Local Gains from Global Minds: The Impact of Collaborating with Foreign-Educated Researchers on Non-Mobile Researchers' Performance

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ABSTRACT

Foreign-educated researchers who cross national borders for training can play an important role in contributing to research in their country of origin. Relying on a unique dataset of Colombian researchers, our study explores how researchers with Ph.D. training abroad affect the performance of researchers who do not work or study abroad (non-mobile researchers) through direct collaboration. Combining Propensity Score Matching and Difference-in-Differences estimations, we find that non-mobile researchers who co-author with foreign-educated researchers experience a significant improvement in their research performance. Co-authoring boosts the number of publications, citations, publications in top journals, and the share of publications in English. Interestingly, the extent of these improvements differs across scientific macro fields.

Keywords: International Scientific Mobility; Co-authorship; Colombia.
JEL codes: O15, O3, 054.

1. Introduction

Foreign-educated researchers who cross national borders for Ph.D. training are often acknowledged as important sources of scientific and innovation capabilities for their origin and host countries (Gibson & McKenzie, 2014; Lissoni, 2018). Their role in diffusing knowledge (Agrawal et al., 2006, 2011; Ganguli, 2015; Kahn & MacGarvie, 2016), advancing the internationalization of innovation activities in their origin countries (Miguélez, 2018; Saxenian, 2005), and connecting national scientific systems (Baruffaldi and Landoni, 2012; Velema, 2012) is well documented. At the individual level, there is a strong consensus among previous studies that, on average, spending time abroad is associated with higher scientific performance than for those who never moved (Cañibano, 2017; Jonkers and Tijssen, 2008; Netz et al., 2020; Petersen, 2018; Scellato et al., 2015). What remains less explored is the effects of these mobility experiences on non-mobile colleagues – those who have never worked or studied abroad.

Scholars have attempted to address this gap recently by exploring how foreign-educated researchers contribute to non-mobile researchers' foreign social capital (Fry, 2023; Ito et al., 2025; Müller et al., 2023) and performance (Franzoni et al., 2018; Fry & Furman, 2023; Yang et al., 2022). However, the focus has tended to be on the aggregate impact of co-location with foreign-educated researchers at a department level rather than on direct collaborative interactions, such as co-authorship. Also, those scholars have mainly investigated scientists within specific Science, Technology, Engineering, and Mathematics (STEM) fields.

The current paper addresses this question by investigating the extent to which researchers who have obtained a Ph.D. abroad influence non-mobile researchers' performance through direct co-authorship channels. We examine the impact of collaborating (measured by co-authorship) with foreign-educated researchers on the number of publications, citations, publications in top journals, and the share of English-language publications of non-mobile researchers. We also explore differences in these four outcomes across the macro scientific fields of the researchers, namely STEM — Science, Technology, Engineering, and Mathematics, and SSH — Social Sciences and Humanities.

To examine our question empirically, we first build a unique dataset of Colombian researchers active between 1990 and 2021. Our dataset includes data on researchers' academic backgrounds, publication lists, and work affiliation history, from different sources: a national centralized CV repository, funding

agencies' records, and an extensive scientific bibliographic database. We gather these data to reconstruct the mobility patterns, differentiate foreign-educated and non-mobile researchers, and retrieve the scientific performance of researchers.

Second, we combine two methods in our empirical strategy: Nearest Neighborhood Matching (Rubin, 1973) and a Difference-in-Differences with multiple time periods estimator (Callaway and Sant'Anna, 2021). Establishing a causal link between co-authoring with a foreign-educated researcher and scientific outcomes (if any) for non-mobile researchers is challenging because these foreign-educated researchers do not randomly select their co-authors. We leverage Propensity Score Matching (PSM) to build comparable groups of non-mobile researchers who co-authored with at least one foreign-educated researcher (treated) and those who never co-authored (control). To make the match, we use variables capturing common performance and socio-demographic characteristics (Jones et al., 2008; Yadav et al., 2023). We next use a Difference-in-Differences estimator to assess the dynamic effects (i.e., an aggregation scheme to observe how the effect changes given the exposure to the treatment for a period of time) of such co-authorships, with the first co-authorship with the foreign-educated researcher as the treatment year.

We have three main findings. First, we find that co-authoring with foreign-educated researchers significantly improves the performance of non-mobile researchers. Specifically, we observe a 22% increase in the number of publications and a 19% rise in the number of citations once a non-mobile is exposed to at least one co-authorship with a foreign-educated researcher. In addition, "treated" researchers experience a 2.6% increase in the number of publications in top journals and a 6 percentage-point increase in the share of English-language publications. This finding indicates that collaborating with foreign-educated researchers is a way for non-mobile researchers to increase their performance, citations, and work exposure.

Second, increasing the *number* of foreign-educated co-authors positively reinforces the effect on performance. We initially observe that non-mobile researchers treated with one foreign-educated collaborator experience an increase in the different outcomes in the year of the first collaboration. This positive effect can be sustained if non-mobile researchers collaborate with more foreign-educated researchers over time. To address the mechanism, we repeat the analysis, excluding publications from the treatment group co-authored with mobile researchers. We find that absent those publications, treated non-mobile researchers publish slightly fewer papers than the control group. These results

imply a shift in energy or focus: treated researchers reduce their collaborations with non-treated colleagues, instead focusing their energies on collaborations with foreign-educated researchers.

Third, disaggregating non-mobile researchers by macro-field, STEM and SSH, we observe that researchers benefit similarly regarding publications. The average STEM and SSH non-mobile researcher experiences an increase of 22% in publications upon collaborating with foreign-educated researchers. On the other hand, STEM non-mobile researchers benefit from more citations, a larger share of English-language publications, and more publications in top journals. Magnitudes are a 25% increase in citations, 3.8% in highly ranked publications, and a 9-percentage-point rise in the share of English-language publications for STEM non-mobile researchers. By contrast, the average SSH non-mobile researcher observes an increase of 13% in citations, 1.6% in highly ranked publications, and 3 percentage points in the share of English publications (although not statistically significant). Overall, these findings imply that the impact of collaborating with foreign-educated researchers on the performance of non-mobile researchers varies across macro-fields.

This study contributes to different strands of literature. The first is to the literature on the extended effects of international scientific mobility. Previous studies have mainly observed positive impacts of foreign-educated researchers on the performance and foreign social capital of non-mobile researchers (Franzoni et al., 2018; Fry & Furman, 2023; Fry, 2023; Müller et al., 2023; Yang et al., 2022). These studies have predominantly explored the impact of foreign-educated researchers at an aggregate level (i.e., department). Nevertheless, asserting that an entire department experiences this peer effect is challenging. Second, their focus has been mainly on researchers from specific STEM fields. However, macro-scientific fields exhibit distinct dynamics, including collaboration patterns (Stephan, 2012; Wuchty et al., 2007). Third, Franzoni et al. (2018), a paper close in spirit to ours, focuses on extended benefits to non-mobile researchers in host countries, while leaving unaddressed the impact on non-mobile researchers in sending countries. Our study investigates the extended effects of international scientific mobility, but it differs in several ways. We rely on the direct collaboration of foreign-educated and non-mobile researchers from a sending country and extend the analysis to other non-STEM fields.

