

Returnee Inventor, Knowledge Spillover and International R&D Collaboration

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Abstract

This paper reconciles two recent trends in corporate innovation and skilled labor investment: growing cross-border recruitment of R&D workers and declining international R&D collaboration. Using patent data, I show that when Chinese firms hire patent inventors returning from abroad (“returnee”), they reduce cross-border R&D collaboration in technologies where the returnee has expertise in, while domestic patenting in those technologies rises. This reduction in R&D collaboration is accompanied by a drop in cross-border knowledge flow, measured by foreign patent citations, with no decline in domestic citations, and is concentrated in fields with strong prior international ties. Focusing on corporate groups with multiple establishments, I find that after a returnee joins, the establishments for external R&D experience a greater fall in international R&D collaboration than the internal R&D arms. This indicates that returnees substitute for international R&D collaboration, shift innovation toward domestic teams, and reduce outward knowledge flow at both the establishment and corporate group level.

Keywords: Innovation, Return Migration, Knowledge Spillovers, Human Capital Investment

JEL Codes: G32, O32, O33, O34, F22

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Recent immigration policy shifts are creating unprecedented uncertainty for skilled workers and the innovative firms that rely on them. For instance, in September 2025, the US government imposed a \$100,000 fee for new H-1B skilled worker visa applications prompting many employers and international researchers to rethink their prospects and options.² This increase in policy uncertainty can have important implications for global talent flows.

At the same time, recent studies show that international R&D collaboration, especially between the US and China, is declining (Jia, Roberts, Wang & Yang, 2022; Ramirez & Thompson, 2023; Tang, 2024). This downward trend may threaten the exchange of knowledge that has been an essential driver of scientific progress for decades.

This paper connects these two observations by demonstrating that returning immigrants contribute to the decline in international R&D collaboration and reshape the innovation strategies of the hiring firms in their home country.

While immigrants are widely recognized in the literature as knowledge brokers who facilitate international R&D collaboration by leveraging their connections (Wagner et al., 2018; Bernstein et al., 2022), whether the same reasoning applies to returning immigrants depends not only on the quality of the returnees but also on firm-level incentives. Negative selection among returnees may reduce their effectiveness as knowledge sources (Borjas & Bratsberg, 1996; Agrawal et al., 2011; Alnuaimi et al., 2012), and from the demand side, firms weigh the pros and cons of international collaboration. Although R&D collaboration can provide valuable access to external resources and expertise (Guan and Yan, 2012; Wagner et al., 2018; Bernstein et al., 2022), it also involves substantial costs, such as the challenges of coordination and communication, the risk of exposing proprietary knowledge (Hsieh et al., 2018; Mathew et al., 2023; Roach and Cohen, 2013; Wang, 2024), and the potential constraints imposed by joint intellectual property arrangements on firms' strategic flexibility (Lampe and Moser, 2012). Whether returnees ultimately lead to an increase or decrease in international R&D collaboration within the hiring firm remains an empirical

² See news coverage for example: <https://www.bbc.com/news/articles/cm2zk4l8g26o>

question

This paper focuses on the Chinese immigrant patent inventors who returned to their home country (“returnees”) and investigate the innovation of the hiring firms located in China, which is at the center of many policy debates.

I first show that after returnees’ return to their home country, the firms that hire them show a significant reduction in international R&D collaboration within technology fields that overlap with the returnees’ expertise (“returnee technologies”). On average, a new patent filed by the hiring firm features 0.23 fewer foreign-based inventors and is 1.5 percentage points less likely to involve any foreign-based inventor.

This drop in R&D collaboration is not a result of firms shifting away from the development of the returnee technologies. Instead, there is an increase in domestic innovation activities in the returnee technologies: a rise in the annual patent count by domestic inventors at the hiring firm, accompanied by an increase in the number of active domestic inventors.

Declining international R&D collaboration may reduce cross-border knowledge flows. Prior literature demonstrates that international R&D collaboration facilitates the diffusion and exchange of knowledge (Guan and Yan, 2012; Acosta, Coronado and Medina, 2024; Wang, 2024). To empirically test whether knowledge flows are reduced, I decompose the citations received by patents from the hiring firms into those originating from within China (“domestic citations”) and those from foreign firms (“foreign citations”). This leverages the dual role of patent citations in capturing both the quality of innovation and the flow of knowledge (Hu, 2003; Roach and Cohen, 2013). The results reveal that following the arrival of a returnee inventor, patents filed in returnee technologies experience a significant decrease in total citations, which is entirely due to a decline in foreign citations. The steady domestic citations suggest that the observed drop does not stem from declining patent quality but reflects a contraction in international knowledge flows.

To provide further evidence that the decline in international knowledge flow is linked to the decline in international R&D collaboration, I next distinguish between technologies with above or below-median levels of international R&D collaboration intensity before the

returnee joined. International R&D collaboration intensity is measured by the share of foreign-based inventors per patent prior to the returnee's arrival. For technologies that were not highly internationally collaborative to begin with, there is little impact on foreign citations. However, for technologies that used to rely heavily on international R&D collaboration, there is a significant fall in foreign citations. Having more ability to develop a technology internally, thanks to the returnee, means patents can focus more on domestic needs and, due to the less international collaborations, they may attract less attention from foreign inventors.

Many firms have multiple branches or locations. Because the patent data provides a variety of locations within the same corporate group, I can ask a deeper question: When a returnee inventor is hired at one location, does it affect innovation in the other establishments of the same institution?

Although the average spillover effect to other establishments within the same institution appears minimal, a closer look reveals important heterogeneity linked to the nature of the R&D unit. Using pre-arrival international collaboration patterns as a proxy, I classify the non-hiring establishments within the same firm into external R&D establishments, those frequently engaged in international R&D collaboration innovation, and internal R&D establishments focused on domestic activities. Firstly, returnees typically join the **internal** R&D establishment (78%). Secondly, the analysis shows that after a returnee joins, external R&D establishments experience a greater decline in international R&D collaboration than the hiring establishment, both along intensive and extensive margins. By contrast, when compared to internal R&D establishments, the reduction in international R&D collaboration is most pronounced at the hiring branch. These results suggest that the arrival of returnees triggers differential reaction in cross-border innovation activities within a company, stronger among units that were previously more internationally engaged, while the impact is more localized for those focused on domestic R&D, with weaker spillover effect.

The evidence so far indicates that the return of immigrant inventors is linked to increased domestic innovation, reduced international R&D collaboration, and decreased international

knowledge flows. However, it remains challenging to prove that these changes are directly caused by the arrival of returnees.

One important concern is the rise of technology nationalism, efforts by governments to protect sensitive technologies, which may drive the return of immigrant researchers and contribute to reduced international R&D collaboration and knowledge flow. These restrictions can result in inventors and patent examiners becoming less aware of foreign technological advances, as reflected in the notable decline of foreign citations for sensitive technologies. When returnee inventors work in fields that strongly overlap with these protected technologies, it is likely that external policy factors, rather than the returnees themselves, are causing these shifts in collaboration and knowledge exchange.

This concern can be alleviated through subsample analyses that focus on the technologies and time periods less affected by the global tensions in recent years. I show that after excluding the top 10 most frequent returnee technologies, the decline in international R&D collaboration persists. Similarly, the findings hold after restricting the sample period to before 2018, when the Trump administration launched the China Initiative, which increased the cost of US-China collaborations (Aghion et al. 2023). The effects are also similar for immigrants returning from neighboring countries of China, rather than the West. These findings together suggest that the results are not driven by some specific technologies, global sentiment turning against collaboration in the recent years, or US policies.

Another concern is that hiring a returnee inventor is an endogenous decision that might be part of broader changes in the hiring company's innovation strategy. Subsequent changes in innovation output and international collaboration might be due to these other changes, rather than due to the returnee. Although hiring a returnee inventor shows that the firm believes it to be worth the investment, it remains an empirical question how large the effects of the returnee inventor actually are.

The first step to alleviating this concern is by plotting the effects over time. The time trend has a visible discontinuity around the estimated arrival of the returnee, suggesting that the drop in international R&D collaboration happens after the returnee joins. Secondly, the

results still hold when I restrict the sample to firms having more than two returnee-hire at different points of time. In this case it is harder to believe that there are multiple rounds of planning within the short period of sample period and each of the shift in innovation strategy happen exactly when the returnee arrives at the company. Even if that is the case, it would suggest that the timing of the arrival of the returnee is an important factor in the strategic planning. These mitigations do not completely rule out endogeneity, but this paper offers a first step toward understanding how returnee inventors influence firm innovation strategies and their relationship to the decline in international R&D collaboration.

The rest of the paper proceeds as follows. Section 1 summarizes the relevant literature and highlights the contribution. Section 2 introduces the data and sample construction. Section 3 describes the empirical framework. Section 4 presents and analyses the main findings on international R&D collaboration. Section 5 discuss the potential mechanism and consequences. Section 6 addresses potential concerns. Finally, Section 7 concludes.

1. Literature Review

This paper connects several strands of literature. First, this paper directly contributes to the recent discussion on the evolving interdependence and decoupling of US–China R&D collaboration. Recent empirical studies have documented a sharp decrease in scientific co-authorship, joint grant activity, and collaborative output between the two countries, particularly in the wake of policy actions such as the China Initiative and more stringent research security rules (Jia et al., 2024; Aghion et al., 2023; Xu, 2023) This paper contribute by adding a potential agent that facilitates these changes – returning immigrants. When immigrant researchers return, companies and research organizations in their home country benefit from their knowledge and shifts innovation strategy. This reduces the home country’s dependence on foreign collaboration.

Second, from the broader literature on innovation and immigration, earlier work has shown that immigrants typically act as brokers for transnational collaboration, leveraging their international networks to foster knowledge exchange between their home and host countries (Wagner et al., 2018; Bernstein et al., 2022). When the migrant is residing in the destination country, their knowledge can be transmitted through the ethnic network from

the destination country to the home country, commonly referred to as the brain bank effect (Agrawal et al., 2011; Wagner et al., 2018; Fackler, Giesing, and Laurentsyeva, 2020).

In this context, returning immigrants, by virtue of their experience and connections, are presumed to potentially initiate new cross-border ties upon their return. Evidence from Cao (2020) and Li (2024) supports this argument by showing that returnees tend to maintain and leverage their international professional networks. However, both studies focus on academic researchers publishing scientific papers. There is a lack of evidence regarding patent inventors, where the cost and complexity of collaboration is higher due to the need to negotiate shared ownership and distribution of profits from joint intellectual property. Thus, the incentives and practical barriers for maintaining or initiating international R&D collaborations may differ substantially in patenting compared to academic publishing.

It also places these effects within the broader debate over inventor quality and returnee selection in the literature of innovation and immigration: studies have suggested returnees might be negatively selected and thus less effective as knowledge sources (Borjas & Bratsberg, 1996; Agrawal et al., 2011; Alnuaimi, Opsahl, & George, 2012). Yet recent studies from China find mixed results regarding returnee productivity (Li, Miao, & Yang, 2015; Yang & Marini, 2019; Li & Tang, 2019; Yang, Cai, & Li, 2022; Marini & Yang, 2021; Shi, Liu, & Wang, 2023). While much of this literature has focused on policy or individual productivity, this research adds new granularity by revealing how changes induced by return migration spill over within multi-establishment firms, affecting both collaboration-oriented and internal-R&D branches, and by documenting these patterns using large-scale patent and citation data.

Finally, in line with prior research that suggests international R&D collaboration as an important channel for global knowledge flow (Guan & Yan, 2012; Hu, 2003; Roach & Cohen, 2013; Iaria, Schwarz, and Waldinger, 2018; Wang, 2024), this study shows the loss of foreign collaboration after a returnee's arrival results in a drop in knowledge diffusion from China to other countries, as captured by declining foreign citations to Chinese patents. These findings confirm and extend the established literature: international networks enhance global impact, and their removal produces immediate consequences for

knowledge transfer and scientific exchange across borders.

2. Data and Sample Construction

The primary data source for identifying returnee inventors and the innovation output of China-based firms is the PATSTAT Global 2024 Autumn version. PATSTAT contains bibliographical patent data, including the location of patent applicants³ and inventors. Coverage begins in 1984 for Chinese applicants and inventors and extends back to 1900 for more advanced economies such as the US and UK.

