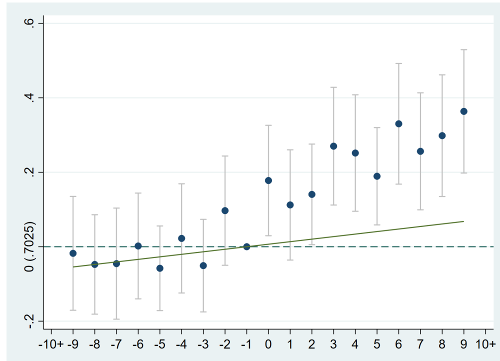
(b) Time-Series

Figure A.8a 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 A.8b plots for the top four knowledge-importing countries (US, Germany, UK, and China), 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.

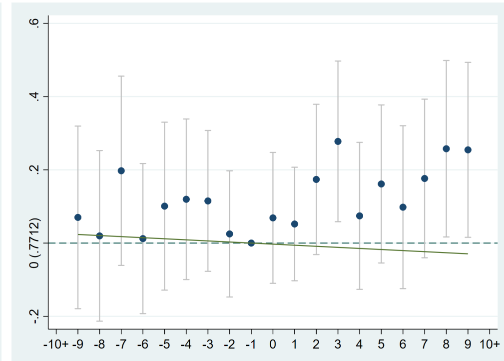
Figure A.9: Dynamic Effects



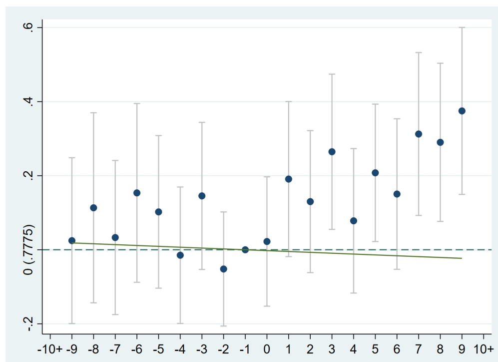
(a) Adoption
(Pre-Trend P-Val=0.77)



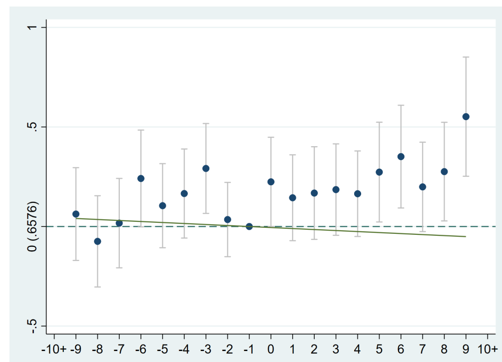
(b) Sourcing: Citation
(Pre-Trend P-Val=0.66)



(c) Sourcing: Transfer
(Pre-Trend P-Val=0.23)



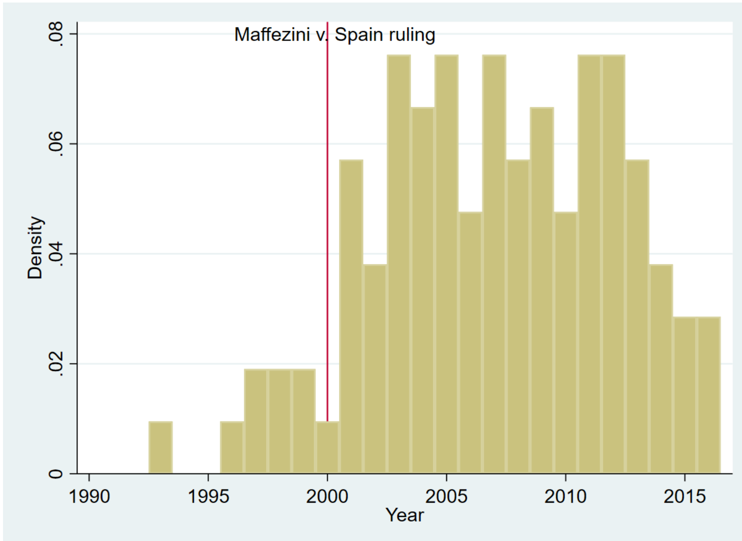
(d) Collaboration: Co-Invention
(Pre-Trend P-Val=0.19)



