When Capital Crosses Borders, So Does Knowledge

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Abstract

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Keywords: Innovation, Foreign Institutional ownership, Patents, Knowledge diffusion,

JEL Classification: G31, G32, O31, O32

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1. Introduction

While knowledge diffusion is widely recognized as a key driver of innovation, productivity, and economic growth, numerous studies have shown knowledge flow is generally geographically localized (e.g., Jaffe, Trajtenberg, and Henderson 1993; Ganguli, Lin, and Reynolds 2020). This localization of knowledge flows suggests that the exchange of ideas and knowledge tends to occur more readily within close geographic proximity than across distant locations. As Glaeser, Kallal, Scheinkman, and Shleifer (1992) aptly noted, "Intellectual breakthroughs must cross hallways and streets more easily than oceans and continents" (p. 1127). Consequently, economic activities tend to gravitate towards knowledge-intensive districts or regions (Marshall 1920), exhibiting regional technology clusters like Silicon Valley in the United States and the vicinity of Cambridge in the United Kingdom.

Considering the already slower spread of knowledge across regional boundaries within a single country, its diffusion across international borders is expected to encounter even more significant barriers (Kogut 1991). National borders extend beyond simple physical divisions, marking territories with distinct cultural, linguistic, and political characteristics. These disparities introduce a multifaceted set of obstacles to the flow of knowledge, as emphasized by Belenzon and Schankerman (2013), further complicating the process of knowledge dissemination.

In this study, we investigate the potential role of foreign institutional investors in promoting knowledge diffusion across international borders. We utilize cross-border patent citations to track the path of global knowledge diffusion and align it with the trail of foreign institutional investors to provide evidence on their potential role in facilitating knowledge flow across international borders. Patent citations function as indicators of the pre-existing knowledge upon which later patents build, and thus can effectively serve as a tangible trail that illuminates the often-elusive diffusion of knowledge across institutions, sectors, geographical

regions, and countries (e.g., Jaffe et al. 1993, Gomes-Casseres, Hagedoorn, and Jaffe 2006; Lee, Sun, Wang, and Zhang 2019; Giroud, Liu, and Mueller 2024).

Institutional investors often possess industry expertise and experience. They can bring knowledge and insights to the companies they invest in, offering guidance on strategic decision-making, market trends, innovations, and technology adoption. Prior research shows that institutional investors contribute positively to firms' innovation outputs, suggesting that they are aware of the innovative knowledge, technology, and approaches adopted within the industries of their portfolio companies (e.g., Aghion, Van Reenen, and Zingales 2013; Bena, Ferreira, Matos, and Pires 2017; Luong, Moshirian, Nguyen, Tian, and Zhang 2017; Brav, Jiang, Ma, and Tian 2018; Kostovetsky and Manconi 2020; Li, Liu, and Taylor 2023). However, whether institutional investors play any role in disseminating innovative knowledge among their investees, especially those in foreign nations, is underexplored. Anecdotal evidence suggests that institutional investors act as bridges, facilitating the exchange of knowledge, technology, and opportunities among firms. For example, Goldman Sachs organizes an annual Technology and Internet Conference to bring together leaders from the technology and internet industries, including institutional investors, entrepreneurs, and executives from both public and private companies. By organizing conferences and forums, these institutional investors provide platforms for knowledge sharing, idea pitching, and networking opportunities that are open to both investee and non-investee firms. By promoting knowledge transfer, institutional investors can achieve wealth creation by improving the innovation and financial performance of their portfolio firms.[1]

We conduct a panel analysis of 20,229 global firms during the period of 2001–2019 to examine the activities of foreign institutional investors and cross-border knowledge diffusion.

[1] Notable examples include financial institutions such as Temasek and SoftBank Vision Fund, which actively pursue global knowledge transfer and cross-border innovation strategies to generate financial returns on their investments. For example, Sumer Juneja, Managing Partner and Head of EMEA & India Investing, posted the following philosophy on Vision's website: "We bring a couple of critical things to the table. First, the knowledge

We document a positive relationship between the ownership stakes of foreign institutional investors from a specific country and the frequency with which their investee firms cite patents originating from that same country, after controlling for an extensive set of control variables and accounting for firm, year, and foreign country fixed effects. In our analysis, each observation unit is at the firm-foreign country-year level. For each firm, we identify multiple candidate foreign countries as potential sources of patent citations, based on whether the firm has ever received any equity investment or cited any patent originating from those countries during our sample period. Therefore, we can control for high-dimensional fixed effects such as firm×year, foreign country×year, and country pair ×year fixed effects to absorb time-varying unobservable confounding factors at various levels and strengthen our causal inferences. Our results hold after controlling for those high-dimensional fixed effects. Overall, our findings suggest that investee firms are more likely to incorporate innovative insights from their foreign investors' home countries into the development of their own patents, consistent with our argument that foreign institutional investors may facilitate the dissemination of innovative knowledge from their home countries to their investees.

One of the implications of our thesis is that when investors and investees are located in countries with different languages and greater geographic and cultural distances, the impact of foreign investment on bridging innovation gaps should be more pronounced. In cross-sectional analyses, we find that the relationship between foreign institutional ownership and investees' citations of patents from the investors' home countries is more pronounced between regions of greater cultural, geographic, and linguistic differences. These results highlight the crucial role

of how to build a company and how to build technology. Second, our ecosystem. I really can't overstate the importance of just connecting founders to other founders—helping them discover people whose work dovetails with their own. And then there's our global expertise. We understand what it means to be part of this world economy, and I think that's essential for founders, who often know their own market extremely well but are less experienced in other contexts." Temasek explicitly states on its website that the company exchanges ideas and shares knowledge on a variety of topics with its partners and portfolio companies (https://www.temasek.com.sg/en/about-us/our-global-advisory-network).

of foreign institutional investors in bridging gaps that hinder global knowledge diffusion. Further, institutional investors' characteristics shape the extent of knowledge diffusion. Specifically, the ownership of foreign institutional investors with a longer investment horizon, those focusing on high-tech investment, or those from countries with higher levels of innovation activities has a stronger association with investees' citations of patents from the investors' home countries. These findings suggest that both the access to innovative knowledge and the incentive to transmit it are critical in shaping the extent of cross-border knowledge diffusion facilitated by foreign institutional investors.

To draw causal inferences with greater confidence, we strengthen our analyses by leveraging two quasi-exogenous shocks. We first utilize the 2003 Jobs and Growth Tax Relief Reconciliation Act (JGTRRA) to examine the influence of US institutional investors on non-US investees' citations of patents originating from the United States. The passage of the JGTRRA in 2003 reduced dividend tax rates for US investors that invest in non-US firms domiciled in countries that have tax treaties with the United States and as a result, should lead to an exogenous increase in US institutional ownership in those firms, especially if they pay dividends.[2] We thus identify dividend-paying firms domiciled in treaty countries and implement a difference-in-differences (DiD) research design to examine changes in their citations of patents originating from the United States relative to those originating from non-U.S. foreign countries before and after the 2003 JGTRRA. Consistent with the JGTRRA increasing the after-tax return for US investors, we document a significant rise in US institutional ownership post-JGTRRA for non-US firms domiciled in treaty countries. In addition, we find that those firms increase their citations of US patents relative to those originating from other foreign countries post-JGTRRA. This pattern suggests that higher US institutional ownership facilitates cross-border knowledge diffusion from the United States to

[2] Our definition of a country includes both economic regions and sovereign nations.

investee firms in non-US countries. The result of the dynamic analysis verifies the parallel-trends assumption, lending support to the validity of this identification strategy.[3]

Second, we exploit firms' inclusion in the Morgan Stanley Capital International (MSCI) index as a quasi-exogenous shock that induces variations in the levels of foreign equity investment (e.g., Aggarwal, Erel, Ferreira, and Matos 2011). Firms included in the MSCI index typically experience an increase of foreign institutional ownership due to enhanced visibility and international portfolio managers closely tracking the MSCI index in forming their investment portfolios. Furthermore, the selection criteria for inclusion in the MSCI index are based on various factors such as float-adjusted market capitalization, trading frequency, trading volume, and the availability of shares for foreign investors (MSCI 2015). As a result, a firm's inclusion in the index is independent of its decisions regarding the citation of patents from specific foreign countries and the bilateral relationships between different countries. We employ a two-stage least squares (2SLS) regression specification using the inclusion in the MSCI index as an instrumental variable (IV) to predict the increase in foreign institutional ownership for our sample firms during the period of 2001–2019. We then examine how this predicted ownership relates to citations of patents from the investors' home countries. We find that the exogenous increase in foreign institutional ownership resulting from inclusion in the MSCI index leads to an increase in citations of patents from foreign countries.

Our study contributes to at least two strands of literature and offers important policy implications. First, as discussed, many economics studies provide evidence of the localized nature of knowledge flows, particularly regarding the challenge of knowledge diffusion across international borders. Prior studies document that local policymakers can employ strategies

[3] To validate the setting of JGTTRA, we conduct a placebo analysis (untabulated) to examine the patent-citation behavior of non-dividend paying firms in those tax-treaty countries with the US We find no significant increase in their citations of patents from the United States. This finding helps mitigate concerns about confounding time trends and lends further support to the validity of this empirical setting.

such as facilitating intellectual property rights (Branstetter, Fisman, and Foley 2006; Juhász and Steinwender 2018), encouraging foreign direct investments (e.g., Aitken and Harrison 1999), and signing of bilateral investment treaties (Bian, Meier, and Xu 2023) to promote global knowledge diffusion. We provide evidence that foreign institutional investors serve as an effective mechanism for overcoming geographic proximity and promoting knowledge diffusion across international boundaries.

Second, our study contributes to the literature on foreign institutional ownership. Prior studies show foreign institutional investors promote improvements in governance (Aggarwal et al. 2011), increase cross-border M&As (Ferreira, Massa, and Matos 2010), and improve price efficiency (Kacperczyk, Sundaresan, and Wang 2021). Our research question and empirical setting are unique because we examine how institutions facilitate the transfer of specific knowledge originating from innovation activities in their country of origin. This focus differs from studies examining the broader impact of foreign institutions on investees' innovation outputs, measured by their own patent filings or the citations of their own patents by other organizations (Bena et al. 2017; Luong et al. 2017).

