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Can scientists remain internationally visible after the return to their home country? A study of Chinese scientists

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Abstract: Returning scientists play a critical role in building up the academic workforce and science in their home country. Yet, in this study we argue that return mobility may limit scientists' international relevance and thus spillover effects may not be realised. We take scientists returning to China as a sample to investigate the impact of return mobility on international visibility/impact. What is more, we explore the roles of the international collaboration network and international knowledge base in this effect. Our findings clarify the limitation of return mobility and provide some empirical evidence on the limits of global knowledge spillovers in science and talent introduction policies.

Keywords: International mobility; international collaboration; academic performance; research visibility; knowledge spillovers

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1 Introduction

The international circulation of scientific talent has been recognised as important for knowledge diffusion and scientific and economic development (Saxenian, 2005, Fernández-Zubieta et al., 2015). Internationally mobile researchers are amongst the most productive (Stephan, 2012, Franzoni et al., 2014) and many retain links with their home countries or even return (Agrawal et al., 2011, Baruffaldi and Landoni, 2012, Wang et al., 2019), which has been described as beneficial to sharing knowledge from the scientific core to the scientific periphery (Saxenian, 2005).

Returning scientists, those returning to their home country from the scientific core, are considered critical to building up the academic workforce and science of a nation. Several countries have invested in programmes to attract emigrant scientists back home, including in China (Marini and Yang, 2021, Shi et al., 2023). These returnees are attracted with funding and career prospects back home, which could provide substantial benefits in terms of scientific performance. Yet, return mobility may not be all positive but could also result in a loss of global knowledge spillovers as scientists remove themselves from the scientific core, which could have a detrimental effect on their overall performance and international relevance.

Despite their important role for countries in the scientific periphery, the literature on returning scientists is still scarce and has only received limited attention to date (Cruz-Castro and Sanz-Menendez, 2010, Baruffaldi and Landoni, 2012, Zhao et al., 2020, Jonkers and Cruz-Castro, 2013, Li et al., 2015). Generally, they are considered in the context of the wider mobility literature, which consistently provides evidence of the superior scientific performance of internationally mobile researchers (Franzoni et al., 2014, Abramo et al., 2019). Findings further suggest that returnees have far better developed international networks compared to local faculty (Scellato et al., 2015, Lawson et al., 2019), but may suffer poorer career prospects back home, perhaps due to a lack of local social capital (Gaughan and Robin, 2004, Lawson and Shibayama, 2015, Li and Tang, 2019, Jonkers and Cruz-Castro, 2013). There are however other issues that face returning scientists. The return may remove them from the scientific core, which could limit their ability to tap into international networks. It may also require scientists to shift research away from ‘international’ topics, due to data availability or local incentives that favour topics of national interest (Das et al., 2013, Ladle et al., 2012). All of this could have negative consequences for their international relevance and, by extension, knowledge spillovers.

This paper thus investigates the impact of return mobility on the international visibility and impact of returning scientists. We hypothesise that this relationship is largely explained by the re-orientation of scientists' research towards less international knowledge bases and topics, and by the loss of international scientific networks. Using data on the return mobility of 291 Chinese scientists, we find evidence of a loss of international visibility/impact (as measured through citations), which is largely explained by the considerable loss of international co-authorship networks following the return to China. It is however not explained by the post-return reorientation of scientists' research towards more domestic topics. We also find that the post-return loss in international visibility is less pronounced for scientists that maintain extensive international co-authorship; it is however more pronounced when a scientist's relevant knowledge base is more international, suggesting that research geared towards international topics is slightly less effective in leveraging international citations following the return to China. These findings are significant for our understanding of global knowledge flows and contribute insights on the limits of global knowledge spillovers in science.

2 Literature review

2.1 Return mobility, scientific impact and the geography of citations

Mobility of academic scientists has long been argued to play a key role in knowledge production and diffusion. The movement of people facilitates the movement of ideas, enabling knowledge recombination and the emergence of new knowledge (Franzoni et al., 2014), and there is consistent evidence that international mobility results in more productive and better connected scientists (Jonkers and Cruz-Castro, 2013, Scellato et al., 2015, Lawson et al., 2019). This extends to those scientists that return to their home countries, who carry with them the connections built elsewhere. Jonkers and Cruz-Castro (2013) for instance, in a study of Argentinian researchers, find that returnees are more likely to co-publish internationally and publish in higher impact journals compared to their non-mobile peers. In a series of publications based on a 16-country survey, Franzoni et al. (2014) and Scellato et al. (2015) confirm this superior position of returnees compared to the non-mobile in terms of networks and research quality. These findings also extend to China, where returnees consistently outperform non-mobile domestic peers in terms of highly cited publications and international collaboration (Cao et al., 2019, Lu and Zhang, 2015).

This notwithstanding, the studies also show that return scientists are lagging behind those migrants who do not return but remain abroad (Cao et al., 2019, Franzoni et al., 2014, Scellato et al., 2015). There are a number of possible explanations for the lesser performance of returning scientists compared to non-returnees. For one, returning scientists may have performed at a lower level prior to their return and returnee policies may fail to bring back the 'best' (Cao et al., 2019, Shi et al., 2023). This would be representative of a selection effect. Alternatively (or in addition), their performance could have dropped following their return, due to a less favourable research environment, underdeveloped research infrastructure, differences in research incentives or culture, and lack of local knowledge or social connections (Li et al., 2018, Kahn and MacGarvie, 2016, Melin, 2005). These difficulties have in particular been voiced in the context of China (Han and Appelbaum, 2018, Lu and McInerney, 2016, Zweig et al., 2020).

There is also another important consideration, which is the difficulty of publishing research from outside the scientific core, particularly from outside the US, in top journals (Das et al., 2013, Kahn and MacGarvie, 2016). This difficulty could also more generally result in reduced international visibility and thus impact of returnee's research. In their study of US PhD graduates, Kahn and MacGarvie (2016) showed that those who leave or return home, for exogenous reasons, publish in lower quality journals and receive fewer citations compared to a matched group of scientists who remain in the US. This effect is only observed for returnees to countries with low levels of science investment and low GDP, suggesting that access to resources and science infrastructure may explain the decline. In this paper we consider the case of China, which has invested heavily in science in the past decades also with a view to attract scholars back home (Cao et al., 2019, Zweig et al., 2020, Xie et al., 2014). For example, fellows of the Changjiang Scholars Program and Overseas Outstanding Youth Science Foundation Program are endowed with substantial funding, allowing them to build research teams. As a result of this, and in line with Kahn and MacGarvie's (2016) observations, they are able to publish more papers in high impact journals compared to overseas Chinese peers who did not return (Shi et al., 2023). Yet, recent research by Marini and Yang (2021) shows that despite this, scholars receive on average fewer citations after their return to China than a group of comparable Chinese scientists who remain abroad (mostly in the US), suggesting that overall visibility declines despite higher outputs.

Given the geographic nature of mobility, it could be expected that the relative loss in citations also has a geographic dimension. Recent studies have investigated the presence of geographic over-citing relative to what would be expected based on paper output. They found that authors have a tendency to over-cite papers of their own country (Bakare and Lewison, 2017, Khelfaoui et al., 2020, Ladle et al., 2012) and generally to over-cite US papers (Bornmann et al., 2018, Chen et al., 2022, Lariviere et al., 2018). Localised spillovers have been suggested as a possible reason, as they could explain the tendency of authors within the same geographic area to cite each other's work (Kahn and MacGarvie, 2016). This would have implications for returning scientists who could lose citations, and thus international impact and visibility, as a result of the mobility. Instead, given the prevalence of localised spillovers and domestic self-citations, especially in China (Khelfaoui et al., 2020, Ladle et al., 2012), returnees could be expected to increase their citations domestically. Thus, return mobility, while enabling knowledge to flow back to the home country, may come with a relative loss of relevance elsewhere. Our first hypothesis thus poses:

H1: Return to the home country leads to a relative decline in scientists' international impact/visibility.

2.2 Return mobility and the geography of collaboration networks and knowledge base

While mobility and the associated relocation itself can explain potential changes in the visibility and impact of scientists' research, there are some other factors that could explain or contribute to this effect. We consider two factors: international collaboration networks and geography of the knowledge base.

We discussed earlier that the networks of mobile scholars, including returnees, are more international than those of their non-mobile peers. Social network theory suggests that this offers returnees access to more diverse information, opportunities for network building, and also control benefits in sparse networks, with positive implications for their future careers and collaboration (Lu and McInerney, 2016). It could also explain the superior performance of mobile scientists, as international collaborations have been shown to result in publications in higher impact journals and in more highly cited papers (Glänzel and Schubert, 2001, Lu and McInerney, 2016) , an effect that is larger for authors in the scientific periphery (de Moya-

Anegon et al., 2018). Prior studies on the performance of returnees to China also highlight the positive effect of international co-authorship on the number of citations (Marini and Yang, 2021).