(e) Collaboration: Co-Application
(Pre-Trend P-Val=0.10)

Figure A.9 shows the dynamic effects of bilateral investment treaties on the adoption, citation, and transfer of partner countries' technologies, as well as co-invention and co-application between the signing countries. The event window goes from 10 years before to 10 years after BIT signing, with the first coefficient corresponding to years≤-10 and the last coefficient years≥10. The green line indicates the linear pre-trend extrapolated from pre-event coefficients. The p-value indicates the statistical significance of the extrapolated pre-trend. All estimates are obtained from the dynamic DID estimator from Freyaldenhoven et al. (2021).

Figure A.10: The Impact of *Maffezini v. Spain* on Investment Disputes Won by Investors



This figure plots the yearly number of investment disputes won by investors at the ICSID (International Centre for Settlement of Investment Disputes), the most important arbitration court. The cases are plotted by year of initiation of a dispute. The data is obtained from the United Nations Conference on Trade and Development (UNCTAD). The vertical line indicates the year (2000) of the *Maffezini v. Spain* ruling.

Table A.1: Variable Definitions

Variable	Definition	Source
BIT Related Variables		
BIT	Dummy that is 1 if country i and country j have an active bilateral investment treaty (BIT), and 0 otherwise.	UNCTAD
# of Partner Countries (BIT)	The number of countries a country has signed BITs with.	UNCTAD
Post-Ruling	Dummy that is 1 if the year is 2000 or a later year, and 0 otherwise. The Maffezini vs. Spain ruling is in January 2000.	Self-Constructed
Sign Year	The year a BIT is signed.	UNCTAD
Measures of the Globalization of Innovation		
Adoption	The number of patents in the host country that have priority rights traced back to the source country. A priority right is a right that 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.	PATSTAT Global
Citation	The number of patents in the host country that cite the source country's patents.	PATSTAT Global
Co-Application	The number of patents whose applicants are in both the source and host country.	PATSTAT Global
Co-Invention	The number of patents whose inventors are in both the source and host country.	PATSTAT Global
Transfer	The number of patents whose inventors are in the source country but whose applicants are in the host country.	PATSTAT Global
Other Innovation Related Outcome Variables		
Drug (Drug-Indication)	The number of medical drug (drug-indications) launched in the distributor country that originate from the originator country.	Cortellis
Drug Launch	Dummy that is 1 if a medical drug is launched in a country, and 0 otherwise.	Cortellis
Drug Launch Country	A country a medical drug is launched in.	Cortellis
Drug Launch Sequence	A country's sequence number in the adoption of a medical drug among the countries that adopted a drug.	Cortellis
Duplicate Patent Filing	Dummy that is 1 if a patent associated with a medical drug is filed in a country, and 0 otherwise.	Cortellis, PATSTAT Global
Duplicate Patent Filing Date	The filing date of a duplicate patent that belongs to the same patent family as the original patent.	Cortellis, PATSTAT Global
Duplicate Patent Filing Sequence	A country's sequence number among the duplicate patent filings among the countries in which duplicate patents for a medical drug are filed.	Cortellis
Forward Citations	The forward citations of a patent.	PATSTAT Global
Globalized (Patent)	A patent for which at least 1 of the 5 measures of the globalization of innovation applies.	PATSTAT Global
Launch Date	The date of launch of a medical drug in a country.	Cortellis
Local (Patent)	A patent for which none of the 5 measures of the globalization of innovation applies.	PATSTAT Globaly
# of Partner Countries (Innovation)	The number of partner countries a country has for its globalized innovation activities.	PATSTAT Global
Originator Country	The country a medical drug originates from.	Cortellis