Our study also contributes to the literature on scientific collaboration. This strand has evolved around understanding the reasons that researchers collaborate (Bozeman and Corley, 2004; Katz and Martin, 1997; Ponomariov and Boardman, 2016) and the effect of collaboration on researchers' scientific performance (Azoulay et al., 2019; Ductor, 2015; Oettl, 2012; Yadav et al., 2023). Much of this

literature has focused on different types of scientific collaborations, such as with star scientists (Azoulay et al., 2019; McHale et al., 2023; Yadav et al., 2023), inter- and transdisciplinary collaboration (Chen et al., 2024; Liu et al., 2021), and international collaboration (Abramo et al., 2011; Kato and Ando, 2013). However, little has been investigated about the collaboration between foreign-educated and non-mobile researchers. By examining this latter collaboration, our study finds that researchers who do not experience mobility can observe a surge in their performance through collaboration with foreign-educated researchers.

The remainder of the paper is organized as follows. Section 2 provides background information on the Colombian scientific system. Section 3 details the data sources and sample, defines the outcome variables, and explains the process of identifying researchers. Section 4 describes the empirical strategy used for the analysis. Section 5 illustrates the regression analysis results. Section 6 explores a potential mechanism that explains our results. Finally, Section 7 concludes the paper by discussing the results and offering policy implications.

2. Institutional Context

Our paper investigates researchers from Colombia, a middle-income country in Latin America. In recent decades, the national government has promoted institutional arrangements and several public policies to improve the quality of science in the country. Some of these changes include the creation of a Science and Technology Ministry (Dutrénit et al., 2021), a plan to allocate funds from mining and oil sectors to science and technology activities (Correa et al., 2014), and new higher education programs, including graduate ones (Camacho et al., 2025; Observatorio Colombiano de Ciencia y Tecnología, 2021). These changes contributed to an increase in Colombia's scientific publications from 6,463 in 2011 to 12,005 in 2019 (Dutrénit et al., 2021).

To strengthen its research capabilities, Colombia has also invested in international mobility over the past two decades. With graduate programs recently established, various public agencies such as Colombia for the Future (Colfuturo) and the Administrative Department of Science, Technology, and Innovation (Colciencias) have supported researchers' graduate training abroad.[1] This reflects the effort to internationalize the country's scientific system by having foreign-educated researchers foster

[1] By 2023, more than 3,000 students had been sponsored to study abroad.

international collaboration (De Wit, 2014), and to strengthen human capital and, thereby, contribute to the country's socio-economic development (Salmi, 2014).

In recent years, Colombian scholars have called for more international scientific mobility to increase international collaboration and obtain external funding (Correa et al., 2014). Nevertheless, despite improvements in the scientific system through mobility policies and institutional changes, the country's science system continues to face budget cuts (Wade, 2017). Thus, assessing the impact of investments in foreign education has become crucial for the country. Investigating the relationship between mobility schemes and productivity will facilitate a deeper understanding of the extended effects of mobility.

3. Data

3.1 Data sources

To assess the impact of collaborations with foreign-educated researchers on the scientific performance of non-mobile researchers, we combine three data sources: (i) the Colombian centralized dataset recording national researchers (CvLAC), (ii) the lists of Ph.D. scholarship beneficiaries, and (iii) a bibliometric dataset, OpenAlex.

We consider the period 1990 to 2021. Since the 1990s, Colombia has increased the number of nationals sponsored abroad and made an effort to strengthen its scientific system, such as increasing the number of graduate programs (Bedenlier, 2018; Losada, 2016).

CvLAC Data. Established by Colombia's national government in 2001, the CvLAC is an integrated database to track the country's research community progress (de los Ríos and Santana, 2001). It contains self-reported information on researchers' demographic data and educational and professional backgrounds, including publication lists. Since CvLAC data are the primary input for national selection processes in academia and research organizations, Colombian researchers are incentivized to maintain up-to-date CVs.

For our analysis, we extract data from researchers with a CvLAC profile and use it for two purposes. First, this data source helps identify researchers' nationality and mobility patterns. Second, it facilitates the matching process with OpenAlex. The recorded academic background allows us to identify foreign-educated researchers, i.e., those students who moved abroad for their Ph.D. and those who

pursued their education domestically, i.e., those who have done a Master's or Ph.D. program in Colombia.[2] Using the affiliations of the researchers' working history, we retrieve the mobility pattern after the Ph.D. The publications reported in CvLAC allow us to refine the matching with those publications retrieved from OpenAlex.

Ph.D. scholarship lists data. Researchers moving abroad do not have the same incentive to maintain an up-to-date national CV, which would lead to incomplete or outdated data. To address this issue, we complement the national CV repository with the lists of Ph.D. scholarships maintained by the three main funding agencies in the country: Foundation for the Future of Colombia (Colfuturo), Ministry of Science, Technology, and Innovation (Colciencias), and Fulbright Colombia. These lists provide information on the scholarship holder's name, Ph.D. institution, destination country, discipline, and starting date of doctoral studies.

OpenAlex data. We rely on OpenAlex, an extensive repository with over 200 million scientific publications (Singh Chawla, 2022), to retrieve researchers' bibliometric data. We use matching procedures (e.g., fuzzy matching) to identify Colombian researchers in OpenAlex and attribute bibliometric indicators to each identified researcher — Appendix A provides the details of the dataset construction and matching procedure.

3.2 Identifying non-mobile and foreign-educated researchers

To determine the impact of co-authoring with foreign-educated researchers for non-mobile peers, we need first to assign researchers to one of the two categories.

In our analysis, Colombian researchers are classified as non-mobile if they have completed their graduate studies (both Master's and Ph.D.) exclusively in Colombia and have not spent more than a year studying abroad. This categorization also includes researchers with only a Master's degree, as Ph.D. programs were introduced only recently within Colombia's graduate system (Observatorio Colombiano de Ciencia y Tecnología, 2021). Given this context, different educational and research institutes have hired researchers holding only a Master's degree to undertake academic and research

[2] In Colombia, it is common for some researchers not to have a Ph.D. For this reason, we also include researchers with a Master's degree in our analysis. To exclude those who do not have a clear research profile in their activity, we define a three-publication threshold for researchers in Colombia to be part of our sample. In the subsection *Identifying non-mobile and foreign-educated researchers*, we further explain our definitions for Colombian researchers.

activities. To ensure researchers are research-active, we set a three-publication threshold for non-mobile researchers in our dataset, i.e., we include only researchers with at least 3 publications during the period of observation, 1990-2021.

Following the literature on international scientific mobility (Ito et al., 2025; Kahn and MacGarvie, 2016, 2012; Liang et al., 2022; Turpin et al., 2008), we label a Colombian researcher as a foreign-educated researcher if they have completed their Ph.D. studies entirely abroad.

3.3 Sample

We consider a sample of non-mobile researchers and compare those who co-author with at least one foreign-educated researcher with those who co-author only with locals. We identify 3,833 Colombian researchers who have not studied or worked abroad, and examine their co-authorship networks to make this sample suitable for our empirical strategy. Looking at the co-authorship network of non-mobile researchers, we distinguish those who have co-authored with foreign-educated researchers and those who have not, forming our treatment and control groups, respectively. Appendix A provides further details on how we identify our sample of non-mobile researchers and the foreign-educated researchers with whom some of them co-authored.

3.4 Outcome variables

In our analysis, we consider four outcome variables: the *number of publications*, the *cumulative number of citations per publication*, the *number of publications in top journals*, and the *share of English-language publications*.