The term "international" in international collaboration indicates the crucial importance of the geographical dimension, that we already highlighted in relation to the localised nature of spillovers (Kahn and MacGarvie, 2016). Internationally co-authored papers can benefit from the existence of local spillovers in multiple places, thus increasing their visibility and potential for impact (Lancho Barrantes et al., 2012). As a result they are more highly cited than those co-authored domestically (Tyfield et al., 2009). Yet, international relationships usually reduce after scientists' return to their home country (Marini and Yang, 2021) and decline continuously with the number of years spent back home (Wang et al., 2019, Li et al., 2015). Therefore, returnees' geographical closeness to the international scientific core weakens with their return mobility, leading to some loss in global knowledge spillovers. A decrease in international citations could thus be a direct result of the loss of international co-authors and collaborators. We hypothesise:

H2a: International collaboration networks mediate the negative effect of return mobility on international impact/visibility.

At the same time, any links that are maintained can be put to positive use. While prior research does not provide strong evidence that international co-authorship results in more novel research (Wagner et al., 2019), international collaboration networks permit returnees to stay abreast of developments in the field, help maintain their relevance and visibility for external non-domestic readers and benefit from positive global citation spillovers (Tyfield et al., 2009, Lancho Barrantes et al., 2012). Maintaining international collaboration networks could thus help overcome the negative effect of return mobility. We hypothesise:

H2b: The extent of scientists' reliance on international collaboration networks moderates the loss of international impact/visibility associated with the return, such that the loss is weaker for those with a strong international collaboration network.

A second mechanism that can impact international visibility is the geography of the knowledge base utilised by returning academics. We already mentioned that authors tend to over-cite papers from their own country. Ladle et al. (2012) discuss the possible reason for this 'insularity', stating that it could relate to poor referencing practices or to nationalistic education in universities with a preference for local research. The reason behind this phenomenon may also be related to the topic of study, which may respond directly to national development needs and focus on a national issue or localized research questions (Ladle et al., 2012). Bakare and Lewison (2017), for instance, find that chemistry and ornithology, scientific areas with a stronger local relevance, display higher over-citation compared to health and astronomy, fields with a more international outlook. Another reason may be the use of bibliometric indicators by national evaluation systems, which incentivises researchers to adopt national self-citation practices (Baccini et al., 2019). Whatever the specific reasons, prior studies have indeed found that this phenomenon exists in China (Khelfaoui et al., 2020, Chen et al., 2022). To a large extent such over-citing of domestic papers is suggestive of a weak international knowledge base being utilised in academic research.

Although there are relatively few studies that focus on the geography of publications' knowledge base, the limited research still demonstrates its association with visibility and impact. Bornmann et al. (2018), for instance, found that less well-cited papers are more likely to cite domestic references, while more highly-cited papers are more likely to rely on international references. There is also evidence that a stronger international knowledge base contributes to higher scientific impact for Chinese publications, although "international" in this prior study is only defined as references using a foreign language (Gong et al., 2019). With their mobility back home, returnees' international knowledge base may weaken as they may turn to more domestic topics and utilise domestic data. A loss in international citations may be the result of such refocusing. We thus hypothesise:

H3a: International knowledge base mediates the negative effect of return mobility on international impact/visibility.

References can also be seen as a proxy for knowledge transmission and combination (Gong et al., 2019). Citing international literature implies the understanding and absorption of international knowledge by scientists. For returnees, keeping an eye on and absorbing international knowledge allows them to remain connected to the international scientific core in their research even after the return. In this way they may be able to compensate for the loss of international visibility that occurs when they leave the international research environment. We hypothesise:

H3b: The extent of scientists' reliance on the international knowledge base moderates the loss of international impact/visibility associated with the return, such that the loss is weaker for those with a strong international knowledge base.

3 Data and Methodology

3.1 Data

To investigate our hypotheses, we rely on information from all 291 Chinese scientists who moved to national research institutes in China from an overseas academic institution between 2011 to 2015 under one of the national returnee recruitment programmes. These ambitious talent attraction programmes were designed to recruit leading scientists working abroad, with the aim of reversing the brain drain of scientists and to boost the country's efforts to become a global leader in technology and innovation (Shi et al., 2023). They offer recruits a one-off tax-exempt income subsidy, start-up grants, other benefits packages, and independent research positions and highly rewarding career prospects (Shi et al., 2023, Han and Appelbaum, 2018). To qualify for the programme, one should possess three or more years of overseas research experience and commit to full-time employment in China (Shi et al., 2023). Upon return, scientists face the challenges of working in the Chinese academic system, which has been said to promote short-term thinking and quick successes, and relies on social connections (Han and Appelbaum, 2018). Overall, the relatively strong academic performance, long-term overseas experience, stable research position in China, and substantial changes in research culture experiences upon return, make the recruits of the programme an ideal sample for this study.

We construct the sample of academic staff at national research institutes based on information from the institutes' websites, and scientists' personal homepages on whether they were attracted via a returnee recruitment programme. The final sample of 291 scientists all have extensive international experience (at least 5 years) and have been back in China for at least 5 years, which provides a sufficiently long time window for us to analyse. We further record their personal information from CVs available on their official homepages. Specifically, we acquire their age, gender, discipline, education and work experience. Where personal details such as date of birth are missing, we infer this data based on other available information. For example, we infer the year of birth from the year of their bachelor's degree, and the discipline from the first-level disciplines of the Chinese Library Classification System based on the research interests displayed on their CVs.

Next, to gain data on academic performance, we firstly obtain scientists' unique Scopus IDs by searching their names and institutes in Scopus one by one and checking all results manually.[1] Secondly, we retrieve and download scientists' journal publication data in batch by Scopus ID. Finally, based on publications' unique identifiers, we retrieve these publications' references and citations from Scopus using the tool pybliometrics (Rose and Kitchin, 2019), a Python wrapper to access Scopus RESTful API. Regarding citations, we only focus on citations that a publication received in the first 5 years after it is published (including the publication year) (Lariviere et al., 2009, Bloomfield et al., 2015, Zuccala, 2010).[2] That is, if a paper is published in 2012, we consider the citations it receives from 2012 to 2016. Then, based on the author affiliation addresses, we capture the scientists' international collaboration activities, that is, their collaboration with authors outside China. We also capture this information for all the publication's citations and references.

We set a 10-year observation window, including 5 years before and 5 years after the scientists return to China to enable us to compare scientists' performance during two distinct periods. Five year windows have also been considered in prior research on the medium-term impact of mobility (Fernández-Zubieta et al., 2015). In the observation window, the scientists in our sample published 9094 publications, citing 397,155 publications (references), and being cited by 345,157 publications (citations). What is more, in our analyses we take a one-year time lag into consideration to account for any delay from paper submission to publishing.

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[1] It is worth noting that Scopus has two typical type errors in assigning authors' IDs. The first is that an author is assigned multiple Scopus IDs, and the second is that multiple authors are assigned the same Scopus ID. The first case results in some omissions in the publication data we download. Through searching on Scopus by name and institution, we supplement these missing publications. The second case leads to redundant publication data. By comparing the publications' affiliation in the publication data with the educational and work institutions in the personal data, we identify publications that do not belong to our target scientists and eliminate these.

[2] Citation data for this paper is as of 2021. Therefore, if a publication is published in 2018, we only consider the citations it received in the first 4 years (2018, 2019, 2020, 2021). Further, if a publication is published in 2019, we only focus on citations in the first 3 years (2019, 2020, 2021). Overall, we can ensure a citation window of at least 3 years.

The basic demographic information for the sample is shown in Figure 1. Graph (a) shows the number of scientists returning to China each year. There are only 34 scientists returning in 2011 but the number increases sharply in the next year. About 60 scientists return to China every year from 2013 to 2015. Graph (b) shows the distribution of scientists' age at the time of return, indicating they are a very young academic group whose ages range from 29 to 41, and most of them are between 32 and 35 years old. Graph (c) shows that our sample is overwhelmingly male, making up 90 percent; Graphs (d) and (e) tell us that nearly half the scientists completed their Ph.D. degrees outside China, and most scientists belong to biological sciences, physics, and chemistry which are the dominant disciplines of the research institutes. Graph (f) reports the top five most popular countries where scientists stayed prior to their return to China.[3] About 74% of scientists returned from the United States, followed by countries in Europe and Canada. Hence they returned to China from the global 'scientific core'.

< Figure 1 about here >

3.2 Variables

Our core objective is to estimate the effect of scientists' return mobility (from overseas back to China) on their international citations. What is more, we will explore the roles of international collaboration and the international research base in this effect.