2.1. Identify Returnee Inventors

Patent application records allow us to track inventor locations over time, a feature commonly used in studies of inventor mobility (e.g. Miguelez and Fink, 2013; Akcigit et al., 2016; Hombert and Matray, 2017; Prato, 2022; Wang, 2022; Sharoni, 2023; Wehrheim et al., 2023; Lissoni et al., 2023).

To identify the cross-border movements of patent inventors, I start with inventors who have filed at least two patent applications—one while residing in China and another while located in a different country. In cases where location information is missing, I supplement it using Rassenfosse and Seliger's (2021) imputation on inventor and applicant country codes. I also further supplement the country code by extracting relevant information from the raw address, and by inferring location from the country code of the patent applicants.

A Chinese returnee inventor must meet two conditions: first, they must relocate from a foreign country to mainland China, indicated by filing at least one patent in another country followed by one in China; second, the inventor must have a Chinese first and last name (Pinyin format). Detailed steps for identifying Chinese returnee inventors are described in the appendix.

This definition has limitations. First, it includes only individuals with at least two patents, excluding, for example, those who studied abroad but had not filed a patent before

³ Patent applicants, or "Assignees" in the context of USPTO registered patents, include companies and research firms such as universities and hospitals.

returning to China. The study's scope is thus limited to examining the impact of returnee inventors with prior foreign patenting experience. Second, the definition is based on ethnic background rather than nationality, similar to studies on immigrant inventors (see Kerr, 2008; Foley and Kerr, 2013). By requiring a Chinese Pinyin first and last name, it may include some inventors originating from outside of mainland China, such as Hong Kong, Macau, Taiwan, or Southeast Asia. It may also exclude some inventors who adopted a Western first name. This is a trade-off between including more potential returnee inventors and reducing measurement error by adding the foreign-born Chinese who do not fit the precise definition of returning immigrants.

2.2. Identifying Hiring Firms in China

In addition to inventor information, patent applications contain data on the applicant. Applicants are non-individual institutions, including companies, universities, and hospitals. If an inventor files a patent for an applicant holding the patent's property rights, I assume that the inventor works for that institution.

The hiring firm is defined as the first China-based⁴ non-individual patent applicant for which the returnee inventor files a patent after return and is classified as a "company" by PATSTAT. Around 20 percent of returnee inventors lack a Chinese-based non-individual hiring institution. For those that I can identify the hiring entity, 85% joined a company. In cases of multiple patent applicants, all applicants are considered hiring firms, allowing a returnee inventor to be associated with multiple hiring firms. This approach may introduce measurement error and attenuation in the results.

Similar to the information on inventors, PATSTAT also reports the address of the hiring firm. Because a later part of the study requires a differentiation between the hiring establishment and other establishments to study the within-institution spillover effect, it is necessary to know the hiring firm's location so that I can identify which establishment within the hiring firm group experiences a direct shock. However, the applicant's address

⁴ China-based means it must be physically located in China, but I do not exclude the Chinese division of international companies such as IBM. Patents within a China-based institution is limited to only patents filed by the establishments located in China.

in PATSTAT usually represents the location of the headquarters, not the actual location of the research facility. Therefore, I use the location of the inventor instead of the applicant to redefine the hiring firm's location. The hiring firm's operations in different provinces are, thus, tracked through patents filed by inventors located in those provinces, defining an institution-province pair as an "establishment". For example, if a returnee inventor files patents for "Huawei Technologies" in Zhejiang province upon returning from the US, I define Huawei's Zhejiang establishment as the hiring establishment. Huawei's Zhejiang establishment is defined by aggregating all patents filed by inventors located within Zhejiang province whose patent applicant name is "Huawei Technologies".

It is noteworthy that the definition of "hiring firm" excludes entrepreneurial firms established by returnee inventors. From the patent data, I infer entrepreneurial firms as those that began patenting activity only after the arrival of the inventor. In fact, around 40% of hiring firms fall into this category. However, these firms are not the focus of this study and are excluded from the analysis due to their lack of pre-return patents for before-after comparison. The rationale for this requirement will be explained in more detail in Section 3.

In addition, in the final sample, I exclude hiring firms that employed more than ten returnee inventors. As will be explained in more details in Section 3.2 when I elaborate the empirical framework, this exclusion is mainly to avoid having results disproportionately influenced by a small number of large organizations that create hundreds of duplicates per technology-year in innovation measures. In unreported tables, I include them with a frequency-weight that gives a lower weight to those with more returnee arrival events, and find the findings hold.

2.3. Measuring the return event and arrival date

Determining when a returnee inventor joins the hiring firm presents an empirical challenge. While the patent data provides timestamps for an inventor's work with each applicant, the exact relocation date between two patents is unknown. While the relocation must happen between the date when last patent is filed while the inventor is in a foreign country and the date when the first patent is filed while the inventor is working for the hiring firm, I need to

make a guess of the actual arrival date. For most of this paper, I define the joining date as the filing date of the first patent for the hiring firm because this is a date on which it is certain that the returnee is working for the hiring firm. In unreported tables, I replicate the results by defining the arrival date as the midpoint between the last foreign patent and the first Chinese patent to allow for time to relocate and create a new patent. This variation does not significantly impact the results.

I restrict the arrival date of returnee inventors to between 2001 and 2016. There are few qualifying return events detected prior to 2001, and the 2016 cutoff ensures that there are at least 7.5 years of patenting activity observed after the returnee's arrival, since the main target of analysis is the hiring firm. This design also addresses the potential issue of a mechanical drop in the count of returnee inventors, as the likelihood increases—closer to 2024—that a returning inventor has not yet filed their first patent in China. Notably, the caveat remains: the later the sample period, the higher the likelihood of underestimating the total number of immigrants returning to China, particularly those who are less active patent filers. To address this, I demonstrate robustness by limiting the sample to arrivals between 2001 and 2012, as discussed in Section 5. It is also noteworthy that this period precedes the launch of the China Initiative by the Trump administration in the US in 2018.

Fig. 1 illustrates the trend of these arrivals. I plot the trend when the arrival year is measured by the filing date of the first Chinese patent post return, which is the main definition used in the rest of this paper. There was a rapid increase in return events from 2001 to 2007, followed by a fluctuation over the next decade.

2.4. Final Sample

I further require the returnee inventor to have at least one hiring firm⁵, filed at most 1000 patents⁶, and have a less than 10-year gap between the foreign and China-located patent

⁵ It is possible that after returning to China, some inventors still file patents, but these patents do not have a non-individual applicant. In this case, it is impossible to identify the hiring firm.

⁶ Random sampling and manual check has revealed that in the rare cases when an inventor is associated with more than 1000 patents, it is very likely a result of measurement error. The error can come from the inventor identifier disambiguation process, or other data errors.

that defines the return⁷. The final dataset used in Section 4 includes 11,417 returnee inventors, and 9,794 hiring firms, forming 12,549 pairs. The sample spans 2001 to 2016 for joining years, allowing sufficient post-return tracking of hiring firms' innovation, especially regarding patent citations. For the analysis of hiring firms, I examine the period between 1993 and 2024, the last year for which the PATSTAT Global 2024 Autumn version contains coverage of China.

Table 1 provides an overview of the sample composition. In Panel A, we observe that the United States is the primary source country for returnees, accounting for approximately 69% of all returnees. Panel B lists the top 10 most common 3-digit International Patent Classification (IPC) codes among returnees. These technologies span a wide spectrum of technology fields. Panel C and D lists a few examples of hiring firms. Panel C lists the top 10 most frequent hiring firms. These firms are not limited to Chinese companies: There are top research firms such as the Chinese Academy of Sciences, and foreign companies such as IBM that has an operation in China. Panel D shows the hiring firms that hired 10 returnees. As mentioned earlier and it will be elaborated more in Section 3.2, only hiring firms hiring 10 or less returnees will be included in the empirical tests.

More technical details regarding sample construction can be found in the Appendix.

3. Empirical design and measures of innovation

To uncover how the arrival of returnee inventors reshapes innovation strategies and international R&D collaboration within the hiring firms, I leverage patent-based proxies to track changes in collaboration, invention activity, and innovation strategies. Patent records provide rich and globally comparable information on technology development, inventor mobility, team structure, and knowledge diffusion.

⁷This is to reduce the estimation error of the return year in the regression sample, which will be used in the event study style analysis.

3.1. Measuring Innovation Outcomes

Innovation output is primarily measured at the patent family level (in short, I call it “patent level”). Using patent families as defined in the PATSTAT database—a collection of patent applications filed across jurisdictions that all cover the same invention and share a common priority—enables more accurate tracking of unique innovations, avoiding inflation from duplicate filings in multiple countries. (Dechezleprêtre, Ménière, and Mohnen, 2017)⁸.

The primary outcome variable in this study is the extent of international R&D collaboration, measured at patent level to infer the change in team location composition, and aggregated at technology (3 digit- IPC) level to represent the average international R&D collaboration per patent within each technology classification. International R&D collaboration is measured along two dimensions. First, the extensive margin is the percentage of patents in a given institution–technology–year cohort that include at least one foreign-based inventor; this metric identifies the breadth of cross-border inventive partnership (Kerr & Kerr, 2018). Second, the intensive margin is the average number of foreign inventors per patent; this captures the depth of international involvement in each patent. These measures are constructed consistently for all periods before and after the returnee’s arrival, allowing for direct tracking of shifts in both the frequency and intensity of cross-border collaboration as the immigrant inventors return.

To show if the hiring firms are changing innovation intensity in different technology fields, I track annual patent counts and annual active inventors counts. These are measured at technology field level (based on 3-digit IPC). I further decompose the patent counts into the number and proportion of patents involving any foreign located inventor, and those involving all domestic inventors. To track active inventor counts, I compute the total count, and also the number and proportion of domestic and foreign located inventors for each technology class. These measures can shed light on the hiring firm’s human capital involvement in each technology class.

⁸Note that I use all available information regarding patent applications to infer the returnee inventors. This is to ensure that I fully utilize the abundance of information including from different filing documents of the same innovation.

Measuring the change in innovation direction is embedded in the empirical framework detailed in the next section, as I compare the effect of the returnee on the hiring firm's innovation in the returnee technology classes against that in other technology classes. A difference in patenting intensity between these two types of technologies has implications for which direction the hiring firm is innovating more in.

Another key dependent variable is patent citation, which is used to investigate shifts in patent quality and also capture the change in knowledge flow. Following the literature, I define citation as the number of times this patent has been cited (by other patent families) within a 3-year window⁹ since the earliest filing date of this patent. I further compute a scaled citation measure, which is defined as the ratio of (a) the number of citations received within 3 years since the filing date of the patent (excluding self-citation) to (b) the average number of such citations within the focal patent's cohort of filing year, technology class and filing year.

3.2. Empirical Framework

I start by describing the change in innovation patterns of the hiring firms as one entity after a returnee inventor arrives. In the baseline analysis, I examine, for each “hiring firm × returnee” pair, whether the hiring firm changes its innovation activity following the joining event. I not only examine the period before and after the arrival of the returnee, but also compare the divergence in trends between the hiring firm's innovation in technologies overlapping with the returnee's knowledge set (“Returnee Technologies”) and technologies unrelated to the returnee (“Other Technologies”).

The returnee's knowledge set is defined using the set of patents they filed in the 20 years preceding their return. For each returnee, I count how often each technology class appears among these patents and include in their knowledge set any technology class that appears more than twice. The key benefit of this approach is that it is more likely to capture the core expertise that the returnee can most meaningfully contribute, reducing noise from

⁹ Note that the finding is robust to alternative definitions such as a 5-year window. The key reason for using 3 rather than 5 is because of the potential data truncation issue. Patents filed later in the sample will be less likely to have observation of citations in 5 years' time. In addition to having a shorter citation window, I further include a technology-year fixed effect to address this potential issue.

incidental or marginal areas. However, its main drawback is the reduction in the number of observations because the returnee needs to file at least 3 patents to enter the baseline test. As a robustness check, I show in Appendix Table A1-A3 that the main results remain consistent when I instead define the knowledge set to include all technology classes represented in the returnee's pre-return patents. This comprehensive mapping of the returnee's technical exposure allow us to study more inventors, especially those less frequent ones, while the downside that it may introduce more noise, incorporating fields in which the returnee has only shallow or incidental involvement, and thus potentially diluting the estimated impact on innovation patterns within the hiring firm.