The *number of publications* measures the researcher's productivity. We use the average annual number of publications of the non-mobile researcher. Regarding citations, we use the yearly *cumulative number of citations per publication* (stock of citations over stock of publications. The third outcome variable is the *number of publications in top journals*. To construct this variable, we match the journals' International Standard Serial Number (ISSN), where non-mobile researchers have published, with the ISSNs in SciMagoJournal Rank indicator – a dataset with the journal ranking constructed based on the quality of citations a journal receives.[3] After matching the journals with the ranking, we publications in

[3] This rank considers the number of citations and the source of citations that publications from a journal receive to classify that journal (Falagas et al., 2008).

journals in the top quartile of the Scimago Journal Rank.[4] For the first three variables, we consider their log transformation. The fourth outcome variable is the *share of English-language publications*, measured by dividing the number of publications in English by the total number of publications yearly.[5,6] With the share of English publications, we want to identify whether the non-mobile researcher's publication language patterns change after collaborating with a foreign-educated researcher.

4. Econometric strategy

4.1 Matching

Our analysis assesses whether a non-mobile researcher's scientific performance changes after co-authoring with a foreign-educated researcher. Ideally, we would need to know how the researcher would have performed without such co-authorship and compare the two scenarios, i.e., with co-authorship and without. This observation is not possible, and to overcome this limitation, we construct a control sample of non-mobile researchers with the same characteristics, differing only in co-authoring with no foreign-educated researcher (Yadav et al., 2023).[7]

We employ nearest-neighborhood matching to create comparable treatment and control groups. This matching employs an algorithm to identify a control unit with the closest propensity score to a treated unit. The main idea is to first calculate the propensity of a unit to be in the treatment based on observable covariates and, second, match treated and control units with similar scores. This method

[4] The number of publications in top journals is constructed by calculating the number of publications a non-mobile researcher has each year in journals ranked in the top quartile according to the Scimago Journal Rank. It is important to acknowledge that the Scimago data is from 1999 to 2024, while our data span from 1990 to 2021. For the merging between our data and the Scimago data, we assume for the years before 1999 that the ranking remains stable. Thus we use the year 1999 and the journal classification for that year to rank the journals for the years proceeding 1999. For the remaining years, we use the ISSN and the year to conduct the merge.

[5] A methodological challenge in calculating the share of English publications arises because non-mobile researchers may not publish any paper in specific years, resulting in an undefined number. To overcome this issue, we took the average share of English publications before and after meeting a foreign-educated researcher for the first time for each non-mobile researcher. Then we replaced the undefined numbers with the averages accordingly. In the case of non-mobile researchers who never collaborated with a foreign-educated researcher, we use the baseline year from the matching and calculate the shares before and after this meeting year.

[6] In Appendix B, we investigate the share of Spanish publications to investigate the impact on non-mobile researchers' publications in the native language.

[7] In their study, Yadav et al. (2023) investigate how co-authoring with a star scientist impacts the productivity of scientists. This is in line with what we research in this paper: how co-authoring with a foreign-educated researcher affects the performance of non-mobile researchers. Hence, their identification strategy technique provides a benchmark for our study.

reduces the imbalance between treated and untreated units, allowing the comparability between groups (Gertler et al., 2016; Rubin, 1973).

In our identification strategy, non-mobile researchers with at least one co-authorship with foreign-educated researchers are included in the treatment group, using the year of the first co-authorship as the treatment year. Non-mobile researchers without such co-authorships are part of the control group. We employ the following observable covariates: stock of publications, citations, co-authors, scientific field, educational level, and gender. We include the current year and the year of first publication as exact-matching covariates to ensure that matched pairs have the same baseline year and seniority.[8] The treatment group's baseline year is the year before the treatment year (*t-1*).

Our sample consists of 3,833 non-mobile researchers (2,532 who have co-authored at least once with a foreign-educated researcher and 1,301 who have never co-authored). After the matching, we obtain 1,656 researchers matched (828 researchers in each group). Table 1 presents the balance of covariates before and after the matching. In Panel A, the three indicators of balance quality (standardized mean difference, variance ratio, and empirical cumulative distribution function (eCDF)) indicate that the covariates are unbalanced. The values for the Standardized Mean Difference and the eCDF mean are far from 0, indicating poor balance. Variance ratios are not within the recommended range of 0.5 to 2 (Greiger,2023)2023). After the matching, balance quality indicators suggest a good matching, as indicated in Panel B.[9,10]

[8] We use the MatchIt package in R to conduct our matching. When performing the nearest neighborhood matching with this package, we rely on the exact function to guarantee that matched pairs have the same scientific field, year of first publication, gender, baseline year, and educational level.
[9] The only exception is the stock of co-authors, in which treated non-mobile researchers have a slightly higher average.
[10] Appendix C displays a plot of the covariates balance before and after the matching.

Table 1 – Assessing the covariates balance before and after the matching

	Panel A - Unmatched (1)					Panel B - Matched (2)				
	Means Treated	Means Control	Std. Mean Diff.	Var. Ratio	eCDF Mean	Means Treated	Means Control	Std. Mean Diff.	Var. Ratio	eCDF Mean
Distance	0.2215	0.1811	0.4158	1.9621	0.1198	0.1852	0.1851	0.0008	0.9973	0.0019
Year of First Publication	2007.0948	2007.4986	-0.0742	1.0292	0.0144	2009.1522	2009.1522	0	1	0
Education level: Master's	0.6619	0.8162	-0.326	.	0.1542	0.8418	0.8418	0	.	0
Education level: PhD	0.3381	0.1838	0.326	.	0.1542	0.1582	0.1582	0	.	0
Gender	0.5806	0.552	0.0579	.	0.0286	0.5519	0.5519	0	.	0
Stock of co-authors	10.2840	6.7625	0.0204	18.3616	0.0015	3.6196	3.0459	0.0033	2.6727	0.0041
Stock of publications	5.0735	5.3216	-0.0294	0.9528	0.0039	3.1787	3.2959	-0.0139	0.8088	0.0027
Stock of citations	10.9139	8.3519	0.0197	5.6755	0.0026	1.6775	1.6002	0.0006	0.345	0.002
Current Year	2012.2129	2012.8001	-0.1202	0.9267	0.0203	2011.9275	2011.9275	0	1	0
Field: Art	0.0667	0.0824	-0.0628	.	0.0157	0.0761	0.0761	0	.	0
Field: Biology	0.1181	0.0775	0.1259	.	0.0406	0.0894	0.0894	0	.	0
Field: Business	0.0731	0.0483	0.0951	.	0.0247	0.0495	0.0495	0	.	0
Field: Chemistry	0.0585	0.0296	0.1231	.	0.0289	0.0326	0.0326	0	.	0
Field: Computer science	0.1035	0.0863	0.0565	.	0.0172	0.1111	0.1111	0	.	0
Field: Economics	0.0071	0.0126	-0.0652	.	0.0055	0.0048	0.0048	0	.	0
Field: Engineering	0.0122	0.0116	0.0061	.	0.0007	0.006	0.006	0	.	0
Field: Environmental science	0.0344	0.0256	0.0479	.	0.0087	0.0266	0.0266	0	.	0
Field: Geography	0.1062	0.1016	0.015	.	0.0046	0.1184	0.1184	0	.	0
Field: Geology	0.0043	0.0042	0.0018	.	0.0001	0	0	0	.	0
Field: History	0.0016	0.0007	0.0213	.	0.0008	0.0012	0.0012	0	.	0
Field: Materials science	0.0225	0.013	0.0638	.	0.0095	0.0121	0.0121	0	.	0
Field: Mathematics	0.0138	0.0168	-0.0256	.	0.003	0.0109	0.0109	0	.	0
Field: Medicine	0.1201	0.1688	-0.1499	.	0.0487	0.1715	0.1715	0	.	0
Field: Philosophy	0.0352	0.0405	-0.0291	.	0.0054	0.0362	0.0362	0	.	0
Field: Physics	0.0099	0.0141	-0.0432	.	0.0043	0.0024	0.0024	0	.	0
Field: Political science	0.1145	0.1303	-0.0495	.	0.0157	0.1292	0.1292	0	.	0
Field: Psychology	0.0608	0.0874	-0.1111	.	0.0266	0.0773	0.0773	0	.	0
Field: Sociology	0.0375	0.0486	-0.0583	.	0.0111	0.0447	0.0447	0	.	0
Number of units	2532	1301				828	828			