3.2.1 Dependent variables

The dependent variable in our regression is the international citation ratio ($ICITR_{it}$). It reveals scientists' international impact or visibility, referring to the proportion of international authors to total authors in the publications that cite our focal scientist's publications in the following 5 years. It is calculated as follows:

$$ICITR = \frac{\sum_{k=1}^{M} \sum_{n=1}^{N} ICS_{nk}}{\sum_{k=1}^{M} \sum_{n=1}^{N} TCS_{nk}} \quad (1)$$

[3] Some scientists stayed in more than one country prior to their return. Therefore the total is greater than 100 percent.

Where the international contribution score (*ICS*) is the number of international authors in a publication, and the total contribution score (*TCS*) is the total number of authors in a publication. $\sum_{k=1}^{M} \sum_{n=1}^{N} ICS_{nk}$ is the sum of the international contribution score of the *M* publications that cite *N* publications. Similarly, the $\sum_{k=1}^{M} \sum_{n=1}^{N} TCS_{nk}$ is the sum of the total contribution scores of a citing publication. It should be noted, that we define an author as an international author if their affiliation address is international, i.e. outside China. Especially, if an author has both Chinese and overseas affiliation addresses, we do not consider them as an international author because of the local affiliation.

3.2.2 Explanatory variables

(1) To investigate scientists' academic performance in the pre- and post-return mobility periods, we set a main explanatory variable ($Post\text{-}return_{it}$) whose value takes 0 prior to scientist *i's* return to China and the value 1 after their return.

(2) Since we plan to explore the potential role of international collaboration, we introduce an explanatory variable called international contribution ratio (ICR_{it}) to measure the proportion of international co-authors over the total number of co-authors listed on scientists' publications. This is calculated as:

$$ICR = \frac{\sum_{n=1}^{N} ICS_n}{\sum_{n=1}^{N} TCS_n} \qquad (2)$$

where $\sum_{n=1}^{N} ICS_n$ and $\sum_{n=1}^{N} TCS_n$ represent the sum of the international contribution score and the sum of the total contribution score of *N* publications respectively.

(3) Our final explanatory variable to measure the international knowledge base is the international reference ratio ($IREFR_{it}$), referring to the proportion of international authors over the total number of authors of publications cited as references by our focal scientist's publication. It has the same calculating rule as $ICITR_{it}$ (equation 1).

3.2.3 Control variables

In addition to our explanatory variables, some other factors may explain the share of international citations. We introduce the number of publications ($Pub\ count_{it}$), overall citations ($Cit\ count_{it}$), and references ($Ref\ count_{it}$) to control for any potential differences in publication and citation standards between scientists and their research specialisms. We consider the average number of authors (*Authors count*$_{it}$) to control for the impact of collaboration more broadly, which has been shown to be an important predictor for citations (Zhang et al., 2020). We also consider the average impact factor of the journals in which publications appear, using the Journal Impact Factor (*Jif*$_{it}$), as higher impact journals likely attract more diverse citations (Judge et al., 2007). Moreover, science develops internationally, and especially basic research relies more on international collaboration (Boyack et al., 2014), and may attract more international citations. We therefore include a measure for the basicness of the publication (*Basicness*$_{it}$), which represents the share of basic science publications (calculated following Boyack et al. (2014)) over all publications. In addition, following prior research we control for a number of demographic characteristics, such as scientists' *Age*$_{it}$, *Gender*$_{it}$, and *Discipline*$_{it}$ (Zuccala, 2010, van Arensbergen et al., 2012, Abramo et al., 2018), overseas PhD (*Overseas PhD*$_{it}$), and overseas postdoctoral experience (*Overseas postdoc*$_{it}$) (Singh, 2018, Baker, 2015). The variables' definitions and summary statistics are shown in Table 1. The correlation between all variables appears in Table 2.

< Tables 1 and 2 about here >

3.3 Empirical Models

Our dataset is balanced with 291 individuals and a 10-year observation window allowing us to estimate panel regressions. Fixed effects models are employed in this study to account for scientists' inherent, unobserved characteristics. The base model to establish if there is any mobility effect is written as:

$$ICITR_{it} = \beta_{1i} + \beta_2 Post\_return_{it} + \beta_i Controls_{it} + \gamma_i + \mu_{it} \quad (1)$$

where $ICITR_{it}$ is scientist *i's* international citation ratio in time *t*. β are the coefficients to be estimated, γ is scientist i's fixed effect term, and μ is the random disturbance term.

To measure the potential mediating roles of international collaboration (*ICR*) and international knowledge base (*IREFR*), we first estimate the impact of return mobility on *ICR*$_{it}$ and *IREFR*$_{it}$ as per equation (1), and then add both variables to the base model, as follows:

$$ICITR_{it} = \beta_{1i} + \beta_2 Post\_return_{it} + \beta_3 ICR_{it} + \beta_4 IREFR_{it} + \beta_i Controls_{it} + \gamma_i + \mu_{it} \quad (2)$$

Finally, to estimate their moderating effects on mobility, we estimate a series of models that add interaction effects as follows:

$$ICITR_{it} = \beta_{1i} + \beta_2 Post\_return_{it} + \beta_3 ICR_{it} + \beta_4 Post\_return_{it} \times ICR_{it} + +\beta_i Controls_{it} + \gamma_i + \mu_{it} \quad (3)$$

$$ICITR_{it} = \beta_{1i} + \beta_2 Post\_return_{it} + \beta_3 IREFR_{it} + \beta_4 Post\_return_{it} \times IREFR_{it} + \beta_i Controls_{it} + \gamma_i + \mu_{it} \quad (4)$$

$$ICITR_{it} = \beta_{1i} + \beta_2 Post\_return_{it} + \beta_3 ICR_{it} + \beta_4 IREFR_{it} + \beta_5 Post\_return_{it} \times ICR_{it} + \beta_6 Post\_return_{it} \times IREFR_{it} + \beta_i Controls_{it} + \gamma_i + \mu_{it} \quad (5)$$

As several of our explanatory and control variables are correlated (see Table 2), we test their variance inflation factor (VIF), which has a mean value of 1.70. This does not exceed 10, indicating that there is no issue of multicollinearity.

Further, we estimate a random effects regression model to test the robustness of the main regression results, and to explore the effects of some time-invariant scientist characteristics, such as gender.

4 Results

4.1 Descriptive analysis

We first present a descriptive analysis of returnees' academic performance pre- and post-return to China. In Figure 2 we firstly show the time trends in terms of (a) publication numbers, and (b) 5-year citations per publication. More importantly, Figure 2 shows us the internationality of scientists' research in terms of the (c) share of international citations, (d) share of international co-authors, and (e) share of international references. We see that the number of publications increases substantially following the return to China, a result that confirms observations by Shi et al. (2023) and is likely linked to the boost in research resources that returnee scholars receive. However, at the same time the average number of citations received over the following 5 years declines significantly, confirming Marini and Yang (2021) and suggesting that overall visibility is reduced post-return. What's more, all three indicators of internationality experience a significant decline after scientists' return to China. This indicates that scientists have a weaker link with the international community in the post-return mobility period. It also suggests that some of the loss of citations could be due to a loss of international visibility.

< Figure 2 about here >

Specifically, from Figure 2c, we can see that during the pre-return mobility period, on average 68.4% of citations are international (from outside China). However, this share drops to 44.4% after their return to China. This suggests that the return mobility has made it more difficult for scientists' academic outputs to be seen by or to be relevant to the international academic community, and that this difficulty becomes more severe as more time passes since leaving the international environment. What is more, we can see a sharp decrease in scientists' international co-authorship in Figure 2d. Before their return to China 76.9% of scientists' co-authors are from outside China, while this share is only 20.0% after the return. International collaboration can thus be severely hindered by return mobility. When we look at trends in international references in Figure 2e, there is also a drop, although it is slight, decreasing from 89.6% of referenced research to 78.5% after their return. This suggests that scientists largely still focus on global research achievements, but that there is an increase in their reliance on a more local knowledge base when in China.

4.2 Regression analysis

Table 3 reports the results of the FE regression analysis, including Model 1 to Model 7, testing our hypotheses. Model 1 presents the main post-return effect; Model 2 includes the other explanatory variables; Model 3-5 include the interaction terms to check for moderation effects; and Models 6 and 7 test for mediation.[4]

Our first hypothesis argues that return mobility exerts a negative effect on scientist's international visibility. Model 1 presents the results for our first hypothesis and shows that

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[4] The results are robust to changes in control variables: (1) if rather than biological age we include academic age, defined as the number of years from the first publication to year t, (2) using total citation count instead of the citation count of per publication. They are also robust to the inclusion of a variables measuring the years spent abroad. The latter is not included in the final regression as it does not vary in the post-return period.

scientists' international citation ratio changes with mobility. The *Post-return* variable is negative and significant (β = -0.072, $p < 0.01$), indicating that the international visibility/impact of scientists after they return to China is reduced by 7.2% compared to when they were overseas. This provides support to H1.