Our evidence suggests that a key mechanism by which foreign institutional investors could enhance investees' innovation outcome is through their facilitation of knowledge diffusion. This finding has crucial implications for policymakers worldwide because the dissemination of innovative knowledge is vital for enhancing firms and countries' competitive advantage and economic growth (Grant 1996; Keller 2004; Peri 2005). These findings highlight a novel channel through which financial globalization can enhance innovation spillovers, suggesting that policies shaping foreign investment flows may have important, unintended effects on the global transmission of ideas.

2. Literature Review and Hypothesis Development

2.1 Literature on Locality of Knowledge Diffusion

Economics researchers have long been interested in the phenomenon of geographically concentrated economic/innovative activities (e.g., Marshall 1920; Jacobs 1969, 1985; Krugman 1992; Kogut 1991; Glaeser et al. 1992; Jaffe et al. 1993; Audretsch and Feldman 1996). Marshall's pioneering study (1920) highlights that one of the reasons for the concentration of industries in cities is due to knowledge spillovers among firms operating within these cities. Jacobs (1969, 1985) further elucidates that the vibrant interactions among people in cities foster idea generation and innovation. Glaeser et al. (1992) use the example of Silicon Valley to explain how physical proximity facilitates free information transmission. They argue that the exchange of knowledge among microchip manufacturers in Silicon Valley occurs through informal means such as conversations, gossip, and the movement of employees.

Prior to Jaffe et al. (1993), there was little empirical evidence on the locality of knowledge diffusion. As Krugman (1992) noted, knowledge flows are invisible and leave no paper trail to measure and track them. Jaffe et al. (1993) address this challenge by using patent citations to capture knowledge flow. They argue that patent citations serve as evidence of the "paper trail" left by the "invisible" knowledge flow as they represent references to previous knowledge upon which current technological developments build. In addition, the patent data contain detailed information about the name and location of each inventor and their employer to which the patent right is assigned. Therefore, patent data and citation information provide the trail of knowledge diffusion across time, space, and different organizations (Jaffe et al. 1993). Using the patent citation data, Jaffe et al. (1993) find a clear pattern of localized knowledge spillover that is more likely to occur within the same country, state, or Standard Metropolitan Statistical Area (MSA).

Since Jaffe et al. (1993), numerous studies have utilized the patent citation data to examine knowledge flow/spillover (e.g., Almeida 1996; Almeida and Kogut 1999; Peri 2005; Singh 2005; Gomes-Casseres, Hagedoorn, and Jaffe 2006; Tallman and Phene 2007; Agarwal, Ganco, and Ziedonis 2009; Belenzon and Schankman 2013; Ganguli, Lin, and Reynolds 2020). These studies largely provide consistent evidence that supports the notion of localized knowledge diffusion. For example, Almeida (1996) shows that knowledge used by foreign subsidiaries of multinationals in U.S. regions is predominantly sourced locally, suggesting that multinationals expand abroad to acquire technological knowledge. Both studies by Almedia and Kogut (1991) and Agarwal et al. (2009) show that the mobility of engineers or inventors affects the localization of knowledge diffusion. Gomes-Casseres et al. (2006) identify interfirm alliances as a mechanism for sharing technological knowledge using patent citations as a proxy for knowledge flows. Tallman and Phene (2007) confirm that knowledge flows are slowed by geographical boundaries. Ganguli et al. (2020) show evidence of localized knowledge spillover by examining patent interferences referring to identical inventions filed by multiple independent inventors. They find that interfering inventions are more likely to be geographically concentrated. Belenzon and Schankerman (2013) examine citations to university patents and scientific publications and find that those citations sharply decline with distance from state borders, suggesting that state borders act as constraints on knowledge flows.

Overall, existing studies provide compelling evidence that knowledge diffusion exhibits a localized pattern, with stronger connections and interactions between neighbouring or closely located regions. A consensus among researchers is that knowledge diffusion across international boundaries has to overcome greater barriers due to spatial, language, cultural, and institutional differences (e.g., Kogut 1991; Jaffe et al. 1993; Belenzon and Schankerman 2013). Our study contributes to this literature by documenting foreign institutional ownership as a

mechanism that can overcome such constraints and promote the diffusion of knowledge across international borders.

2.2 Literature on Foreign Institutional Ownership

Prior studies have highlighted the active role played by foreign institutional investors in influencing their investees' strategic direction and decision-making (e.g., see the survey paper by Gillan and Starks 2007). Compared to domestic institutional investors, foreign institutional investors have more independent and diversified positions, lack conflicts of interest and thus are more capable of monitoring their investees (e.g., Ahmadjian and Robbins 2005; Gillan and Starks 2007; Aggarwal et al. 2011). In addition, foreign institutional investors, who often hold significant number of shares, can also exert influence through active engagement with company management and board of directors and participating in shareholder meetings, and proxy voting to express their views and concerns.[4] Prior work documents that foreign institutional investors have significant influence on investees' various corporate policies including corporate governance (Aggarwal et al. 2011), voluntary disclosure (Tsang et al. 2019), cross-border mergers and acquisitions (Ferreira et al. 2010), convergence of financial reporting (Fang et al. 2015), ESG performance (Dyck et al. 2019), investment efficiency (e.g., Chen, Ghoul, Guedhami, and Wang 2017).

Two studies by Bena et al. (2017) and Luong et al. (2017) document that foreign institutional ownership is positively associated with investees' own innovation activities. The findings of their studies echo that of Aghion et al. (2013), who show a positive relationship between institutional ownership and innovation in the United States. These studies attribute the role of foreign institutional ownership in enhancing innovations to institutional investors' monitoring skills and their ability to tolerate failure (e.g., David et al. 2001; Aghion et al. 2013;

[4] Foreign institutional ownership can account for as high as 50% of the total equity stake for non-US firms (e.g. Luong et al. (2017)).

Bena et al. 2017; Luong et al. 2017; Jiang and Yuan 2018; Brav et al. 2018). Different from these studies focusing on firms' overall innovations, our study follows Jaffe et al. (1993) to track cross-border knowledge diffusions using patent citations and provide novel and direct evidence on foreign institutional investors' role in facilitating the flow of innovative knowledge across international borders.

2.3 Hypothesis Development

Based on the discussions above, the diffusion of knowledge across international borders presents a challenge. However, foreign institutional investors, by leveraging their influence, network, and industry knowledge, may be able to overcome the geographic barriers and facilitate the spread of innovative knowledge globally, while aiming to maximize their investment returns. Therefore, we hypothesize that when institutional investors from a particular country invest in a foreign firm, they enhance the investees' awareness of the innovative knowledge originating from the investors' home countries. This increased awareness is expected to be reflected in more frequent citations of patents/inventions originating from the home countries of the foreign institutional investors in the investees' own patent filings. We thus formally develop the main hypothesis as follows:

Hypothesis: Ceteris paribus, there is a positive association between the ownership percentage of foreign institutional investors from a specific country and the number of citations referencing the patents from the home country of those institutional investors in the patent applications of the investee firm.

3. Sample, Data, and Empirical Design

3.1 Empirical Design and Identification Strategies

To test the hypothesis, we follow prior studies to develop the following model (e.g., Bena et al. 2017; Luong et al. 2017).

$$\begin{aligned} Num\_Citation\_FC_{i,j,t} = {} & \beta_0 + \beta_1 FIO_{i,j,t-1} + \Sigma\gamma\, Investee\ Firm\ Controls_{i,t-1} \\ & + \Sigma\mu\, Investee\_Country\ Controls_{t-1} + \Sigma\lambda Country\_Pair\ Controls_{t-1} \\ & + Investee\ Firm\ FE + Year\ FE + Foreign\_Country\ FE + \varepsilon_{i,t} \end{aligned} \quad (1)$$

Num_Citation_FC$_{i,j,t}$ is measured as the log value of one plus the number of citations referencing patents/inventions from foreign country *j* in firm *i*'s patent applications in year *t*, where country *j* is any foreign country that firm *i* may cite in its patent applications. *FIO*$_{i,j,t-1}$ is measured as the aggregated ownership percentage of firm *i*'s shares held by all institutional investors from foreign country *j* at the beginning of year *t*. We expect a positive coefficient on *FIO*$_{i,j,t-1}$.

We include in Eq. (1) a large set of firm *i*'s characteristics that may potentially affect its patent-citation behaviour (e.g., Luong et al. 2017; Bena et al. 2017). The firm controls include firm size (*log_SALES*), asset tangibility (*TANGIBILITY*), leverage (*LEVERAGE*), free cash flows (*FCF*), percentage of foreign sales over total sales (*FXSALES*), ownership structure defined as the percentage of shares held by large shareholders with a holding of 5% or above (*CLOSE*), Tobin's Q (*TOBIN Q*), cash holdings over total assets (*CASH*), research and development expenditure (*RD_EXP*), the ownership of domestic institutional investors (*DIO*), and annual stock return (*STOCK RETURN*).

We also include in Eq. (1) the characteristics of the country where firm *i* (the investee firm) is located as controls. The investee-country characteristics include the patent regulatory environment (*PROP RIGHTS PROTECTION*), measured by the Patent Right Protect Index of Park (2008), the rule of law (*RULE OF LAW*), the measure of government effectiveness (*GOVE EFFECTIVENESS*) constructed by Kaufmann, Kray, and Mastruzzi (2011), capital market development (*MKTCAP/GDP*) measured by a country's stock market capitalization divided by its gross domestic product (GDP), equity market development measured (*CREDIT/GDP*) by a country's domestic credit divided by its GDP, GDP per capita (*GDP_PER_CAPITAL*), levels of exports (*EXPORT/GDP*), and levels of imports(*IMPORT/GDP*).

Belenzon and Schankerman (2013) note that the impediments to knowledge diffusion across national boundaries include differences in language, culture, and institutional

frameworks. These factors further hinder the flow of knowledge beyond international borders, posing challenges for international knowledge exchange and collaboration. Therefore, in Eq. (1), we control for the geographic distance (*Geo Distance*), culture (*Diff_Culture*), and language variations (*Diff_Language*) between foreign country *j* (the country where the cited patents originated) and the country where firm *i* is located. We hand collect data on the geographic distance between two countries (*Distance*). For cultural differences, we follow Gokmen (2017) and Huntington (1998) to define culture based on civilization. We assign each country to a civilization: Western, Sinic, Islamic, Hindu, Orthodox, Latin American, African, Buddhist, and "Lone" States. For each country pair, we construct an indicator variable *Diff_Culture* that takes the value of 1 if the pair belongs to different civilizations, and 0 otherwise. Similarly, we define *Diff_Language* as an indicator variable that takes the value of 1 if the dominant languages of the country pair are different, and 0 otherwise. Appendix 1 provides detailed definitions for each of the variables in Eq. (1).

