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# The value of an overseas research trip

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## Abstract

As an essential part of the academic environment, international scientific mobility draws considerable attention from researchers. Previous studies have indicated a strong relationship between scientific mobility and scientific output. However, few researchers have addressed the causality between them. The research questions in this study focused on how the international scientific mobilization of the researchers affects their number of international collaborations, their ability to get published at higher impact factor journals, the number of citations that they get. Based on the SCOPUS database of English language scientific journal articles, this paper revealed the causal effects of international scientific mobility of the researchers on their scientific productivity, collaborations, and impact on science using the synthetic control method. The author's affiliation on their articles provided the geographical location that can be tracked in time to infer the international scientific mobility of each author. A sample of more than 79,000 immobile scientists was used to create the synthetic versions of over 1500 internationally mobile scientists, so that, the synthetic version of each mobile author best resembled the academic ability of her/his counterpart mobile author in the pre-mobilization period. This allowed investigating the effects of the international mobilization on their publications by comparing the post-mobilization publication characteristics of the mobile authors and their immobile synthetic controls.The findings show strong evidence of a substantial positive effect of scientific mobility on the ability to get published in more prestigious journals, the number of citations received in total and from overseas, and international collaborations. The magnitude of the effect is conditional on the duration of scientific mobility.

**Keywords** Scientist mobility · High-skilled labor · High-skilled labor migration · Brain drain · Bibliometrics · Scientific productivity

**JEL Classification** J61 · F22 · J24 · O15

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## Introduction

It's not surprising that the migration of highly skilled labor through the developed world has been recognized as a serious detriment for developing nations. A variety of studies (Lucas, 1988; Klenow & Rodrigez-Clare, 2005; Saxenian, 2005, 2006) show that lack of human capital has a direct negative effect on the output level. However, home countries can benefit from the migration of their highly skilled labor under certain conditions such as the appearance of remittances, return migration, network creation (or expansion) (Gibson & McKenzie, 2012), or increasing human capital formation (Beine et al., 2008). Especially mobility[1] of highly skilled labor has a larger potential on creating such "feedback" effects. Acquisition of new knowledge and skills in the host country and benefiting from diaspora externalities that international networks create, may lead to an improvement in labor productivity through increasing human capital and import of new technology and innovations. This mechanism might be even more salient for the mobile scientific labor force not only because they have higher human capital, but also, they are the primary source of creating local human capital. Besides, mobilization of scientific labor potentially contribute to the competitiveness, capacity development, and performance (Jonkers & Cruz-Castro, 2013) of the national research system.

International mobility of the scientists is an important and rapidly growing source of globalization of science which has a great potential to lead the global production frontier to shift out more instantaneously (Freeman, 2010). The world of science is getting more globalized in terms of the diversity of origin and destination countries and lower mobility frictions for overseas mobile scientists (Czaika & Orazbayev, 2018). Scholars and scientists of the developing world mobilize increasingly more to developed countries (OECD, 2008). This mobility can be in a variety of forms from a short research trip to a permanent asylum. There may be various reasons for scientific mobilization such as expectations on accessing new scientific knowledge, infrastructure, and skills, sharing present research, making new research, seeking new possibilities for new careers, or attaining a decent living.

Looking from a developing country perspective: since a considerable amount of financial resources are allocated to the education of scientists and to temporarily mobilization of them (in terms of scholarships and grants for education in a foreign country as well as postdoctoral research in a foreign country or visiting scholars etc.), the question of what kind of changes might be occurring on the scientific output of the mobile scientists seems worth to address. This study investigates the case of Turkish scientists who have been to the USA for scientific purposes. Several reasons make the Turkish case interesting. First, Turkey ranks 2nd among the developing world for the weighted number of scientists who had chosen the USA as a destination.[2] Second, two different state regulations[3] provide an

[1] Short-term migration of highly skilled labor for employment, visiting, and training purposes.

[2] The number of observed mobility is 7615 between Turkey and the USA for the years 2006–2016. The number of total mobility between the USA and the developing World is 201,067 for the same period. Turkey ranks the 2nd after Iran when countries are weighted by their population and 7th on level (OECD, 2017).

[3] More information and their practical contributions to the methodology are discussed in the Methodology part of the paper. Shortly, one of these regulations led back to 1935 and requires all the citizens to have "*pure*" Turkish family names which make it possible to identify Turkish scientists. The other regula-

opportunity to carry out a methodologically more robust analysis. Moreover, the Turkish government encourages and supports the reverse brain drain by making a considerable amount of resources available to the returner scientists[4] which may increase the return mobility and allows to work on more representative data. On the other side, the USA is the major destination and departure country of scientific mobility being a part of all top ten bilateral flows (Czaika & Orazbayev, 2018: 3) and, involving nearly 28% of the world wide scientist mobility (OECD, 2018).[5]

Recent studies on the effects of the scientists' overseas mobility have shown that there is a statistical relationship between scientific productivity and mobility of the scientists (Baruffaldi & Landoni, 2012; Basu, 2013; Gibson & McKenzie, 2014; Hoisl, 2007; Jonkers & Tijssen, 2008; Teichler, 2017; Yasuda, 2016). However, few researchers have addressed the question of causality and selection (Hoisl, 2007; Kahn & MacGarvie, 2016; Tartari et al., 2020). Previous research has indicated potential unobserved heterogeneity caused by omitted variables such as scientist's ability or readiness: Scientists who had an international mobility experience may have been the ones with the most potential to benefit from the international mobility in the first place (Jonkers & Cruz-Castro, 2013).

This study seeks to understand the causal effects of overseas mobility of the scientists who have scholarly been to the USA. The potential effects of the international mobilization on their scientific productivity as well as their scientific collaborations and their contributions to diffusion and impact on science are investigated using the synthetic control method of Abadie & Hainmueller (2010). The research also sets out to determine how these relations differ between the mobile scientists who have stayed in the USA for a longer period, to explore the likely negative selection effect on returnees. In particular, the study aimed to address the following research questions:

How international scientific mobilization of the published scientists affect

- The number of their international collaborations on their articles?
- Their ability to get published at higher impact factor journals?
- The number of citations that they get?

The bibliometric data from SCOPUS is used to track the authors' credentials such as impact factor (IF) of the journals that they got published, citations they got, their collaborations, and also their affiliations. The author's affiliation on their articles provides the geographical location that can be tracked in time to infer the international scientific mobility of each author. This study provides an opportunity to advance our knowledge of the

Footnote 3 (continued)

tion limits the number of foreign citizens to 2% in Turkish Universities—delegated legislation no:75 dated 09.02.1983—which enables us to construct a more identified data set.

[4] There are several programs of The Scientific and Technological Research Council of Turkey (TUBITAK) which makes significant amounts of resources available for research purposes, compensations, grants, various kinds of allowances for the family of the returner researchers and the returner researchers themselves (http://www.tubitak.gov.tr/en). The period of the grants vary between 1 and 36 month, and the total funding available for each return project is nearly up to 500.000 $ depending on the length and content of the project. Some other countries such as Germany, Australia, and China have carried out similar brain gain oriented programs for their elite scientists abroad. See Wang et al. (2019), Laudel (2003), and Jonkers (2008) for a more detailed discussion about these kinds of programs.

[5] OECD calculations based on the affiliation information of the authors who have published scientific articles on Scopus between 2006 and 2016. See the Methodology section for more information.

relationship between scientific mobility and scientific output by revealing the causality between them.

The remaining part of the paper proceeds as follows: "Literature review" section gives a review of the literature on the relationship between scientific mobility and scientific output. "Results and discussion" section describes the data and methodology employed. "Design and data" section addresses each of the research questions. The results of the research are presented and discussed in "Results and discussion" section. "Conclusion" section concludes the paper.