We further posit that scientists' international collaboration networks and knowledge bases mediate the loss of international visibility associated with the return. To test for this, we estimate equation (2) in Model 2 of Table 3. The results show that they are both positively associated with our dependent variable ICITR (for ICR, β = 0.260, $p < 0.01$; for IREFR, β = 0.490, $p < 0.01$). This suggests that a 10% increase in international collaboration (ICR) is associated with a 2.6% increase in international impact/visibility (ICITR), and a 10% increase in the international reference ratio (IREFR) with a 4.9% increase in international impact/visibility (ICITR). We compare the coefficients of these two main explanatory variables using dominance analysis (Luchman, 2021), and find that the international reference ratio is more important than the international contribution ratio in explaining international visibility/impact, suggesting that an international knowledge base is essential for visibility/impact.

After adding these variables, the effect of *Post_return* turns insignificant, telling us that the negative effect of return mobility is fully compensated for by the two variables. Models 6 and 7 help us understand if this is a result of mediation. We observe that the *Post_return* variable is negative and significant in Model 6 (β = -0.208, $p < 0.01$), indicating that international collaboration (ICR) reduces by 20.8% post-return. At the same time it is negative but insignificant in Model 7. Thus, the international contribution ratio declines with return mobility, but the international reference ratio is rather stable. This allows us to conclude that international collaborations (ICR) mediate the effect of return mobility on international impact/visibility and gives strong support to H2a. However, the international knowledge base is not a mediator and H3a is therefore not supported.

< Table 3 about here >

We further hypothesised that scientists' international collaboration and international knowledge base moderate the loss of international visibility associated with the return (H2b and H3b). Models 3 to 5 of Table 3 show evidence of this. We firstly observe that there is a positive effect of the interaction between *Post_return* and *ICR* on *ICITR* (Model 3). In general, scientists work has lower international impact/visibility after their return. However, if returnees keep a tight international collaboration network, they can retain their international impact/visibility, confirming H2b. The interaction term between *Post_return* and *IREFR* instead is negative, contrary to the positive prediction in H3b, showing that there is a negative moderating effect of international knowledge base on the relationship between return mobility and international impact/visibility. This suggests that those with a strong international research orientation may suffer a greater loss in international impact/visibility upon their return to China.

To further illustrate the interaction effects, we plot the margins in Figure 3. Figure 3a shows that a scientist with a tighter international collaboration network will be more effective in attracting international citations after their return than before. This shows that international collaboration mitigates the negative effect of return mobility on international impact/visibility. Figure 3b presents the interaction with *IREFR* and shows that, regardless of how international the knowledge base is, scientists always lose international citations after the return. When it comes to the extent of the loss, we find that scientists that have a more international knowledge base lose relatively more international citations. This means that when scientists leave the international scientific core to return to China, the international knowledge base plays a less effective role in their access to the international spotlight compared to prior to their return. The average marginal effects of *ICR* and *IREFR* pre- and post-return, presented in Figures 3c and 3d, illustrate this further. After scientists return to China, an increase in their international collaboration network boosts international citations more (from a 2% increase to a 3% increase when the international collaboration ratio increases by 10%) while any increase in the international knowledge base is less effective than prior to the mobility (reducing from a 5.5% to a 4.5% increase when the international reference ratio increases by 10%).

Overall, we can conclude that in the relationship between return mobility and international visibility/impact (*ICITR*), the international collaboration network (*ICR*) plays a dual role as mediator and as moderator. Further, scientists’ reliance on the international knowledge base (*IREFR*) acts as negative moderator. Based on these results, we can put forward several mechanisms for the effect of return mobility on international visibility, summarised in Figure 4. Firstly, returning to China weakens scientists' international visibility/impact, but this weakening is largely explained and can be compensated for by their international collaboration network. The ability of tight links with the international knowledge base to compensate is, however, reduced post-return.

Several controls provide additional interesting insights. Reference count (*Ref count*) has a positive and significant effect on scientists' international visibility/impact, although the coefficients are relatively small. More references may indicate a greater diversity of ideas and topics (Fox et al., 2016), and, in containing more citation information, may also attract the authors of these references to cite (Webster et al., 2009). Thus, if publications have a richer research-base, they have more opportunities to be cited, including internationally. We also find that the *Basicness* variable shows a positive and significant sign (Model 1 to 5), indicating that research outputs on basic research topics are more likely to be cited by the international academic community. The positive sign in Models 6 and 7 suggests that the more basic-oriented the research, the more it relies on international collaboration networks and an international knowledge base, thus likely representing research that is more international in outlook.

< Figures 3 and 4 about here >

4.3 Robustness tests

To confirm the robustness of our results, we check them by changing regression models and using variable substitution respectively. We further perform a treatment comparison to confirm our results and the direction of causality.

4.3.1 Random effects model

Firstly, we use a random effects (RE) model to replace the previous fixed effect regression model. Table 4 reports the RE regression results, which confirms all the results shown in Table 3. In addition, we can see the role of time-invariant control variables: gender, location of the PhD degree, and post-doc experience. The results show that none of these has a significant effect on international impact/visibility.

< Table 4 about here >

4.3.2 Alternatively dependent variable

Secondly, we define a new proxy variable called real international impact (*RII_{it}*) as an alternative measure for international visibility/impact. *RII* excludes any self-citation that come from our focal scientist's network, that is, their co-authors or past affiliations. The new variable may therefore more accurately present the international impact and visibility of the research. More precisely, *RII* is the proportion of the international citations coming from outside the scientist's international network over all citations. If there is an international author who has not collaborated with our focal scientist, and their institution is not where our focal scientist stayed previously, we consider this author outside the focal scientist's international network. The number of such authors is taken as the real international citation score (RICS). Then we can define RII as follows.

$$RII = \frac{\sum_{k=1}^{N} \sum_{n=1}^{N} RICS_{nk}}{\sum_{k=1}^{N} \sum_{n=1}^{N} TCS_{nk}}$$

In the formula, $\sum_{k=1}^{N} \sum_{n=1}^{N} RICS_{nk}$ is the sum of the real international citation score of the *M* citations that cite *N* publications.

We first look at *RII* descriptively. Figure 5 shows that during the pre-mobility period, 48.0% of citations represent their real international citations, but this drops to 33.5% during the post-mobility period. This suggests that return mobility also makes it more difficult for scientists to gain international recognition beyond their existing network when returning to China. This trend is relatively similar to *ICITR*, suggesting that the international impact of scientists has indeed declined after their return, whether or not self-citations from within the network are taken into account.

< Figure 5 about here >

Then, we estimate the FE regression model with the new dependent variable (*RII_{it}*) to estimate the effect of scientists' return mobility on their real international visibility/impact. The results reported in Table 5 suggest a pattern similar to Table 3. Model 1 confirms the negative impact of scientists' return mobility on international visibility/impact. Model 2 confirms the positive roles of the international collaboration network and the international knowledge base, and after the dominance analysis (Luchman, 2021), the coefficients again indicate that maintaining a larger international knowledge base brings more benefits than keeping close collaboration with international partners. Further, the moderation effects are also confirmed via the significant interaction effects in Model 4 and 5.

< Table 5 about here >

In addition to the previous results being verified, we test the differences in coefficients of our main independent variables between Tables 3 and 5 (Clogg et al., 1995). The coefficients of *Post_return* do not show a significant difference between models, suggesting that return mobility has a similar impact on scientists' international citation (*ICITR*, including self-citations from network) and real international citation (*RII*, excluding self-citations from network). As for the coefficients of *ICR* and *IREFR*, the absolute values in Table 5 are significantly smaller than those in Table 3, indicating that while *RII* can partly be explained by scientists' international collaboration and international knowledge base, it is explained to a lesser extent than *ICITR*.

4.3.3 Treatment comparison

Investigations of academic performance and careers suffer from issues of endogeneity as a result of unobserved effects. In our analysis, the change in international visibility and the return event could both be explained by scientist-specific skills, which would upward bias our results. We investigate this problem by conducting a treatment comparison, to help us confirm that scientists' international visibility and impact declines as a result of their return mobility. Specifically, we take the scientists in our sample who return to China in 2012 (treatment) and compare them to the group of 2015 returnees. This group was eligible to return in 2012, but did not do so, providing us with a control group for the 2012 returnees. We exclude any 2012 returnees who were already above 40 by 2015 to improve the comparability between the two. The final analysis has 73 scientists in the treatment group and 62 in the control group.

Figure 6 reports the ICITR, ICR and IREFR comparison for both groups for the period 2009 to 2015, that is three years before and after the treatment. We can see that the international impact/visibility, network and knowledge base of the treatment group drops starting in 2012, while the control group remains stable or shows an upward trend during the post-treatment years. They do not decline until around 2015, which is the year they also return.[5] The results thus confirm that return mobility can explain the decline in scientists' integration into the international community.