This empirical design resembles a difference-in-differences approach, where the returnee technologies within the hiring firm serve as the “treatment” group, while the institution's other technologies act as a “control” group. The rationale behind this comparison is that returnees are most likely to contribute significantly to areas aligned with their prior expertise. However, it is important to note that this analysis does not necessarily yield a causal effect, and I do not impose the parallel trend assumption typically required for causal inference in standard difference-in-differences studies. Instead, observing the patterns that prior to the returnee's arrival is equally important, as this can reveal pre-return selection effects and shed light on how returnees and hiring firms match with one another, which remains an underexplored area in the literature.

I compare the post-arrival change in the hiring firm's innovation in the returnee technologies and non-returnee technologies by estimating the following linear regression:

$$\begin{aligned} \text{Innovation Measures}_{i,j,k,t} &= \alpha + \beta_1 * \text{Returnee Tech.}_{i,j,k} * \text{Post}_{i,j,t} + \beta_2 * \text{Returnee Tech.}_{i,j,k} \\ &+ \beta_3 \text{Post}_{i,j,t} + \text{Controls} + \alpha_{k,t} + \alpha_{i,j} + \varepsilon \end{aligned} \quad (1)$$

In Equation 1, the subscript i identifies a returnee inventor, j a hiring firm, k a technology class (based on 3 digit IPC), and t the year.

The key coefficient of interest is β_1 that captures the interaction effect between returnee technology dummy and the post arrival dummy (“Post”). This coefficient captures the

differential trend between the development of returnee technologies and other technologies following the arrival of the returnee.

I include a technology-year fixed effect to remove any time-varying shocks or policy interventions that may differentially affect specific technology classes in specific years, independent of the returnee's arrival at a given institution. For example, contemporaneous national or international policy changes—such as US export controls, targeted trade restrictions, or government funding priorities—can impact the overall innovation climate, growth trajectory, or international R&D collaboration opportunities within certain technology fields across China as a whole. It also addresses the data truncation issue in the citation measures towards the end of the sample period.

The pair fixed effect absorbs all time-invariant characteristics shared by both the hiring firm and the returnee inventor. It controls for persistent features of the institution such as organizational culture and baseline technological capability, and characteristics of the returnee such as gender, abilities, background. This fixed effect ensures that the variation comes only from within-pair, effectively comparing changes in collaboration and innovation strategies in returnee technologies against the changes in other technologies not directly impacted by the returnee's arrival within the institution.

Returnee Technology is a dummy variable equals to 1 if, for a given institution-technology, the technology class overlaps with the returnee's knowledge set, inferred by their pre-return patent classifications. This is unique at pair-technology level because the overlap is measured between the returnee-institution pair. This implies that the unit of analysis in this study is returnee-institution-technology-year. If the institution has multiple returnees, it will appear multiple times in the sample. The potential issue of duplicates in observations (as technology is institution's technology) is addressed in two ways. First, I cluster standard error at hiring firm – year level so that inference is robust to within-institution correlation and any mechanical duplication across returnee-institution pairings. Standard error is also clustered at the pair level to account for correlation across time and technologies within each returnee-institution pair. Second, I exclude hiring firms that employed more than ten returnee inventors. This exclusion

balances the need to avoid having results disproportionately influenced by a small number of large organizations, which could introduce excessive duplication, against the benefit of retaining prominent firms and research firms—such as the Chinese Academy of Sciences or Huawei Technologies Company—that play a key role in the innovation ecosystem. Firms having more than the ten-returnee threshold comprise only 1.1% of all hiring organizations in the sample, so their removal does not materially affect the external validity or generalizability of the study’s findings. Importantly, eliminating these firms helps ensure that observed effects are more cleanly attributable to individual returnee events, rather than confounded by simultaneous arrivals of multiple returnees within the same institution and time period.

The time window of the analysis is within eight years before and eight years after the returnee’s arrival to include a broader range of hiring firms, especially those with less frequent patenting activity. This timeframe allows me to study the selection process of returnee inventors in the pre-arrival period while providing sufficient post-arrival observation to assess whether any effects associated with the returnee’s integration are sustained over the long term.

It is important to note that all analyses in this study EXCLUDE any patent filed by the returnee inventor herself. This design allows for the identification of knowledge spillovers from the returnee to the broader organization, rather than simply capturing the mechanical effect of adding another inventor to the institution’s patenting team. In cases where an institution previously collaborated with the returnee while they were based in another country and continues to do so after their return, any resulting drop in international R&D collaboration due solely to this change in the inventor’s location is not captured in the estimates.

3.3. Summary Statistics

Table 2 provides summary statistics describing the sample. Panel A reports characteristics of hiring events and hiring firms. The "Patenting Gap" variable captures the number of years between a returnee’s first patent with the hiring firm and their last patent filed prior to returning to China. The median gap of 1 year indicates these returnees patent frequently

and helps address potential alternative definitions of the arrival date. The median company hired only one returnee inventor during the sample period, while the mean is 2.25. Approximately 7% of hiring events involve relocation within the same corporate group, as indicated by the “Same employer” variable. The majority of hiring firms have less than five years’ patenting experience (“Young”, 58%). It should be noted that the categories firm, university, government, non-profit, and hospital are not mutually exclusive.

Panel B presents patent-level characteristics for patents filed by the hiring firm. The average patent lists 5.59 inventors, including 1.31 foreign inventors and 3.81 domestic inventors. Nearly 25% of these patents have at least one foreign-located inventor, underlining the prevalence of international patent collaboration in China. Panel C summarizes team composition within an average technology class. Each year, an average of 15.32 inventors is active per technology class, with 5.51 patents filed. Panel D reports summary statistics at the establishment level, where the number of observations triples, as measures are now assessed for each establishment.

4. The decline in international collaboration

4.1. Main results

Table 3 shows that following the arrival of a returnee inventor, the hiring firm’s patents in returnee technologies experience a significant decline in international R&D collaboration, both on the extensive and intensive margins, relative to trends observed in other technology fields.

Column (1) estimates the change in the total number of inventors per patent. Before the returnee’s arrival, returnee technologies generally required, on average, 0.47 more inventors than other technologies within the same institution. However, after the returnee joins, this difference drops by 0.23 inventors per patent.

Columns (2) and (3) decompose this change by inventor location. Comparison of these columns reveals that the reduction in the number of inventors can be entirely attributed to a decline in foreign inventors. With an average patent in the sample having only 1.31 foreign inventors (standard deviation 3.8), a decrease of 0.22 foreign inventors per patent

is both statistically and economically significant. Column (4) reinforces the decline in international engagement by measuring the proportion of foreign-based inventors per patent. The average drop of 1.2 percentage points, from a baseline foreign inventor share of 11.9 percent, represents a substantial contraction in cross-border collaboration activities.

The results along the extensive margin are shown in Column (5), where the outcome is a dummy variable indicating whether a patent includes at least one foreign-located inventor. The -1.5% coefficient means the relative probability of filing a patent that collaborates with foreign inventors drops by 1.35 percentage points, out of a sample mean of 24.7 percentage points.

These findings contrast the existing evidence on immigrant inventors, who are generally recognized as information brokers and catalysts for new international R&D collaboration, using their networks and cross-border experience to facilitate knowledge exchange between their home and host countries (Bernstein et al., 2022; Wagner et al., 2018; Agrawal et al., 2011). Why are returnee patent inventors different?

A potential hypothesis behind the divergence of the findings is the tradeoff between the cost and benefits of international R&D collaboration. On one hand, international research partnerships enable both sides to access broader knowledge bases and capabilities, facilitate the recombination of ideas, and often spark new technology through the sharing of complementary resources and expertise (Guan and Yan, 2012; Wagner et al., 2018; Bernstein et al., 2022).

However, these benefits do not come without cost. Engaging in cross-border cooperation generally requires significant investments in coordination and communication, especially when collaborators are separated by language, institutional culture, and time zone (Hsieh et al., 2018; Mathew, Napolitano, and Rizzo, 2023). More importantly, collaborating on patent-related projects can require the disclosure of tacit knowledge and proprietary details, which may form the unique competitive advantage of a firm's R&D efforts (Roach and Cohen, 2013; Wang, 2024). There is an inherent risk that such disclosure could weaken a firm's position or erode the exclusivity of its technology. Furthermore, jointly developed intellectual property often leads to the need for profit-sharing and may constrain each

party's ability to fully capitalize on or further develop the technology independently, due to licensing, patent pooling, or contractual limitations. (Lampe and Moser, 2012)

Thus, while the knowledge-broker role of immigrant inventors would still apply to the returnee inventors, the value from this role is possibly smaller: During the period in which they reside overseas, returnees may have already established professional networks in both their home and host countries, as described in the literature on migrant-driven knowledge flows (Bernstein et al., 2022; Agrawal et al., 2011; Wagner et al., 2018). By the time these inventors return and are integrated into domestic firms, the marginal benefit of continued international R&D collaboration may be diminished.

The empirical results presented in Table 3 suggests a “substitution effect”, that the returnee's arrival substitutes the demand for international R&D collaboration. Assuming that the hiring firms are rationale, this implies that in those cases of hiring, the marginal cost of collaboration exceeds the marginal benefit. In other words, direct, proprietary access to the inventor's expertise and tacit knowledge is judged to be more valuable than the less exclusive benefits of international partnership.

4.2. Heterogeneity

This section investigates and addresses some key concerns regarding the previous analysis and provide a broader understanding of how different types of returnees or hiring firms experience different effects.

For illustrative purposes, I only show subsample results with the proportion of foreign inventors to represent the intensive margin, and the has-foreign dummy to represent the extensive margin. The unreported findings on total, foreign and domestic inventor counts remain consistent with the analysis.

Table 4 summarizes the findings. Panel A and B addresses the importance question on whether the findings are driven by returnees from the US (Column (2) and (3)), by internal relocation and remote working (Column (4) and Column (5)), by the most frequent set of returnee technologies that happen to be the target of national technology protectionism (Column (6)), or by the China Initiative (Column (7)). The findings suggest that the results

are not unique to inventors returning from the US, not completely driven by the most frequent set of technologies (top 10 in frequency) especially along the intensive margin and not driven by the post-2018 period (when returnee arrives before 2012).

It is noteworthy that Columns (4) and (5) check whether the effect persists when the relocation happens within the international institution. It is not surprising that the contribution of an inventor from within the institution could be fundamentally different, especially in terms of international R&D collaboration. Results show that the Chinese-located division of these multinational firms does not experience a significant differential impact on international R&D collaboration as the returnees move back to China. This is consistent with the trade-off elaborated in the previous section: for a domestic institution in China, international R&D collaboration can bring in access to knowledge, but at the cost of the externality of knowledge outflow and costly communication (Hsieh et al., 2018; Mathew, Napolitano, and Rizzo, 2023). A multinational company, with the returnee moving within it, does not subject to this cost, due to the existing knowledge exchange practice, and the diminished issue of knowledge and profit sharing. This finding also act as a sanity check to ensure that the negative findings come from any mechanical effects or biases introduced in the set up of this empirical design.

Columns (6) and (7) explore whether the contribution would be weaker for a temporary return. It is possible that some of these returnees, especially those who have worked for a long time in other countries, experienced reverse cultural shock and are not accustomed to the working environment in their home country. Could their contribution be lower compared to the ones that do not leave? The results in Panels A, B, and D suggest otherwise: these temporary returnees are as important as, if not more than, the returnees who stay. This could be related to the difference in quality: those who are able to relocate multiple times are those who have stronger abilities and are better paid to cover the cost. This finding implies that attracting the returnees to stay is of secondary importance compared to attracting inventors to return.

Panel C and D of Table 4 move on to explore the heterogenous effect from types of returnees and hiring firm. Column (1) and (2) explores young and established firms.