## Literature review

It is important to understand how scientific productivity changes after international mobilization to have a clearer view of its contribution to the performance of national and global research systems. The greater part of the literature on scientific mobility confirms a positive relationship between scientific mobility and scientific productivity (Fernandez-Zubieta et al., 2015; Zubieta, 2009; Baruffaldi & Landoni, 2012; Velema, 2012; Kato & Ando, 2013; Dubois et al., 2014; Azoulay et al., 2012; Franzoni et al., 2014; Hoisl, 2009; Jonkers & Tijssen, 2008; Edler et al., 2011). Productivity, however, is defined in different ways. Franzoni et al. (2014) find evidence that mobile scientists' performance is better than the ones without a mobility experience in terms of the 'quality' of their papers (measured as the impact factor of the articles). Baruffaldi and Landoni (2012) showed that the maintained linkage of the current mobile researchers with their home countries is positively related to the scientific productivity (measured as the number of papers per year) in the host country. Likewise, OECD (2015: 128) suggests that outflows from the countries which has lower median citation impact values, get published in higher-rated publications than their staying or returning counterparts. The impact of scientists on science[6] who move affiliations across national boundaries is nearly 20% higher than that of those who never move abroad (OECD, 2013). The gains in the form of spillovers from brain circulation (Jaffe et al., 1993; Saxenian, 2005; Franzoni et al., 2012; Appelt et al., 2015; Van Der Wende, 2015) and knowledge brokerage (Slavova, 2016) play important roles on explaining the relationship between mobility and the performance. Furthermore, several studies show a positive relationship between mobility and collaboration (Wang et al., 2019; Jonkers & Cruz-Castro, 2013; Agrawal et al., 2006; Azoulay et al., 2012; Jonkers & Tijssen, 2008; Woolley et al., 2008; Melkers & Kiopa, 2010). The positive relationship between the mobility of researchers and the diffusion of knowledge (Gibson & McKenzie, 2014; Agrawal et al., 2011; Agrawal et al., 2006, 2008; Zubieta, 2009; Kato & Ando, 2013) is also noteworthy.

The literature on mobility and scientific productivity highlighted a strong relationship. However, few researchers (Hoisl, 2007; Kahn & MacGarvie, 2016; Franzoni et al., 2014; Tartari et al., 2020) have addressed the question of causality. Previous research has indicated potential unobserved heterogeneity caused by omitted variables such as scientist's ability or readiness. Therefore, it is still an unanswered question whether mobility results in greater productivity. The majority of the academic mobility literature focuses on the foreign-born in the US and on comparing immigrants with non-immigrants without any

[6] As the number of non-self-citations.

consideration to a comparison between the ones with a mobility experience and the ones without any mobility experience (Franzoni et al., 2012). The standard theory of migration postulates a positive selection in the advantage of the most talented scientists. On the other hand, mobility can cause an increase in mobile scientists' knowledge and propensity to establish international effective networks resulting in a scientific productivity increase. For instance, Appelt et al. (2015) findings of a strong statistical relationship between collaboration and mobility of the scientific authors didn't point out a causality. Correspondingly, Franzoni et al. (2012) finding of a strong statistical relationship between international mobility and the productivity of academics does not reveal a finding of causality because of the cross-sectional structure of their data. Furthermore, Franzoni et al. (2012) suggest that their findings may be pointing out that academic international mobility can lead to a productivity increase or a selection bias in the advantage of potentially more productive researchers having more tendency of being internationally mobile or both. Besides, more collaborative researchers might be recognizing mobility opportunities better. Appelt et al. (2015) underline the importance of understanding whether the collaboration is derived by academic mobility or academic mobility is a result of collaborations. Causality in mobility & research output relation has been addressed in a few studies. In their influential study, Kahn and MacGarvie (2016) concludes that being in the USA has a positive effect on scientific output and foreign-born US Ph.D.'s who remain in the USA are scientifically more productive than those who had returned to low GDP per capita countries.

The mobility of scientists has also a major role in the creation and diffusion of knowledge in a global manner (OECD, 2010). International mobility of the scientists is one of the most important ways of knowledge flows in science especially involving tacit knowledge (Laudel, 2003: 215; Appelt et al., 2015; Fontes et al., 2013) and social capital (Wang et al., 2019). The international mobility of the scientists has a great potential to fasten the spread of tacit scientific knowledge specific to local research areas and reduce the "stickiness" of the knowledge (Freeman, 2010). Gathering the tacit knowledge and expanding the social network may require some time spent in the host country. Jonkers and Tijssen (2008) argue that, the longer the researchers' academic visit abroad, the more the scientific social capital and scientific human capital accumulated. Therefore, one can expect that the duration of being abroad has a positive correlation with the number of international collaborations (Agrawal et al., 2006; Autant-Bernard et al., 2007; Fangmeng, 2016) and the quality and quantity of the publications after the experience overseas.

As well as their productivity, mobile scientists' collaboration patterns also indicate some difference from the immobile ones. Involving in international scientific networks is commonly evaluated as one of the main potential contribution of being internationally mobile (Ackers, 2005; Jöns, 2007; Fontes et al., 2013; Appelt et al., 2015; Sugimoto et al., 2017, Gibson & McKenzie, 2014). Among many other reasons (Beaver, 2001), an increase in the mobility of the researchers is seen as one of the important reasons for the dramatic increase of international collaborations on scientific papers in the late twentieth century (Glänzel & Schubert, 2001). Jonkers and Tijssen (2008) have also concluded that there is a positive correlation between foreign experience and the number of papers as well as the number of international collaborations. Using Bozeman et al. (2001) idea of scientific & technical human capital, Jonkers and Tijssen (2008: 313) found a positive correlation between an overseas experience of a scientist and the number of his/her international collaborations with the scientists in the host country. Appelt et al. (2015: 17, 18) show that collaboration and international mobility are highly correlated. International collaboration and citations are also found to be related. The higher the number of co-authors on a paper, the more citations it receives (Abramo & D'Angelo, 2015; Didegah & Thelwall, 2013) and they are more likely to get published in high IF journals (Abramo & D'Angelo, 2015). Countries with high international collaboration rates have also higher citation rates (OECD, 2013).

It becomes a very important issue especially in developing countries when temporary scientific mobility becomes the brain drain. Some of the literature argued that the mobile scientists who have returned to their home countries can be more productive in terms of the total cites they get, number of international collaborations, and IF of the journals where they have published compared to their immobile scholars (Agrawal et al., 2006; Fontes et al., 2013; Jonkers & Cruz-Castro, 2013; Jonkers & Tijssen, 2008; Jöns, 2009; Oettl & Agrawal, 2008; Ynalvez & Shrum, 2011). Moreover, mobile scientists who have returned to their home countries perform no different than the ones who didn't return (Franzoni et al., 2012). Many countries are making effort to recall their scientists by implementing policies aiming to promote their scientists abroad to return (Gibson & McKenzie, 2012: 339; Han et al., 2015: 4). On the other hand, scientists residing abroad not only help the researchers of their origin country to access the most recent scientific knowledge by new collaboration opportunities but also presents new "temporary" scientific mobility opportunities for the researchers in their origin country.

Not all of the literature claims that international mobilization of scientists is correlated with better academic performance. Using their survey data on Argentinian scientists, Jonkers and Cruz-Castro (2013) found that internationally mobile researchers do not publish more and do not get more citations. However, they publish more on high IF journals including their publications that they do not collaborate with the researchers in the former host country. They argue that this finding points out a positive learning effect of international mobility on scientific and technological human capital. Overall, a larger part of the literature above highlights the need for investigating the causal effects of international scientific mobilization on the number of international collaborations, the impact factor of the journals that mobile scientists get published, and the number of citations that they get.

## Design and data

Bibliometric data of the 2015 SCOPUS database is used to track the scientists' geographical locations, the number, and the "quality" of their published articles as well as the citations they received. The reason for using the SCOPUS database is the larger coverage of journals and a larger presence of Turkey-affiliated authors in it (36,450) compared to the ISI-WOS (30,501) (TUBITAK, 2017). The data covers the 1985–2014 period. Authors' country of institutional affiliation is assumed to be their geographical location for the year the article is published.[7] As an indicator of quality, 2-year IF of the journal is used. For a clearer view of "quality", self-citations are excluded. The author sample is constructed from Turkish named authors as Turkey is assigned as the departure country. The methodology of this study can be applied to any departure and arrival country.