In addition, we include investee-firm fixed effects to control for firm-specific time-invariant confounding factors that may simultaneously affect institutional ownership and citation of patents from a particular foreign country. As a result, in Eq. (1), we capture the time-series variations in foreign institutional ownership and cross-sectional variations in foreign institutional ownership from different countries within the same firm. We then include year fixed effects to control for possible worldwide inter-temporal macroeconomic variations. We also include foreign countries' fixed effects to control for the effect of country-level time-invariant confounding factors that could simultaneously affect the citation of patents and institutional ownership originating from the same foreign countries. To address heteroskedasticity and serial-correlation issues, we implement a two-way clustering adjustment for standard errors at the firm–foreign country pair and year levels.

To provide additional evidence consistent with a causal interpretation, we leverage two

plausibly exogenous policy changes. The first quasi-exogenous shock is the passage of the JGTRRA in 2003, which significantly reduced income tax rates on dividend payments to 15% for dividends paid by US firms and those paid by non-US firms domiciled in countries that have tax treaties with the United States. This change increased the after-tax return of equity investment in treaty countries for US institutional investors, but had no influence on non-US institutional investors. Consequently, the JGTRRA generates a plausibly exogenous increase in foreign institutional ownership from the United States for firms domiciled in tax-treaty countries (Fang, Maffett, and Zhang 2015). We thus employ a DiD approach and a three-year pre- and post-JGTRRA window (2001–2003 vs. 2004–2006) to test the change in these firms' citations of patents originating from the United States relative to their citations of patents originating from other foreign countries.[5]

The second quasi-exogenous shock is MSCI index inclusion. When a firm is added to the MSCI indices, its visibility and accessibility to global investors increase. Moreover, foreign institutional investors often benchmark their portfolios to MSCI indices and mechanically increase their holdings of a firm upon its inclusion in an MSCI index (Cremers, Ferreira, Matos, and Starks 2016). Following prior studies (e.g., Bena et al. 2017; Kim, Pevzner, and Xin 2019), we use the inclusion in the MSCI All Country World Index (ACWI) as an IV for foreign institutional ownership. This IV meets both the relevance and exclusion conditions for its validity, because inclusion in or exclusion from the index induces variations in foreign institutional ownership that are exogenous to a firm's propensity to cite patents from specific foreign countries.

For the DiD analysis based on JGTRRA adoption, we estimate the following regression, which is derived from Eq. (1) above:

$$Num\_Citation\_FC_{i,j,t} = \beta_0 + \beta_1 Treat\_firm\_US\_Pair_{i,j} \times Post_t$$

[5] We follow Fang et al. (2015) to include 2003 in the pre-shock window because the passage of JGTRRA happened in mid-2003.

$$+ \Sigma\gamma\, Investee\ Firm\ Controls_{i,t-1} + \Sigma\mu\, Investee\_Country\ Controls_{t-1} + \Sigma\lambda Country\_Pair\ Controls_{t-1} + Investee\ Firm\ FE + Year\ FE + Foreign\_Country\ FE + \varepsilon_{i,t}. \quad (2)$$

We define $Treat\_firm\_US\_Pair_{i,j}$ as an indicator equal to 1 for firm–foreign country pairs in which firm *i* is domiciled in a country that has tax treaties with the United States and foreign country *j* is the United States, and 0 otherwise. The variable *Post* is an indicator that takes the value of 1 for the post-JGTRRA period (2004–2006) and 0 for the pre-JGTRRA period (2001–2003).[6]

For the IV approach, we employ a 2SLS method. In the first stage, we estimate foreign institutional ownership as a function of an indicator for whether the firm is included in the MSCI ACWI index in the previous year, along with the same set of controls and fixed effects in Eq. (1). In the second stage, we estimate Eq. (1) by replacing $FIO_{i,j,t-1}$ with the instrumented value of $FIO_{i,j,t-1}$ estimated from the first-stage regression ($Instrumented\_\ FIO_{i,j,t-1}$).

3.2 Sample and Data

We obtain detailed patent data from PATSTAT Global, which covers more than 100 global industrialized and developing countries and regions during 2001–2019.[7] We rely on FactSet to obtain ownership data and historical accounting data. FactSet provides data on global institutional equity ownership compiled directly from reports filed by the institutions (e.g., the 13F filings), company financial reports, and from regulatory bodies around the globe (e.g., Securities Exchange Commission). In addition, FactSet provides comprehensive historical accounting information for 100,000+ international companies. We start our analysis in 2001 because FactSet ownership-data coverage begins in 2000, and we end our sample in 2019 due to the potential impact of COVID-19.

[6] For this analysis, we cluster standard errors at the firm and year level because the standard errors cannot be estimated if we cluster by firm–foreign country–pair and year possibly because this sample contains a much shorter period and a much smaller number of unique firms.

[7] Please see https://inspire.wipo.int/patstat-online for the full list of countries covered by PATSTAT.

For investee country–level control variables, we obtain country-level governance data and economics data, such as GDP from the World Development Indicators. To control for the cross-country differences, we obtain data from various public sources to measure the cultural (Gokmen 2017; Huntington 1998), language, and physical distances between different countries. Appendix 1 provides data sources for measuring each variable.

Panel A of Table 1 summarizes the sample construction procedures for the large panel data sample used for estimating Eq. (1). We obtain a sample of 21,475 unique firms covered by both PATSTAT and FactSet databases during 2001–2019. Then, for each firm, we identify candidate foreign countries that could serve as potential sources of patent citations. We apply two criteria when identifying candidate foreign countries for each firm: (1) The country must be covered by PATSTAT, and (2) the firm must have either cited a patent from that country or received institutional investment from it during our sample period. Our implicit assumption is that for each year during our sample period of 2001–2019, the firm is likely to cite patents from any of these foreign countries. By doing so, we expand the 21,475 unique firms into a sample of 5,099,296 firm–foreign country–years. Subsequently, to obtain the variable $FIO_{i,j,t-1}$, we convert the raw ownership data in FactSet into the firm–foreign country–year level by aggregating the ownership percentage of firm *i* by all institutional investors from the same foreign country *j* at the end of year *t-1*. Similarly, to obtain the variable $RNum\_Citation\_FC_{i,j,t}$, which represents the raw value of $Num\_Citation\_FC_{i,j,t}$ before log transformation, we aggregate the raw citation data in PATSTAT into the firm–foreign country–year level by counting the number of patents registered in foreign country *j* and cited by firm *i* in its patent applications filed in year *t*. We then match these two variables to the originally constructed sample of 5,099,296 firm–foreign country–years and fill the missing values of $FIO_{i,j,t-1}$ and $RNum\_Citation\_FC_{i,j,t}$ with 0. Finally, we exclude observations with missing data for calculating the control variables used in our main regressions and remove firms in financial

and utilities industries. Our final sample for the panel analysis based on Eq. (1) consists of 3,156,327 firm–foreign country–year observations for 18,380 unique firms and 222,596 unique firm-years from 140 countries around the globe. Please refer to Appendix 2 for an example of the data structure and the measurement of the two key variables—$FIO_{i,j,t-1}$ and $RNum\_Citation\_FC_{i,j,t}$—using a Japanese company, CHINO CORP, in 2018.

Panel B shows the distribution of firm–foreign country–year observations for the top 15 economies based on the citations of patents originating from the economy. The top five economies with the largest number of citations in this sample are the United States, Japan, China, Germany, and the UK. In addition, the United States on average has the largest institutional ownership in foreign countries.

Panel C reports summary statistics for the panel data sample described above. It shows that, on average, a firm cites 3.05 patents, with a standard deviation of 41.93 patents from a foreign country in a particular year. The average foreign institutional holding from a particular country is 0.27%, with a standard deviation of 1.79%. The firms in our sample are relatively large, with an average of 31% sales from foreign countries and 20% cash holdings over total assets. The firms tend to do well in our sample period with an average stock return of 12%.

To examine the effect of the JGTRRA of 2003, we focus on firms domiciled in countries that have tax treaties with the United States. For this same set of firms, we compare changes in their citations of US patents with changes in the citations of non-US patents around the passage of JGTRRA. From the panel data sample described above, we identify 3,679 non-US firms domiciled in countries that have tax treaties with the United States and that paid dividend in 2002 ─ those most likely to be affected by the tax reform. To capture changes in the citation behavior of these firms before and after the policy shock, we focus on a three-year pre- and post-shock window (2001–2006), yielding 3,609 unique firms, 20,740 firm-year observations, and 365,111 observations at the firm–foreign country–year level. Within this

sample, the 20,740 firm–US–year observations belong to the treatment group, whereas the remaining 344,371 firm–non-US foreign country–year observations serve as the control group. Using this sample, we perform the DiD analysis as specified in Eq. (2). Two firms are dropped from the estimation of Eq. (2) because they are singletons. Therefore, the final sample used for estimating the regressions includes 3,607 unique firms, 20,390 firm-year observations, and 340,696 firm–foreign country–year observations.[8]

For the IV analysis based on MSCI inclusion, we use both the large panel data sample of 3,156,327 firm-foreign country-year observations and another sample constructed using the propensity score matching (PSM) approach. The MSCI may include larger and more liquid firms, which could cause the instrument to correlate with patent citations, thus violating the exclusion restriction. To address this issue, we adopt a PSM approach to construct a group of control firms that are comparable to those included in MSCI ACWI. Specifically, we match each MSCI ACWI firm with a corresponding control firm from the same country and year based on the firm characteristics as controlled in Eq. (1), including size, leverage, profitability, and other relevant variables. By doing so, we eliminate observable differences in these characteristics between the MSCI ACWI firms and control firms. The PSM sample consists of 112,971 firm–foreign country pairs and 880,409 firm–foreign country–year observations.