Because the age of the firms are not directly observable, I use the number of years of patenting experience as a proxy for age. Young firms are those that started patenting within 5 years before the arrival of the returnee, while established firms are those that have at least 5 years' patenting experience prior to hiring the returnee inventor. The combined results suggest that the change in intensive margin of international R&D collaboration is more significant for established firms, while the change in extensive margin of collaboration is more significant for young firms. This result is not surprising, as established firms often have a history of cross-border collaborations and internal capacity to selectively scale down the intensity of these relationships when internal knowledge and expertise increases. For such firms, the arrival of a returnee inventor leads to smaller but persistent international teams—reflecting a careful reduction in the depth of international R&D collaboration, but not its complete elimination. In contrast, young firms, which typically have fewer or less institutionalized international partnerships, may find it less beneficial to maintain any cross-border ties once a returnee provides in-house expertise. Consequently, these firms exhibit the most significant drop on the extensive margin; the probability of having any foreign collaborator on a patent falls as international involvement is abandoned rather than just reduced. This pattern aligns with the broader literature on firm heterogeneity and collaboration strategies, which shows that established organizations adapt existing global teams by reallocating and optimizing collaboration, while young firms respond more discretely, often opting for full internalization once key talent is secured (Oxley, 1999; Guan & Yan, 2012; Hagedoorn & Zobel, 2015).

Column (3) and (4) compares firms versus universities as the hiring firm. It is not surprising that the effect is much stronger to firms, as firms and universities differ fundamentally in their incentives and costs associated with international R&D collaboration. Universities, in contrast to firms, operate in an environment that places a premium on open science, publication, and knowledge dissemination. For academic researchers, the primary rewards of collaboration are academic reputation, publication, and scientific advancement rather than immediate financial gain. As a result, the costs and risks inherent in international R&D collaboration are considerably less pronounced for universities than for firms. This interpretation is consistent with the findings of Cao (2020) and Li (2024), who report that academic researchers publishing scientific papers (instead of patents) do not experience

declines in international co-authorship rates after returning.

5. Mechanism and Consequence

In this section, I investigate the shift in innovation strategies accompanied by the change in international R&D collaboration. Specially, whether firms respond by increasing domestic inventive activity in returnee technologies. Next, I assess the broader consequence for cross-border knowledge flows by analyzing changes in domestic and foreign patent citations, as well as the spillover effects within multi-establishment firms.

5.1. Strategic Shifts: From International R&D collaboration to Domestic Innovation

A decline in international R&D collaboration can simply be a bad sign, indicating that the hiring firm is shifting away from these returnee technologies. Although this does not explain why the hiring firms invest in the returnee inventors at the first place, it is an empirical question whether the arrival of the returnee inventor is also associated with a series of strategical changes in innovation activities and direction in the hiring firm.

Table 5 estimates equation (1) using patent counts and inventor counts at the technology class level, allowing a detailed understanding of innovation dynamics across fields. Note that as described in Section 3.2, all analyses exclude both patents filed by the returnee inventor and the returnee inventor herself, ensuring the focus is on knowledge spillover rather than the direct effect of adding an inventor who changed location.

Column (1) presents the annual patent count in each technology class, showing that after a returnee's arrival, there are, on average, 1.4 more patents per year in returnee technologies compared to other fields. This increase is driven mainly by domestic inventors, as revealed in Column (2). Column (3) shows that the proportion of domestic inventors in returnee technologies rises by 1.7 percentage points, underscoring the shift towards internal innovation.

Column (4) counts the total number of active inventors working on patenting in a technology class each year. Active inventor is defined by the sample of inventors whose name appears on the patents filed by the hiring firm within the year. This measure is only

a proxy that could underestimate the number of active inventors, as we don't directly observe the number of R&D employees. The finding further supports the idea that the hiring firm is actively developing the returnee technologies, rather than shifting away, while international R&D collaboration is declining. Returnee technologies each on average has 4.6 more active inventors than before, as compared to the trend in other technologies. Finally, Columns (5) and (6) highlight that the increase in inventive activity is primarily attributable to an increase in domestically based inventors.

The findings on the decline in international R&D collaboration, alongside the increase in domestic inventive activity within returnee technologies, collectively illustrate a strategic shift in innovation strategy by hiring firms—moving from reliance on external, cross-border collaboration to a greater emphasis on internal, locally driven innovation.

5.2. Cross-border knowledge flow

A key theoretical implication of declining international R&D collaboration is the potential reduction in cross-border knowledge flow.

In Table 6, I test and show that consistent with this prediction, there is a disproportionate decline in citations made from firms located outside of China to the new patents in returnee technologies, filed post arrival, as compared to the trend in other technologies. I decompose the citations received by patents from the hiring firms into those originating from within China (“domestic citations”) and those from foreign firms (“foreign citations”). The decomposition is motivated by the view that patent citations are a metric for knowledge flows (see Thompson and Fox-Kean, 2005; Alcácer and Gittelman, 2006; Roach and Cohen, 2013; González-Urbe, 2020).

Column (1) and (4) shows the change in the full sample along these two dimensions. The new patents on average receive 0.11 fewer citations from patent applicants located outside of China, while experience insignificant change in domestic citation. The change in foreign citation is economically meaningful, as the average number of foreign citations in the sample is 0.21, with a standard deviation of 0.8.

The distinction between different sources of citation alleviates the concern over innovation

quality. Patent citation is commonly used in the innovation literature as a proxy for quality of innovation (see Trajtenberg, 1990; Hall, Jaffe, and Trajtenberg, 2005). One would expect that a returnee inventor brings new knowledge, skills, and experiences to the institution, which should result in the creation of high quality patents. However, as shown in Appendix Table A4, both the raw citation measures and scaled citation controlling for year, technology and patent office measures drop significantly following the arrival of the returnee inventor. Without the decomposition, these findings would be surprising.

So far, there is a key link missing. How is the drop in international knowledge outflow related to the decline in international R&D collaboration? Is it possible that these are just two trends happening simultaneously? In Column (2) and (3), I find that the decline in foreign citations occurs exclusively in the subsample of returnee technologies that exhibited above-median international R&D collaboration intensity prior to the arrival of the returnee. International R&D collaboration intensity is measured as the share of foreign-based inventors per patent in each technology within the institution before returnee arrives. The rationale behind this split is that for technology fields that were not experiencing high international R&D collaboration to begin with, there is little to change in collaboration. In that case, we shouldn't see drop in foreign citations, if the international collaboration is a key driver for foreign citations. This is confirmed in Column (3) where those returnee technologies below the median level of pre-arrival international collaboration do not experience any drop in foreign citation. In fact, we even see an increase, which could be related to the quality of the patents. In contrast, Column (2) shows that for those technologies previously dependent on more international R&D collaboration, increased internal development capacity after hiring a returnee redirects inventive efforts toward internal R&D. As these patents become less reliant on international teams, they naturally may receive less attention from foreign inventors, and become more adapted to the domestic market, reflecting a decline in cross-border knowledge diffusion. While it is important to understand and differentiate further the attention story and the application story, it is out of the scope of this paper.

5.3. Internal Innovation and Resource Reallocation

In addition to the external consequence on knowledge flow from China to other countries, what is the internal consequence on the reallocation of innovation resources within the hiring firm? In other words, how does the hiring event heterogeneously affect other R&D establishments within the same institution in China?

For multi-establishment firms, different R&D establishments can play distinct roles. Some are primarily structured to manage international R&D collaboration, engaging in joint projects, sharing resources, managing risks, and splitting profits, while others are oriented toward internal R&D for domestic markets (Fritsch & Schilder, 2020; Fu et al., 2022).

Ideally, a detailed mapping of each establishment's function would enable clear comparisons between collaboration-oriented and domestically focused sites. With this mapping, we can show how having a returnee inventor affects the innovation dynamics of these two types of R&D establishments differently. However, patent records alone do not directly reveal the strategic purpose of each location. To address this, I classify establishments as “international-collaboration-oriented” if, prior to the returnee's arrival, they fall within the top quartile in the observed frequency of international R&D collaboration, proxied by the share of patents involving foreign inventors.

Table 7 presents results from a triple difference style analysis by estimating equation (2), where the three layers of comparison are: pre- versus post-returnee arrival, returnee technologies versus other technologies, and hiring establishments relative to other branches within the same institution. Subscript e represents an establishment in institution j . The key coefficient of interests are β_1 and β_2 , that captures the difference between the hiring and other establishments, as well as if the previous relative decline in international R&D collaboration in returnee technology vs other technologies still holds. In columns (1), (4), and (7), the effect of the returnee's arrival on the hiring establishment is benchmarked against all other establishments in the organization. Columns (2), (5), and (8) more narrowly compare the hiring establishment to branches identified as international-collaboration-oriented. Column (3), (6) and (9) compare the hiring establishments with other R&D establishments that do not have top quartile international R&D collaboration intensity prior to the returnee's arrival, which are more likely to be the internal R&D

facilities.

Innovation Measures_{*i,j,e,k,t*}

$$\begin{aligned}
&= \alpha + \beta_1 * Returnee\ Tech_{i,j,k} * Post_{i,j,t} * Hiring_{i,j,e} + \beta_2 \\
&\quad * Returnee\ Tech_{i,j,k} * Post_{i,j,t} + \beta_3 * Returnee\ Tech_{i,j,k} * Hiring_{i,j,e} \\
&\quad + \beta_4 * Post_{i,j,t} * Hiring_{i,j,e} + \beta_5 * Returnee\ Tech_{i,j,k} + \beta_6 Post_{i,j,t} \\
&\quad + \beta_7 * Hiring_{i,j,e} + Controls + \alpha_{k,t} + \alpha_{i,j} \\
&\quad + \varepsilon
\end{aligned} \tag{2}$$

Column (2) and (8) shows that compared to the shift in international R&D collaboration in the hiring establishment, it is the international-collaboration-oriented establishments that experience a negative and significant drop in collaboration intensity (in terms of foreign inventor count per patent) and propensity (in terms of the proportion of patents that have foreign inventors). Within the hiring establishments, there is a marginally significant increase, especially on the extensive margin, suggesting a potential reallocation or internal transfer of collaborative resources—a phenomenon consistent with the substitution or redistribution effects documented in multi-establishment organizations.

Column (3), (6) and (9) shows that compared to internal R&D branches not previously focused on international R&D collaboration, the hiring establishment exhibits a stronger reduction in cross-border collaboration post-returnee. For these other branches, the effects are weaker or only marginally present, likely in part because such knowledge spillovers attenuate with organizational or geographic distance (Aghion et al., 2024; Moreira et al., 2024). The findings are consistent with emerging research that highlights the complex spillover and substitution dynamics triggered by the arrival of high-skill talent in large, multi-site research organizations.

6. Towards a causal relationship

The evidence described above documents the change in in collaboration dynamics, knowledge flows, and resource allocation within firms following the return of immigrant inventors to their home country. However, it has not been established that this is a causal relationship.

One major concern is the possibility of confounding global trends. Specifically, rising restrictions targeting sensitive technologies which could drive both the return migration of skilled researchers and a parallel reduction in international R&D collaboration. Such policy shifts, by curbing cross-border innovation activities, may make inventors and patent examiners less aware of technological advances in other countries, naturally resulting in fewer foreign citations. If returnee technologies systematically overlap with these targeted sectors, the observed changes might reflect external shocks rather than the direct effect of returnees themselves.

As already elaborated in details in Section 4.2, to test the robustness of this relationship, I conduct targeted subsample analyses accounting for potential confounders. First, I exclude the top ten most prevalent returnee technologies and find that the decline in international R&D collaboration persists, indicating the result is not solely driven by a handful of sensitive sectors. Second, I restrict the analysis to pre-2018 patents, predating the China Initiative and associated increases in US-China collaboration costs (Aghion et al., 2023), and observe consistent effects. The findings are also robust for immigrants returning from countries neighboring China, which reassures that the observed effects are not merely an result of US-specific policy shifts. Taken together, these robustness checks indicate that the patterns identified are not driven by just a handful of sensitive technology areas, global policy events, or individual countries, but seem to generalize across different technology fields and contexts.

Another challenge for causal interpretation is the possibility of endogenous hiring: it could be that firms plan to shift their innovation strategy—perhaps by building up domestic teams and scaling back on international R&D collaborations—before they ever decide to recruit a returnee inventor. In that case, the effect I observe may simply reflect the institution’s broader agenda, with the returnee serving to formalize an existing plan rather than acting as a catalyst. While the hiring of a returnee already reveals something about what the institution values, it is still important to establish whether the returnee actually plays a causal role.