Data on the authors with a name that matches in the common Turkish names-surnames list are pulled from the SCOPUS to exclude any foreign authors with a Turkish affiliation, then classified by their overseas mobility patterns using the reported affiliation location. The final data consists of 2021 authors whose mobility pattern is trackable from Turkey to

[7] The institutional affiliations in the bibliometric data may not necessarily screen the location that the research has been made but according to Appelt et al. (2015: 9) it can be assumed that the affiliation shows some form of "intellectual presence".

the USA and over 79,000 "immobile" authors for the construction of the donor group for the matching process.

### Bibliometric mobility measures

What we know about the relationship between scientific mobility and scientific productivity is largely based on the research made with bibliometric data.[8] Mobility is usually identified depending on the authors with at least two publications in the reference period and changes in the affiliation and sequence of publications (Meho & Sugimoto, 2009; Moed & Halevi, 2014; Moed et al., 2013; Czaika&Orazbayev, 2018). On this basis, stayers are defined as the ones who do not change their affiliations during the reference period. Accordingly, returnees are defined as the ones who return to the country that they have firstly reported an affiliation in that country before (OECD, 2015: 128). The steps taken in this study to infer the geographical location of the scientists proceed very much in the same way as some previous studies: Appelt et al. (2015) inferred the mobility of the authors from the address information that they have gathered from authors with at least two publications over the 1996–2011 period, based on the sequence of changes in institutional affiliation reported in those publications. Pierson and Cotgreave (2000), uses Science Citation Index data to track British scientists' publications, current countries of stay, and citations to their publications who have their Ph.D. from the UK in 1988. Laudel (2003) uses author affiliation data of PubMed, WoS, and Inspec to track inter-institutional mobility of the 131 biomedical scientists[9] and checks the same 131 authors' online CVs to determine whether the bibliometric data provides a true mobility tracking. He confirms that all three bibliometric databases can be used for mobility analysis and as a matter of fact, he concluded that the bibliometric methods appear to be the best solution to identify the researchers' international mobility analysis. The data on the mobility of the Turkish researchers are formed using a similar methodology with Meho and Sugimoto (2009), OECD (2015), Appelt et al. (2015), and Laudel (2003).

Bibliometric mobility measures have also some limitations. They are less accurate for two specific author groups. First is the less prolific authors. The second group involves the authors who change their careers to a job that does not require disclosure in scholarly journals (Appelt et al., 2015). Common names of the authors appearing in the bibliometric data is also a common issue (Laudel, 2003; Appelt et al., 2015). This homonyms problem gets more important if the name of the author is represented by the initial. In the sense of mobility tracking of the authors, homonyms cause an overstating for mobility. Laudel (2003), conducts a content analysis on the titles, abstracts, and full texts of the papers to overcome the homonymous situation by discerning the authors. In this research, the homonyms are eliminated as in Appelt et al. (2015). The incidence of multiple affiliations is

[8] There are also different measurement ways of scientific mobility in the literature. Laudel (2003) and Appelt et al. (2015) have compiled different techniques that has been used in the literature such as encyclopedias of scientists (Allison & Long, 1987), information gathered from scientific associations (Stephan & Levin, 2001), census data and surveys (Shauman & Xie, 1996), curriculum vitaes (Canibano et al., 2011; Dietz et al., 2000), specific survey designs (Auriol, 2010; Auriol et al., 2013; Franzoni et al., 2012; Stephan & Levin, 2001) and bibliometric methods (Pierson & Cotgreave, 2000).

[9] Laudel assumes that researchers' first publications are derived from their PhD dissertations. Thus, their affiliation on their first publication is assumed to be the starting of their academic career and mobility history.

another problem with bibliometric data. Affiliations in multiple countries are removed to deal with it as in Appelt et al. (2015: 9, 10).

Collaboration is generally measured by co-authorship (Jonkers & Tijssen, 2008; Appelt et al., 2015). This approach requires caution because of its partial ability to represent all of the aspects of collaboration. Thus co-authorship should be seen as a partial indicator of collaboration as usually it has been in the literature (e.g. Jonkers & Tijssen, 2008; Katz & Martin, 1997). On the other hand, some studies (Glänzel & Schubert, 2005) claim that co-authorship is a very tangible representative of scientific collaboration.

## Identifying the Turkish Authors

Author names are used to identify the Turkish authors in the Scopus database. The strategy for doing this is based on several reasonable criteria. First, a common Turkish names and family names list with frequencies is used for matching the Scopus authors' name list. Especially, Turkish family names have a special characteristic that is regulated by law that makes them easier to recognize. The Law on Family Names (1935) required all the citizens to have "*pure*" Turkish family names, helping the construction of the new identity of the Turkish nation (Doğaner, 2009). In addition to this, the spelling of Turkish names and family names is unique regardless of the origin of the name. As an example, the Turkish name "Ayşe" has its origins in Arabic—as Aisha-, but it is written with a unique Turkish spelling. Surnames with obvious Turkish compounds that are frequently added to family names such as "oğlu" are also included. Another criterion for identifying the Turkish authors is the unique letters that appear in Turkish names such as "ğ, ü, ö, ş, ç" as well as the letters that never appear in Turkish names such as "q, w, x". As an additional precaution, names with a frequency of less than 5000 in Turkey are excluded. Using these criteria, 135,439 Scopus authors with a Turkish name are identified. The publication year of the article and the affiliation of the author are essential information for the research. After articles with missing publication year and affiliation are dropped from the sample, 112,527 Turkish authors remained.

The number of articles with a Turkish affiliation in the entire SCOPUS data is 313,126 until the year 2014.[10] The number of articles with a Turkish affiliation in the sample that was drawn from the SCOPUS data depending on whether they had an author whose name appears in the Turkish names and surnames list is 220,679 in the same period. The former also includes the non-Turkish named authors with a Turkish affiliation since the latter includes only Turkish named authors with a Turkish affiliation. Table 1 shows the number of articles, authors, and coverage rates.

Assuming that the number of non-Turkish named authors with a Turkish affiliation is small enough to ignore,[11] the comparison indicates a 70.48% of coverage in terms of the articles. On the other hand, most of the articles have more than one author, and not every

[10] The SCOPUS data that is used in this study does not cover all publications in 2014. Thus, excluding this year would result more robust coverage evaluation.

[11] This assumption seems to be reasonable since the number of non-Turkish named authors with a Turkish affiliation who were in the sample because of the fact that they were a co-author in an article written by a Turkish-named author is miniscule. Under any circumstances, this assumption may yield a small underestimation of the coverage rate in the worst case.

Turkish-named author would necessarily be captured[12] within the articles in the sample. Accordingly, the coverage ratio in terms of Turkish-named authors is expected to be lower than the coverage rate for the articles with a Turkish-named author. The coverage ratio in terms of Turkish-named authors can be induced by making the same reasonable assumption that the number of non-Turkish named authors with a Turkish affiliation is small enough to ignore. Among the authors whose names appeared in the sample because they were co-authors in the articles written by at least one Turkish-named author recognized by the name list, the number of authors with a Turkish affiliation whose names are not on the list is 112,243 where the number of the same whose names are on the list is 99,872. This means that the sample covers 47,1% of all Turkish named authors assuming the distributions are normal.