Notes: This table displays the covariates used for matching and averages for the treatment and control groups before (Panel A) and after (Panel B) the matching. This table also provides statistics to indicate the quality of covariate balance (i.e., standardized mean difference, variance ratios, and empirical cumulative distribution function (eCDF)). For standardized mean differences and eCDF means, an absolute value close to 0 indicates a good balance; for variance ratios, values between 0.5 and 2 are recommended. After the matching, the three statistics are close to the recommended values.

Table 2 provides the descriptive statistics summary of our sample at the baseline year (the year preceding treatment). In our treatment and control units sample, 55% of researchers are male, 46.2% are in STEM fields, and 16% hold a PhD degree. Both groups have a similar stock of publications and citations in the baseline year. A slight difference is observed in the number of co-authors, with the treatment group averaging 3.619 and the control group averaging 3.045.

Table 2 – Descriptive Statistics

Variables	Treatment group (N= 828)	Control group (N= 828)	p-value
	Mean	Mean	
Number of publications	0.899	0.870	0.623
Cumulative number of citations/publication	0.358	0.270	0.047
Number of publications in highly-ranked journals	0.021	0.019	0.761
Share of English publications	0.253	0.229	0.163
Stock of citations	1.677	1.600	0.833
Stock of co-authors	3.619	3.045	0.027
Stock of publications	3.178	3.295	0.492
Gender (male:1)	0.551	0.551	
STEM	0.462	0.462	
Education level (PhD: 1)	0.158	0.158	

Notes: This table summarizes the descriptive statistics for the treatment and control groups at baseline. The variables we use for matching indicate that the two groups are similar. The only exception is the stock of co-authors, in which the treatment group has a slightly higher average than the control group. Most researchers in both samples are male (55%) in SSH fields (53,8%) with a Master's degree (84,2%).

4.2 Difference-in-Differences

We then apply to our matched sample the Difference-in-Differences multiple time period estimator of Callaway and Sant'Anna (2021), which allows units to be treated at different points in time, and to receive heterogeneous treatments.[11] An important part of this estimator is the Average Treatment Effect on the Treated (ATT) for a specific group (g) in a specific time period (t), denoted as ATT (g,

[11] In assessing the impact of collaborating with a star researcher on her peers, Yadav et al. (2023)complement the matching with a Two-Way Fixed Effects estimator. Nevertheless, recent developments in the causal inference literature acknowledge that this latter estimation lacks robustness in heterogeneous treatment effects, multiple-period setups, and treatment timing variation (Callaway, 2020; Cunningham, 2021; de Chaisemartin and D'Haultfœuille, 2020; Goodman-Bacon, 2021). To overcome these limitations we implement the Callaway and Sant'Anna estimator.

t). This parameter differentiates the path for the treated group from the path that group would have had if not treated, assuming this would be similar to the path of the control group:

$$ATT(g,t) = E\left[Y_t(g) - Y_t(0) \mid G_g = 1\right] \quad (1)$$

Where $ATT(g,t)$ is the group ATT; g indicates a group that becomes treated in a specific year; $\mathcal{G}$ is the set of treated groups; and $G_g = 1$ is a binary that turns to one when units are first treated in year g.

Callaway and Sant'Anna (2021) require that three assumptions be satisfied for the estimation to be consistent. First, staggered treatment adoption implies that once a unit receives the treatment in a period *t*, the unit remains treated for the following periods. Second, the no-anticipation assumption asserts that the outcome of a unit receiving the treatment should not have any impact before the treatment. Third, and most importantly, the parallel trend assumption requires that the paths of the treated units before receiving the treatment are not statistically significantly different. The authors suggest that parallel trends hold among units with similar characteristics.

In our econometric framework, we consider those three assumptions. First, once non-mobile researchers co-author with foreign-educated researchers for the first time, they become treated and remain as such. Second, we assume no anticipation. Third, our matching guarantees comparability between treated and control groups before the treatment, reinforcing the assumption of parallel trends.

Initially, we estimate dynamic effects (i.e., an aggregation scheme to observe the effects given the exposure to treatment during an elapsed time) for each outcome variable (number of publications, cumulative number of citations per publication, number of publications in top journals, and share of English publications):

$$ATT^{ES}(e) = \sum_{g \in \mathcal{G}} w^{ES}(g,e) ATT(g, g+e) \quad (2)$$

Where e is the number of periods during which the subject is exposed to the treatment. Our analysis includes the five years before and after the treatment.[12]

By estimating the dynamic effects, we first obtain an Aggregate ATT to capture the average effect of participating in the treatment during an elapsed time. Subsequently, we conduct an event study to investigate the effect over time and to verify parallel trends in the pre-treatment period.

Initially, our treatment is simply having collaborated with at least one foreign-educated researcher. The treatment moment is the date of the first collaboration (or more precisely the date of the first publication co-authored with a mobile researcher). We find an effect that continues over time. To uncover to some extent the process underlying this extended effect we sub-divide the treated population by the number of distinct mobile co-authors the non-mobile researcher has (we use n=1, n=2, n=3 and n>0 as categories, the last being our initial study).

We repeat the analysis to explore heterogeneity across fields, distinguishing between STEM and non-STEM fields.

Finally, as a robustness check, we present Event Study figures using alternative estimators (Sun & Abraham, 2021; Two-way Fixed Effects) (see Appendix D). We also conduct a robustness check to investigate the intensity of treatment. Instead of using the number of foreign-educated collaborators, we employ the number of joint co-publications with foreign-educated researchers as the treatment variable (see Appendix E).

5. Results

5.1 Co-authoring with at least one foreign-educated researcher

Table 3 displays the estimated Average Treatment Effects on the Treated (ATT) from Equation (2) for all outputs. The ATT compares the performance of researchers who co-authored with foreign-educated researchers to that of individuals who did not, but who were otherwise similar in all relevant aspects. We find a positive association between co-authoring with foreign-educated researchers and the scientific performance of non-mobile researchers. Notably, Column 1 shows that non-mobile researchers' productivity (number of publications per year) increases by 22% relative to the control

[12] We have chosen this window to have considerable data points to observe the parallel trends before the treatment and the effect over the years after the treatment.

group. Column 2 provides the point estimate on the citations, showing a rise of 19% in the number of citations for the treated group compared to the control group. In column 3, we observe a small positive impact of publications in top-tier journals: on average, researchers in the treatment group have 2.6% more publications in top journals than researchers in the control group. Column 4 shows changes in publication language patterns: a 6 percentage-point upward shift in the share of English publications among researchers in the treatment group after co-authoring with foreign-educated researchers.