4. Empirical Results

4.1 Baseline Regressions

Table 2, Panel A, presents OLS estimates of Eq. (1) using the full sample of 3,156,327 firm–foreign country–year observations to examine the relationship between foreign institutional ownership (*FIO*) and the frequency of investee firms citing patents from the home

[8] For detailed sample selection procedure, please refer to Panel A of Appendix 3. In Panel B of Appendix 3, we report the summary statistics for the JGTRRA sample, which are similar to those of the panel data sample except for the variable *DIO* because the JGTRRA sample drops US firms which have substantially higher domestic institutional ownership compared to firms in other countries.

countries of the foreign institutional investors in their own patent filings (*Num_Citation_FC*). Column (1) reports the results of the univariate regression (without controls and fixed effects). Column (2) includes a full set of control variables, firm fixed effects, and year fixed effects, whereas in column (3), we further include the foreign-country fixed effects. Across all columns, we find a significantly positive coefficient of *FIO*, suggesting that as the ownership of foreign institutional investors from a particular country increases, investee firms tend to cite a greater number of patents originating from the same countries. Those citations represent the diffusion of knowledge across borders from the home countries of foreign institutional investors to the investee firms. Therefore, our results suggest that foreign institutional investors could play a role in facilitating global knowledge diffusion. Based on the most conservative estimate of the coefficient of *FIO* as reported in column (3) (0.031), a one-standard-deviation increase in *FIO* from a given country is associated with a 7.6% increase in the number patents cited from that country, compared with the average level of foreign patent citations.[9]

The coefficients of control variables are largely aligned with our a priori expectations and those reported by prior studies. Specifically, the results in column (3) reveal that firm size (*log_SALES*), foreign sales (*FXSALES*), and R&D expenditure (*RD_EXP*) exhibit statistically significant positive relationships with citations of foreign patents. Our findings also show that firms in economically developed countries (*GDP*) cite more foreign patents, suggesting that firms from developed countries are more aware of innovative knowledge originating from other countries. Furthermore, we find the expected results for the variables capturing cross-country barriers. Specifically, our findings confirm that firms are more inclined to cite patents from countries sharing a common culture or language or that are geographically closer.

In Panel B, we drop the observations with zero *FIO* from the full sample and present

[9] log (*RNum_Citation*+1) – log (3.05+1) = 0.031*1.79, where 3.05 is the average number of citations in our sample. Thus, *RNum_Citation* = 3.28, and the increase over the average case = 3.28/3.05 -1 = 7.6%.

the estimated results of Eq. (1) using this restricted sample. Excluding zero values helps mitigate potential distortions in the regression estimates caused by the heavy clustering of observations with *FIO* equal to 0 and improves the plausibility of linear functional-form assumptions. In columns (1) and (2), the coefficients on *FIO* are still positive and significant. In addition, the magnitudes of the coefficients are comparable to those reported in Panel A. Therefore, our results are unlikely to be biased by the existence of observations with zero *FIO*.

Because our analysis is at the firm–foreign country–year level, we can control for high-dimensional fixed effects to further address the endogeneity concern. First, we control for firm-year fixed effects to alleviate the concern that firm-level unobservable and time-varying confounding factors contribute to the observed positive relationship between foreign institutional ownership and the citation of patents from the home countries of the foreign investors. Second, our results could also be driven by the time-variant economic and technological advancements within the foreign institutions' home countries. In other words, as a foreign country develops, it not only produces higher-quality patents, but also witnesses the expansion of overseas investments of its financial institutions. We thus additionally control for foreign country–year fixed effects. Lastly, our results could be due to cross-country economic integration or bilaterial business relationships driving both cross-border equity investment and patent citations (e.g., Bian et al. 2023). To mitigate this concern, we check the robustness of our results by including country pair–year fixed effects. These three sets of fixed effects account for any time-varying unobserved characteristics that may vary across firms, different foreign countries, and country pairs.

Panel C presents the results of including these additional high-dimensional fixed effects in our regressions. Column (1) includes firm-year fixed effects; column (2) includes firm-year fixed effects and foreign country-year fixed effects; and column (3) includes firm-year fixed effects and country-pair-year fixed effects. The positive and statistically significant coefficients

of *FIO* across all three columns affirm the robustness of our findings, addressing the concern of potential alternative explanations.

4.2 Cross-sectional Analyses

Cross-border Barriers Analyses

As previously discussed, factors such as geographic distance, language difference, and cultural disparities create barriers that impede the diffusion of knowledge across international borders. If foreign institutional investors indeed facilitate cross-border knowledge diffusion, we should observe that they have greater influence on increasing their investees' citations of patents originating from their home countries, particularly when greater disparities exist between investors' home countries and investees' host countries.

We thus conduct cross-sectional analyses based on the three variables of country-pair differences defined earlier: geographical distance (*Distance*), language difference (*Diff_Lanugage*) and cultural difference (*Diff_Culture*). To this end, we include interaction terms between foreign institutional ownership and the three variables representing country-pair differences in Eq. (1) and report the results in Table 3. As expected, we find a positive coefficient for the interaction term for each country-pair difference (i.e., *FIO x Diff_Culture*, *FIO x Diff_Lanugage, FIO x Distance*). This result suggests that foreign institutional investors could play a more prominent role in facilitating cross-border knowledge transfer to their investee firms when there exists greater geographic distance, language differences, and culture variations between their home countries and the countries where their investees are located. Such a finding provides further support for the significance of foreign institutional investors in bridging the gap and facilitating knowledge diffusion across borders.

Types of Foreign Institutional Investors

Foreign institutional investors differ in their specialties and investment horizon. We argue that institutional investors focusing on high-tech firms are better acquainted with

innovative knowledge, technology, and approaches prevalent in the business sectors of their portfolio companies. As a result, such institutional investors are more likely to bring the innovative knowledge originating from their countries to the attention of their investee firms. In addition, prior studies suggest that institutional investors with longer investment horizons are more actively involved in monitoring and advising their investee firms (e.g., Bushee 1998; Chen, Harford, and Li 2007). Building on this finding, Bena et al. (2017) and Luong et al. (2017) find that long-term foreign institutional ownership has a stronger effect on increasing firms' innovation outcomes. Furthermore, institutional investors from countries with higher levels of innovation engagement are more likely to introduce fresh innovative knowledge to their investees, resulting in a more significant increase in these firms' citations of patents originating from their home countries.

We thus conduct cross-sectional analyses to explore the heterogeneity in the effect of different types of foreign institutional investors. First, we divide the foreign institutions into high- and low-tech types (*Hightech_FIO* and *Lowtech_FIO*), based on the investment portfolio of each foreign institutional investor.[10] Second, we measure the investment horizon of the foreign institutional investors and divide them into long- and short-horizon groups (*Longhor_FIO* and *Shorthor_FIO*). Finally, to capture the level of innovation engagement in investors' home countries, we calculate the total number of patent applications filed by each country in a given year. Based on this metric, we classify investors into *Ctry_Inno_Rich_FIO* and *Ctry_Inno_Poor_FIO*, depending on whether they originate from countries with above- or below-median innovation intensity.

In column (1) of Table 4, we replace *FIO* in Eq. (1) with *Hightech_FIO* and *Lowtech_FIO*. The result shows a significantly positive coefficient only for *Hightech_FIO*,

[10] We classify a foreign institution as high-tech if the weighted average number of patent applications of the companies in its investment portfolio exceeds the sample mean in a specific year.

suggesting that foreign institutional investors focusing on high-tech investment can play a more influential role in cross-border diffusion of innovative knowledge. Column (2) reports the estimated result of Eq. (1) by replacing *FIO* with *Longhor_FIO* and *Shorthor_FIO*. Again, we find a positive and significant coefficient only for *Longhor_FIO* and not for *Shorthor_FIO*, consistent with our expectation that long-term-oriented foreign institutional investors are more likely to bring up-to-date innovative knowledge to their investees in other countries. In column (3), we again replace *FIO* with *Ctry_Inno_Rich_FIO* and *Ctry_Inno_Poor_FIO*. Both coefficients of *Ctry_Inno_Rich_FIO* and *Ctry_Inno_Poor_FIO* are statistically significant; however, the coefficient of *Ctry_Inno_Rich_FIO* is approximately six times larger in magnitude than that of *Ctry_Inno_Poor_FIO*. This substantial difference suggests that investors from more innovation-intensive countries may contribute more to cross-border diffusion of innovative knowledge.

4.3 JGTRRA Analysis

The passage of the JGTRRA of 2003 significantly reduced personal income tax rates for dividend payments to 15% for US firms as well as firms domiciled in foreign countries with tax treaties with the United States. In contrast, firms in non-treaty countries, such as Brazil and Singapore, did not benefit from this preferential tax treatment and dividends from firms in those countries still remain taxable at the normal personal income tax rate after the passage of the JGTRRA. Consequently, the JGTRRA is expected to increase U.S. institutional ownership for firms in treaty economies relative to non-treaty economies, holding all else constant.

The JGTRRA is an ideal candidate for a quasi-natural experiment, as it generates plausibly exogenous variation in foreign institutional ownership from the United States in firms located in non-US countries, with no direct intent to influence knowledge diffusion from the United States to the foreign treaty economies. We employ a DID approach and a three-year pre- and post-JGTRRA window (2001–2003 vs. 2004–2006) to examine whether firms in

foreign economies that have tax treaties with the United States experience an increase in their citations of U.S. patents. Our treatment group consists of firm-US pairs for dividend-paying firms domiciled in tax treaty economies. We define a firm as dividend paying if it pays dividend in 2002. Firms in non-treaty economies are matched against firms in treaty economies using propensity score matching with all firm-level control variables in Eq. (1) measured as of 2002, the year before JGTTRA, as covariates. The control group consists of two parts; (i) all firm-country pairs for firms located in non-treaty economies and (ii) firm- non-U.S. pairs for firms located in treaty economies.

This analysis compares changes in US patent citations by non-US firms in tax-treaty countries, relative to their citations of patents from non-US countries, before and after the passage of the JGTRRA. Table 5, Panel A, reports the DiD estimation results of Eq. (2). In column (1), we first verify that the JGTRRA can lead to a significant increase in US institutional ownership of these firms, relative to ownership by non-US institutional investors. The coefficient of *Treaty_firm_U.S._Pair* × *Post* (0.751, t = 9.441) indicates that following the passage of the JGTRRA, US institutional ownership of treaty-country firms increased significantly more than ownership by non-US institutional investors. This observed increase supports the relevance of the JGTRRA as a plausibly exogenous source of variation in US institutional ownership. In column (2), where the dependent variable is the number of citations of patents originating from the United States, the coefficient on *Treaty_firm_US_Pair* × *Post* is positive and significant at the 1% level (0.103, t = 4.197), which suggests that, following the passage of the JGTRRA, non-US firms domiciled in tax-treaty countries cite more US patents relative to patents from other foreign countries, consistent with increased knowledge flow from the United States.