## Final data

Mobile scientists are defined as Turkish scientists whose first article is published with a Turkish affiliation and also who published at least one article with a US affiliation. Accordingly, immobile scientists are Turkish scientists who have never published an article with a "non-Turkish" affiliation. As appears in Table 2, the sample consists of 2021 mobile scientists who have published nearly 44 thousand English language articles and nearly 80 thousand immobile scientists who have published more than 400 thousand English language articles. The number of forward citations per article is winsorized at the 99th percentile. Since the intensity of the publications varies across different fields, it would be more appropriate to analyze the productivity of the researchers by fields as in Abramo & D'Angelo (2007: 2014). Collaboration also differs among the science fields (Katz & Martin, 1997: 16; Jonkers & Tijssen, 2008). Out of 2021 mobile scientists, 146 of them (7%) publish in a different subject area[13] in the USA. Thus, their outcomes are not comparable. On the other hand, 13% of authors have very unique characteristics (for instance, very early first publication year & decades between the first and the second publication) that their donor groups couldn't be constructed.[14] The summary of the data is represented in Table 2.

Looking at Table 2, it is apparent that mobile scientists publish in more prestigious journals and get more forward citations than the immobile scientists get (almost two times the immobile gets on average). They also collaborate with non-Turkish co-authors significantly more. In terms of the number of articles they publish, mobile authors collaborate internationally six times more than immobile authors do on average.

## Methodology

Economics uses an extensive number of procedures for studying causal inference using non-experimental data such as regression-based designs, regression discontinuity designs,

[12] Because of the limitations on the Turkish names and surnames list that were used for the matching process.

[13] All Science Journal Classification (ASJC) scheme is used to classify the journals and the articles. For a detailed information on ASJC, see https://service.elsevier.com/app/answers/detail/a_id/14882/supporthub/scopus/~/what-are-the-most-frequent-subject-area-categories-and-classifications-used-in/.

[14] The limitations on "very unique" scientists can be gradually relaxed. As a robustness check, these "very unique" scientists are included in the analysis by relaxing the criteria for being in the donor group to construct the synthetics of them. The results are robust.

**Table 1** Number of Authors and Articles

| | Number of articles | Number of authors |
|---|---|---|
| with a Turkish affiliation | 313,126 | 212,215 |
| Turkish name list match | 220,679* | 99,872* |
| coverage rate (%) | 70.48 | 47.1 |

*Turkish affiliated and captured in the Turkish name list

difference in differences, and synthetic control methods. However, selection bias constitutes a serious problem in measuring causality. Since randomized trials are the gold standard in revealing causality, it is often unattainable to conduct randomized social experiments. On the other hand, regression procedures for semi-experimental set-ups depend critically on controlling for confounding variables that might be unobserved. Difference in differences methodology can provide a more robust estimate of the treatment effect compared to regression-based designs -e.g. instrumental variables, Heckman procedure (Heckman, 1979), Granger causality (Granger, 1969)- when the data is longitudinal (Blundell & Costa Dias, 2000). However, regression discontinuity designs and difference in differences methods use a single control unit or a simple average of control units which require an assumption of a functional form. Furthermore, the difference in differences approach commonly allows control for time-invariant factors. As a recent development to the difference-in-differences approach, the synthetic control method (Abadie et al., 2010) uses a weighted average of the set of controls to reveal causal effects (Athey & Imbens, 2017; Li, 2020) allowing for time-varying individual-specific heterogeneity (Abadie et al., 2010).

The comparative case set-up of the study is based on Abadie et al. (2010) synthetic control approach that uses data-driven procedures to construct suitable comparison groups. A synthetic control is a weighted average of untreated units chosen to reproduce characteristics of the treated unit before the intervention. The idea behind synthetic controls is that a combination of untreated units may provide a better comparison to the treatment unit than any untreated unit alone (Abadie & Cattaneo, 2018).

There are a large number of studies (e.g., Abadie et al., 2010; Billmeier & Nannicini, 2013; Peri & Yasenov, 2019; Castillo et. al., 2017) that utilized the synthetic control method to reveal the casual treatment effects. One advantage of the synthetic control method is that it avoids the problem of identifying the best controls that could be resolved by perfect matching. The synthetic control method creates better matching controls using the weighted averages of untreated units. Another benefit of this approach is that it does not rely on the assumption of a parallel trend.[15] Instead, it allows other shocks affecting the treated and untreated units before and after the treatment in question.

Different proportions of some immobile authors ($X_0$) are used to construct a synthetic author with these proportions for each mobile author ($X_1$) so that, the synthetic author is as close as it can be to the mobile author with regard to their characteristics before the mobility takes place. An objective function is optimized to minimize the discrepancy between the mobile author and the synthetic author before mobility. In other words: different weights ($w$) for each immobile author are selected such that the characteristics of the mobile author are best resembled by the characteristics of the synthetic author.

[15] Parallel trend is the assumption that the treatment is the only shock the system of treated cases within the observed time frame (Robbins et al., 2017).

**Table 2** Summary of Scopus Data—including the pre-mobilization and the post-mobilization periods-

| | Mobile Scientists | | Immobile Scientists | |
|---|---|---|---|---|
| | Mean | sd | Mean | sd |
| Journal impact factor | 1.86 | 2.23 | 1.11 | 1.14 |
| Number of forward citations* | 2.28 | 3.49 | 1.37 | 2.38 |
| Number of articles with non-Turkish coauthors | 0.36 | 0.48 | 0.06 | 0.24 |
| Number of forward citations* from a USA affiliated author | 0.75 | 4.59 | 0.19 | 0.79 |
| Number of forward citations* from a Turkey-affiliated author | 0.12 | 0.51 | 0.16 | 0.64 |
| Journal impact factor of forward citations (per citation) | 1.29 | 1.83 | 0.8 | 1.31 |
| Number of coauthors with a Turkish name | 2.83 | 4.3 | 2.26 | 2.63 |
| Journal impact factor of forward citations | 5.7 | 10.43 | 2.64 | 5.88 |
| | $N=43{,}971$** | | $N=404{,}558$** | |
| | $n=2021$*** | | $n=79{,}752$*** | |

*Non-self-citations in a 2-year window winsorized at 99th percentile

**Indicates the number of articles

***Indicates the number of authors

$$\text{Choose the vector } w^* = \left(w_2^*, \dots, w_{j+1}^*\right) \quad \text{to} \quad \text{minimize} \quad \|X_1 - X_0 w\| \tag{1}$$

$$\text{s.t.} \qquad w_j \geq 0 \quad \text{for} \quad j = 2 \tag{2}$$

and

$$w_2 + \cdots + w_{j+1} = 1 \tag{3}$$

$X_1$ represents the (k × 1) vector of pre-mobilization characteristics for the mobile authors and $X_0$ represents (k × 1) vector of pre-mobilization characteristics for the immobile authors. $V$ is a diagonal that controls the relative importance of obtaining a good match between each value in $X_1$ and the corresponding value in $X_0 w^*$. Abadie and Gardeazabal (2003) and Abadie et al. (2010, 2015) propose data-driven selectors of V. In this study, a data-driven regression-based method is used to obtain the variable weights contained in the V-matrix.

$$\|X_1 - X_0 w\| = \sqrt{\left(X_1 - X_0 w\right)' V \left(X_1 - X_0 w\right)} \tag{4}$$

The synthetic control estimator of the effect of the mobilization for the mobile authors in a post-intervention period $t$ $\left(t \geq T_0\right)$is:

$$\hat{\alpha}_{1t} = Y_{1t} - \sum_{j=2}^{j+1} w_j^* Y_{jt} \tag{5}$$

Since each synthetic unit best resembles the treated unit, the only difference between the treated unit and its synthetic counterpart is the presence of the treatment. The causal effect that is aimed to reach is the difference between the treated unit and the synthetic control, in the post-intervention period.