The first step to alleviate this concern is by plotting the time trend of effects. Figure 2 plots

the coefficients from estimating the following equation (3) in the years around the arrival event:

Innovation Measures_{*i,j,k,t*}

$$\begin{aligned}
&= \alpha + \sum_{t=-8}^{-2} \beta_t * Returnee\ Tech_{i,j,k} * Event_{i,j,t} \\
&+ \sum_{t=0}^8 \beta_t * Returnee\ Tech_{i,j,k} * Event_{i,j,t} + \gamma * Returnee\ Tech_{i,j,k} \\
&+ \sum_{t=-8}^{-2} \gamma_t * Event_{i,j,t} + \sum_{t=-8}^{-2} \gamma_t * Event_{i,j,t} + \alpha_{k,t} + \alpha_{i,j} \\
&+ \varepsilon
\end{aligned} \tag{3}$$

Panels A and B illustrate the dynamics of the hiring firm's foreign inventor count per patent and domestic inventor count per patent. Panels C and D replace inventor counts with proportion and propensity of having foreign inventors. These variables have the same definition as in Section 4.1. For illustration purpose, only the coefficient of the 10 years around the event is plotted in this figure. On the x-axis, “p5” through “p2” are the years leading up to the estimated arrival year, while “f1” through “f5” are the years after the arrival year. The coefficient in the year right before the return is normalized to zero.

The time trend has a visible discontinuity around the estimated arrival of the returnee, providing suggestive evidence towards the causal argument that the drop in international R&D collaboration tends to happen only after the returnee is on board. It would be harder to explain this discontinuity with the strategic planning hypothesis.

Figure 2 also underscores the persistence of the change, as the deduction in international R&D collaboration continues to hold over the eight years following the returnee's arrival, suggesting a lasting change in the hiring firm's collaboration strategy.

In unreported tables, I also show that the results are robust when I restrict the sample to firms that have more than two separate hiring events at different points in time. In these

cases, it is difficult to argue that multiple rounds of strategic planning just happen to occur exactly when each returnee arrives; if that were true, the timing of the returnee's arrival would itself be central to the institution's innovation strategy.

Altogether, these patterns provide suggestive evidence for the idea that the shift of collaboration strategy and resource allocation is not just a background trend but is closely tied to the arrival of returnee inventors. In future my work, more efforts to establish the causal relationship is scheduled.

7. Conclusion

This paper provides evidence on how recent shift in immigration trends and the decline in international R&D collaboration are shaping the strategies of innovation-driven firms. I show that returning immigrants are not just passive participants in these trends—their knowledge allow them to substitute international R&D collaboration observed in countries like China.

The main findings reveal that hiring returnee inventors prompts a shift away from international R&D collaboration toward domestic innovation activities, especially in technology fields that overlap with their expertise. The drop in the average number and share of foreign-based inventors per patent, coupled with increased domestic patenting and no decline in domestic patent citations, makes it clear that the arrival of a returnee inventor is associated with increased domestic knowledge production and a reduction in the outflow of knowledge across borders. This effect is most pronounced in technology areas with high prior international R&D collaboration, indicating that return migration can reshape not only the team structure but also the direction of knowledge transfer.

Extending the analysis to multi-establishment firms, the results reveal that collaboration-oriented branches experience an even larger decline in international R&D collaboration than the hiring branch, showing that the shift is not just local, but institutional. These findings persist after controlling for technology type, global policy actions, and potential endogeneity in hiring. Together, the evidence underscores how return migration substitutes for international R&D collaboration and changes the allocation of innovative human capital

within organizations.

As policy uncertainty increases and the global landscape for skilled migration and R&D collaboration evolves, the importance of this topic cannot be overstated. This paper shows that returnee inventors play a pivotal role in the realignment of knowledge production and collaboration strategies at the institutional level, with far-reaching implications for both scientific progress and policy design. Understanding these mechanisms is critical for anticipating how organizations can adapt—and how global knowledge flows may shift—in response to both policy changes and the return migration of highly skilled talent.

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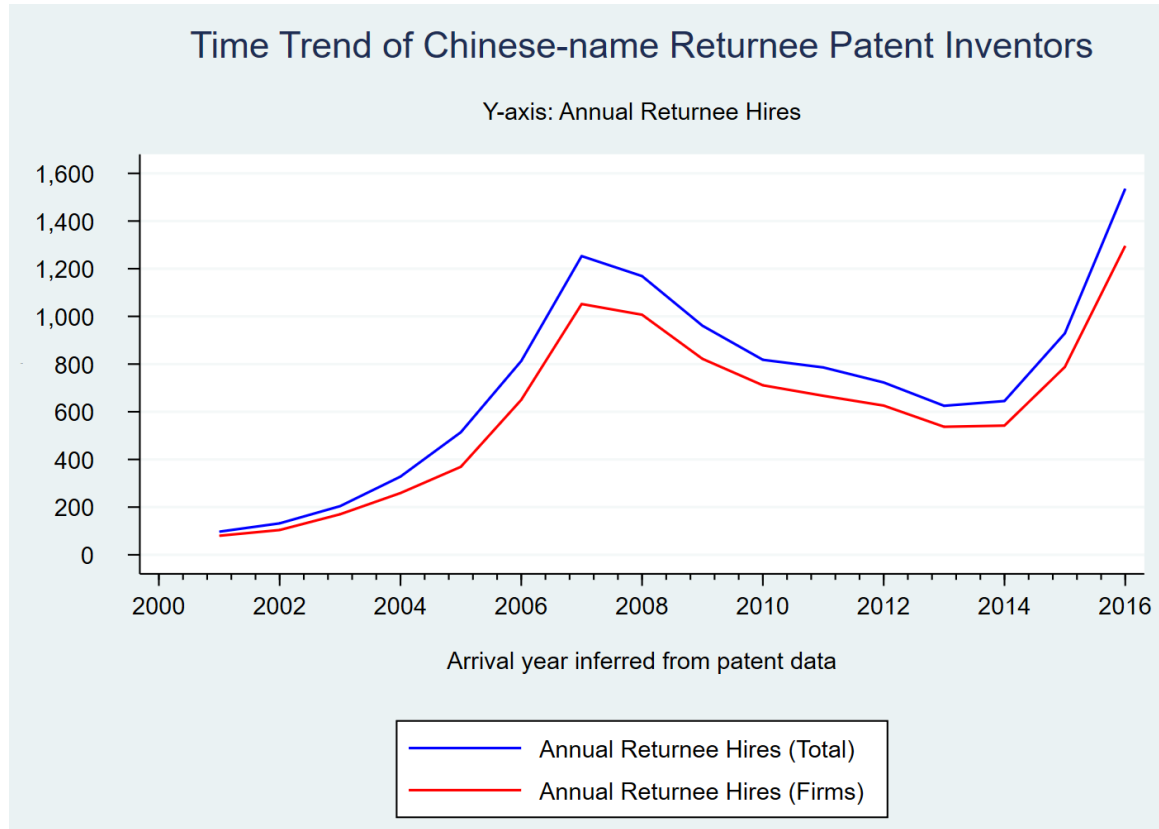
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Figures and Tables

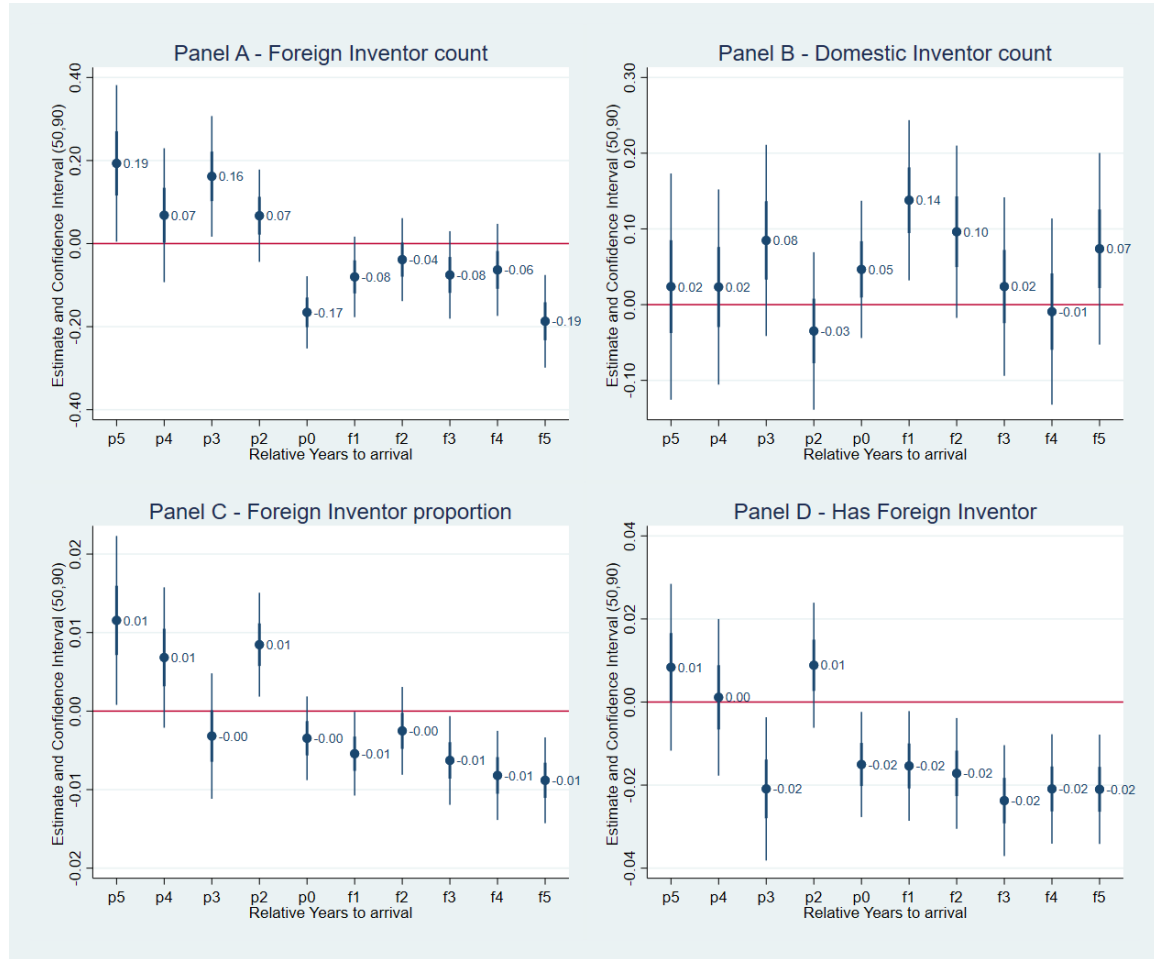
Fig. 1 Time Trend of the return of Chinese returnee inventors



Note:

This table plots the number of returnee inventors return hired by all firms (Total) and firms (Firms) that are physically located in China each year, starting from 2001 to 2016. Each data point is a count of return events, where the return event is constructed by patent location information as explained in Section 2.3. The X-axis represents the arrival year, and the Y-axis represents the count.

Fig. 2. Dynamics of innovation team composition before and after returnee's arrival



Note:

This figure plots the coefficients from estimating equation (3) in the years around the arrival event. Panels A and B illustrate the dynamics of the hiring firm's foreign inventor count per patent and domestic inventor count per patent. Panels C and D replace inventor counts with proportion and propensity of having foreign inventors. These variables have the same definition as in Section 4.1. On the x-axis, "p5" through "p2" are the years leading up to the estimated arrival year, while "f1" through "f5" are the years after the arrival year. The coefficient in the year right before the return is normalized to zero.