To verify the parallel-trends assumption, we conduct a dynamic analysis by replacing the variable *Post* with indicators for the years 2001, 2002, 2004, 2005, and 2006. We treat 2003

as the benchmark year. We then interact each of the year indicators with the variable *Treaty_firm_US_Pair*. As shown in column (3), the coefficients on *Treaty_firm_US_Pair* × *2001*, *Treaty_firm_US_Pair* × *2002* are neither economically nor statistically significant, confirming the parallel-trends assumption. By contrast, the positive and significant coefficients on *Treaty_firm_US_Pair* × *2005* and *Treaty_firm_US_Pair* × *2006* suggest the JGTRRA has a positive effect on investees' citations of US patents, resulting from the increase in US institutional ownership.

In the analysis above, we focus only on dividend-paying firms in countries that have tax treaties with the United States, using their relationships with non-US countries as the control group. By employing the same set of firms, this specification can better identify the effect of JGTRRA passage. However, broadly speaking, the patent-citation behavior of firms in non-tax-treaty countries can also serve as the control group. Using the PSM method, we thus select a group of dividend paying firms from non-treaty countries that closely match firms from treaty countries based on the firm-level covariates in Eq (1). We then add these matched control firms and re-estimate the DiD specification (Eq. (2)) using this broader sample. The result reported in Panel B is consistent with that in Panel A, suggesting that relative to control firms and their own citations of non-US patents, dividend-paying firms in treaty countries increase their citations of US patents after the passage of the JGTRRA. To some extent, this finding can also mitigate the concern that the passage of the JGTRRA influences the US economy and innovations, leading to higher citations of US patents, because the control group also contains the citations of US patents by dividend paying firms in non-treaty countries.[11]

[11] Also, due to the inclusion of dividend paying firms in non-treaty countries, in Panel B, *Treaty_firm_US_Pair* cannot be fully absorbed. In Panel A, because the sample is restricted to firms in treaty countries, *Treaty_firm_US_Pair* is perfectly collinear with foreign country fixed effects when US is the foreign country from which the investee firms might cite patents. In other words, *Treaty_firm_US_Pair* equals one (zero) whenever US fixed effect equals one (zero). In Panel B, however, there is no perfect collinearity between *Treaty_firm_US_Pair* and US fixed effect because *Treaty_firm_US_Pair* would be zero for firms in non-treaty countries when the foreign country is United States. Thus, *Treaty_firm_US_Pair* still loads in Panel B.

4.4 MSCI Index Inclusion

In Table 6, we present the results of the IV analysis based on MSCI index inclusion. Columns (1)–(3) report the results estimated using the full panel data sample. In the first stage (column (1)), we observe that the inclusion of a firm's stock in the MSCI ACWI prompts foreign institutions to augment their holdings by approximately 12% relative to the sample mean (0.033%/0.27%). The results of the second stage (column (2)) reveal that this uptick in foreign institutional ownership is associated with an increase in citations of patents originating from the institution's home country, thereby reinforcing our findings that foreign institutions facilitate knowledge diffusion. In column (1), we estimate the effect of MSCI inclusion on overall foreign institutional ownership for all countries together, assuming the same effect of MSCI inclusion on foreign institutional ownership from different countries. Alternatively, in the first-stage regression, we estimate the effect of MSCI inclusion on foreign institutional ownership separately for each of the 140 countries in our sample to allow MSCI inclusion to have a varied impact on the investment decisions of foreign institutional investors from different countries (untabulated). Column (3) presents the second-stage regression results using this alternative first-stage estimation. The results are similar to those in column (2). In columns (4) and (5), we re-estimate the 2SLS regressions using the PSM sample and find results consistent with those reported in columns (1) and (2), respectively.

4.5 Additional Analyses

Within-Country-Pair and Subsample Analyses

In this section, we first take advantage of the variations in foreign institutional ownership across different firms within each country/region pair to conduct within country-pair analyses. This analysis can help mitigate the concern that bilateral relationships between two countries/regions may simultaneously influence cross-border institutional holdings and parent citations. Specifically, we select the top five countries/regions that have the most

observations as foreign countries/regions and another top five countries/regions that have the most observations as the investee countries/regions in our sample. We then estimate Eq. (1) separately for each pair among those countries/regions.

Panel A of Table 7 presents the coefficients of *FIO* for each of the country/region pairs. The results generally support the finding that foreign institutional ownership facilitates knowledge diffusion from their countries/regions to the investees' countries/regions. One exception is China, possibly due to the limited role of foreign institutional investors in China (Qian, Ritter, and Shao 2014).

We also perform several subsample analyses to check the robustness of our main results. A key consideration is that our results may be unduly influenced by US or European Union (EU) institutional investors. To address this concern, we separate observations where the foreign institutional investors are from either US or EU countries. Columns (1) and (2) of Table 7, Panel B, present the results for two subsamples: one that includes only the United States as the foreign country and another that excludes the United States, respectively. Columns (3) and (4) present the results for the subsamples focusing solely on EU countries as the foreign countries and excluding EU countries, respectively. The positive and statistically significant coefficients of *FIO* observed across all four columns indicate that our findings are not primarily driven by either US or EU institutions.

The Incremental Effect of the Presence of the Largest Foreign Institutional Holdings

We argue that foreign institutional investors play a significant role in introducing innovative knowledge from their home countries to the investee firms. Institutions with larger holdings could have a stronger influence on their investee firms and are also more willing to expend resources and efforts to engage with them (e.g., Lewellen and Lewellen 2022). We thus conduct an analysis to explore the effect of the presence of large foreign institutional holdings. To do so, we construct an indicator variable equal to 1 if the ownership of the largest foreign

institutional investor from the focal foreign country exceeds the threshold of 0.05% (*IO Big 005*), 0.1% (*IO Big 01*), or 0.5% (*IO Big 05*). We then include the indicator variables in Eq. (1).

Panel C of Table 7 presents the results for each indicator variable in columns (1)–(3), respectively. We find that the coefficients on *IO Big 005*, *IO Big 01*, and *IO Big 05* are all significantly positive, suggesting that institutions with larger holdings play an incrementally important role in facilitating knowledge diffusion from their home countries. In addition, the economic magnitudes of the coefficients for the indicators increase monotonically across the 0.05% to 0.5% thresholds, providing further supporting evidence on the role of large foreign institutional investors.

Dissection of Citations

A recent working paper by Kostovetsky and Manconi (2020) examines the role of institutional investors in innovation diffusion using US patent-citation data and focuses on the mechanism of common institutional ownership. Our paper differs from theirs because we focus on foreign institutional investors of international firms. In addition, because Kostovetsky and Manconi (2020) focus solely on US firms, they have to rely on common ownership to identify innovation diffusion across firms. Our paper uses cross-border patent-citation data and thus can trace knowledge diffusion across countries, which allows us to assess more broadly how institutional investors contribute to knowledge diffusion beyond the confines of common ownership. Nevertheless, we conduct robustness checks to exclude the effect of common ownership.

First, we isolate citations of patents assigned to public companies (*Num_Citation_Public*) and report significant results in Table 7, Panel D, column (1). Knowledge diffusion related to these patents could be affected by common ownership. Second, we use a textual approach to identify cited patents assigned to recipients other than public

companies such as universities (*Num_Citation_uni*) and individuals and other types of entities (*Num_Citation_other*). Columns (2) and (3) present the results of the citations of patents assigned to universities and the remaining recipients including individuals in foreign countries, respectively. These two samples are less affected by common ownership. We find positive and statistically significant coefficients for *FIO* in both columns. In addition, this result suggests that foreign institutional investors could also help diffuse innovative knowledge developed outside public companies.

Alternative Measurements of Patent Citations

In Eq. (1), the dependent variable *Num_Citation_FC* is measured as the log value of 1 plus the number of citations of patents originating from a foreign country. We replace this variable with an indicator indicating whether the firm cites any patent from a particular foreign country (*D_Citation_FC*) and estimate Eq. (1) using the linear probability model in column (1) of Table 7, Panel E. In column (2), we use the unlogged raw value of the number of patent citations (*RNum_Citation_FC*) as the dependent variable. Following Bian et al. (2024), we also use technology transfer as an alternative measure of knowledge diffusion. Specifically, we measure technology transfer by the log value of one plus the number of patents granted to a firm whose inventors are from a particular foreign country (*Patent Transfer)*) and report the estimated results of using this measure as the dependent variable in column (3). We find that the coefficients of *FIO* remain positive and significant across all three columns.

Alternative Paths of Knowledge Diffusion

In the above analyses, we focus on knowledge diffusion from foreign institutional investors' home countries. In this section, we also consider alternative paths of knowledge diffusion potentially facilitated by institutional investors.

We first examine whether domestic institutional investors who invest in foreign countries could bring back innovative knowledge from those foreign countries. To investigate

this possibility, we construct a variable, *DIO_FC_Investment*, as the aggregated investment by the firm's domestic institutional investors in a given foreign country. We include this variable in the main regression. Table 7, Panel F, column (1) reports the results. The positive and significant coefficient of *DIO_FC_Investment* suggests that domestic institutional investors could also bring back innovative knowledge gained through their investment in foreign countries. Importantly, the coefficient on *FIO* remains significant and economically comparable.

Moreover, foreign institutional investors often invest in multiple countries and are therefore exposed to innovative knowledge around the world. We thus examine whether foreign institutional investors could also help disseminate innovative knowledge gained from their investment in other countries. Specifically, we identify the country where an institutional investor has the largest shareholdings outside its home country and the focal investee's country as the alternative home country of the investor. We then redefine *FIO* based on this alternative home country and construct the measure of *FIO_Alternative_Country*. Column (2) presents the results. The positive and significant coefficient of *FIO_Alternative_Country* suggests that foreign institutional investors can potentially leverage global innovative knowledge within their networks. Notably, the economic magnitude of this coefficient (0.0007) is smaller than that of *FIO* (0.029), suggesting that foreign institutional investors may play a stronger role in disseminating innovative knowledge from their home country than from other countries, reinforcing our main findings.

5. Conclusion

This study examines the role of foreign institutional investors in facilitating cross-border knowledge diffusion. Whereas prior literature has documented barriers that impede innovation spillovers across national boundaries and the localized nature of knowledge flows,

our research identifies foreign institutional investors as a mechanism that helps overcome geographic and cultural barriers to knowledge transmission.