< Figure 6 about here >

Overall, from the empirical results we find evidence of the effect of return mobility on international visibility/impact of returning scientists, and the roles that international scientific networks and international knowledge base play in the relationship. We find that mobility back to China leads to a decline in scientists' international visibility (H1). We also find that collaborative links with overseas colleagues mediates and moderates the loss of international visibility associated with the return (confirming H2a and H2b). The extent of scientists' reliance on the international knowledge base shows a greater catalytic effect than international collaborative links, while negatively moderating the loss of international visibility (rejecting H3a and H3b)

5 Discussion and conclusions

In this study we explored the factors associated with the negative effect of scientists' return mobility on their international relevance, building on insights from the literature on return mobility and knowledge flows (Glänzel and Schubert, 2001, Franzoni et al., 2014, Kahn and MacGarvie, 2016, Lariviere et al., 2018). Our empirical analyses focused on 291 Chinese scientists who return under a talent attraction programme between 2011 to 2015, investigating their mobility experience and their publications 5 years before and 5 years after their return to China. The results show a relative decline in international citations post-return, and point to the importance of two factors that help us understand the negative correlation between return mobility and the international impact/visibility of scientists' research.

First, the loss in international citations is largely mediated by the loss in international network. Upon returning to China, scientists experience a significant decrease in the share of

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[5] Comparison of means tests between the treatment comparison groups are insignificant during most of the pre-treatment period (2009-2011), however, in the post-treatment period (2013-2015), the treatment group of 2012-returnees becomes significantly less international than the control group of 2015-returnees.

international co-authors, which directly translates into their research being cited less by the international scientific core. This finding suggests that international scientific networks are critical for global knowledge flows but are not completely mobile. Further, links with international colleagues gain in importance when scientists leave the scientific core, meaning that post-return scientists experience a greater loss in international citations when their international co-author network is smaller. Second, return mobility is more likely to be negatively associated with international citations when the relevant knowledge base is more international as opposed to when it is more locally based. Thus, when scientists move to the scientific periphery, an international knowledge base becomes less effective in gaining access to the international spotlight. Regardless, our results do show that despite the observed negative moderation effect, an international knowledge base is the most important predictor for international citations. Scientists who maintain an international outlook and connection to the scientific core, be that via co-authorship or by responding to research questions of global reach, remain relevant to international science and thus visible even after they leave the scientific core to return to their home country. What is more, our results also show that basic-oriented research can receive relatively steady attention from the international academic community and suffer less from scientists leaving the scientific core, likely because of its stronger global relevance.

These findings show that the rule of localized knowledge spillovers, i.e. that people tend to cite others' work within the same geographical area (Kahn and MacGarvie, 2016, Bakare and Lewison, 2017), is also observed in top scientists who return to China from the scientific core. After scientists' return, it is more difficult for their knowledge to spill over into the international community which continues to be dominated by the US. Therefore, while scientists brought back to China may receive more funding and improve career prospects and productivity (Shi et al., 2023), they also have to pay the price of reduced international impact and relevance. This loss may be difficult to mitigate. COVID travel restrictions and rising geopolitical tensions over the past couple of years have limited mobility and collaboration between China and the rest of the world, for example leading to a decline in China-US co-authorship since 2021 (Lau, 2022). Such isolation carries the risk of segregation in science, the costs of which are high, as previously shown in the case of the USSR (Borjas and Doran, 2012, Ganguli, 2015). This is thus bad news for scientists in China, whose work may be even less visible, but also for the world as it could miss out on science by leading scholars.

Our study also improves our understanding of the role of other international dimensions of scholarship. Although previous studies already showed that international collaboration can promote scientists' citations and impact (Marini and Yang, 2021, Glänzel and Schubert, 2001), our study highlights its importance for sustained international impact/visibility. Importantly, such collaboration networks play an even greater role in ensuring international relevance after scientists have left the scientific core to return home, as international collaborators may bring a global perspective to research, a larger group of external readers, and greater spillovers of knowledge to the international community.

Our study also highlights the importance of scientists' knowledge base and its geography, which is only just emerging as a topic of interest (Chacua and Freeman, 2022). In particular, our finding that research relying on domestic references does attract more domestic citations can help explain domestic over-citing (Ladle et al., 2012). In our sample of top Chinese scholars, we do not find that returning scientists shift their knowledge base towards domestic sources, yet they experience a loss in international citations regardless. This loss is greater for those that rely more heavily on international sources, which may suggest that the global community no longer considers them experts in global topics.

Turning back to the opening question of our paper: can scientists remain internationally visible after they return to their home country? Our results show that when scientists return, they inevitably lose some international visibility. Fortunately, such loss can be counteracted by enhancing international collaboration and upgrading the international knowledge base. Thus, if scientists want to attract the continued attention of the international academic community, on the one hand, once back, they need to actively maintain contact and collaboration with their international partners, for example by keeping regular online discussions, participating in international conferences, and taking up short-term international visits. They may even actively take on the role of bridging international collaborations, facilitating collaborations between domestic and foreign groups, and pushing themselves to become more deeply involved in international teams. On the other hand, it is imperative that scientists maintain an international knowledge base for their individual research (especially for applied-oriented research), such as remaining highly sensitive to international results and keeping abreast of the latest international developments in the field. In short, scientists can actively increase connections to international scholars and international outputs to counter the loss of the international impact brought on by leaving the scientific core.

This paper also has implications for research management and talent introduction policy. Research institutions and funders that aim to attract emigrant scientists back home should provide support to enable continued links with the international community and provide resources for researchers to access international knowledge, such as encouraging scientists' short-term international visits, setting up international collaboration funds and other incentives to maintain international networks, and responding positively to scientists' needs for international literature resources. In addition to this, research institutions should encourage scientists to actively conduct basic research and tackle basic scientific research problems, rather than pursuing short-term outputs of an applied nature. As basic research often takes longer to produce results, research institutions and funders should reconsider the short-term evaluation of scientists and lengthen the assessment period to give scientists more time to work on basic research challenges.

The paper has some limitations that call for additional investigations. Firstly, we rely on a small sample of returnee scientists to China. These returned as part of a talent policy, and have been shown to be amongst the most productive scientists, able to increase their research productivity post-return (Marini and Yang, 2021, Shi et al., 2023). The loss observed in international network and visibility may thus be larger for other returnees outside such a well-funded programme. Second, we focus on the return to China, which has in recent years emerged from the science periphery, ranking second in terms of publication quantity and rapidly closing the gap to the elite in terms of highly cited publications (Cao et al., 2019, Lau, 2022, Xie et al., 2014). The loss of international network and visibility may be felt significantly more by returnees to more peripheral regions. At the same time, recent travel restrictions and geopolitical tensions have isolated China and could hamper its attractiveness for returning scientists and reduce global knowledge flows in the future (Lau, 2022). Further, the relative absence of a local knowledge base in less developed countries could also link returnees outside of China more closely to the core post-return. This is something that future research should investigate.

Despite these limitations our study helps to bring attention to the costs of return mobility, exposing how returnees' connections to the international elite and knowledge base shape their visibility post-return. In doing so we have enriched our understanding of mobility in the context of brain circulation and on the limits of global knowledge spillovers in science.

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Tables

Table 1. Variables' definition and summary statistics

Variables	Definition	Mean	SD	Min	Max
Dependent variable					
$ICITR_{it}$	International citations ratio in t	0.45	0.32	0	1
Explanatory variables					
Post-return$_{it}$	Dummy==1 if back to China in year t; Dummy==0 if in overseas in *t*	0.49	0.50	0	1
ICR_{it}	International contribution ratio in t	0.38	0.41	0	1
$IREFR_{it}$	International references ratio in t	0.67	0.36	0	1
Control variables					
Pub count$_{it}$	Total number of publications in *t*	3.19	3.80	0	40
Cit count$_{it}$	Average number of citations to publications in *t* in the first 5 years	31.45	50.26	0	702.75
Ref count$_{it}$	Average number of references on publications in *t*	34.57	24.71	0	362.50
Authors count$_{it}$	Average author number of publications in *t*	7.131	17.747	0	423.375
Jif_{it}	Average Journal impact factors of per publication in *t*	7.17	7.51	0	55.47
$Basicness_{it}$	Share of basic publications in *t*	0.50	0.45	0	1
Age_{it}	Age in t	34.50	3.76	24	46
$Gender_{i}$	Dummy==1 if male	0.90	0.30	0	1
Overseas PhD_{i}	Dummy==1 if overseas PhD degree	0.45	0.50	0	1
Overseas $postdoc_{it}$	Dummy==1 if worked as postdoc before *t*	0.89	0.32	0	1
Discipline_1_{i}	Dummy==1 if Biological Science	0.37	0.48	0	1
Discipline_2_{i}	Dummy==1 if Physics	0.25	0.43	0	1
Discipline_3_{i}	Dummy==1 if Chemistry	0.22	0.41	0	1
Discipline_4_{i}	Dummy==1 if Astronomy and Earth sciences	0.11	0.31	0	1
Discipline_5_{i}	Dummy==1 if Environmental sciences	0.02	0.13	0	1
Discipline_6_{i}	Dummy==1 if Mathematics	0.02	0.15	0	1
Discipline_7_{i}	Dummy==1 if Industrial Technology	0.02	0.13	0	1
$Year_{it}$	Actual year in t	2013.45	3.06	2007	2019