Table 3 – Aggregate results: non-mobile researchers' performance

	Number of publications (in log)	Cumulative number of citations per publication (in log)	Number of publications in top journals (in log)	Share of English publications
	(1)	(2)	(3)	(4)
Co-authoring with foreign-educated researchers	0.2193*	0.1906*	0.026*	0.0645*
	(0.0231)	(0.0177)	(0.0057)	(0.0149)
Observations	16,866	16,866	16,866	16,866
N non-mobile researchers	1,656	1,656	1,656	1,656

Notes: This table provides point estimates for various performance indicators. In Column 1, the data show a 22% increase in publications among non-mobile researchers following co-authorship with foreign-educated researchers. Similarly, Column 2 shows a 19% increase in citations per publication. Column 3 shows that non-mobile researchers have a slight yet positive increase of 2.6% in the number of publications in top journals. Column 4 indicates a 6-percentage-point positive shift in the share of English publications. The level of statistical significance is * $p < 0.05$. Standard errors in parentheses are clustered at the individual level.

5.2 Event Studies results

We adopt an event study framework to investigate the effect over the years and test the assumption of parallel trends in the pre-treatment period. Figures 1 to 4 present the event study results, each corresponding to one outcome variable (i.e., number of publications, cumulative number of citations per publication, number of publications in top journals, and share of English publications).

In Figures 1-4, the point estimates for the pre-treatment period confirm the parallel trend assumption for our matched sample: they are close to zero and statistically insignificant. This indicates that there are no discernible pre-trends between the treatment and control groups for all four outcomes,

suggesting that the groups do not differ in scientific performance and publish the same share of English publications before the treatment.

With respect to the year of treatment and the following five years, we observe two main patterns in the effects of co-authoring with foreign-educated researchers on the number of publications by non-mobile researchers (Figure 1). First, there is a marked increase in the productivity coinciding with the (first) year they publish with foreign-educated researchers (year 0). Second, we see a positive reinforcement as the stock of foreign-educated researchers expands (from Panels 1 to 4). These results suggest that the increase in productivity in the treatment year results from a publication with a foreign-educated researcher, adding to the number of works the non-mobile researcher would have published anyway. Subsequently, productivity gains are maintained as the non-mobile co-author with more foreign-educated researchers. Nevertheless, whether productivity is sustained through increasing collaborations with foreign-educated researchers or by indirect effects such as spillovers and learning processes remains an open question. We further explore these results in Section 6.

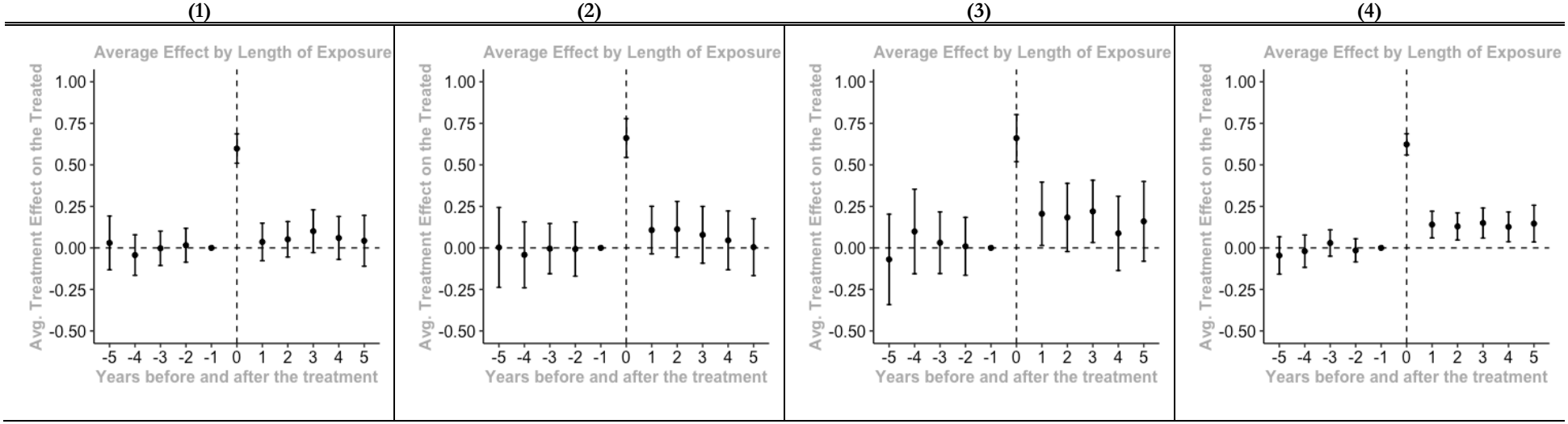
The Event Studies for the cumulative number of citations per publication (Figure 2) show a different pattern. When non-mobile researchers co-author with foreign-educated researchers, we find a significant increase in the cumulative number of citations per publication. In this case, the positive impact is long-lasting even after a co-authorship with only one foreign-educated researcher (Panel 1).

Figure 3 illustrates the dynamic effects of having mobile co-author(s) on a publications in top journals. Results follow a pattern similar to those for total publications. Although smaller, there is a positive impact on the year of co-authoring a paper, but not in subsequent years, unless the non-mobile researchers co-author with several foreign-educated researchers. In other words, when co-authoring with foreign-educated researchers, non-mobile researchers experience a slight improvement in the quality of their publications.

Figure 4 shows changes in the publication language patterns. Across the panels, a positive, statistically significant increase in the share of English publications is observed. The only exception is Panel 3, where the treatment group sample size is small, leading to large standard errors and turning the point estimates statistically insignificant. Overall, non-mobile researchers who co-author with foreign-educated researchers become more inclined toward international publishing, as observed by the increase in the share of English publications.

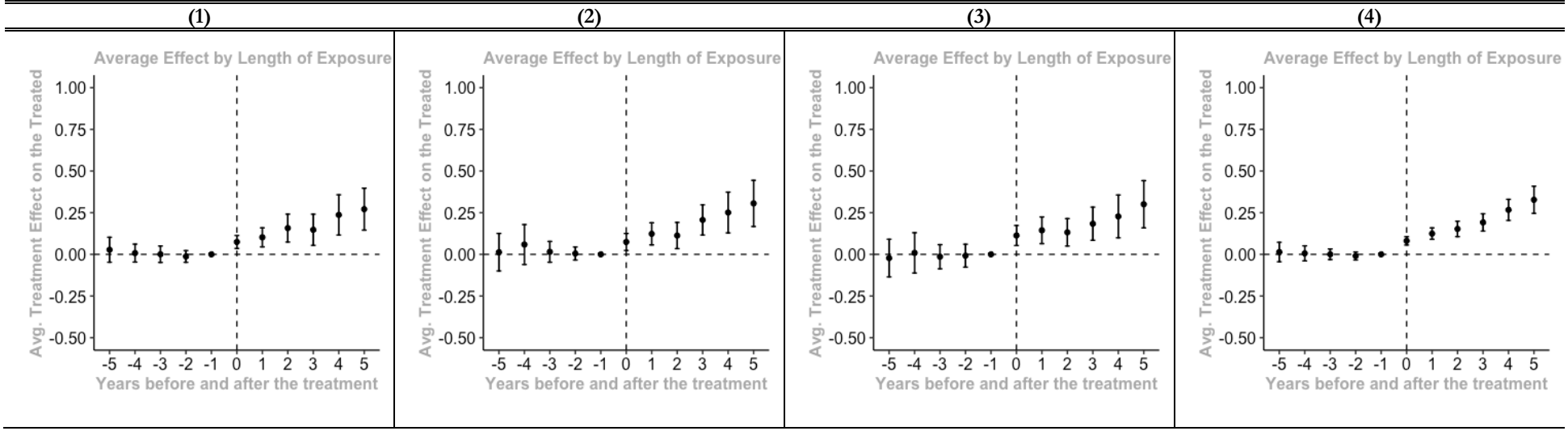
Our findings are qualitatively unchanged when alternative estimators are applied (see Appendix D) (Callaway & Sant'Anna, 2021; Sun & Abraham, 2020; Two-way Fixed Effects).