Our empirical strategy employs multiple identification approaches to examine the relationship between foreign institutional ownership and cross-border patent citations that indicate the path of global knowledge flow. The quasi-exogenous variation provided by the 2003 tax reform—JGTRRA—shows that increases in US institutional ownership are associated with greater citations of US patents by non-US firms in tax-treaty countries. This finding is supported by our IV approach using MSCI index inclusion, which similarly indicates increases in foreign institutional ownership correspond to higher citations of patents from the investors' home countries. The consistency of results across these identification strategies strengthens confidence in the inferences of our findings. Further, our panel analysis of over 20,000 global firms during 2001–2019 establishes the broader applicability of these results.

The cross-sectional analyses reveal important patterns in how foreign institutional investors may facilitate knowledge diffusion. The relationship between foreign institutional ownership and knowledge diffusion from investors' home countries appears more pronounced when investors and investees are separated by greater cultural, geographic, and linguistic distances, contexts where knowledge transfer typically faces higher barriers. Additionally, the relationship varies with investor characteristics: institutional investors with longer investment horizons, those focusing on high-technology sectors, and those from countries with more innovations show stronger associations with knowledge transfer from their countries. These results suggest that both access to innovative knowledge and incentives to transmit it influence the extent of knowledge diffusion.

Our study thus contributes to understanding the mechanisms underlying financial globalization and its effects on innovation. The finding that foreign institutional investors may facilitate knowledge diffusion provides evidence of potential spillover effects from

international capital flows that extend beyond direct financial benefits or governance monitoring. Through their investments, institutions are bringing markets to be closer to the concept that "innovation is borderless".

The implications extend to corporate strategies and regulatory policies. Our evidence suggests that firms seeking to access innovative knowledge from specific regions may benefit from attracting institutional investors from those regions. In addition, the results highlight the potential value of institutional investor diversity in promoting access to global knowledge networks. Rather than focusing solely on attracting the largest volume of foreign capital, policies that encourage investment from various countries with complementary technological capabilities may help maximize knowledge-diffusion benefits for domestic firms.

Our findings also suggest that policies promoting cross-border investment flows may have broader implications for innovation ecosystems than previously recognized. For example, the JGTRRA result demonstrates that international tax policies and bilateral investment treaties can alter cross-border investment patterns and potentially affect cross-border knowledge flows, suggesting policymakers should account for these broader innovation effects when designing international regulatory frameworks.

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Table 1. Sample construction, distribution, and summary statistics

Panel A. Sample construction

Steps	Unique Firm	Unique Firm-Year	Firm–Foreign Country–Year
Unique firms covered by both PATSTAT and FactSet during 2001–2019	21,475		
Expand the unique firm sample into the firm–foreign country–year level using the procedure described in the text	21,475	408,025	5,099,296
Drop observations with missing data for calculating control variables	(1,246)	(162,340)	(1,555,801)
Drop firms from the financial and utilities industries	(1,849)	(23,089)	(387,168)
Final full sample for panel analysis	18,380	222,596	3,156,327

Panel B: Country Distribution – Top 15 Most Cited

Country/Region	Mean(FIO)	Obs. FIO>0	Mean(Num_Cite)	Obs. Num_Cite>0
United States	4.20	88,182	96.20	63,186
Japan	0.20	34,757	27.12	45,821
China	0.17	5,462	36.75	33,842
Germany	0.54	65,500	10.80	29,520
United Kingdom	1.61	92,488	6.12	26,061
South Korea	0.05	4,959	12.03	22,641
France	0.38	61,196	4.25	15,734
Canada	0.69	62,363	2.93	10,615
Taiwan	0.08	12,541	13.73	9,128
Russia	1.06	64	4.77	5,839
Australia	0.12	42,211	2.39	5,537
Switzerland	0.50	57,533	1.78	3,552
Netherlands	0.48	38,345	1.34	1,857
Austria	0.08	28,547	1.86	1,839
Belgium	0.16	34,538	1.32	1,630

Panel C. Summary statistics

	Mean	Median	Std. Dev.	Min	P25	P75
RNum_Citation_FC	3.05	0	41.93	0	0	0
FIO	0.27	0	1.79	0	0	0.02
CLOSE	0.23	0.14	0.25	0	0	0.43
FXSALES	0.31	0.20	0.33	0	0	0.56
log_SALES	5.83	5.95	2.34	0	4.42	7.43
log_cap_lab	0.07	0.03	0.16	0	0.01	0.07
TOBIN Q	1.33	0.80	1.60	0	0.38	1.61
FCF	-0.04	0.01	0.21	-1.32	-0.04	0.05
LEVERAGE	0.21	0.18	0.19	0	0.04	0.32
CASH	0.2	0.13	0.20	0	0.06	0.27
TANGIBILITY	0.26	0.22	0.20	0	0.1	0.37
DIO	19.23	3.64	27.64	0	0.05	29.85
STOCK RETURN	0.12	0	0.56	-0.81	-0.18	0.29
RD_EXP	0.04	0.01	0.09	0	0	0.04
GOV EFFECTIVENESS	1.24	1.50	0.61	-0.16	1.03	1.62
RULE OF LAW	1.14	1.48	0.71	-0.60	0.98	1.61
PROP RIGHTS PROTECTION	4.49	4.67	0.42	3.16	4.29	4.88
GDP_PER_CAPITAL	3.29	3.72	1.10	0	3.38	3.91
MKTCAP/GDP	1.04	0.95	1.22	0	0.56	1.30
CREDIT/GDP	1.29	1.14	1.34	0	0	2.33
EXPORT/GDP	0.27	0.17	0.31	0	0.12	0.31
IMPORT/GDP	0.26	0.17	0.28	0	0.15	0.30
Diff_Culture	0.58	1	0.49	0	0	1
Diff_language	0.84	1	0.37	0	1	1
Geo Distance	7.04	7.18	4.18	0	3.24	9.64

Table 2. Generalized results

Panel A: Full sample

Variables	(1)	(2)	(3)
		Num_Citation_FC	
FIO	0.070***	0.073***	0.031***
	(21.976)	(21.834)	(13.945)
CLOSE		0.023***	0.021***
		(5.734)	(5.143)
FXSALES		0.010***	0.012***
		(3.165)	(3.365)
log_SALES		0.015***	0.018***
		(10.767)	(12.315)
log_cap_lab		-0.020***	-0.020***
		(-10.472)	(-11.537)
LEVERAGE		-0.016***	-0.020***
		(-4.463)	(-5.411)
CASH		0.016***	0.023***
		(3.922)	(5.230)
DIO		-0.000***	-0.000**
		(-3.430)	(-2.743)
RD_EXP		0.083***	0.078***
		(7.586)	(6.855)
GOV EFFECTIVENESS		0.048***	0.049***
		(4.477)	(4.351)
PROP RIGHTS PROTECTION		0.033***	0.030***
		(4.145)	(3.782)
GDP_PER_CAPITAL		0.043***	0.038**
		(2.996)	(2.712)
CREDIT/GDP		0.013**	0.010**
		(2.737)	(2.232)
EXPORT/GDP		-0.235***	-0.233***
		(-5.229)	(-5.272)
IMPORT/GDP		0.135**	0.152***
		(2.772)	(3.156)
Diff_Culture		0.052***	-0.038***
		(4.023)	(-7.491)
Diff_language		0.002	-0.019***
		(0.605)	(-4.581)
Geo Distance		0.002	-0.008***
		(1.548)	(-12.182)
Other control variables with insignificant coefficients		Yes	Yes
Observations	3,156,327	3,156,327	3,156,327
Adj. R-squared	0.033	0.135	0.302
Fixed Effects	None	Firm&Year	Firm, Year, & Country

Panel B: Non-zero FIO sample

Variables	(1)	(2) *Num_Citation_FC*	(3)
FIO	0.067***	0.074***	0.024***
	(18.937)	(20.085)	(10.223)
Observations	1,138,495	1,138,495	1,138,495
Adj. R-squared	0.052	0.195	0.386
Controls	Yes	Yes	Yes
Fixed Effects	None	Firm&Year	Firm, Year, & Country

Panel C: High-dimensional fixed effects

Variables	(1)	(2) *Num_Citation_FC*	(3)
FIO	0.032***	0.031***	0.033***
	(14.089)	(13.822)	(14.705)
Observations	3,149,296	3,148,918	3,138,630
Adjusted R-squared	0.307	0.323	0.349
Controls	Yes	Yes	Yes
Fixed Effects	FirmxYear & Foreign Country	FirmxYear & Foreign CountryxYear	FirmxYear & Country PairxYear

This table reports OLS regressions of patent citations on foreign institutional ownership during 2001–2019 based on Eq. (1). Panel A uses the full sample, Panel B drops observations with zero FIO, and Panel C includes high-dimensional fixed effects. In Panel C, column (1) includes Firm×Year fixed effects and Foreign_Country fixed effects, column (2) includes Firm×Year and Foreign_Country×Year fixed effects, and column (3) includes Firm×Year and CountryPair×Year fixed effects. Variable definitions are provided in Appendix 1. Standard errors are adjusted for *Year* and *Firm-foreign_country* clustering. * p < .1; ** p < .05; *** P < .01.

Table 3. Cross-sectional analysis: Barriers to knowledge diffusion

	(1)	(2)	(3)
Variables		*Num_Citation_FC*	
FIO_×_ Diff_Culture	0.030***		
	(4.996)		
FIO_×_ Diff_language		0.034***	
		(7.463)	
FIO_×_Geo Distance			0.004***
			(7.618)
FIO	0.024***	0.014***	0.007*
	(9.508)	(4.352)	(1.938)
Diff_Culture	-0.042***	-0.034***	-0.036***
	(-8.138)	(-6.579)	(-6.993)
Diff_language	-0.021***	-0.036***	-0.020***
	(-5.012)	0.000	(-4.940)
Geo Distance	-0.008***	-0.008***	-0.009***
	(-12.024)	(-12.288)	(-12.533)
Observations	3,156,327	3,156,327	3,156,327
Adjusted R-squared	0.303	0.304	0.304
Control	Yes	Yes	Yes
Fixed Effects		Firm, Year, & Country	

This table presents results of OLS regressions of patent citations on foreign institutional ownership (Eq. (1)), conditional on country-pair differences, i.e., language difference, geographical distance, and cultural difference. Language difference (*Diff_Culture*) is coded as 1 if the investee and the investor's countries do not share the same official language. Geographical distance (*Geo Distance*) measures the distance between the capital cities of the two countries. We proxy cultural difference (*Diff_Culture*) of two countries following Gokmen (2017) and Huntington (1998). Variable definitions are provided in Appendix 1. Standard errors are adjusted for *Year* and *Firm-foreign_country* clustering. * p < .1; ** p < .05; *** P < .01.