A unique comparison control group design is employed that utilizes immobile scientists' publication-based characteristics to construct a synthetic author for each mobile scientist. First, donor groups from "immobile" scientists for each "mobile" scientist are established by the same basic attributes such as main subject area,[16] year of first publication[17] (as a proxy for age), and the number of years with a publication (as a proxy for experience). This allowed for constructing each synthetic-scientist indigenous to the consistent donor group of each "mobile" scientist. Second, a matrix of pseudo "overseas research trip timing" is generated for each "immobile" scientist coinciding with the actual "overseas research trip timing" of each "mobile" scientist as the order position of the first publication in the USA. Third, a synthetic-scientist is constructed as a weighted combination of immobile scientists in the consistent donor group depending on the proximity of their qualifications before the pseudo overseas research trip year of the immobile scientists. These qualifications are the level of ability (measured as the 2 years IF of the journal where the article is published), number of articles, collaboration patterns (measured as the number of articles with a foreign co-author), scientific recognition overseas (measured as the number of non-self forward citations in foreign country journals) and contributions to diffusion and impact on science (measured as the number of the non-self forward citations). The synthetic control approach also accounts for the effects of confounders changing over time even after the treatment which also presents reasonable control for the unobservables both before and after the treatment. Having constructed the matching control group of synthetic immobile scientists with the closest characteristics to the mobile ones, synthetic control procedure is followed to estimate the causal effects of scientific authors' mobility on scientific productivity, collaboration patterns, scientific recognition, and contributions to the dissemination of scientific knowledge.

The synthetic control approach allowed each synthetic scientist best resembles the mobile scientist's scientific qualifications so that the only difference between the mobile scientist and its synthetic counterpart is the presence of the international mobilization. Accordingly, the difference between the mobile scientist and their counterpart synthetic scientists in terms of their number of international collaborations, the impact factor of the journals that they get published, and the number of citations that they get in the post-mobilization period shows the causal effect of the mobilization. The synthetic control method has some advantages over alternative causality-exploring methods methodologies. For instance, Granger causality (Granger, 1969) requires the potential effects to be separable from various other causal factors. Yet, the synthetic control method in the research set-up uses one-to-one counterfactuals that are remained unaffected by the mobilization but affected by all common factors that would affect the whole immobile scientists. Using a weighted average of the set of controls, the synthetic control method provides better fitting counterfactuals compared to other treatment effect models such as differences in differences and regression discontinuity designs. Additionally, the difference in differences

[16] Either of physical, health or life sciences. Social sciences are excluded due to the insufficient number of observations on English language social science articles published by Turkish authors in SCOPUS. Turkish social scientists mostly tend to publish on Turkish social science journals and there are very few Turkey based social science journals indexed in SCOPUS compared to the number of journals of other disciplines. This phenomenon also showed at the SCOPUS data that, the number of Turkish social scientists in SCOPUS database is not enough to carry out a reasonable research on them.

[17] The calendar year of the first English language article in SCOPUS is let to vary 5 years to control the age and the scientific environment changes by time as well as the stages of the academic progress of the authors.

methodology relies on parallel pre-mobilization trends which would result in comparing the outcomes of inaccurate matches especially in terms of their scientific abilities. The synthetic control method minimizes this issue by creating a synthetic scientist which resembles each mobile scientist best in the pre-mobilization period. This allows making a comparison in the post-mobilization period between almost equals. The difference in differences estimation also relies on the assumption that unobserved confounders are constant over time. In our case, this assumption implies an unrealistic situation that the scientific progress such as new advancements in the scientific methodologies, theories, or applications that would stimulate the subsequent scientific research and output stays unchanged. The synthetic control method allows for such effects to alter over time. Moreover, one-to-one counterfactuals constructed by the synthetic control method allow discipline-specific unobserved confounders to vary over disciplines.

The affiliation country of the author gathered from each article represents the geographical location of the author when the article in concern was published. After identifying the Turkish authors and keeping a track of every single of them, their scientific life timeline is identified. The scientific timeline includes the author's geographical location, productivity, collaboration, and citations they got. After the recognition of the timelines, Bozeman et al. (2001) and Jonkers and Tijssen's (2008: 313) approach of scientific & technical human capital are used. In Bozeman's framework, a researcher's mobility and collaborations depend on the researcher's stock of scientific human capital (SHC)[18] and scientific social capital (SSC).[19] Bozeman et al. (2001) scientific and social capital approach considers researchers' tacit knowledge, craft knowledge, know-how, and gains from being a part of a productive social capital network in addition to the standard human capital context. Thus, scientific human capital is proxied by the IF of the journals that the tracked authors got published in (as in Franzoni et al., 2012). They used the IF of the journal where the article was published as an indicator of the performance of the author. In other words, the IF of the journal is used as a proxy of the author's ability and scientific knowledge. It is a strong assumption that a scientist with better scientific knowledge and ability can publish in more prestigious journals. However, the IF of a scientific journal somehow shows the prestige of the journal and the prestige of research in them. Thus, it can alternatively be assumed that the IF of the journal that the authors are got published reflects the prestige of the author. Scientific social capital is proxied by the author's involvement in an overseas collaboration network which is the number of articles that the authors collaborated with at least one overseas affiliated co-author—published before period "0" (mobilization). Besides the scientific human capital and scientific social capital, the effects of scientific mobility on diffusion and impact on science are also studied and proxied by the number of the non-self citations that the authors get in a two-year window and their overseas "recognition" proxied by the number of non-self forward citations they get in an article with at least one US affiliated co-author (in a two-year window).

Table 3 shows the predictor means before the mobilization of each author. Nearly 35,000 actual immobile authors out of 79,000 immobile authors were used with replacement to

[18] SHC is the researcher's level of knowledge and scientific expertise, the stock of a researcher's scientific and technological knowledge and skills (Jonkers & Tijssen, 2008: 313).

[19] Scientific social capital is researcher's stock of relevant professional ties, researcher's relations's quantity, quality or intensity with the other writers (Jonkers & Tijssen, 2008: 313).

**Table 3** Mobile Scientist Means & Predictor Means before the Mobilization

| | Actual authors | | Synthetic authors by approximating criteria | | | |
|---|---|---|---|---|---|---|
| | Mobile authors | Immobile authors* | Scientific human capital | Diffusion & impact on science | Overseas recognition | Scientific social capital |
| Impact factor | 1.27 [0.03] | 1.11 [0.00] | 1.25 [0.03] | | | |
| Forward citations** | 1.66 [0.05] | 1.37 [0.00] | | 1.64 [0.05] | | |
| Forward citations** from a US affiliated author | 0.34 [0.02] | 0.19 [0.00] | | | 0.31 [0.02] | |
| Number of articles with non-TR*** coauthors | 0.16 [0.01] | 0.06 [0.00] | | | | 0.16 [0.01] |
| Number of authors | 1601 | 79,752 | 1601 | | | |

Standard errors in parenthesis

*Mean for all immobile author sample in the whole period

**Non-self-citations per an article in a two-year window

***Non-Turkish

construct 1601 synthetic authors for 1601 mobile authors.[20] The synthetic authors are constructed so that, they are as close as that they can be to the mobile ones in terms of these variables and approximating criteria.

What stands out in Table 3 is the actual authors and the synthetic ones are almost identical in terms of their (a) level of scientific human capital proxied by the mean IF of the articles, (b) their contribution to diffusion & impact on science proxied by the number of non-self forward citations in a two-year window, (c) their overseas recognition proxied by the number of non-self forward citations from a US affiliated author in a two-year window and finally (d) their scientific social capital level proxied by the number of articles with non-Turkish (non-TR) coauthors.

## Results and discussion

The main results on the scientific human capital of the scientists are represented in Fig. 1. Post-mobilization scientific output of the mobile and the synthetic scientists are compared in terms of the IF of the journals where they get published, the citations they get per article, the fraction of their international collaborated articles, and the per-article citations that they get from a USA affiliated author respectively in part a, b, c, and d. Observation numbers for all parts of the Figure are presented in part d and part e. The sudden increase of the mean IF of the journals that the mobile scientists get published after the mobility can be seen in part a. The ability to get published in the Journals with higher IF seems to increase dramatically. The mobile scientists and the synthetic scientists had a mean of 1.27 (sd = 1.18) and 1.25 (sd = 1.14) respectively before the mobility takes place. It increases to 2.63 (sd = 2.87) for mobile scientists with their first article in the USA.