Table 1. Sample decomposition**Panel A: Distribution of Source Country and Region (Top 10)**

Country	Returnee Count
United States	7,920
Japan	638
Canada	563
Singapore	441
South Korea	259
Germany	258
United Kingdom	258
Australia	179
Switzerland	145
Netherland	133

Panel B: Distribution of Returnee technologies (Top 10)

IPC (first 3 digits)	Technology Class Name	Returnee Count
A61	Medical or Veterinary Science; Hygiene	1173
G01	Measuring; Testing	1037
H01	Basic Electric Elements	952
G06	Computing; Calculating; Counting	879
H04	Electric Communication Technique	788
C07	Organic Chemistry	596
H02	Generation, Conversion, or Distribution of Electric Power	379
F16	Engineering Elements or Units; General Measures for Producing and Maintaining Mechanical Effects	348
B01	Physical or Chemical Processes or Apparatus in General	343
A01	Agriculture; Forestry; Animal Husbandry; Hunting; Trapping; Fishing	313

Panel C: Examples of Hiring Firms (Top 10)

Hiring firm	Returnee Count
Huawei Technologies Company	510
SGCC State Grid Corporation of China	304
SINOPEC China Petro Chemical Corporation	201
HONGFUJIN Percision Industry Shenzhen Company	160
PETROCHINA Company	144
AUO AU Optronics Corporation	140
FOXCONN	131
IBM Corporation	120
BAOSHAN Iron Steel Company	116
Tencent Technology Shenzhen Company	95

Panel D: Examples of Hiring firm (Hiring 10)

Hiring firm	Returnee Count
Alcatel Shanghai Bell Company	10
High Tech Computer Corporation	10
Spreadtrum Communications Shanghai	10
Beijing Baidu Netcom Science And Technology Company	10
Offshore Oil Engineering Company	10
Advanced Technology Materials	10
GlaxoSmithKline	10
BYD Company	10
Zhongxing Communication Company	10
Biyadi Company	10
Shanghai Micro Electronics Equipment Company	10
Toppoly Optoelectronics Corporation	10
Corning	10
Molex	10
Sharp Corporation	10
Eli Lilly Company	10
Wengfu Group Company	10
Wanghong Electronic Company	10

Table 2. Summary Statistics

Panel A. Characteristics of Hiring Event and Hiring Institution (Pair Level)

Variable	Count	Mean	Median	Standard Deviation
Arrival Year	12549	2010.31	2010.00	3.91
Patenting Gap (years)	12549	2.33	1.00	2.28
Total Hire	12549	2.25	1.00	2.09
Same employer	12549	0.07	0.00	0.26
Young Institution	12549	0.58	1.00	0.49
Established Institution	12549	0.25	0.00	0.43

Panel B. Patent Characteristics

Variable	Count	Mean	Median	Standard Deviation
Total Inventor per patent	522111	5.59	4.00	5.31
Foreign Inventor per patent	522111	1.31	0.00	3.81
Domestic Inventor per patent	522111	3.81	3.00	2.89
Proportion of Foreign per patent	522111	0.12	0.00	0.24
Has Foreign Dummy per patent	522111	0.25	0.00	0.40
Raw citation	522111	1.56	1.00	2.16
Scaled Citation	522111	1.14	0.70	1.54
Foreign Citation	522111	0.21	0.00	0.81
Domestic Citation	522111	0.72	0.00	1.32

Panel C. Technology Characteristics

Variable	Count	Mean	Median	Standard Deviation
Total Inventor per technology	522111	15.32	6.00	29.13
Foreign Inventor per technology	522111	2.33	0.00	7.66
Domestic Inventor per technology	522111	12.24	5.00	24.08
Proportion of Foreign per technology	522111	0.14	0.00	0.28
Total Patent per technology	522111	5.51	2.00	12.22
Foreign Patent per technology	522111	1.17	0.00	3.31
Domestic Patent per technology	522111	5.11	2.00	11.37
Proportion of Foreign per technology	522111	0.25	0.00	0.40

Table 2. Summary Statistics (continue)

Panel D. Establishment Level Measures

Variable	Count	Mean	Median	Standard Deviation
Foreign Inventor	2376057	0.24	0.00	0.59
Proportion of Foreign	2376057	0.04	0.00	0.09

Has Foreign Dummy	2376057	0.16	0.00	0.35
Foreign Citation	2376057	0.05	0.00	0.26
Domestic Citation	2376057	0.84	0.00	1.58

Table 3. Foreign and domestic patent inventor decomposition (per patent)

	(1) Total Inventor	(2) Foreign Inventor Count	(3) Domestic Inventor Count	(4) Proportion of Foreign	(5) Has Foreign Dummy
Returnee Technology X Post	-0.227** (-2.344)	-0.219*** (-3.986)	0.013 (0.245)	-0.012*** (-4.581)	-0.015*** (-2.810)
Post	0.054 (0.946)	0.043* (1.938)	0.049 (1.316)	0.008*** (4.998)	0.004 (1.146)
Returnee Technology	0.471*** (5.644)	0.314*** (6.068)	0.111*** (2.724)	0.013*** (4.886)	0.017*** (3.651)
Constant	5.939*** (125.738)	1.498*** (88.636)	3.883*** (127.395)	0.132*** (120.982)	0.271*** (100.408)
Adjusted R-squared	0.597	0.766	0.536	0.767	0.574
Observations	522111	522111	522111	522111	522111
Sample Mean	5.59	1.31	3.81	0.12	0.25

Note: This table reports the coefficient and t-statistics (in parentheses) from estimating equation (1) on the different measures of international R&D collaboration. The observations are at returnee-institution pair, technology and year level. The explanatory variables are “Post” arrival, an indicator variable that equals one after the returnee inventor arrives at the hiring firm and create a patent for the first time, “Returnee Technology” which equals to one if the technology is overlapping with the returnee’s past innovation experience, and “Returnee Technology X Post” which is the interaction between the two. The dependent variable in column (1) counts the average number of inventors involved in a patent given a technology class each year. Column (2) and (3) isolate the number of foreign (domestic) inventors whose residential address is outside of (within) China. The dependent variable in column (4) computes the proportion of foreign located inventors and column (5) is an average of the indicator variable that equals one for patents that have at least one foreign located inventor. All regressions include returnee-institution pair fixed effect and technology-year fixed effect. Standard errors are clustered at the returnee-institution pair level and institution-year level. * < .1, ** < .05, *** < .01 indicate statistical significance.

Table 4. Panel A. Proportion of foreign inventors (per patent)– Subsamples

	(1) Full sample	(2) Return from US	(3) Return from neighbor	(4) Change employer	(5) Same employer	(6) Less freq. tech	(7) Early sample
Returnee Technology X Post	-0.012*** (-4.581)	-0.014*** (-4.291)	-0.025*** (-3.233)	-0.009*** (-2.961)	-0.001 (-0.163)	-0.013*** (-3.137)	-0.026*** (-4.042)
Post	0.008*** (4.998)	0.006*** (3.319)	0.008** (2.021)	0.005*** (3.432)	0.002 (0.320)	0.007*** (4.368)	0.012*** (5.031)
Returnee Technology	0.013*** (4.886)	0.016*** (4.868)	0.014** (2.462)	0.009*** (3.332)	0.007 (1.160)	0.012*** (3.410)	0.028*** (4.082)
Constant	0.132*** (120.982)	0.109*** (84.817)	0.264*** (95.320)	0.096*** (86.233)	0.370*** (110.429)	0.127*** (111.813)	0.155*** (89.613)
Adjusted R- squared	0.767	0.717	0.857	0.673	0.866	0.764	0.734
Observations	522111	345774	76723	449927	71921	361424	241685

Note: This table reports the coefficient and t-statistics (in parentheses) from estimating equation (1) on the “Proportion of Foreign” in Panel A and C, and “Has Foreign Dummy” in Panel B and D, as dependent variables. The observations are at returnee-institution pair, technology and year level. The explanatory variables are “Post” arrival, an indicator variable that equals one after the returnee inventor arrives at the hiring firm and create a patent for the first time, “Returnee Technology” which equals to one if the technology is overlapping with the returnee’s past innovation experience, and “Returnee Technology X Post” which is the interaction between the two. In Panel A and B, Column (1) repeats the full sample analysis as in Table 3 Column (4), for benchmark purposes. Column (2) isolates the subsample of returnees that return from the US, while Column (3) isolates the subsample of returnees that return from Japan, Korea and Singapore. Column (4) and (5) separate the sample by whether the institution after arrival is the same as the institution right before, according to the patent records. Column (6) looks at the subsample of technologies that is not one of the top 10 most frequent technologies in sample. Column (7) investigates arrivals that happen on or before 2012, and investigates the hiring firm for up till 2018. All regressions include returnee-institution pair fixed effect and technology-year fixed effect. Standard errors are clustered at the returnee-institution pair level and institution-year level. * < .1, ** < .05, *** < .01 indicate statistical significance.

Table 4. Panel B. Proportion of foreign inventors (per patent) – Heterogeneity

	(1) Young	(2) Established	(3) University	(4) Hospital, Gov, Non-Profit
Returnee Technology X Post	-0.006 (-1.323)	-0.013*** (-3.679)	-0.002 (-0.619)	0.002 (0.382)
Post	0.004** (2.130)	0.009*** (3.320)	0.002 (1.094)	-0.002 (-0.782)
Returnee Technology	0.007* (1.954)	0.011*** (3.689)	0.001 (0.167)	-0.001 (-0.229)
Constant	0.075*** (51.315)	0.168*** (102.744)	0.060*** (42.721)	0.061*** (35.168)
Adjusted R-squared	0.531	0.808	0.574	0.487
Observations	206217	273219	167372	85942

Note (continue): In Panel C and D, Column (1) and (2) isolates the subsample of hiring firms that have less (more) than 5 years of patenting experience before the returnee arrives. Column (3) studies the hiring firms that are firms, and Column (4) looks at only Universities. The categorization is provided in PATSTAT. All regressions include returnee-institution pair fixed effect and technology-year fixed effect. Standard errors are clustered at the returnee-institution pair level and institution-year level. * < .1, ** < .05, *** < .01 indicate statistical significance.

Table 4. Panel D. Propensity of being a collaboration patent (per patent) - Heterogeneity Cont.'

	(1) Young	(2) Established	(3) University	(4) Hospital, Gov, Non-Profit
Returnee Technology X Post	-0.020** (-2.056)	-0.014** (-2.083)	-0.005 (-0.493)	-0.004 (-0.287)
Post	0.010* (1.949)	-0.000 (-0.003)	0.006 (1.230)	-0.014* (-1.919)
Returnee Technology	0.022*** (2.615)	0.013** (2.348)	0.000 (0.044)	0.003 (0.255)
Constant	0.202*** (54.837)	0.314*** (83.140)	0.153*** (39.846)	0.207*** (40.297)
Adjusted R-squared	0.398	0.641	0.437	0.400
Observations	206217	273219	167372	85942

Table 5. Patenting Activities (per technology class)

	(1) Annual Patents	(2) Domestic Patents	(3) Proportion of Domestic Patents	(4) Total Active Inventor	(5) Domestic Inventor	(6) Proportion of Domestic Inventors
Returnee Technology X Post	1.412*** (3.489)	1.406*** (3.706)	0.017*** (4.121)	4.566*** (4.837)	3.769*** (4.740)	0.013*** (4.275)
Post	-0.136 (-1.577)	-0.137* (-1.719)	-0.012*** (-6.519)	-0.148 (-0.763)	-0.025 (-0.154)	-0.009*** (-4.779)
Returnee Technology	4.084*** (12.471)	3.548*** (11.984)	-0.011*** (-3.499)	9.717*** (13.564)	6.642*** (12.870)	-0.013*** (-4.755)
Constant	5.811*** (88.167)	5.337*** (87.754)	0.936*** (727.712)	16.115*** (109.462)	12.537*** (102.772)	0.832*** (633.454)
Adjusted R-squared	0.183	0.183	0.502	0.239	0.249	0.712
Observations	522165	522165	522165	522165	522165	522111
Sample Mean	5.51	5.11	0.75	15.32	12.24	0.86

Note: This table reports the coefficient and t-statistics (in parentheses) from estimating equation (1) on the different measures of international R&D collaboration measured at technology class level. The observations are at returnee-institution pair, technology and year level. The explanatory variables are “Post” arrival, an indicator variable that equals one after the returnee inventor arrives at the hiring firm and create a patent for the first time, “Returnee Technology” which equals to one if the technology is overlapping with the returnee’s past innovation experience, and “Returnee Technology X Post” which is the interaction between the two. The dependent variable in column (1) counts the total number of patents filed in a technology class each year. Column (2) isolate the number of domestic patents, which is defined as patents filed by inventors located in China. Column (3) calculates the proportion of domestic patents, out of total number of patents filed in the same year by the institution in a particular technology. The dependent variable in column (4) counts the total number of inventors involved in patenting, as implied by having their name on the patent application document in that year. Column (5) does the same for only inventors located in China. Column (6) computes the proportion of the domestic inventors out of all active inventors. All regressions include returnee-institution pair fixed effect and technology-year fixed effect. Standard errors are clustered at the returnee-institution pair level and institution-year level. * < .1, ** < .05, *** < .01 indicate statistical significance.