Figure 1 - Effects of co-authoring with foreign-educated researchers on number of publications (in log)



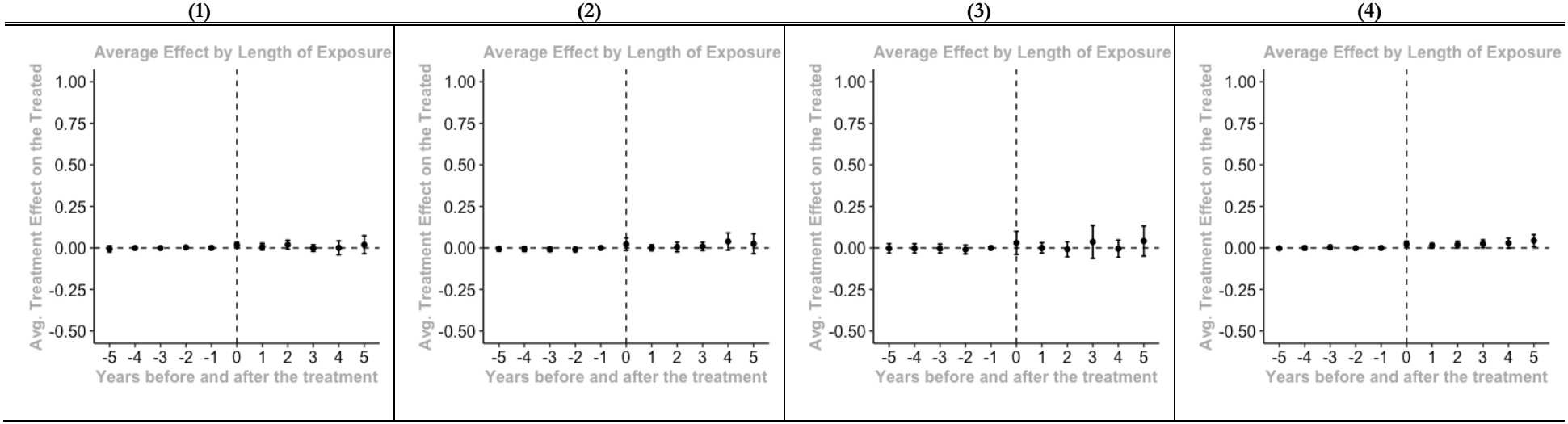
Notes: This figure exhibits the dynamic effects on non-mobile researchers' productivity after co-authoring with one (panel 1), two (panel 2), three (panel 3), and any foreign-educated researchers (panel 4). The panels show a pattern: the productivity of non-mobile researchers improves and displays long-lasting effects as they increase the stock of foreign-educated researchers. The bars indicate 95% confidence intervals. Standard errors are clustered at the individual level.

Figure 2 - Effects of co-authoring with foreign-educated on cumulative number of citations per publication (in log)



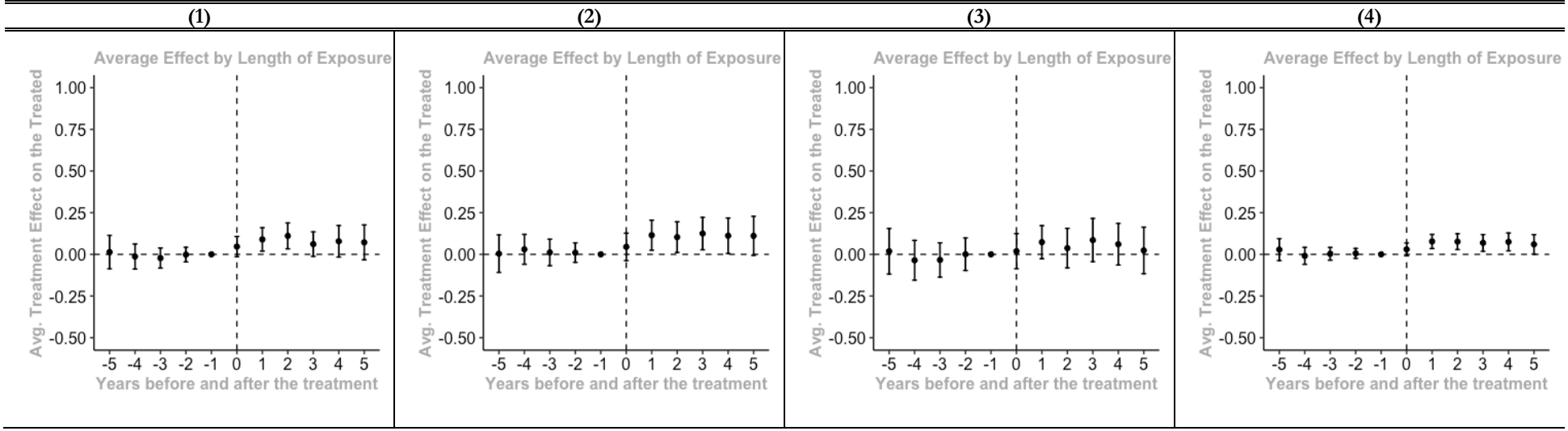
Notes: This figure exhibits the dynamic effects on non-mobile researchers' cumulative number of citations per publication after co-authoring with one (panel 1), two (panel 2), three (panel 3), and (any) foreign-educated researcher (panel 4). The panels illustrate a trend: Non-mobile researchers experience an increased number of citations, even after a single co-authorship with a foreign-educated researcher. Effects intensify as non-mobile researchers co-author with more foreign-educated researchers. The bars indicate 95% confidence intervals. Standard errors are clustered at the individual level.

Figure 3 - Effects of co-authoring with foreign-educated researchers on number of publications in top journals (in log)



Notes: This figure exhibits the dynamic effects on non-mobile researchers' number of publications in top journals after co-authoring with one (panel 1), two (panel 2), three (panel 3), and any foreign-educated researcher (panel 4). The panels illustrate a modest and not statistically significant impact on publications in top journals even after increasing the number of foreign-educated researchers. The bars indicate 95% confidence intervals. Standard errors are clustered at the individual level.

Figure 4 - Effects of co-authoring with foreign-educated researchers on share of English publications



Notes: This figure demonstrates the dynamic effects on non-mobile researchers' share of English publications after co-authoring with one (panel 1), two (panel 2), three (panel 3), and any foreign-educated researcher (panel 4). The panels indicate a consistent pattern: A noticeable increase in the share of English publications after co-authoring with foreign-educated researchers. The only exception is panel 3, where, despite positive point estimates, the results are not statistically insignificant. The bars indicate 95% confidence intervals. Standard errors are clustered at the individual level.

5.3 Exploring field heterogeneity

In this section, we ask whether the patterns reported above differ across macro fields. To examine possible heterogeneous effects, we group researchers into two fields: STEM — Science, Technology, Engineering, and Mathematics, and SSH — Social Sciences and Humanities.

Table 4 displays the effects on non-mobile researchers' performance in the case where they have co-authored with any strictly positive number of foreign-educated researchers. Panel A shows these effects for researchers in STEM fields, while Panel B focuses on SSH researchers.