Table 2. Correlation between key variables

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1	**$ICITR_{it}$**	1.000												
2	**ICR_{it}**	0.754	1.000											
3	**$IREFR_{it}$**	0.828	0.619	1.000										
4	**Post-return$_{it}$**	-0.212	-0.502	-0.002	1.000									
5	**Pub count$_{it}$**	0.091	-0.009	0.267	0.283	1.000								
6	**Cit count$_{it}$**	0.307	0.332	0.329	-0.137	0.109	1.000							
7	**Ref count$_{it}$**	0.520	0.281	0.661	0.179	0.310	0.254	1.000						
8	**Authors count$_{it}$**	0.137	0.081	0.161	0.093	0.196	0.105	0.146	1.000					
9	**Jif_{it}**	0.459	0.392	0.499	-0.077	0.111	0.591	0.368	0.132	1.000				
10	**$Basicness_{it}$**	0.535	0.319	0.598	0.046	0.092	0.177	0.503	0.148	0.376	1.000			
11	**Age_{it}**	-0.151	-0.364	-0.039	0.653	0.167	-0.127	0.132	0.114	-0.064	0.017	1.000		
12	**$Gender_{it}$**	0.010	0.010	0.041	0.002	0.114	0.006	0.005	0.021	0.033	0.055	-0.079	1.000	
13	**Overseas PhD_{it}**	-0.032	-0.013	-0.052	0.006	-0.068	-0.075	-0.100	0.001	-0.126	-0.089	-0.028	-0.093	1.000
14	**Overseas $postdoc_{it}$**	0.043	0.019	0.045	0.039	0.031	0.064	0.094	0.037	0.092	0.072	0.097	-0.119	-0.114

Table 3. FE regression results of the effect of mobility on international citations ratio

	ICITR					ICR	IREFR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post-return	-0.072***	-0.014	-0.012	-0.018*	-0.017*	-0.208***	-0.007
	(0.015)	(0.010)	(0.010)	(0.011)	(0.010)	(0.019)	(0.015)
ICR		0.260***	0.251***	0.246***	0.194***		
		(0.015)	(0.015)	(0.017)	(0.023)		
IREFR		0.490***	0.492***	0.516***	0.561***		
		(0.022)	(0.022)	(0.025)	(0.029)		
Post-return×ICR			0.032*		0.113***		
			(0.018)		(0.029)		
Post-return×IREFR				-0.048***	-0.116***		
				(0.015)	(0.024)		
Pub count	0.002	-0.001	-0.001	-0.001	-0.000	0.001	0.004**
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Cit count	0.000	-0.000	-0.000	-0.000	-0.000	0.001***	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ref count	0.004***	0.001***	0.001***	0.001***	0.001***	0.003***	0.005***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Authors count	0.001	0.000	0.000	0.000	0.000	0.001**	0.001
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Jif	0.007***	0.001	0.001	0.001	0.001	0.010***	0.009***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Basicness	0.305***	0.040***	0.041***	0.041***	0.043***	0.243***	0.410***
	(0.026)	(0.014)	(0.014)	(0.014)	(0.014)	(0.026)	(0.032)
Age	-0.015***	-0.003	-0.002	-0.003	-0.003	-0.031***	-0.010**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	(0.004)
Gender	-	-	-	-	-	-	-
Overseas PhD	-	-	-	-	-	-	-
Overseas postdoc	0.006	0.013	0.012	0.013	0.012	-0.021	-0.001
	(0.038)	(0.028)	(0.028)	(0.028)	(0.028)	(0.062)	(0.041)
Discipline	-	-	-	-	-	-	-
Year				Controlled			
_cons	0.618***	0.073	0.159	0.430***	0.515***	1.204***	0.473***
	(0.122)	(0.113)	(0.112)	(0.118)	(0.116)	(0.196)	(0.154)
N	2848	2848	2848	2848	2848	2848	2848
r2	0.571	0.812	0.812	0.813	0.814	0.551	0.671

Robust standard errors in parentheses="* p<0.1, ** p<0.05, *** p<0.01"

Table 4. RE regression results of the effect of mobility on international citations ratio

	ICITR					ICR	IREFR
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Post-return	-0.084***	-0.014	-0.011	-0.018*	-0.016	-0.264***	-0.007
	(0.015)	(0.010)	(0.010)	(0.010)	(0.010)	(0.020)	(0.015)
ICR		0.269***	0.257***	0.258***	0.203***		
		(0.015)	(0.015)	(0.017)	(0.023)		
IREFR		0.487***	0.490***	0.508***	0.556***		
		(0.021)	(0.020)	(0.024)	(0.028)		
Post-return×ICR			0.041**		0.118***		
			(0.019)		(0.029)		
Post-return×IREFR				-0.039***	-0.111***		
				(0.014)	(0.023)		
Pub count	0.003	-0.002*	-0.002*	-0.002*	-0.002	0.003*	0.008***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Cit count	0.000	-0.000	-0.000	-0.000	-0.000	0.001***	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ref count	0.004***	0.001***	0.001***	0.001***	0.001***	0.003***	0.006***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Authors count	0.001	0.000*	0.000*	0.000	0.000	0.001	0.000
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Jif	0.008***	0.001	0.001	0.001	0.001	0.010***	0.010***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Basicness	0.267***	0.045***	0.045***	0.045***	0.047***	0.190***	0.331***
	(0.024)	(0.013)	(0.012)	(0.013)	(0.012)	(0.024)	(0.029)
Age	0.001	0.002	0.002	0.002	0.002	-0.003	0.001
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Gender	-0.018	0.003	0.003	0.003	0.003	-0.029	-0.024
	(0.025)	(0.017)	(0.017)	(0.017)	(0.017)	(0.031)	(0.025)
Overseas PhD	0.018	0.011	0.011	0.012	0.013	0.019	0.005
	(0.017)	(0.010)	(0.010)	(0.010)	(0.010)	(0.020)	(0.016)
Overseas postdoc	-0.004	0.002	0.002	0.002	0.003	-0.002	-0.011
	(0.019)	(0.013)	(0.013)	(0.013)	(0.013)	(0.025)	(0.019)
Discipline Year	Controlled						
_cons	0.170*	-0.020	0.079	0.313***	0.411***	0.378***	0.170*
	(0.090)	(0.062)	(0.061)	(0.066)	(0.064)	(0.119)	(0.092)
N	2848	2848	2848	2848	2848	2848	2848
r2	0.570	0.812	0.812	0.813	0.814	0.547	0.667

Robust standard errors in parentheses="* p<0.1, ** p<0.05, *** p<0.01"

Table 5. FE regression results of the effect of mobility on the real international impact

	RII				
	(1)	(2)	(3)	(4)	(5)
Post-return	-0.041***	-0.020*	-0.019*	-0.023**	-0.022**
	(0.013)	(0.011)	(0.011)	(0.011)	(0.011)
ICR		0.088***	0.083***	0.077***	0.043*
		(0.015)	(0.015)	(0.017)	(0.023)
IREFR		0.403***	0.404***	0.422***	0.452***
		(0.022)	(0.022)	(0.026)	(0.029)
Post-return×ICR			0.018		0.074***
			(0.018)		(0.028)
Post-return×IREFR				-0.035**	-0.080***
				(0.015)	(0.024)
Pub count	0.002	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Cit count	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Ref count	0.003***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Authors count	-0.000	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Jif	0.006***	0.002***	0.002***	0.002***	0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Basicness	0.223***	0.037**	0.037**	0.037**	0.038***
	(0.022)	(0.015)	(0.015)	(0.015)	(0.015)
Age	-0.008***	-0.002	-0.002	-0.002	-0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Gender	-	-	-	-	-
Overseas PhD	-	-	-	-	-
Overseas postdoc	0.027	0.030	0.029	0.030	0.029
	(0.023)	(0.024)	(0.024)	(0.024)	(0.025)
Discipline	-	-	-	-	-
Year			Controlled		
_cons	0.313***	0.017	0.043	0.308***	0.332***
	(0.106)	(0.112)	(0.111)	(0.115)	(0.112)
N	2848	2848	2848	2848	2848
r2	0.542	0.702	0.702	0.703	0.704