Table 6. Domestic and Foreign Knowledge Outflow (citations per patent)

	(1)	(2)	(3)	(4)	(5)	(6)
Pre-arrival Collaboration	Full	High	Low	Full	High	Low
	Foreign Citation	Foreign Citation	Foreign Citation	Domestic Citation	Domestic Citation	Domestic Citation
Returnee Technology X Post	-0.113*** (-5.114)	-0.105*** (-3.869)	0.029* (1.925)	-0.004 (-0.178)	-0.005 (-0.201)	0.020 (0.449)
Post	0.024*** (3.094)	0.016 (1.347)	0.012** (1.969)	0.016 (1.063)	0.013 (0.651)	0.050*** (3.103)
Returnee Technology	0.124*** (6.166)	0.112*** (4.932)	-0.011 (-1.106)	0.051*** (2.961)	0.052*** (2.649)	-0.005 (-0.154)
Constant	0.229*** (37.204)	0.392*** (49.519)	0.051*** (14.456)	0.715*** (61.994)	0.844*** (60.203)	0.542*** (57.156)
Adjusted R-squared	0.446	0.487	0.171	0.302	0.345	0.315
Observations	522165	236114	148177	522165	236114	148177

Note: This table reports the coefficient and t-statistics (in parentheses) from estimating equation (1) on the foreign and domestic citation counts, for the full sample as well as subsamples based on the level of pre-arrival international R&D collaboration intensity. The observations are at returnee-institution pair, technology and year level. The explanatory variables are “Post” arrival, an indicator variable that equals one after the returnee inventor arrives at the hiring firm and create a patent for the first time, “Returnee Technology” which equals to one if the technology is overlapping with the returnee’s past innovation experience, and “Returnee Technology X Post” which is the interaction between the two. The dependent variable in column (1) and (4) decompose the citations received by patents from the hiring firms into those originating from within China (“domestic citations”) and those from foreign firms (“foreign citations”). These measures counts the number of citations received within 3 years since the filing date of the patent (excluding self-citation). In Column (2), (3), (5) and (6), I separate the sample into two, based on whether returnee technologies that exhibited above-median international R&D collaboration intensity prior to the arrival of the returnee. International R&D collaboration intensity is measured as the share of foreign-based inventors per patent in each technology within the institution before returnee arrives. All regressions include returnee-institution pair fixed effect and technology-year fixed effect. Standard errors are clustered at the returnee-institution pair level and institution-year level. * < .1, ** < .05, *** < .01 indicate statistical significance.

Table 7 Strategic change in international R&D collaboration across establishments within hiring firms

Compared to Collaboration- Oriented Estab.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Full	Yes	No	Full	Yes	No	Full	Yes	No
	Foreign Inventor	Foreign Inventor	Foreign Inventor	Proportion of Foreign	Proportion of Foreign	Proportion of Foreign	Has Foreign	Has Foreign	Has Foreign
Returnee Tech. X Post X Hiring	-0.011 (-0.605)	0.039* (1.952)	-0.033* (-1.799)	-0.003 (-1.220)	0.003 (0.974)	-0.005** (-2.333)	-0.002 (-0.209)	0.023** (2.322)	-0.013 (-1.539)
Returnee Tech. X Post	-0.032** (-2.486)	-0.058*** (-3.008)	-0.022* (-1.791)	-0.001 (-0.723)	-0.002 (-0.792)	-0.000 (-0.292)	-0.009* (-1.662)	-0.016** (-1.971)	-0.007 (-1.229)
Returnee Tech. X Hiring	0.024 (1.489)	-0.001 (-0.044)	0.039** (2.289)	0.001 (0.705)	0.001 (0.546)	0.003 (1.402)	0.001 (0.205)	-0.003 (-0.287)	0.008 (1.074)
Post X Hiring	0.005 (0.564)	0.185*** (18.250)	-0.029*** (-3.568)	0.001 (1.560)	0.032*** (22.965)	-0.005*** (-4.885)	0.007* (1.959)	0.142*** (25.684)	-0.018*** (-4.899)
Returnee Tech. Post	0.030*** (2.884)	0.042*** (2.613)	0.021** (2.142)	0.001 (1.022)	-0.000 (-0.164)	0.001 (0.664)	0.010** (2.054)	0.008 (1.125)	0.008* (1.666)
Hiring Establishment	-0.016** (-1.996)	-0.147*** (-13.482)	0.010 (1.220)	0.000 (0.283)	-0.022*** (-18.375)	0.004*** (6.654)	-0.003 (-0.962)	-0.099*** (-19.210)	0.015*** (4.025)
Constant	-0.004 (-0.515)	-0.252*** (-27.344)	0.049*** (6.785)	-0.000 (-0.339)	-0.042*** (-29.646)	0.009*** (10.561)	-0.006** (-2.035)	-0.190*** (-35.361)	0.032*** (10.092)
	0.246*** (36.187)	0.430*** (47.026)	0.212*** (32.018)	0.036*** (70.583)	0.067*** (69.230)	0.029*** (57.476)	0.166*** (57.926)	0.303*** (72.117)	0.140*** (48.839)
Adjusted R-squared	0.333	0.383	0.337	0.327	0.328	0.329	0.313	0.386	0.306
Observations	2375300	577787	1820747	2375300	577787	1820747	2375300	577787	1820747

Note: This table reports the coefficient and t-statistics (in parentheses) from estimating equation (2) on the several international R&D collaboration intensity measures, for the full sample, as well as subsamples. The subsamples separate the non-hiring establishments into two categories: “international R&D collaboration-oriented” establishments and other establishments. The former is defined by failing in the top quartile of observed frequency of international R&D collaboration (measured before the returnee joins). The observations are at returnee-establishment pair, technology and year level. Each institution correspond to one or more establishments. The full sample analysis in Column (1), (4) and (7) compares the differential effect on the hiring establishment against all other establishments within the same institution. Analysis in Column (2), (5) and (8) compares the differential effect on the hiring establishment against the collaboration-oriented establishments, which are presumably the international R&D collaboration arm of the institution group. Analysis in Column (3), (6) and (9) compares the hiring establishment with other establishments that are more likely to be the other internal R&D divisions of the institution group. The independent variables represent the triple difference across three dimensions: pre- versus post-returnee arrival, returnee technologies versus other technologies, and hiring establishments relative to other branches within the same institution. All regressions include returnee-institution pair fixed effect and technology-year fixed effect. Standard errors are clustered at the returnee-institution pair level and institution-year level. * < .1, ** < .05, *** < .01 indicate statistical significance.

Appendix

1. Sample Construction Details

1.1. Measuring province level location of firms

The province information is identified using multiple attributes from PATSTAT. I start with address information (TLS206 and TLS226) for all China located inventors and applicants. I first detected the province name is included in the string of addresses. I further detect provinces from the name of the non-individual applicant. At this point, I can obtain province information on 25% of all China located inventors and applicants. Next, I detect city information to infer province. I obtained the full list of Chinese cities and their province correspondence from gov.cn and I translated them into Chinese Pinyin to be able to screen in both the Chinese and English versions of the addresses and applicant names. With city, I can obtain another province information on an additional 21% Chinese inventors and applicants.

I further infer the location of the inventors by the location of their applicants. For each inventor PERSON ID, I count the highest frequency of the province of the patent applicant, and I assign the applicant's province to be the inventor's province.

1.2. Construct research establishments

My unit of analysis of hiring firms is not only at institution level, but also at their province level establishment level. This way I can study the spillover of the knowledge from the returnee inventor within the hiring establishment, but also across establishments serving different functions.

We cannot directly use the province of the hiring firm to define establishments because the applicant address typically is the location of the headquarters or IP holding entities, rather than the establishment of where the innovation actually took place.

Instead, I define establishment based on the province level cluster of inventors working for the same applicant. I infer pseudo province-level company establishments by tracking the location of the patent inventors. I assume that the company has establishment in that

province if its inventors are located in that province and define a province level establishment as the group of inventors in that province that patents for the company and the set of patents filed by these inventors for this company. For instance, for patents filed by HUAWEI, some of them come from inventors located in Guangdong province while some come from inventors located in Zhejiang province. I define HUAWEI Zhejiang and HUAWEI Guangdong as HUAWEI's province level establishments and treat them as separate entities when evaluating the returnee's effect. In other words, for a returnee inventor who returned to HUAWEI Zhejiang, I only evaluated his or her effect on HUAWEI Zhejiang, not HUAWEI in general, nor other establishments of HUAWEI such as HUAWEI Guangdong. It would be interesting to extend this study to look at the effect of returnee inventors' spillover across corporate groups, but this is not the focus of this study.

1.3. Identifying the returnee inventors

I started from the full universe of PATSTAT individual inventors (individual defined as having PSN SECTOR being "INDIVIDUAL" or "UNKNOWN" with available country code. There are 42M PERSON ID corresponding to 13M PSN IDs.

Next, I isolate the inventors who have ever filed a patent in China. This is because I am studying returnee inventors to China, and we need the inventor to file a patent in China to identify the return event, if any. From this sample of inventors, I get their active years and the corresponding locations. For each PERSON ID and each location country, I obtain a series of years when they are actively producing patents. I define return events as the first time CN appears in the time series and also CN is not the first country in the time series. However, this would exclude those who filed patents in CN first and then go to another country before returning. To include those people, I first drop all the CN patents they file before foreign patents: this requires first identifying those who start filing in CN; second identifying their first patent not in CN and dropping all the CN patents before this date; third re-identify their first CN patent and define return event as the date of the first CN patent. Note that if an inventor moves between China and another country frequently, I do not exclude him from the sample, but I only count the first time he moves back to China as

the return event.

So far there is no guarantee that the inventor identified is a returnee inventor. Foreign experts hired by Chinese companies or universities for collaboration are also included in the previous steps. To pin down the Chinese ethnicity, I require both the first and last name of the inventor to be able to match to Chinese Pinyin, which is the most common romanization system for Standard Mandarin Chinese. There can be two potential concerns. Firstly, by limited the first name to also be in the format of Pinyin, I am eliminating not only foreign-born Chinese but also Chinese origin inventors who chose to adopt a foreign preferred name for ease of communication. Therefore, the returnee inventors identified in this step could be a subset of all returnee inventors, and my sample is biasing towards the effect from the group of returnees who choose not to adopt a foreign name. The left-out group of returnees could potentially stay in a foreign country for a longer period of time, having more social connections with foreign investors and firms, and as a result, this could bias the effect of returnee inventors downward. Secondly, as a common issue facing research on ethnicity in innovation, I am not inferring the nationality of the returnee inventor. The returnee inventor I identified may as well be a US citizen choosing to work in China after migrating from China to the US. However, this does not conflict with the initiative to study returnee inventors, nor does it create measurement errors in the identification because most of the global talent settlement programs do not put a restriction on nationality.

The return event described here is the date the first Chinese patent is filed post return, which may not necessarily correspond to the joining event used extensively in this paper, which measures whether the returnee inventor started working for the Chinese hiring firm. For most cases, the joining event correspond to the return event. However, if an inventor filed a patent in China where the applicants are all Individuals, no hiring firm is identified. Because the focal entity for study is the hiring firm, I do not look at the return event, but rather the joining event. Joining event is only for the first non-individual applicant and I define the joining date as the date the return inventor filled the first patent for this applicant. As a robustness check, I explored an alternative measure of the joining year, which is defined as the mid-year between the first patent filing year for the hiring firm patent and

the filing year of the last patent filed before the hiring firm patent. Some returnee inventors may return due to a relocation within the institution he/she has been working in. In this case, I create a dummy variable that differentiates those who changed employer (i.e. not within- institutional relocation) and those not. I track this by looking at whether the returnee inventor is filing new inventions with the same patent applicant (based on PSN ID) post return.