Table 4. Cross-sectional analysis: Types of foreign institutional investors

	(1)	(2)	(3)
Variables		*Num_Citation_FC*	
Hightech_FIO	0.046***		
	(15.987)		
Lowtech_FIO	-0.009*		
	(-1.916)		
Longhor_FIO		0.040***	
		(14.397)	
Shorthor_FIO		-0.002	
		(-0.310)	
Ctry_Inno_Rich_FIO			0.031***
			(13.912)
Ctry_Inno_Poor_FIO			0.005**
			(2.429)
Differences in FIO Coef.	0.055***	0.042***	0.026***
p-value F-test	(0.000)	(0.000)	(0.000)
Observations	3,156,327	3,156,327	3,156,327
Adjusted R-squared	0.303	0.303	0.302
Control	YES	YES	YES
Fixed Effects		Firm, Year, & Country	

This table summarizes results of OLS regressions of patent citations on foreign institutional ownership (Eq. (1)), conditional on the types of foreign institutional investors. *Hightech_FIO* is the total ownership held by foreign institutions whose portfolio has an average number of patent applications above sample median. *Lowtech_FIO* is the total ownership held by foreign institutions whose portfolio has an average number of patent applications below the sample median. *Longhor_FIO* is the total ownership held by foreign institutions whose portfolio has an average holding period above the sample median. *Shorthor_FIO* is the total ownership held by foreign institutions whose portfolio has an average holding period below the sample median. *Ctry_Inno_Rich_FIO (Ctry_Inno_Poor_FIO)* is the total ownership held by foreign institutions from foreign countries that are ranked higher (lower) than the median country in terms of total patent applications in a year. Variable definitions are provided in Appendix 1. Standard errors are adjusted for *Year* and *Firm-foreign_country* clustering. * p < .1; ** p < .05; *** P < .01.

Table 5: DiD Analyses on the passage of the JGTRRA

Panel A: The sample of firms in countries that have tax treaties with the United States

	(1)	(2)	(3)
Variables	*FIO*	*Num_Citation_FC*	
Treaty_firm_US_Pair _×_post	0.751***	0.103***	
	(9.441)	(4.197)	
Treaty_firm_US_Pair _×_2001			-0.022
			(-0.530)
Treaty_firm_US_Pair _×_2002			-0.030
			(-0.739)
Treaty_firm_US_Pair _×_2004			0.057
			(1.380)
Treaty_firm_US_Pair _×_2005			0.121***
			(2.836)
Treaty_firm_US_Pair_ ×_2006			0.079*
			(1.871)
Observations	340,696	340,696	340,696
Adjusted R-squared	0.150	0.290	0.290
Controls	Yes	Yes	Yes
Fixed Effects		Firm, Year, & Country	

Panel B: A PSM sample

	(1)	(2)
Variables	*Num_Citation_FC*	
Treaty_firm_US_Pair	0.128*	0.138*
	(1.919)	(1.956)
Treaty_firm_US_Pair_×_post	0.097***	
	(4.023)	
Treaty_firm_US_Pair_×_2001		-0.011
		(-0.281)
Treaty_firm_US_Pair_×_2002		-0.021
		(-0.538)
Treaty_firm_US_Pair_×_2004		0.058
		(1.426)
Treaty_firm_US_Pair_×_2005		0.119***
		(2.836)
Treaty_firm_US_Pair_×_2006		0.082**
		(1.960)
Observations	732,597	732,597
Adjusted R-squared	0.274	0.274
Controls	Yes	Yes
Fixed Effects	Firm, Year, & Country	

This table reports the result of the DiD analysis (Eq. (2)). Panel A uses a sample of firms domiciled in countries that have tax treaties with the United States from 2001–2006 and shows US institutional ownership rises post-JGTRRA among treaty-country firms (column (1)), with columns (2) and (3) reporting the main and dynamic DiD results of patent-citation analysis, respectively. Panel B replicates columns (2) and (3) of Panel A using a PSM sample that includes non-US firms in treaty countries used in Panel A and non-US firms in other countries that are matched with non-US firms in treaty countries using PSM scores. Variable definitions are provided in Appendix 1. Standard errors are adjusted for *Firm*Year* clustering. * p < .1; ** p < .05; *** P < .01.

Table 6. The IV analysis based on MSCI inclusion

	Baseline IV		IV (First stage —per country)	IV with matched control sample	
	(1)	(2)	(3)	(4)	(5)
	First stage	Second stage	Second stage	First stage	Second stage
Variables	*FIO*	*Num_Citation_FC*	*Num_Citation_FC*	*FIO*	*Num_Citation_FC*
MSCI	0.033***			0.024***	
	(6.446)			(4.747)	
(Instrumented) *FIO*		0.180**	0.043***		0.291***
		(2.111)	(13.335)		(2.576)
Observations	3,156,327	3,156,327	3,154,096	878,568	878,568
Adj. R-squared	0.143	-	0.304	0.307	-
Controls	Yes	Yes	Yes	Yes	Yes
Fixed Effects			Firm, Year, & Country		

This table reports results of the IV regressions based on MSCI inclusion during 2001–2019. Column (1) presents the result of first-stage regression using the full sample to estimate MSCI inclusion; column (2) presents the second stage using instrumented FIO; column (3) uses an alternative first stage estimated separately by foreign country. Columns (4) and (5) replicate the first and second stages using a PSM sample matched on MSCI inclusion. Variable definitions are in Appendix 1. Standard errors are clustered by year and firm–foreign country pair in columns (1)–(3); in columns (4)–(5), clustering is by firm–foreign country only due to limitations in two-way clustering. * p < .1; ** p < .05; *** P < .01.

Table 7: Additional Analyses

Panel A: Within-country-pair analyses

		Investee Country/Region				
		US	JP	CN	TW	KR
Foreign Country/region	US		0.013***	0.004*	0.009*	0.016***
			(4.835)	(1.876)	(1.918)	(4.187)
	JP	0.061***		-0.090***	0.153*	0.039
		(4.187)		(-3.422)	(1.745)	(0.642)
	GB	0.004***	-0.003	-0.001	0.008***	0.005**
		(3.261)	(-1.465)	(-0.501)	(3.111)	(2.244)
	DE	0.007**	0.027***	-0.038***	-0.016	-0.005
		(2.035)	(2.662)	(-2.931)	(-0.611)	(-0.509)
	CN	-0.014	-0.674**		0.004	0.156
		(-0.766)	(-2.283)		(0.113)	(0.630)

Panel B: Subsample analysis

	(1)	(2)	(3)	(4)
	US	Non-US	E.U.	Non-E.U.
Variables		*Num_Citation_FC*		
FIO	0.007***	0.008***	0.029***	0.032***
	(5.500)	(6.267)	(6.674)	(11.927)
Observations	168,849	2,987,333	412,520	2,743,807
Adjusted R-squared	0.719	0.252	0.321	0.300
Controls	YES	YES	YES	YES
Fixed Effects	Firm &Year	Firm, Year, & Country	Firm, Year, & Country	Firm, Year, & Country

Panel C: Existence of a single large investor

	(3)	(2)	(3)
Variables		*Num_Citation_FC*	
FIO	0.031***	0.030***	0.029***
	(13.114)	(12.699)	(11.647)
IO_big_005	0.012		
	(1.649)		
IO_big_01		0.024***	
		(2.881)	
IO_big_05			0.038***
			(3.868)
Observations	3,156,327	3,156,327	3,156,327
Controls	Yes	Yes	Yes
Adjusted R-squared	0.302	0.302	0.302
Fixed Effects		Firm, Year, & Country	

Panel D: Dissection of citations

Variables	(1) Log(1+*Num Citations_public*)	(2) Log(1+*Num Citations_uni*)	(3) Log(1+*Num Citations_other*)
FIO	0.024***	0.011***	0.029***
	(12.217)	(10.736)	(13.964)
Observations	3,156,327	3,156,327	3,156,327
Adjusted R-squared	0.208	0.133	0.294
Controls	Yes	Yes	Yes
Fixed Effects		Firm, Year, & Country	

Panel E: Alternative measurements of dependent variables

Variables	(1) *D_Citation_FC*	(2) *RNum_Citation_FC*	(3) Log(1+*Patent Transfer*)
FIO	0.004***	3.039***	0.012***
	(9.929)	(8.934)	(8.388)
Observations	3,156,327	3,156,327	3,156,327
Adjusted R-squared	0.279	0.105	0.160
Controls	Yes	Yes	Yes
Fixed Effects		Firm, Year, & Country	

Panel F: Alternative diffusion mechanisms

Variables	(1) *Num_Citation_FC*	(2) *Num_Citation_FC*
FIO	0.030***	0.029***
	(13.470)	(13.159)
DIO_FC_Investment	0.028***	
	(16.921)	
FIO_Alternative_Country		0.007***
		(11.094)
Observations	3,156,327	3,156,327
Adjusted R-squared	0.304	0.303
Controls	Yes	Yes
Fixed Effects	Firm, Year, & Country	

This table reports OLS regressions of Eq. (1) by panel: (A) within top five country/region pairs; (B) subsamples by foreign country (US, non-US, EU, non-EU); (C) large investor thresholds IO_big_05, IO_big_01, IO_big_005; (D) citations by public companies, universities, and others; (E) alternative dependent variables (non-zero-citations dummy, raw counts, patents with foreign inventors per Bian et al. (2023); (F) alternative diffusion mechanisms (DIO_FC_Investment, FIO_Alternative_Country). Variable definitions are in Appendix 1. Standard errors are adjusted for *Year* and *Firm-foreign_country* clustering. * p < .1; ** p < .05; *** P < .01.