Table A.1: Variable Definitions (Continued)

Variable	Definition	Source
Other Innovation Related Outcome Variables		
Patent	A patent.	PATSTAT Global
Patent Family	The duplicate patents filed with different patent offices and the initial patent that is duplicated together form a patent family. All duplicate patents share the priority date and priority right of the initial patent.	PATSTAT Global
Private Value of a Patent	The private economic value of a patent based on the patent-level stock market response measure from Kogan et al. (2017). Patent values are in millions of dollars (nominal).	PATSTAT Global, Kogan et al. (2017)
Other Outcome Variables		
FDI	The foreign direct investment flow (FDI) from country i to country j. The sample includes country pairs for which either the source or host country is an OECD country.	fDi Markets
JV with [without] Tech. Purposes	The number of joint ventures (JV) with (without) a technology licensing or technology transfer purpose between country i and country j. Information on deal purpose and deal synopsis is used to identify technology transfer or technology licensing.	SDC Platinum
M&A in R&D-Active [Inactive] Ind.	The number of M&As in R&D-active [inactive] industries from country i to country j. R&D-active industries are 2-digit SIC industries with above median R&D-to-total assets ratio.	SDC Platinum.
SA with [without] Tech. Purposes	The number of strategic alliances [SA] with (without) a technology licensing or technology transfer purpose between country i and country j. Information on deal purpose and deal synopsis is used to identify whether a deal involves technology transfer or technology licensing.	SDC Platinum
Technology Licensing	The number of patent licenses between country i and country j in a given year. The sample includes only country pairs for which the US is either a source or a host country. The sample is based on US publicly-listed firms that file with the Securities and Exchange Commission.	ktMine
VC Investment	The number of venture capital (VC) deals from country i to country j.	SDC Platinum
Other Variables		
GDP per Capita	GDP per capita of a (host) [source] country.	Worldbank
Institution Diff.	Country i's rule of law score minus country's j rule of law score. The difference is standardized (removing the mean, dividing by standard deviation). We take the rule of law values for the year 2000.	Worldwide Governance Indicators
Investment Disputes Won by Investors	The yearly number of investment disputes won by investors at the ICSID (International Centre for Settlement of Investment Disputes), the most important arbitration court.	UNCTAD
Obsolescence	The negative of the log change in forward citations received by the knowledge base of a technology class over a three year window, where the knowledge base is defined as all patents cited by the patents in a technology class. We aggregate firm-level obsolescence measures from Ma (2023) to the SIC 3-digit level, which is then mapped to technology classes.	Ma (2023)
Patent Application Year	The year a patent application is filed.	PATSTAT Global

Table A.2: The 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***
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***

This table 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 US public firms by USPTO. Patent values are in millions of dollars (nominal). The 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 A.3: Summary Statistics for Drug-Based Adoption Measures

	Full Sample			Restricted Sample		
Globalization Measures	# of obs	Drug	Drug-Indication	# of obs	Drug	Drug-Indication
Adoption	1,547,340	0.07	0.09	826,950	0.12	0.17
Number of Countries	205			150		
Number of Country Pairs	41,820			22,350		

This table presents the mean number of drugs and drug-indications for the adoption measure based on drug launches at the country-pair-year level. The full sample includes all countries and the restricted sample excludes countries with few innovations (below 50 patents).