It doubles the synthetic scientists get in period 0 and stabilizes around the mean 2.08 (sd = 1.89) within the next coming articles. The mean difference between mobile scientists and the synthetic ones in the post-mobility period is 0.95 (sd = 2.02) since it is larger (1.38, sd = 2.68) with the first article in the USA. The variation between the first and the following articles may provide a potential ground for splitting the effect into two parts; the access effect and the learning effect.

Access effects arising from the new resources such as a laboratory, new data, or scientific social capital may allow the mobile scientist to benefit within the first publication from a scientific setup built in advance. The learning effect might be coming after some experience with the new resources and it requires time. It can be seen from Fig. 1 that the positive effect at the peak levels with the first article in the USA -represented by 0 on the horizontal axis-[21] can be attributed to the access effect. It is important to mention that Fig. 1 includes both the returnees and the stayers. Thus, evaluating these two groups separately would provide a more robust analysis. Besides, the rise in IF seems to be stable for the following publications where the frequency of international collaborations tends to decrease. This

[20] As mentioned in the the Data section, the final data used in the SCM contains 1601 mobile scientists after excluding 146 authors who published in a different discipline in the USA and 174 authors who have a very unique publication pattern such as first publication date, very low number of publications and publishing frequency so that their donor group couldn't be constructed.

[21] As a robustness check, the authors who published only two articles –one at the USA and one at Turkey- are exluded to control the possibility that these scientists cause the sharp peaks at the graphs. The results are almost identical.

might imply a positive learning effect as Jonkers and Cruz-Castro (2013) argue. However, it would necessitate making a robustness check for temporary and permanent (or longer) international mobilizations to track any different tendencies for human and social scientific capital measures.

The non-self-citation counts per an article in a two-year window also increases sharply with the first article published with a USA affiliation on it in period zero (see Fig. 1b). This demonstrates a remarkable increase in the impact on science and the diffusion of knowledge after mobility. The per article means of citations that the mobile scientists and the synthetic scientists receive is 1.67 (sd = 0.05) before the mobility and jumps up to 3.05 (sd = 3.87) with their first publication in the USA. It again almost doubles the count that the synthetic scientists get.

Overseas mobility has an important effect on international collaborations. In Fig. 1c "the fraction of international collaborations" basically shows the ratio of the "number of articles where the mobile scientists collaborated with at least one foreign scientist in "the number of all articles of the mobile scientists". It is apparent in the graph that the international collaboration of the mobile authors significantly increased compared to their synthetic counterparts. It can also be seen in part c of Fig. 1 that the ratio of internationally collaborated articles of the synthetic scientists slightly decreases in period 0, which might be because of the possibility that the scientists who used to link them to the international collaboration network moved to the USA. The immense effect on the collaboration is robust to the alternative set-up, that the synthetic is constructed using the immobile scientists who had never collaborated with the mobile scientist.

As can be seen from Fig. 1d, the overseas recognition of the mobile scientists and the magnitude of overseas diffusion of their research increase as the citations from a USA-affiliated author rise immensely. The mean for the number of citations received from a USA-affiliated scientist before the mobility takes place is around 0.33 (sd = 0.89) for the mobile scientists and 0.31 (sd = 0.70) for the synthetic scientists. This count reaches 1.1 (sd = 2.67) with the first article in the USA for mobile scientists. It is almost four times the synthetic control units.

While prior studies have noted the importance of international scientific mobility, the results of this research not only reflect those of researchers mentioned in the literature review who also found a statistical relationship between the scientific mobility and the scientific output but also reveals the causality between them. The results in this part indicate that international mobility significantly increases the scientific outcome, scientific human capital, and scientific social capital. The next section, therefore, moves on to report and discuss the results for scientists who stay for a longer period in the USA (including the permanent immigrants) and who return to the home country.

## Stayers and returnees

Scientific mobilization can be in various ways. One important type of scientific mobilization is based on its permanence. Scientifically mobile scientists can stay where they have moved to –stayers- or return to their home countries –returnees-. In this case, analyzing the difference in gains of the mobilization for stayers and returnees would help to a better understanding of the effects of the mobilization and also the selection problem. Part a of Fig. 2 compares the gap between the mobile scientists and the synthetic units in terms of the IF of the journals that they got published while controlling their type of mobilization. The stayers represent the mobile Turkish authors, who have published their last article with

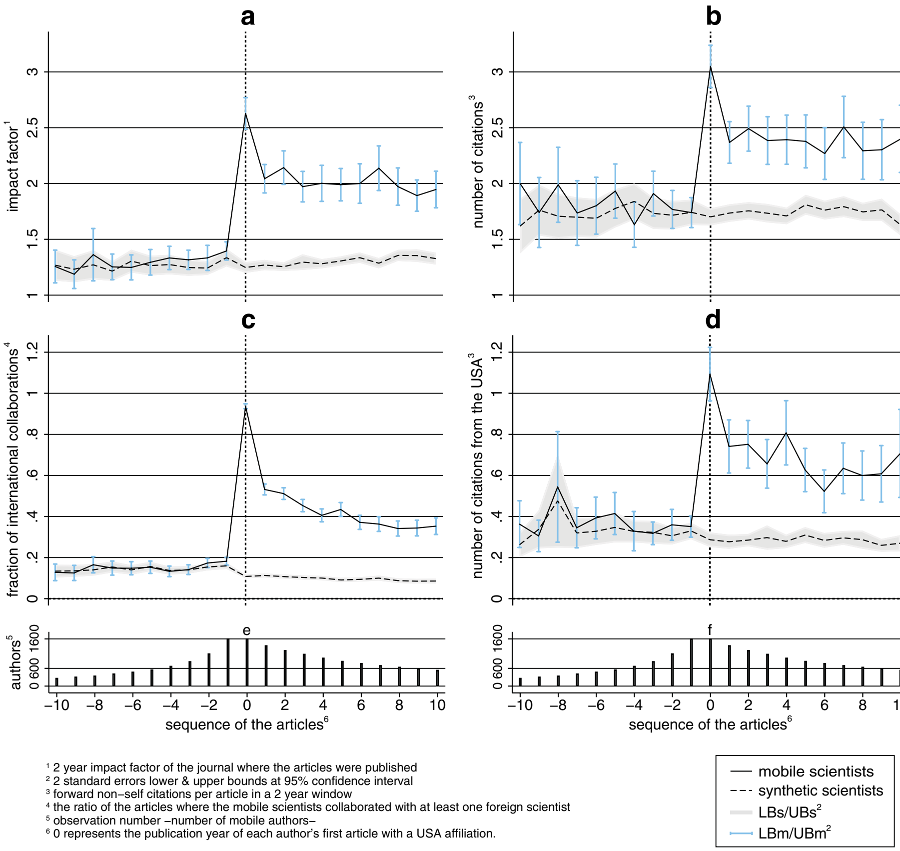


**Fig. 1** Synthetic Control Estimates for Author Credentials (means)

their USA affiliation on it and the returnees represent the ones, who have published their last article with their Turkish affiliation on it.