Appendix 1: Variable Definitions

Variable	Definition
cap_lab	Net property, plant, and equipment divided by the number of employees. (FactSet)
CASH	Cash holdings divided by total assets. (FactSet)
CLOSE	Number of shares held by insiders (shareholders who hold 5% or more of the outstanding shares, such as officers, directors, immediate families, and other corporations or individuals), as a fraction of the number of shares outstanding.
CREDIT/GDP	Domestic credit provided by financial sector (% of GDP) of the investee's country. (World Bank)
Ctry_Inno_Poor_FIO	The total ownership held by foreign institutions from foreign countries that are ranked lower than the median country in terms of total patent applications in a year (PATSTAT)
Ctry_Inno_Rich_FIO	The total ownership held by foreign institutions from foreign countries that are ranked higher than the median country in terms of total patent applications in a year. (PATSTAT)
$D\_Citation_{i,j,t}$	An indicator that equals 1 if $RNum\_Citation\_FC_{i,j,t}$ is greater than zero, and 0 otherwise.
Diff_Culture	An indicator that equals 1 if the investee's country and the foreign country do not share the same civilization, and 0 otherwise, where the civilization of a country is defined by Gokmen (2017) and Huntington (1998).
Diff_Language	A dummy variable that equals 1 if the investee's country and the foreign country share no official languages, and 0 otherwise. (https://en.wikipedia.org/wiki/List_of_languages_by_the_number_of_countries_in_which_they_are_recognized_as_an_official_language)
DIO	Holdings by domestic institutions as a fraction of market capitalization. (FactSet/LionShares)
DIO_FC_Investment	The aggregated shareholdings by domestic institutional investors of the firm in the foreign country.
EXPORT/GDP	Exports of goods and services (% of GDP) of the investee's country. (World Bank)
FCF	Net income before extraordinary items plus depreciation minus capital expenditures divided by total assets. (FactSet)
FIO_Alternative_Country.	The home country of the foreign institutional investor is redefined by the second largest country where the foreign institutional investors have equity holdings.
$FIO_{i,j,t-1}$	Total holdings of firm *i*'s shares by institutions located in a foreign country *j* as a fraction of market capitalization at the beginning of year *t*. (FactSet/LionShares)
FXSALES	Foreign sales divided by total sales. (FactSet)
GDP_PER_CAPITAL	GDP (gross domestic product) per capita of the *Investee's country.* Data are in current US dollars. (World Bank)
Geo Distance	The geographical distance between the capital cities of the investee's country and the foreign country. (http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=6)
GOV EFFECTIVENESS	Government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. (Kaufman and Kraay 2023)

Hightech_FIO	The total ownership held by foreign institutions that have portfolios containing companies with average patent citations above the median. (FactSet/PATSTAT)
IMPORT/GDP	Imports of goods and services (% of GDP) of the investee's country. (World Bank)
IO_big_005	An indicator of whether the institutional ownership of any single foreign investors exceeds the threshold of 0.05%.
IO_big_01	An indicator of whether the institutional ownership of any single foreign investors exceeds the threshold of 0.1%.
IO_big_05	An indicator of whether the institutional ownership of any single foreign investors exceeds the threshold of 0.5%.
LEVERAGE	Total debt divided by total assets. (FactSet)
Log_SALES	Log value of total sales in £ million. (FactSet)
Longhor_FIO	The total ownership held by foreign institutions that have a portfolio average holding period above the median. (FactSet)
Lowtech_FIO	The total ownership held by foreign institutions that have portfolios containing companies with average patent citations below the median. (FactSet/PATSTAT)
MKTCAP/GDP	Market capitalization of listed domestic companies (% of GDP) of the investee's country. (World Bank)
MSCI	An indicator that equals 1 for all years if the focal firm is included in the MSCI All Country World Index, and 0 otherwise. (MSCI)
$Num\_Citation\_FC_{i,j,t}$	The log value of 1 plus $RNum\_Citation\_FC_{i,j,t}$
Num_Citation_other	The number of citations of patents applied by those other than public companies and universities such as individual applicant(s). (PATSTAT)
Num_Citation_Public	The number of citations with the cited patents applied by at least one public company in our sample.
Num_Citation_uni	The number of citations of patents applied by a university. (PATSTAT)
Patent Transfer	The number of patents granted to a firm whose inventors are from a particular foreign country.
PROP RIGHTS PROTECTION	An index constructed in Ginarte and Park (1997) and updated in Park (2008) that indicates how strongly patent rights will be protected in a country.
RD_EXP	R&D expense divided by total assets. (FactSet)
$RNum\_Citation\_FC_{i,j,t}$	The non-repetitive count of patents registered in a foreign country *j* that firm *i* cites in its patent applications in year *t*. (PATSTAT)
RULE OF LAW	Rule of law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular, the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. (Kaufman and Kraay 2023)
Shorthor_FIO	The total ownership held by foreign institutions that have a portfolio average holding period below the median. (FactSet)
STOCK_RETURN	Fiscal-period-end stock price of current year divided by fiscal-period-end stock price of the previous year. (FactSet)
TANGIBILITY	Net property, plant, and equipment divided by total assets. (FactSet)
TOBIN_Q	Market capitalization divided by total assets. (FactSet)
Treaty_firm_US_Pair	An indicator variable that equals 1 for firm–foreign country pairs in which the firm is domiciled in countries that have tax treaties with the US and the foreign country is the US, and 0 otherwise.

Appendix 2: Data Structure and Variable Measurement of CHINO Corp in the year of 2018, an investee firm located in Japan

Foreign Country *j*	Number of Citations of Patents cited from the foreign country (*Num_Citation_FC)*	Institution/Fund from the foreign country	Ownership by each institutional investor from the foreign country	Total ownership from the foreign country (*FIO*)
US	**8**	1. JOHN HANCOCK TR INTL S	0.0043197	
		2. EQ ADVR TR PUTNAM INTL E	0.0043197	
		3. DIMENSIONAL GLOBAL CORE	0.0043197	
		4. FLORIDA STATE BOARD ADMI	0.0107991	
		5. TA WLD EX US CORE EQUITY	0.0107991	
		6. OLD WESTBURY GBL SML&MID	0.0140389	
		7. DFA INTL SOCIAL CORE EQ	0.0151188	
		8. JOHN HANCOCK FDS II INTL	0.0161987	
		9. DFA WLD EX US TARGTD VAL	0.0183585	
		10. METROPOLITAN SER-MET DIM	0.0291577	
		11. DIMENSIONAL FDS PLC GBL	0.0302376	
		12. DFA INTL CORE EQUITY FUN	0.0334773	
		13. DFA INTERNATIONAL VECTOR	0.0356371	
		14. DFA INTL SML CAPITAL VAL	0.1090713	
		15. DFA INTL CORE EQUITY POR	0.1436285	
		16. DFA JAPANESE SMALL CO SE	0.4006479	**0.8801296**
CN	**2**	-	-	**0**
AU	**0**	DIMENSIONAL PAC BAS SML	0.0064780	**0.0064780**
FR	**0**	LYXOR ETF JAPAN (TOPIX)	0.0251620	**0.0251620**
KR	**0**	-	-	**0**
DE	**0**	-	-	**0**
NL	**0**	-	-	**0**

Note: Of the countries covered by PATSTAT, we first identify seven potential candidate countries (other than Japan) from which CHINO might cite patents based on whether CHINO ever receives non-zero institutional holdings from this country or ever cites any patent originating from this country during our sample period of 2000-2019. In 2018, CHINO cited 10 unique patents registered outside Japan when filing its own patent applications. We link the 10 patents to each of the seven candidate foreign countries identified earlier and expand the single CHINO-2018 data point into seven firm-foreign country pairs for the year of 2018. For example, for the CHINO-US-2018 observation, *RNum_Citation_FC* is 8 as CHINO cites eight US patents. The test variable *FIO* is 0.88% because at the beginning of 2018, CHINO had shares owned by 16 institutional investors from the US with total holdings of 0.88%. For the CHINO-CN-2018 observation, *RNum_Citation_FC* equals 2 with *FIO* equal to 0 due to no Chinese holdings. For CHINO-Korea-2018, both *RNum_Citation_FC* and *FIO* are 0 due to the absence of Korean institutional ownership and citations of Korean patents.

Appendix 3: Sample Selection and Summary Statistics for the JGTRRA Sample

Panel A: Sample Selection

Steps	Unique Firm	Unique Firm-Year	Firm-Foreign Country-Year
Final full sample for the panel analysis	18,380	222,596	3,156,327
Drop US firms and firms that are not domiciled in countries that have tax treaties with the United States and those that do not pay dividends in 2002	(14,701)	(162,021)	(2,070,597)
Drop years 2007–2019	-	(39,447)	(719,713)
Drop firms either with only US or non-US country as relevant foreign countries	(70)	(388)	(906)
Final sample for the JGTRRA analysis	3,609	20,740	365,111
Among which:			
Firm-US-year observations (Treated)	3,609	20,740	20,740
Firm–non-US foreign country–year observations (Control)	3,609	20,740	344,371
Observations dropped in the regressions due to being singletons	(2)	(350)	(24,415)
Final sample used for estimating the regressions of the JGTRRA analysis	3,607	20,390	340,696

Panel B: Summary Statistics

	Mean	Median	Std. Dev.	Min	P25	P75
RNum_Citation_FC	3.28	0	46.65	0	0	0
US_FIO	0.06	0	0.24	0	0	0
CLOSE	0.17	0	0.24	0	0	0.30
FXSALES	0.27	0.14	0.31	0	0	0.48
log_SALES	6.33	6.22	1.75	0	5.05	7.50
log_cap_lab	0.07	0.04	0.12	0	0.01	0.08
TOBIN Q	0.92	0.60	1.08	0	0.32	1.09
FCF	0.01	0.01	0.08	-1.26	-0.03	0.04
LEVERAGE	0.21	0.20	0.16	0	0.07	0.32
CASH	0.14	0.10	0.12	0	0.05	0.18
TANGIBILITY	0.32	0.30	0.18	0	0.18	0.42
DIO	4.18	0.98	7.56	0	0	4.63
STOCK RETURN	0.16	0.05	0.49	-0.81	-0.12	0.34
RD_EXP	0.02	0	0.03	0	0	0.02
GOV EFFECTIVENESS	1	1.16	0.71	-0.16	0	1.54
RULE OF LAW	0.96	1.21	0.71	-0.60	0.12	1.41
PROP RIGHTS PROTECTION	4.43	4.67	0.41	3.16	4.33	4.67
GDP_PER_CAPITAL	3.24	3.59	0.90	0.38	3.38	3.66
MKTCAP/GDP	0.80	0.74	0.42	0	0.49	1
CREDIT/GDP	1.33	0	1.42	0	0	2.88
EXPORT/GDP	0.25	0.21	0.14	0.11	0.14	0.34
IMPORT/GDP	0.23	0.23	0.13	0.10	0.12	0.29
Diff_Culture	0.71	1	0.45	0	0	1
Diff_language	0.92	1	0.27	0	1	1
Geo Distance	6.76	8.11	4.26	0	2.10	9.60

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