Table A.4: Effect of BITs on Adoption: A Product-Based Measure

	1	2	3	4
Dep. Var.	$Y_{ijt}/\sum_i Y_{ijt}$: Share Among All Partner Countries			
	Adoption Based on Drug Launches			
Product Unit:	Drug	Drug-Indication	Drug	Drug-Indication
BIT	0.146***	0.156***	0.105**	0.124***
	(0.029)	(0.030)	(0.042)	(0.043)
Sample Period	1980-2016		1995-2016	
Country × Year FE	YES	YES	YES	YES
Country-Pair FE	YES	YES	YES	YES
Obs	826,950	826,950	491,700	491,700
Adj. R-Sq	0.538	0.521	0.593	0.577

The table shows the effect of BITs on innovation adoption using a product-based adoption measure based on medical drug launches. The dependent variable is defined based on the number of drugs (or drug-indications) launched in country j (the "distributor country") that originate from country i (the "originator country"), and is scaled by the total amount between country j (the host country) and all partner countries. Each product is a drug in columns 1 and 3 and a drug-indication in columns 2 and 4. The unit of observation is a country-pair year. The panel estimates the 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 host country, and t indexes year. $\boldsymbol{\gamma_{ij}}$ indicates country-pair fixed effects, and $\boldsymbol{\alpha_{i,t}}$ and $\boldsymbol{\delta_{j,t}}$ indicate country × year fixed effects for source and host countries, 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 sample period is 1980 to 2016 in columns 1-2 and 1995-2016 in columns 3-4. 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: Extensive Margin

	1	2	3	4	5
Dep. Var.	Dummy for Positive Number of Patent Applications				
	Adoption	Citation	Transfer	Co-Invention	Co-Application
BIT	0.058***	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 source country, j indexes the host 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.6: Role of Omitted Unobservable Variables — Oster Test

Panel A: Comparing Coefficients With and Without Controls

Dep. Var.	Adoption	Citation	Transfer	Co-Invention	Co-Application
No Control	0.177	0.259	0.169	0.268	0.218
With Controls	0.158	0.235	0.12	0.233	0.147
% Shrink	11%	9%	29%	13%	33%

Panel B: $R_{max} = min\{1.25R_c, 1\}$, δ=1

Dep. Var.	Adoption	Citation	Transfer	Co-Invention	Co-Application
β_{adj}	0.151	0.225	0.102	0.218	0.127
Identified Set	(0.151, 0.158)	(0.225, 0.235)	(0.102, 0.121)	(0.218, 0.233)	(0.127, 0.147)
Reject Null	YES	YES	YES	YES	YES
δ s.t. $\beta_{adj} = 0$	24.9	21.97	6.67	15.63	7.25

Panel C: $R_{max} = min\{1.25R_c, 1\}$, δ=2

Dep. Var.	Adoption	Citation	Transfer	Co-Invention	Co-Application
β_{adj}	0.145	0.214	0.084	0.203	0.088
Identified Set	(0.145, 0.158)	(0.214, 0.235)	(0.084, 0.121)	(0.203, 0.233)	(0.088, 0.147)
Reject Null	YES	YES	YES	YES	YES
δ s.t. $\beta_{adj} = 0$	24.9	21.97	6.67	15.63	7.25

Panel D: $R_{max} = min\{2R_c, 1\}$, δ=1

Dep. Var.	Adoption	Citation	Transfer	Co-Invention	Co-Application
β_{adj}	0.132	0.192	0.048	0.173	0.029
Identified Set	(0.132, 0.158)	(0.192, 0.235)	(0.048, 0.121)	(0.173, 0.233)	(0.029, 0.147)
Reject Null	YES	YES	YES	YES	YES
δ s.t. $\beta_{adj} = 0$	6.23	5.49	1.67	3.91	1.24

Panel E: $R_{max} = min\{2R_c, 1\}$, δ=2

Dep. Var.	Adoption	Citation	Transfer	Co-Invention	Co-Application
β_{adj}	0.107	0.15	-0.024	0.114	-0.09
Identified Set	(0.107, 0.158)	(0.150, 0.235)	(-0.024, 0.121)	(0.114, 0.233)	(-0.090, 0.147)
Reject Null	YES	YES	NO	YES	NO
δ s.t. $\beta_{adj} = 0$	6.23	5.49	1.67	3.91	1.24