1.4. Define hiring firm

I start with all the patents filed by the returnee inventor post-return and while the inventor is known to be in China (applicable to those who later left China again). I sort these patent applications by the time order and look for the first patent application whose applicant is a non-individual. Around 20 percent of the returnee inventors do not have a Chinese located non-individual hiring firm. The location of the inventor determines which establishment of the applicant the inventor joins. As explained before, non-individual patent applicants are defined in the unit of province- level establishments. Therefore, if we observe an inventor filing the first post-return patent with IBM while the inventor is located in Shanghai, the inventor is viewed as joining IBM Shanghai establishment, despite the applicant PSN ID for IBM refers to the IBM headquartered in the US. IBM Shanghai is what I define as a “hiring firm”.

2. Alternative measure of knowledge overlap between the returnee and the hiring firm

Recall that *Returnee Technology* is a dummy variable equal to 1 if, for a given institution-technology, the technology class overlaps with the returnee's knowledge set, inferred from their pre-return patent classifications. One potential concern regarding this measure is that a returnee must have filed at least three patents to be included in the baseline test, since I only count technology classes that appear more than twice in their history. The main drawback of this approach is a reduction in the number of observations, as only returnees with at least three patents enter the baseline sample.

To check robustness, I show that the main results are consistent when the knowledge set is instead defined as all technology classes represented in the returnee's pre-return patents.

Table A1 summarizes the findings on the decline in international R&D collaboration by estimating equation (1) as in Table 3. Table A2 replicates the test in Table 4, studying the surge in domestic patenting activities. Table A3 repeats the test in Table 5, splitting the citation received from foreign and domestic origin to study the change in knowledge outflow.

The results, as expected, are weaker in general, but are consistent with the findings. This is likely because including any technology class from the returnee's patent history introduces noise from incidental or marginal areas, rather than capturing the core expertise where the returnee can most meaningfully contribute.

3. Evidence on Raw and Scaled citation

This section complements the discussion in Section 5.2, where I present the estimation of equation (1) with raw and scaled citations as dependent variables. One would expect that a returnee inventor brings new knowledge, skills, and experience to the institution, which should result in the production of high-quality patents. However, as shown in Table A4, both the raw citation measures and scaled citation measures—controlling for filing year, technology, and patent office—drop significantly following the arrival of the returnee inventor.

Decomposing these citation measures reveals the same pattern: the effects are concentrated in technologies that previously had above-median levels of international R&D collaboration. However, without further decomposing citations by their source, it is difficult to draw strong conclusions. In principle, this result could also be consistent with firms hiring returnees to reduce reliance on foreign technology and the costs associated with collaboration but ultimately producing patents that are of lower quality.

Table A1. Foreign and domestic patent inventors decomposition (per patent)

	(1) Total Inventor	(2) Foreign Inventor	(3) Domestic Inventor	(4) Proportion of Foreign	(5) Has Foreign
Returnee Technology X Post	-0.107** (-2.000)	-0.110*** (-3.808)	0.006 (0.197)	-0.005*** (-3.032)	-0.006* (-1.895)
Post	0.038 (0.835)	0.046*** (2.577)	0.023 (0.773)	0.006*** (4.815)	0.005* (1.682)
Returnee Technology	0.242*** (5.607)	0.164*** (6.300)	0.061*** (2.638)	0.004*** (3.187)	0.005** (2.106)
Constant	5.534*** (146.840)	1.261*** (90.883)	3.790*** (155.365)	0.115*** (123.676)	0.244*** (106.606)
Adjusted R-squared	0.609	0.774	0.509	0.747	0.551
Observations	703981	703981	703981	703981	703981

Note: This table reports the coefficient and t-statistics (in parentheses) from estimating equation (1) on the different measures of international R&D collaboration. The observations are at returnee-institution pair, technology and year level. The explanatory variables are “Post” arrival, an indicator variable that equals one after the returnee inventor arrives at the hiring firm and create a patent for the first time, “Returnee Technology” which equals to one if the technology is overlapping with the returnee’s past innovation experience, but under the new definition as discussed in Appendix 2, and “Returnee Technology X Post” which is the interaction between the two. The dependent variable in column (1) counts the average number of inventors involved in a patent given a technology class each year. Column (2) and (3) isolate the number of foreign (domestic) inventors whose residential address is outside of (within) China. The dependent variable in column (4) computes the proportion of foreign located inventors and column (5) is an average of the indicator variable that equals one for patents that have at least one foreign located inventor. All regressions include returnee-institution pair fixed effect and technology-year fixed effect. Standard errors are clustered at the returnee-institution pair level and institution-year level. * < .1, ** < .05, *** < .01 indicate statistical significance.

Table A2. Patenting Activities (per technology class)

	(1) Annual Patents	(2) Domestic Patents	(3) Proportion of Domestic Patents	(4) Total Active Inventor	(5) Domestic Inventor	(6) Proportion of Domestic Inventors
Returnee Technology X Post	0.703*** (3.869)	0.668*** (3.990)	0.006*** (2.910)	2.122*** (4.852)	1.783*** (4.804)	0.005*** (2.905)
Post	-0.118 (-1.570)	-0.109 (-1.575)	-0.009*** (-5.945)	-0.218 (-1.327)	-0.108 (-0.782)	-0.007*** (-4.410)
Returnee Technology	2.362*** (15.533)	2.086*** (15.268)	-0.003* (-1.686)	5.805*** (16.531)	4.046*** (16.197)	-0.004*** (-2.971)
Constant	5.115*** (88.250)	4.762*** (89.556)	0.946*** (881.473)	14.268*** (108.533)	11.449*** (106.072)	0.851*** (770.214)
Adjusted R-squared	0.177	0.177	0.471	0.236	0.244	0.687
Observations	704041	704041	704041	704041	704041	703981

Note: This table reports the coefficient and t-statistics (in parentheses) from estimating equation (1) on the different measures of international R&D collaboration measured at technology class level. The observations are at returnee-institution pair, technology and year level. The explanatory variables are “Post” arrival, an indicator variable that equals one after the returnee inventor arrives at the hiring firm and create a patent for the first time, “Returnee Technology” which equals to one if the technology is overlapping with the returnee’s past innovation experience, under the new definition detailed in Appendix 2, and “Returnee Technology X Post” which is the interaction between the two. The dependent variable in column (1) counts the total number of patents filed in a technology class each year. Column (2) isolate the number of domestic patents, which is defined as patents filed by inventors located in China. Column (3) calculates the proportion of domestic patents, out of total number of patents filed in the same year by the institution in a particular technology. The dependent variable in column (4) counts the total number of inventors involved in patenting, as implied by having their name on the patent application document in that year. Column (5) does the same for only inventors located in China. Column (6) computes the proportion of the domestic inventors out of all active inventors. All regressions include returnee-institution pair fixed effect and technology-year fixed effect. Standard errors are clustered at the returnee-institution pair level and institution-year level. * < .1, ** < .05, *** < .01 indicate statistical significance.

Table A3. Domestic and Foreign Knowledge Outflow (citations per patent)

	(1)	(2)	(3)	(4)	(5)	(6)
Pre-arrival Collaboration	Full	High	Low	Full	High	Low
	Foreign Citation	Foreign Citation	Foreign Citation	Domestic Citation	Domestic Citation	Domestic Citation
Returnee Technology X Post	-0.056*** (-5.222)	-0.047*** (-3.085)	0.008* (1.646)	-0.019 (-1.543)	-0.015 (-0.910)	-0.017 (-0.949)
Post	0.027*** (4.228)	0.017* (1.712)	0.010** (2.240)	0.016 (1.253)	0.024 (1.385)	0.044*** (3.320)
Returnee Technology	0.056*** (6.080)	0.047*** (3.799)	-0.005 (-1.614)	0.042*** (4.262)	0.043*** (3.452)	0.019 (1.505)
Constant	0.190*** (36.807)	0.340*** (48.720)	0.045*** (16.725)	0.707*** (71.119)	0.837*** (66.950)	0.533*** (68.798)
Adjusted R-squared	0.453	0.494	0.157	0.282	0.324	0.292
Observations	704041	303078	213538	704041	303078	213538

Note: This table reports the coefficient and t-statistics (in parentheses) from estimating equation (1) on the foreign and domestic citation counts, for the full sample as well as subsamples based on the level of pre-arrival international R&D collaboration intensity. The observations are at returnee-institution pair, technology and year level. The explanatory variables are “Post” arrival, an indicator variable that equals one after the returnee inventor arrives at the hiring firm and create a patent for the first time, “Returnee Technology” which equals to one if the technology is overlapping with the returnee’s past innovation experience, under the new definition detailed in Appendix 2, and “Returnee Technology X Post” which is the interaction between the two. The dependent variable in column (1) and (4) decompose the citations received by patents from the hiring firms into those originating from within China (“domestic citations”) and those from foreign firms (“foreign citations”). These measures counts the number of citations received within 3 years since the filing date of the patent (excluding self-citation). In Column (2), (3), (5) and (6), I separate the sample into two, based on whether returnee technologies that exhibited above-median international R&D collaboration intensity prior to the arrival of the returnee. International R&D collaboration intensity is measured as the share of foreign-based inventors per patent in each technology within the institution before returnee arrives. All regressions include returnee-institution pair fixed effect and technology-year fixed effect. Standard errors are clustered at the returnee-institution pair level and institution-year level. * < .1, ** < .05, *** < .01 indicate statistical significance.

Table A4. Raw and Scaled Patent Citations

	(1)	(2)	(3)	(4)	(5)	(6)
Pre-arrival Collaboration	Full	High	Low	Full	High	Low
	Raw citation	Raw citation	Raw citation	Scaled Citation	Scaled Citation	Scaled Citation
Returnee Technology X Post	-0.146*** (-3.735)	-0.146*** (-3.060)	0.051 (0.856)	-0.100*** (-3.467)	-0.097*** (-2.834)	0.038 (0.875)
Post	0.034* (1.648)	0.017 (0.601)	0.109*** (4.953)	0.031** (2.340)	0.015 (0.820)	0.085*** (4.702)
Returnee Technology	0.225*** (6.597)	0.213*** (5.461)	-0.005 (-0.109)	0.152*** (6.195)	0.142*** (5.103)	0.009 (0.273)
Constant	1.150*** (69.967)	1.489*** (74.312)	0.748*** (57.306)	0.822*** (80.073)	1.047*** (84.425)	0.571*** (55.314)
Adjusted R-squared	0.305	0.339	0.267	0.210	0.250	0.164
Observations	522165	236114	148177	522165	236114	148177

Note: This table reports the coefficient and t-statistics (in parentheses) from estimating equation (1) on the raw and scaled citation counts, for the full sample as well as subsamples based on the level of pre-arrival international R&D collaboration intensity. The observations are at returnee-institution pair, technology and year level. The explanatory variables are “Post” arrival, an indicator variable that equals one after the returnee inventor arrives at the hiring firm and create a patent for the first time, “Returnee Technology” which equals to one if the technology is overlapping with the returnee’s past innovation experience, and “Returnee Technology X Post” which is the interaction between the two. The independent variable in Column (1)-(3) is raw citation, measured as the number of times this patent has been cited (by other patent families) within a 3-year window since the earliest filing date of this patent. The independent variable in Column (4)-(6) is Scaled citation, which is defined as the ratio of (a) the number of citations received within 3 years since the filing date of the patent (excluding self-citation) to (b) the average number of such citations within the focal patent's cohort of filing year, technology class and filing year. In Column (2), (3), (5) and (6), I separate the sample into two, based on whether returnee technologies that exhibited above-median international R&D collaboration intensity prior to the arrival of the returnee. International R&D collaboration intensity is measured as the share of foreign-based inventors per patent in each technology within the institution before returnee arrives. All regressions include

returnee-institution pair fixed effect and technology-year fixed effect. Standard errors are clustered at the returnee-institution pair level and institution-year level. * < .1, ** < .05, *** < .01 indicate statistical significance.