Robust standard errors in parentheses="* p<0.1, ** p<0.05, *** p<0.01"

Figures

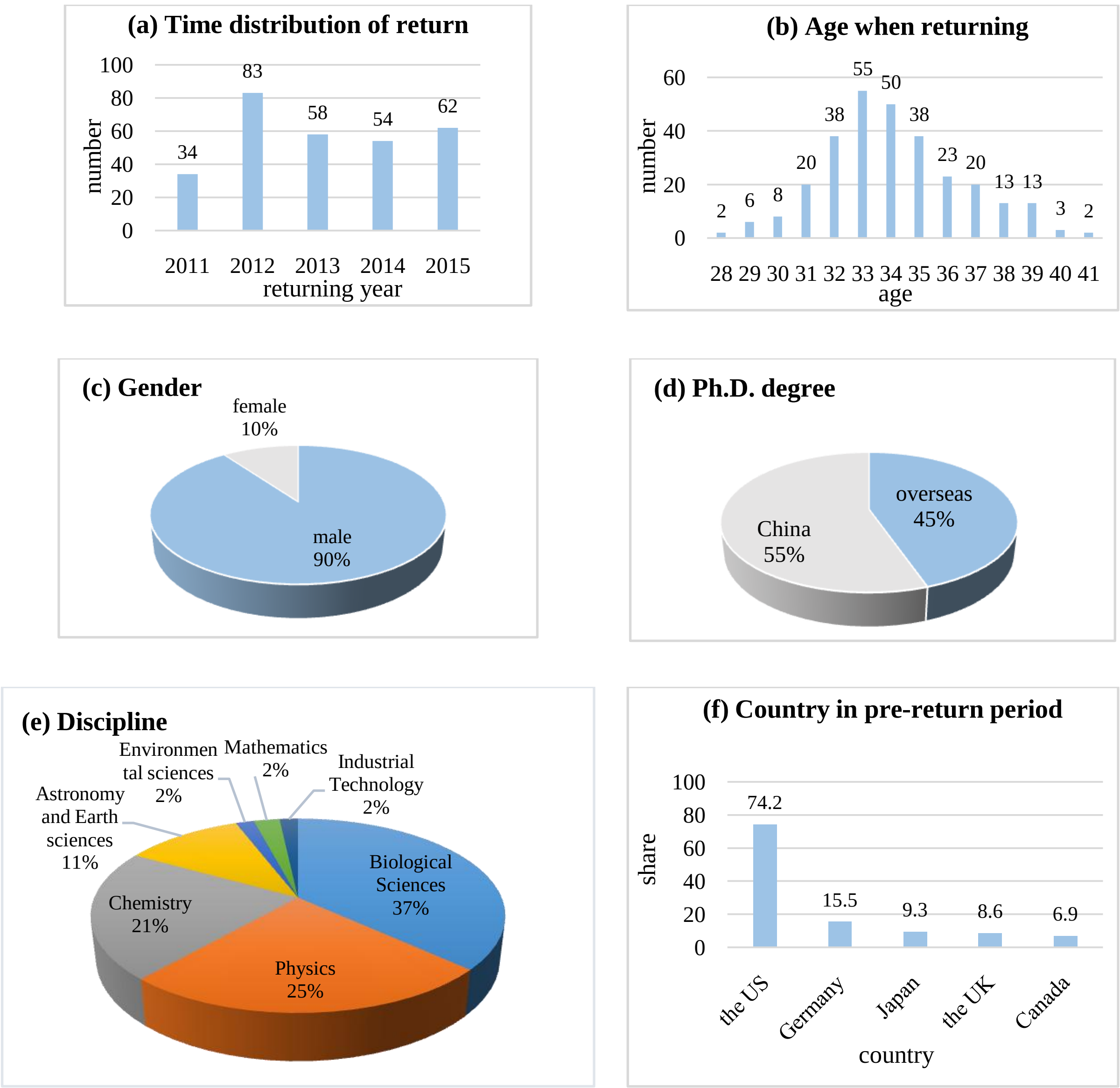
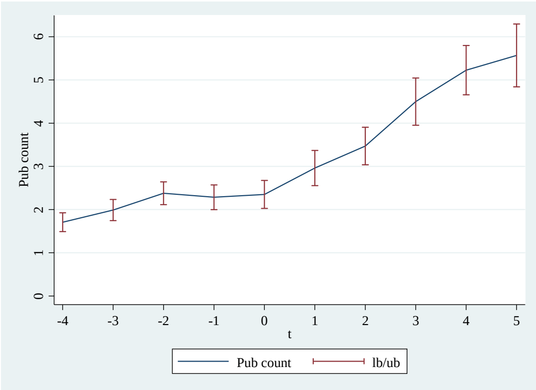


Figure 1. Demographic profile of the sample

(a)



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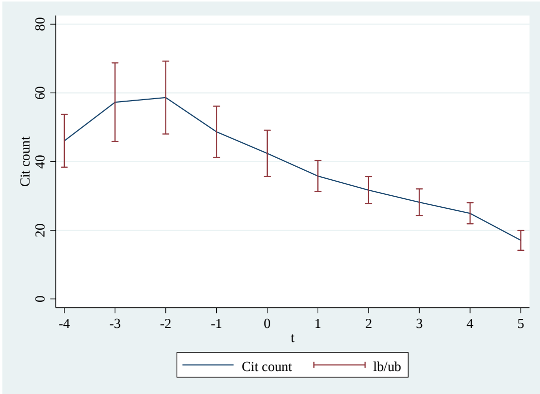

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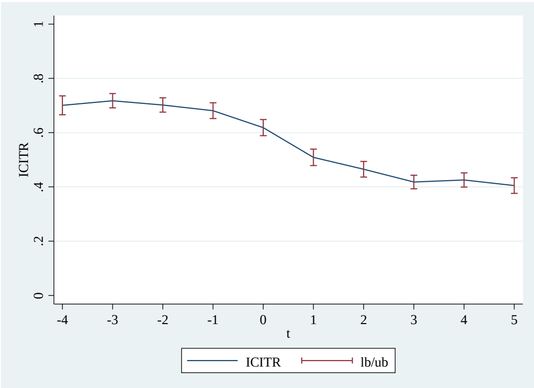

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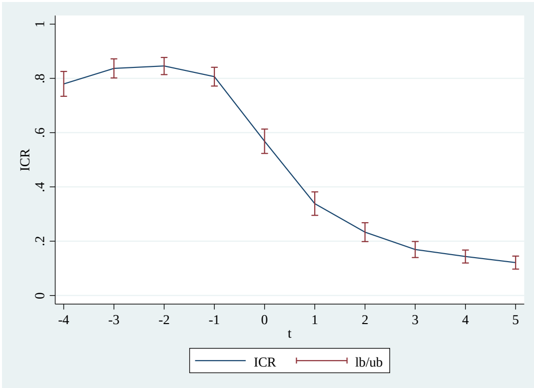

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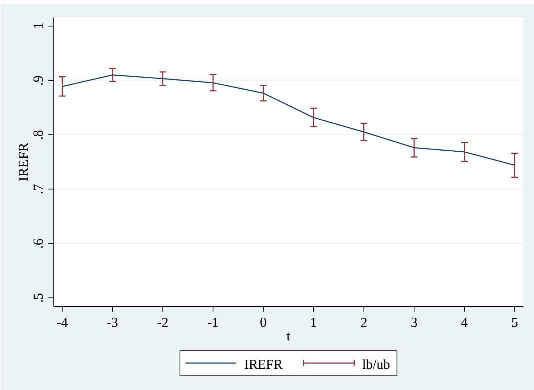

Figure 2. The trends of academic performance of scientists in the 5 years before and after returning to China

Note: Scientists return to China in *t=0*. (a) shows returnees' number of publications, (b) the average number of citations per publication, (c) the international citation ratio, (d) the international contribution ratio, and (e) international reference ratio, respectively.