This table evaluates the robustness to omitted variable bias using the tests developed in Oster (2019) with different test parameter combinations. We first estimate equation (2) without controls. We obtain β_u and R_u — the coefficient on BIT and the R-squared for the specification without controls — from Panel B of Table 3. We then estimate equation (2) with the addition of controls, including 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, and membership statuses for Patent Cooperation Treaties, Patent Law Treaties, membership of the World Intellectual Property Organization, and membership of the Agreement on Trade-Related Aspects of Intellectual Property Rights. The results are reported in row 2 of Figure A.6a, from which we obtain β_c and R_c, the coefficient on BIT and the R-squared for the specification with controls. For any given test parameter combination δ and R_{max}, Oster (2019) defines the following as an approximation of the bias-adjusted treatment effect, or β_{adj}:

$$\beta_{adj} = \beta_c - \delta[\beta_u - \beta_c]\frac{R_{max} - R_c}{R_c - R_u}$$

The recommended identified set is then the interval between β_{adj} and β_c. In the table, we report the bias-adjusted coefficient and identified set for different combinations of parameters ($R_{max} = min\{1.25R_c, 1\}$ or $R_{max} = min\{2R_c, 1\}$; $\delta = 1, 2$). We also report whether the identified set rejects the null of $\beta = 0$ and the δ value to produce a bias-adjusted coefficient of zero.

Table A.7: Robustness — Fixed-Effect Poisson Pseudo-Maximum Likelihood (PPML)

Panel A

	1	2	3	4	5
Dep. Var.	Unscaled Patent Count				
	Adoption	Citation	Transfer	Co-Invention	Co-Application
BIT	0.737***	1.116***	0.832***	0.829***	1.014***
	(0.069)	(0.181)	(0.125)	(0.094)	(0.153)
Year FE	YES	YES	YES	YES	YES
Country-Pair FE	YES	YES	YES	YES	YES
Obs	177,859	312,021	232,434	278,462	186,776
Adj. R-Sq	0.851	0.939	0.865	0.878	0.771

Panel B

	1	2	3	4	5
Dep. Var.	Unscaled Patent Count				
	Adoption	Citation	Transfer	Co-Invention	Co-Application
BIT	0.307***	-0.069	0.252**	0.253***	0.329**
	(0.058)	(0.102)	(0.113)	(0.077)	(0.134)
Country-Specific Trends	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Country-Pair FE	YES	YES	YES	YES	YES
Obs	177,859	312,021	232,434	278,462	186,776
Adj. R-Sq	0.904	0.972	0.89	0.901	0.801

The table examines how bilateral investment treaties affect technological exchange between the signing countries, using fixed-effect Poisson pseudo-maximum likelihood (PPML) model and raw patent counts as dependent variables. The unit of observation is a country-pair year. The sample sizes are smaller than those in OLS regressions because fixed-effects PPML requires dropping groups for which the outcome variable is zero for all observations. Panel A follows the specification in equation (1) while Panel B additionally includes country-specific linear trends. $BIT_{ij,t}$ 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 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* (transferred from country i's inventors, *co-invention* (co-invented with country i's inventors), and *co-application* (co-applied with country i's applicants). 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 A.8: Correlation Between Duplicate Patent Filing and Drug Launch

Panel A. An Example

Originator Country	Drug Launch Country	Launch Date	Duplicate Patent Filing Date
JP	LU	31-Jan-09	24-Apr-09
JP	NL	31-Jan-09	02-Apr-09
JP	PT	29-Oct-09	25-Sep-09
JP	RU	30-Nov-09	25-Sep-09
JP	US	22-Jan-10	25-Sep-09
JP	BR	03-Feb-10	25-Sep-09
JP	PL	03-Aug-11	25-Oct-10
JP	HU	03-Aug-11	25-Oct-10
JP	SI	03-Aug-11	25-Oct-10
JP	KR	01-Feb-13	10-Oct-13
JP	TW	27-Mar-13	11-Oct-13
JP	CN	23-Nov-13	10-Oct-13
JP	MX	04-Oct-16	25-Mar-16