Looking at part a of Fig. 2, it is apparent that the stayers' articles are published on higher impact journals compared to the returnees'. On the other hand, returnees are still capable of publishing on the higher IF journals compared to the synthetic authors. Similarly, citations received per article, international collaborations, and citations from the USA also alter significantly after the mobilization. The effect of mobility seems considerably high for the stayers. One interesting thing in Fig. 2 might be the indistinguishability of the magnitude of the effects between the stayers and the returnees for their first article published in the USA –represented by 0 in the horizontal axis of part e and f- for all of the four aspects. The effects are statistically not different for returnees and the stayers in their first article in the USA and the effects differentiate remarkably for the subsequent articles. There are two possible explanations for the difference in effects. First, this difference may be occurring because the stayers were already more productive scientists than the returnees before the mobility thus are more ready to benefit from an overseas research trip. Second, they became more productive because they stay in the USA for a longer period (or had the opportunity to publish more in the USA). Both might be valid. Borjas and Bratsberg

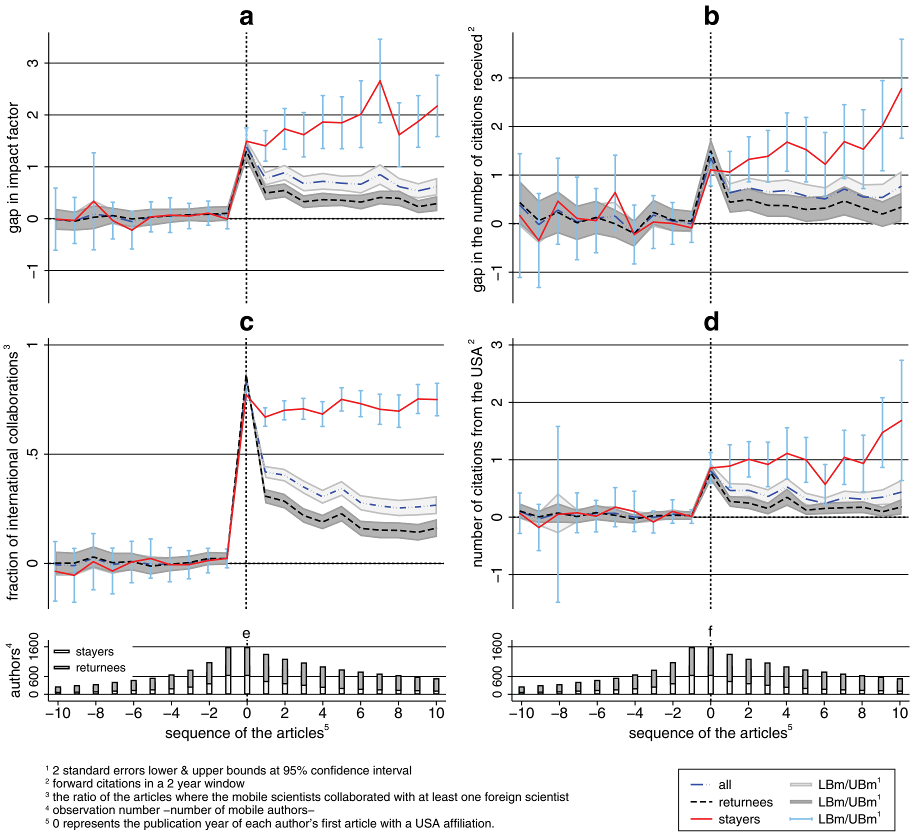


**Fig. 2** Synthetic Control Estimates for stayers and returnees—Gaps between the credentials of mobile authors and synthetic authors

(1994) showed that it is the least skilled migrants returning to their home countries if the immigrant flow is positively selected in the first place. Likewise, Robinson-Garcia et al. (2019) found that Permanent migrants get more forward citations to their publications than the returnees get. This implies that scientists who stay in the USA might be the ones who are more productive before the mobilization compared to the ones who returned to Turkey. The information about the difference between the returnees and the stayers before their mobility takes place already exists to make a proper comparison. Table 4 shows that there are statistically significant differences, at the 0.05 level of significance, between returnees and stayers before the mobilization.

Table 4 reveals that stayers already published at higher IF journals had more citations and internationally collaborated more frequently than the returnees before the mobilization. Regarding this information, it seems that the first explanation might be holding better. Broadly speaking, the stayers were already more ready for benefiting from the mobility than the returnees, before their research trip. This finding thus far supports the findings of Borjas and Bratsberg (1994) that the least skilled migrants return to their home countries if there is a positive selection. The access effect for returnees is higher compared to the learning effect, given all of the four measures are significantly lower after the first article in the

**Table 4** Results of *t*-tests impact factor, citations, share of international collaborated articles and citations from the USA before the mobilization by return status

| | Group | | | | | | 95% CI** for mean difference | *t* | df** |
|---|---|---|---|---|---|---|---|---|---|
| | Returnee | | | Stayer | | | | | |
| | *m*** | sd** | *n*** | *m*** | sd** | *n*** | | | |
| If.[1] | 1.12 | 1.01 | 962 | 1.50 | 1.37 | 622 | −0.50, −0.26 | −6.31* | 1582 |
| Cit.[2] | 1.50 | 1.87 | 971 | 1.93 | 2.46 | 629 | −0.64, −0.22 | −3.97* | 1598 |
| Int. collab[3] | 0.13 | 0.26 | 972 | 0.21 | 0.35 | 629 | −0.11, −0.05 | −5.19* | 1599 |
| Cit.-USA[4] | 0.28 | 0.70 | 973 | 0.43 | 1.09 | 634 | −0.24, −0.06 | −3.37* | 1605 |

*$p < .05$

***m* for mean, sd for standard deviation, *n* for observation numbers, CI for confidence interval, df for degrees of freedom

[1]Impact factor of the journals that the authors got published. [2]Non-self-citations received in a two-year window. [3]Share of internationally collaborated articles in all English language articles. [4]Citations received from a USA-affiliated author in a two-year window

USA. On the other hand, it seems that the learning effect on the stayers is larger than the access effect on them as their measures tend to increase more during the post-mobilization period. Nevertheless, returnees still benefit from mobilization. It is possible to make a categorization[22] for the returnees considering their duration in the USA in Fig. 3.

The black solid lines in Fig. 3 represent the returnees who stayed in the USA for one year or less. In other words, these are the mobile scientists who have published their articles in one calendar year in the USA. The gray dashed lines represent the returnees who have stayed in the USA for more than one year which means they have published their articles in at least two different years in the USA.[23] The statistically significant gaps between the black and dashed gray lines indicate that, among the returnee scientists, the ones who had stayed longer in the USA have published at considerably more prestigious journals (Fig. 3a), got more citations to their articles (Fig. 3b), collaborated more with foreign scientists (Fig. 3c), and got more citations from the scientists residing in the USA (Fig. 3d) after their research trip. The effects are larger with their first article in the USA for all the variables in concern.

While the enormous increase at all four variables for “the returnees with more than one year in the USA” are vigorous and continued, apparently the returnees who have stayed for

[22] Moed et al. (2013) categorizes the stays at the host country in three types, short stays (scholarships, visiting and post-doc positions that are less than 2 years), longer stays (double post-doc periods and temporary stuff members that are more than 2 years) and permanent stays. In this study, the stays are cetegorized in two types, shorters stays (1 year or less) and longer stays (more than 1 year) because the vast majority of the locally available scholarhips for international academic mobility is less than 1 year in Turkey. Visits more than 1 year strongly imply an additional financial allowance in the USA (usually secured by double post-doc activity and being temporary stuff members). Permanenet stays are not included in the categorization due to the likely potential of a complication arising from the nature of the bibliometric data that the affiliation on the last published paper can hardly imply a permanent stay in that country.

[23] The data doesn’t allow to track the authors in monthly basis. Thus, the authors are classified by their duration in the USA annually, ignoring that the duration may even be shorter than a month between two articles published in succesive years. At this point, it is assumed that this doesn’t change the nature of the findings.

one year or less in the USA almost do not benefit at all -except a slight increase for international collaborations- considering the subsequent articles that they published after the mobility. As can be seen from the independent *t*-test results in **Table 5**, the readiness and ability of the two categories of the returnees do not statistically differ before their mobilization.[24] Thus, the exception mentioned above implies that social capital gains might be somewhat more permanent than the human capital gains from relatively short scientific mobility.