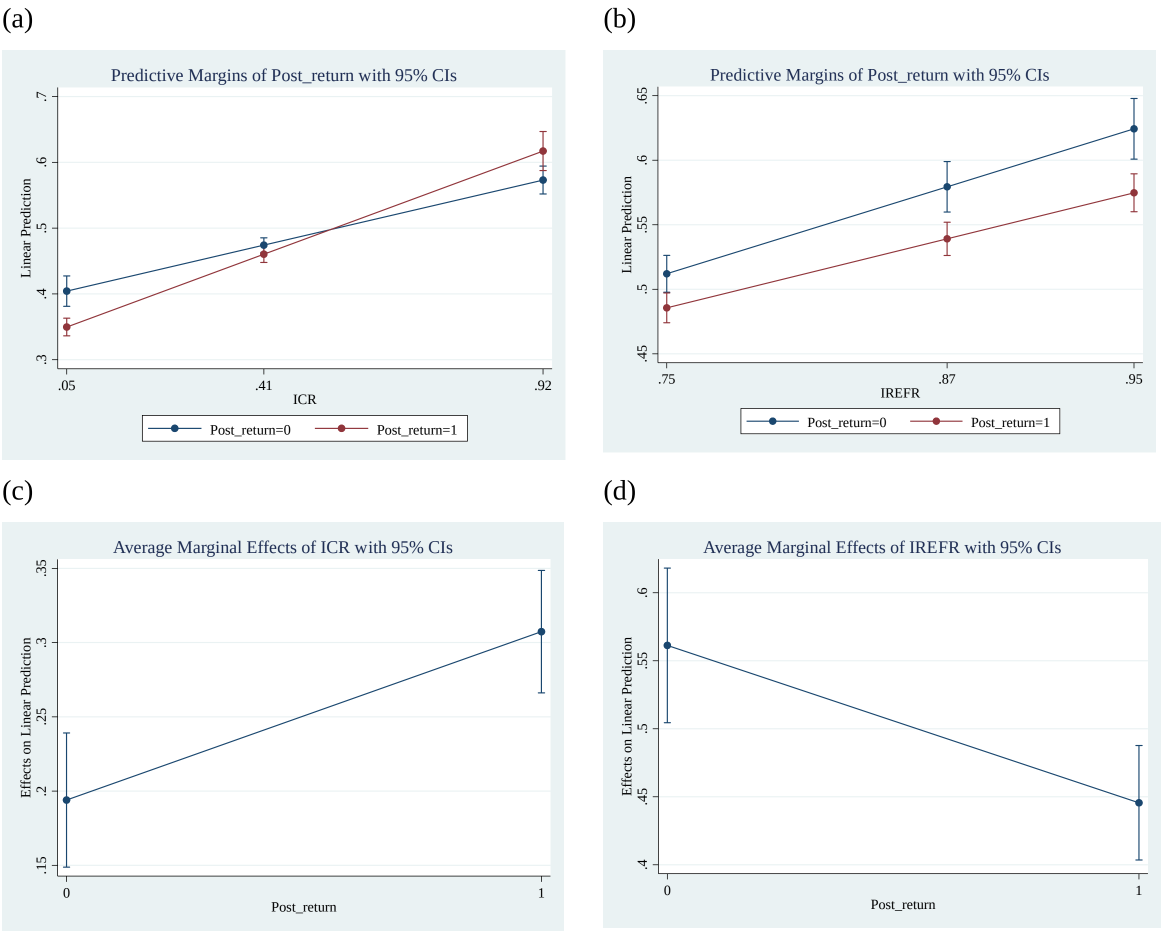

Figure 3. Moderating effects of ICR and IREFR on the relationship between Post_return and ICITR (with 95% confidence interval)

Note: (a) shows the margins of return mobility when ICR is in 25, 50 and 75 percentiles. And (b) reports the margins of return mobility when IREFR is in 25, 50 and 75 percentiles. (c) and (d) shows the average marginal effects of ICR and IREFR respectively.

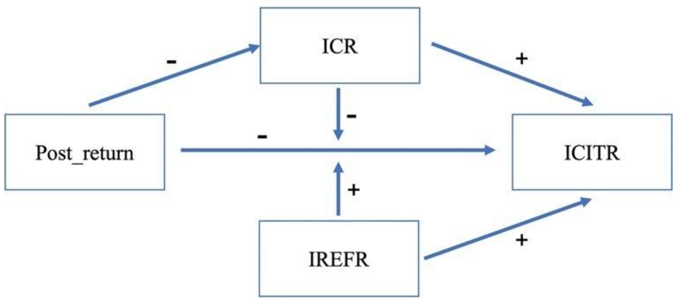

Figure 4. The mechanisms of the effect of mobility on the international visibility/impact

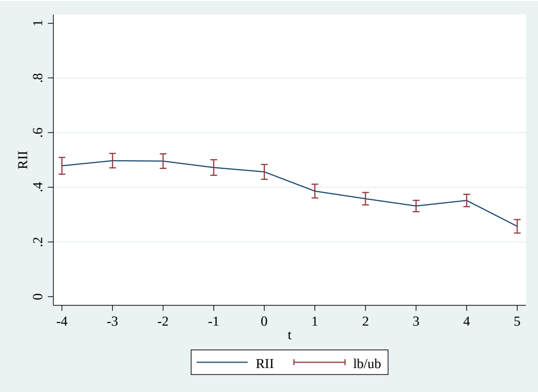

Figure 5. The trends of real international impact in the 5 years before and after returning to China

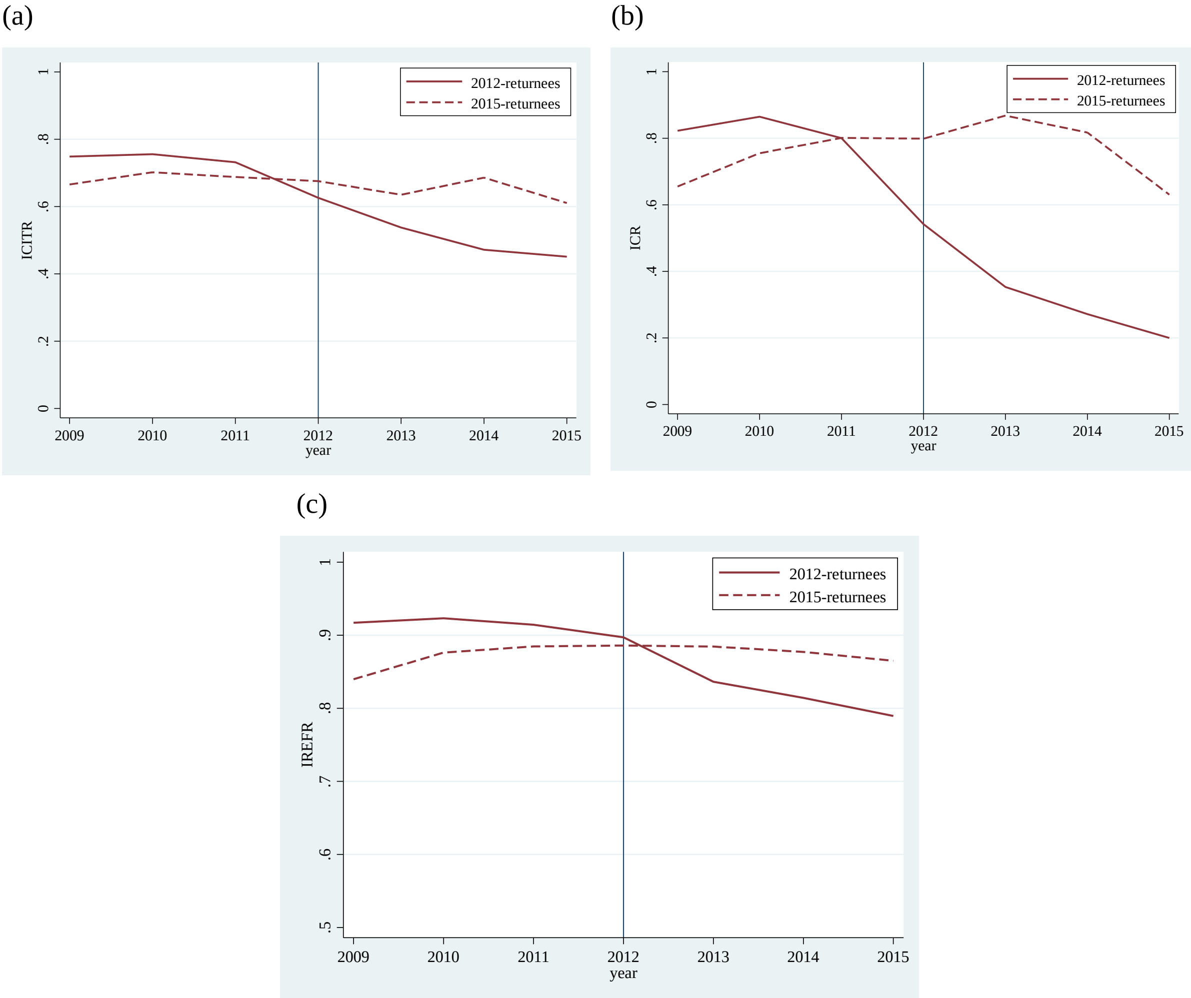

Figure 6. The performance trends of 2012 returnees and 2015 returnees by year

Note: 2012 returnees are the treatment group and return to China in 2012; 2015 returnees are the control group. (a) shows the international citation ratio, (b) the international contribution ratio, and (c) international reference ratio, respectively. Differences pre-treatment (2010 and 2011) are insignificant (p>0.05); differences post-treatment are significant (p<0.001).

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