Panel B. Extensive Margin Correlation – Launched/Filed or Not

	1	2	3	4
	Drug Launch		Duplicate Patent Filing	
Duplicate Patent Filing	0.116***	0.117***		
	(0.009)	(0.008)		
Drug Launch			0.386***	0.389***
			(0.025)	(0.025)
Drug FE	No	Yes	No	Yes
Obs	408,138	408,138	408,138	408,138
Adj. R-Sq	0.045	0.112	0.045	0.108

Panel C. Intensive Margin Correlation – Launch/Filing Sequence Number

	1	2	3	4
	Drug Launch Sequence		Duplicate Patent Filing Sequence	
Duplicate Patent Filing Sequence	0.159***	0.103***		
	(0.010)	(0.015)		
Drug Launch Sequence			0.428***	0.238***
			(0.025)	(0.032)
Drug FE	No	Yes	No	Yes
Obs	15,578	15,269	15,578	15,269
Adj. R-Sq	0.068	0.410	0.068	0.489

The table validates our patent-based adoption measure using medical drug launch data. Panel A shows an example of how patent priority traces the product launches. The patent is filed by Chugai Pharmaceuticals, a Japanese pharmaceutical company, for the drug Tocilizumab (intravenous) for the indication of rheumatoid arthritis. The third column shows the drug launch date in different countries. The last column shows the filing date of the duplicate patents that belong to the same patent family (i.e., share the same priority). Panel B examines the correlation between the extensive margins of duplicate patent filing and drug launch. The sample is at the drug-adoption-country level. The dependent variables are dummies indicating whether a drug is launched in a country and whether a patent associated with the drug is filed in a country between 1980 and 2016. Panel C correlates a country's sequence number in the adoption a drug with its sequence number in duplicate patent filings of that drug within the period of 1980 to 2016. Drug and linked patent data are from Cortellis. Standard errors (reported in brackets) are clustered by adoption-country-originating-country pair. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table A.9: Decomposition of Direct and Indirect Effects: Including Additional Channel Variables

	Adoption	Citation	Transfer	Co-Invention	Co-Application	
			Total Effect			
	0.177	0.259	0.169	0.268	0.218	
			2nd-Stage Coeff.			*1st-Stage Coeff.*
JV & SA w/ Tech Purp.	0.142	0.139	0.099	0.126	0.086	0.116
M&A in R&D-Active	0.092	0.087	0.129	0.122	0.106	0.288
VC Investment	0.148	0.179	0.211	0.221	0.178	0.130
Tech Licensing	-0.642	1.241	1.506	0.942	1.368	0.009
JV & SA w/o Tech Purp.	0.110	0.157	0.171	0.193	0.143	0.181
M&A in R&D-Inactive	0.042	0.039	0.069	0.064	0.064	0.133
FDI	0.021	0.013	0.037	0.033	0.04	0.108
			1st-Stage Coeff. × *2nd-Stage Coeff.*			
JV & SA w/ Tech Purp.	0.016	0.016	0.011	0.015	0.010	
M&A in R&D-Active	0.026	0.025	0.037	0.035	0.031	
VC Investment	0.019	0.023	0.027	0.029	0.023	
Tech Licensing	-0.006	0.011	0.014	0.008	0.012	
JV & SA w/o Tech Purp.	0.020	0.028	0.031	0.035	0.026	
M&A in R&D-Inactive	0.006	0.005	0.009	0.009	0.009	
FDI	0.002	0.001	0.004	0.004	0.004	
			Explained Effect			
Total Explained Effect	0.084	0.111	0.134	0.134	0.115	
Direct	0.056	0.064	0.076	0.078	0.064	
Indirect	0.028	0.046	0.058	0.055	0.051	
			% of Total Effect if Unexplained has Same Decomposition			Average
Direct	67%	58%	57%	59%	56%	59%
Indirect	33%	42%	43%	41%	44%	41%
			% of Total Effect if Unexplained is All Direct			Average
Direct	84%	82%	66%	79%	77%	78%
Indirect	16%	18%	34%	21%	23%	22%