There is a positive access effect of the mobilization on "returnees with one year or less in the USA", given that all the four measures make a peak for their first article published in the USA–represented by 0 in the horizontal axis in Fig. 3, part e, and f-. As the black solid lines -representing the "returnees with one year or less in the USA" on Fig. 3 stabilizes after the mobilization around its pre-mobilization levels, it is possible to rule out any learning effect of the mobility on them. However, stayers with more than one year in the USA (represented by the dashed gray lines) benefitted from the mobilization with a positive access effect and a positive learning effect as well, since all the four measures stabilize over the pre-mobilization period even if not continue increasing. These findings are in line with Jonkers & Tissen's (2008) insight of duration of the academic visit may potentially influence the building up of scientific social capital, and scientific human capital as they point out a strong positive correlation between an overseas work experience longer than 2 years and international co-publications and number of publications as well. Edler et al. (2011) also found that international mobile scientists publish more than the immobile ones and the longer their visits are, the higher the propensity of transferring knowledge –measured by statements of the participants of the survey implemented to the mobile scientists—both in the origin and host country.

## Conclusion

This present study was designed to determine the effect of international scientific mobilization on the scientific output by comparing the internationally mobile scientists' scientific outcomes in their pre-mobilization period with their synthetic counterparts. Returning to the research questions posed at the beginning of this study, it is now possible to state that international mobilization of the scientists to the USA significantly contributes to their scientific human capital and scientific social capital. The mobile scientists are found to get published in more prestigious journals, be cited more, and collaborate more internationally compared to their almost the same counterparts created by the synthetic control method. The findings indicate that mobile scientists who had returned –returnees- to the origin country—Turkey- and the scientists who stayed –stayers- at the arrival country –the USA- noticeably differentiate on the effects of the mobilization. Stayers remarkably benefit more, compared to the returnees owing to their greater readiness and ability before the mobilization. The research also showed that the effects differ among the returnees with regard to their time in the USA. Returnees who stay for an extended period benefits more from the mobilization where returnees with one-year-long -or less- research trips do not benefit at all with an exception of a limited increase in their international collaborations

[24] The returnees who stayed for one year or less and the returnees who stayed for more than one year at the USA are not statistically different in terms of their ability to publish at a high IF journal, the number of citations they receive and their international collaborations before their mobilization to the USA.

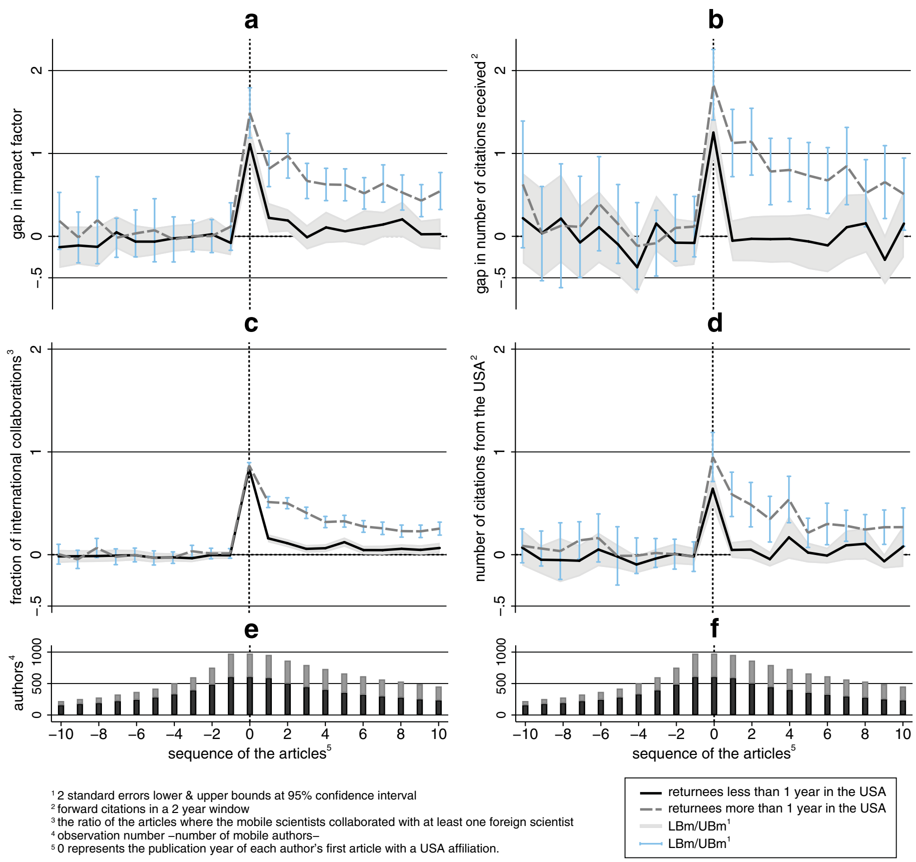


**Fig. 3** Synthetic Control Estimates for returnees by their duration in the USA—Gaps between the credentials of mobile authors and synthetic authors –

after the mobilization. The findings also provide insights for splitting the total effect of the mobilization into two parts, the access effect, and the learning effect.

The study adds to our understanding of the importance of international academic mobilization's contributions to science both at individual and collective levels by revealing the magnitude of it as well as the causality between them. However, a number of limitations need to be considered. First, the sole use of bibliometric data precludes including the changes in non-bibliometric credentials like promotions, wage raise, teaching skill, etc. Second, the lack of scientists from developing countries other than Turkey in the sample adds further caution regarding the generalizability of these findings. Yet, the results may also be found as being distinct enough to allow a limited generalization. Finally, an issue that was not addressed in this study was, including some additional controls such as gender, host country, and field of study to evaluate how the effects might differ. A further study could usefully explore how these controls have a part in the effects of international mobility.

The finding of this study has a number of practical implications. Primary policy priorities for governments and scientific institutions should therefore be to plan for promoting

**Table 5** Results of *t*-tests impact factor, citations, share of international collaborated articles and citations from the USA before the mobilization by duration in the USA

| | Group | | | | | | 95% CI* for Mean Difference | *t* | df* |
|---|---|---|---|---|---|---|---|---|---|
| | One year or less | | | More than one year | | | | | |
| | *m** | sd* | *n** | *m** | sd* | *n** | | | |
| If.[1] | 1.12 | 0.92 | 604 | 1.10 | 1.15 | 357 | −0.11, 0.15 | 0.33 | 959 |
| Cit.[2] | 1.50 | 1.78 | 604 | 1.48 | 2.01 | 366 | −0.22, 0.27 | 0.19 | 968 |
| Int. collab[3] | 0.13 | 0.26 | 603 | 0.13 | 0.28 | 368 | −0.04, 0.03 | −0.39 | 969 |
| Cit.-USA[4] | 0.27 | 0.57 | 605 | 0.30 | 0.87 | 367 | −0.13, 0.05 | −0.82 | 970 |

**m* for mean, sd for standard deviation, *n* for observation numbers, CI for confidence interval, df for degrees of freedom

[1]Impact factor of the journals that the authors got published. [2]Non-self-citations received in a two-year window. [3]Share of internationally collaborated articles in all English language articles. [4]Citations received from a USA-affiliated author in a two-year window

the researchers for making academic visits for longer periods as well as constituting strong enough incentives that encourage the mobile scientists to return. It would also be beneficial for the national research system to motivate mobile scientists for a more scientifically efficient overseas experience. This kind of efficiency can be triggered by designing a reward system (including scholarships, grants, awards, or fellowships) that benefits productive returnee scientists more while they were abroad. The reward structure would also be designed to evoke the incentive to make new research in the post-mobilization period utilizing the acquisitions of the mobility. Furthermore, this system would include encouragement for the returnee scientists to collaborate more with local immobile scientists. This could induce a spillover effect both for increased scientific human capital and scientific social capital acquired from overseas research. Needless to say, increasing the number of available resources to eligible researchers who would consider making academic visits abroad would also be the right policy choice for the policymakers. However, this brings up the question of eligibility and identification of the reward candidates. Identification of the local researchers who have a higher probability to benefit more from an overseas academic mobilization is an important issue for future research.

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**Data availability** The data used in this research is available on demand.

**Code availability** STATA is used for statistical procedures. GIMP is used for the Figures.

#### Declarations

**Conflict of interest** The author has no conflicts of interest to declare that are relevant to the content of this article.

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