Table 4 presents two patterns. First, non-mobile researchers from both macro fields exhibit increased performance indicators following collaborative efforts with foreign-educated researchers. However, the magnitude of these effects varies between macro fields. The positive impact on publication numbers is similar for SSH and STEM researchers. However, the effect on the other indicators (mainly those related to visibility) appears larger in STEM than in SSH. Notably, the impact on citations and publication language patterns is large. The cumulative number of citations per publication of STEM non-mobile researchers increases by almost 26% (column 2), the number of publications in top journals increases by 3.8% (column 3), and the share of English publications increases by 9 percentage points (column 4). In comparison, SSH counterparts experience a 13% increase in citations (column 6), a 1.6% increase in the number of publications in top journals (column 7), and almost a 3 percentage point increase in the share of English publications, although statistically insignificant (column 8). These results show that STEM non-mobile researchers benefit more in citations and reach a wider audience than SSH researchers. But this may simply be due to the nature of the subject matter in the two domains. SSH research tends in general (though not always) to be much more context specific (in this case specific to Colombia or perhaps Latin America) than STEM research. This would imply reduced value for publishing in English, and (thus) a smaller audience of potential "citers".

Table 4 – Aggregate results: Non-mobile researchers' performance by macro field (STEM and SSH)

	Panel A - STEM				Panel B - SSH			
	Number of publications (in log)	Cumulative number of citations per publication (in log)	Number of publications in top journals (in log)	Share of English publications	Number of publications (in log)	Cumulative number of citations per publication (in log)	Number of publications in top journals (in log)	Share of English publications
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Co-authoring with foreign-educated researchers	0.22*	0.2563*	0.0377*	0.0913*	0.2287*	0.1295*	0.0164*	0.035
	(0.0359)	(0.0259)	(0.008)	(0.0228)	(0.0312)	(0.0203)	(0.0072)	(0.0202)
Observations	7,851	7,851	7,851	7,851	9,015	9,015	9,015	9,015
N non-mobile researchers	766	766	766	766	890	890	890	890

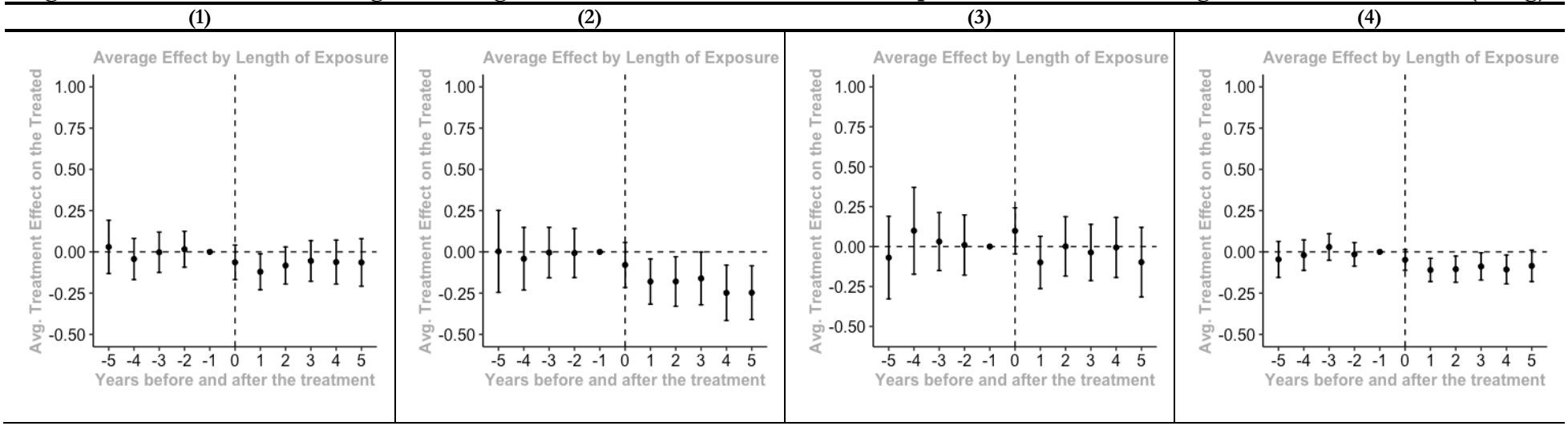
Notes: This table presents point estimates across various performance indicators for non-mobile researchers in STEM and SSH fields. Columns 1 to 4 detail the performance indicators of STEM non-mobile researchers, while Columns 5 to 8 are dedicated to those in SSH fields. In general, STEM non-mobile researchers benefit more from co-authoring with foreign-educated researchers than SSH non-mobile researchers do, in terms of citations, publications in top journals, and the share of English publications. However, there is one exception: SSH and STEM non-mobile researchers experience a similar increase in the number of publications. The level of statistical significance is * $p < 0.05$. Standard errors in parentheses are clustered at the individual level.

6. Long-term effects: Removing co-authored publications with foreign-educated researchers

In section 5.2, we have shown that non-mobile researchers publish more, including in top journals, only if they collaborate with several foreign-educated researchers. Moreover, a possible concern is that the productivity gains are linked to joint publications with mobile researchers. To address this concern and assess the long-term effects, we perform the same analysis, but removing all publications co-authored with foreign-educated researchers.

Figure 5 shows that excluding publications co-authored with foreign-educated researchers, the treated researchers publish slightly fewer papers than the control group. Treated researchers do not publish more independently from the foreign-educated researchers. It seems that, as non-mobile researchers frequently co-author with foreign-educated peers, the time invested in this co-authorship is substantial, crowding out other publications (single authored or authored with non-mobile colleagues).

Figure 5 - Effects of co-authoring with foreign-educated researchers on number of publications without foreign-educated researchers (in log)



Notes: This figure exhibits the dynamic effects on non-mobile researchers' productivity (without publications with foreign-educated researchers) after co-authoring with one (panel 1), two (panel 2), three (panel 3), and any foreign-educated researchers (panel 4). The panels show a pattern: non-mobile productivity is not sustained when foreign-educated researchers are not involved. The bars indicate 95% confidence intervals. Standard errors are clustered at the individual level.

7. Discussion and conclusion

In this paper, we tackle a significant yet underexplored question in the literature: do foreign-educated researchers, through direct collaboration, influence the performance of their non-mobile colleagues who remain in their sending countries? To explore this question, we construct a panel dataset combining CV, publication, and Ph.D. scholarship list data from active Colombian researchers in different fields between 1990 and 2021. We implement a nearest-neighborhood matching to create comparable groups. We also use a Difference-in-Differences with multiple time period estimator to estimate the impact over the years. Furthermore, we explore heterogeneity across researchers in the STEM and SSH fields.

Our initial findings demonstrate a positive, statistically significant association between co-authoring with foreign-educated researchers and increased scientific performance among non-mobile researchers. Notably, non-mobile researchers who co-author with foreign-educated peers experience higher performance: a 22% rise in publications, a 19% increase in citations, a 2.6% increase in publications in top journals, and a 6 percentage-point boost in the share of English publications. Disaggregating by macro-fields, we observe different dynamics. Non-mobile researchers in SSH and STEM fields have similar productivity benefits. But STEM researchers exhibit higher gains in citations, frequency of publications in top journals, and share of English publications.

The Event Study results show distinct patterns. First, we find that the size of the effect on publications increases, and is temporally prolonged with the number of distinct mobile co-authors. These results align with those of Yadav et al. (2023), who found that a single co-authorship with a star scientist increases peers' productivity only in the first year, but as peers expand collaborations with other star scientists, productivity has increased over the years.