This Table shows robustness of Table 7 to including technology licensing as an additional direct channel variable and FDI as an additional indirect channel variable. This table decomposes the total effect of BITs on our innovation outcomes into direct and indirect effects, based on the channel variables examined in Table 8. Direct channel variables include JVs & SAs with tech purposes, M&As in R&D-active industries, VC investment, and technology licensing. Indirect channel variables include JVs & SAs without tech purposes, M&As in R&D-inactive industries, and FDI. We use a two-stage approach to compute the effects through these channel variable. The first stage is the effect of BITs on these channel variables, as examined in Table 8. The second stage is the effect of these channel variables on our innovation outcomes, estimated through multivariate regressions that include all channel variables at the same time. The effect of BITs on innovation outcomes through each channel is then the product of the first and second stage coefficients. We conduct the composition under two assumptions: 1) unexplained effect has the same direct-vs-indirect decomposition as explained effect; 2) unexplained effect is all direct effect.

Table A.10: Decomposition of Direct and Indirect Effects: Using Only JV, SA, and M&A

	Adoption	Citation	Transfer	Co-Invention	Co-Application	
	Total Effect					
	0.177	0.259	0.169	0.268	0.218	
	2nd-Stage Coeff.					*1st-Stage Coeff.*
JV & SA w/ Tech Purp.	0.142	0.139	0.099	0.126	0.086	0.116
M&A in R&D-Active	0.092	0.087	0.129	0.122	0.106	0.288
JV & SA w/o Tech Purp.	0.110	0.157	0.171	0.193	0.143	0.181
M&A in R&D-Inactive	0.042	0.039	0.069	0.064	0.064	0.133
	1st-Stage Coeff. $\times$ 2nd-Stage Coeff.					
JV & SA w/ Tech Purp.	0.016	0.016	0.011	0.015	0.010	
M&A in R&D-Active	0.026	0.025	0.037	0.035	0.031	
JV & SA w/o Tech Purp.	0.020	0.028	0.031	0.035	0.026	
M&A in R&D-Inactive	0.006	0.005	0.009	0.009	0.009	
	Explained Effect					
Total Explained Effect	0.068	0.075	0.089	0.093	0.075	
Direct	0.043	0.041	0.049	0.050	0.041	
Indirect	0.025	0.034	0.040	0.043	0.034	
	% of Total Effect if Unexplained has Same Decomposition					Average
Direct	63%	55%	55%	53%	54%	56%
Indirect	37%	45%	45%	47%	46%	44%
	% of Total Effect if Unexplained is All Direct					Average
Direct	86%	87%	76%	84%	84%	83%
Indirect	14%	13%	24%	16%	16%	17%

This Table shows robustness of Table 7 to dropping VC investment and focusing only on JV, SA and M&As. This table decomposes the total effect of BITs on our innovation outcomes into direct and indirect effects, based on the channel variables examined in Table 8. Direct channel variables include JVs & SAs with tech purposes and M&As in R&D-active industries. Indirect channel variables include JVs & SAs without tech purposes and M&As in R&D-inactive industries. We use a two-stage approach to compute the effects through these channel variable. The first stage is the effect of BITs on these channel variables, as examined in Table 8. The second stage is the effect of these channel variables on our innovation outcomes, estimated through multivariate regressions that include all channel variables at the same time. The effect of BITs on innovation outcomes through each channel is then the product of the first and second stage coefficients. We conduct the composition under two assumptions: 1) unexplained effect has the same direct-vs-indirect decomposition as explained effect; 2) unexplained effect is all direct effect.

Appendix References

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