Further exploring the Event Study on scientific productivity, we find no effect on independent production (without the foreign-educated researchers). This suggests that non-mobile and foreign-educated researchers have complementary assets, which leads them to collaborate. There might also be opportunity costs: it might be more expensive for non-mobiles to produce independently than to maintain the collaboration with foreign-educated researchers. I think what we can say in this paragraph is 2 things: first, (since other output falls) there is a budget constraint, and time spent with a mobile reduces time spent on other things. Possibly, though, the time/effort in producing something that the

mobile finds acceptable is higher than producing other things (we need something like that to explain the fall in other output). Second (or maybe first) working on his own or with non-mobile colleagues produces "lower quality" output (or takes more time to produce the same quality output). This suggests that the mobile is bringing something to the table that non-mobile colleagues are not.

Regarding citations, we find a long-lasting impact even after one co-authorship with a foreign-educated researcher. These findings can be interpreted in various ways. First, non-mobile researchers might benefit from simply associating with foreign-educated researchers, often perceived as more productive (Gibson and McKenzie, 2014; Scellato et al., 2015). These collaborations potentially increase non-mobile researchers' reputations, contributing to the perception of their work as high-quality. Second, co-authoring with foreign-educated researchers provides non-mobile researchers opportunities to acquire new skills and knowledge, positively reinforcing these latter researchers' performance (Fry & Furman, 2023; Yang et al., 2022). Lastly, the increase in citations can be attributed to network effects (Uddin et al., 2013)). Foreign-educated researchers often have more extensive and diverse networks (Petersen, 2018; Scellato et al., 2015). By co-authoring with foreign-educated researchers, non-mobile researchers' citations may also be affected by reinforcing network effects. A possible concern is that the additional citations are linked to joint publications with foreign-educated researchers.

The Event Study results on publications in top journals indicate a small effect, even after a non-mobile researcher collaborates with more foreign-educated researchers. Nevertheless, this small effect does not necessarily indicate that non-mobile researchers are not learning from foreign-educated researchers or becoming more productive. Instead, it might be attributed to the nature of publishing in top journals, where acceptance rates are relatively low (Haensly et al., 2008; Sugimoto et al., 2013).

From the Event Study graphs, we also show that treated non-mobile researchers increase their share of English as they start collaborating with foreign-educated researchers. This shift suggests that foreign-educated researchers are essential for non-mobile ones to reach a broader and more global audience.

Overall, this study underlines the role of foreign-educated researchers in helping non-mobile researchers increase their scientific performance. Notably, our findings suggest that collaborating with

foreign-educated researchers significantly improves the positioning of non-mobile researchers in the scientific community while also increasing the share of publications in English.

Our work makes several contributions to the existing literature. Along with other authors (Franzoni et al., 2018; Fry & Furman, 2023; Fry, 2023; Müller et al., 2023; Yang et al., 2022), our study diverges from the traditional work on researchers' mobility which focuses on how mobility directly affect foreign-educated researchers. Instead, we look at the implications of mobility experiences at large, particularly on researchers who have never moved abroad. What differentiates our work from others investigating the extended effects of a mobility experience is that we consider an analysis at the micro-level, focusing on individuals as units of analysis rather than considering the meso-level, such as a department. Second, we expand the research scope to include researchers from a broad range of scientific fields instead of narrowing it to one field.

This paper opens opportunities for future research. Our findings indicate that co-authoring with foreign-educated researchers increases the performance of non-mobile researchers. However, the mechanisms behind this improvement remain to be further explored. Previous studies have identified potential mechanisms. For instance, according to Ito et al. (2025), foreign-educated researchers offer access to networks of foreign researchers. But future research is needed to determine whether the benefits of co-authoring with foreign-educated researchers also arise from knowledge transfer and access to skills, as stated in the literature on teams in science (Ductor, 2015; Hart, 2000). A promising research avenue also involves expanding this study to include researchers from other middle-income countries, such as Mexico and South Africa. These countries have centralized CV systems similar to Colombia's CVLAC (González-Sauri & Rossello, 2023; Müller et al., 2023), providing an opportunity to validate our findings in the context of middle-income countries with different sizes and levels of socio-economic development. A final opportunity involves differentiating foreign-educated researchers into diaspora (i.e., those researchers who have remained abroad) and returnees (i.e., those who have returned to their country of origin). We have attempted to isolate the impact of returnees and diaspora researchers; however, given the small sample size, we could not detect any differential effect.

Our findings carry significant policy implications, especially for middle-income countries with scientific systems akin to those in Colombia, such as Peru and Chile. Those countries can increase the overall productivity of their scientific systems by sponsoring scientific mobility programs that enable

their nationals to go abroad. In return, those who benefit from those programs can carry novel scientific and technological knowledge back to their countries of origin and co-author with researchers who never moved. Also, those foreign-educated researchers who remain abroad can provide access to infrastructure and a network of international colleagues. However, this policy implication alone is not a complete solution. Countries should foster collaborations among their researchers but improving local training and scientific infrastructure is also important for non-mobile researchers to establish effective collaborations and assimilate the knowledge brought by foreign-educated researchers.

Acknowledgements

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Appendix A – Dataset and sample construction

We construct our database, including researchers' profiles and their publications, by combining three primary data sources: CvLAC, the lists of PhD fellowship beneficiaries from the three main national funding agencies (Colfuturo, Colciencia, and Fulbright in Colombia), and OpenAlex.

As the first step, starting from CvLAC, we extracted the names of all the Colombian researchers who uploaded their CVs to the national dataset between 1990 and 2021, identifying 28,729 individuals. To ensure the coverage of the whole Colombian population of researchers and also retrieve those who did not register in CvLAC (maybe because they were abroad), we complemented the original list of names with the names appearing in the lists of the PhD holders from the main national funding agencies, adding another 3,917 individuals. As the next step, we matched our list of names with OpenAlex's publication data. When matching OpenAlex's publication data, we encountered multiple identifiers for a single researcher. To overcome this issue, we employed several author name disambiguation strategies, such as Author name fuzzy match, ORCID match, Title fuzzy match, Bibliographic info match, and DOI match. Using the information of the publications self-declared and uploaded to CvLAC in the latter two matching strategies helped us attribute unequivocal publications to researchers. In OpenAlex, we matched 68% of our initial sample. In other words, we identified 19,661 researchers with at least one publication from OpenAlex.

Considering the affiliations retrieved in CvLAC's CVs and OpenAlex publication affiliations, we identified 10,666 researchers who have completed a master's or Ph.D. in Colombia and have not spent more than 11 consecutive months abroad. However, some of these non-mobile researchers are not active in publishing. We set a 3-publication threshold to restrict our final sample of active researchers. As a result, we ended up with 6,609 non-mobile researchers.

We reconstructed the complete co-authorship network to distinguish among non-mobile researchers, those who collaborated with foreign-educated researchers, and those who restricted their collaborations to locals. Following previous studies, we consider foreign-educated researchers as those who pursued their PhD abroad (Kahn & MacGarvie, 2012, 2016; Liang et al., 2022; Turpin et al., 2008).

The final step in constructing our sample involves removing non-mobile researchers who collaborated with a foreign-educated researcher in their first year of entry into the dataset. This adjustment is necessary when applying a Difference-in-Differences approach since it requires observing pre-treatment trends to assume that treated non-mobile researchers would have behaved similarly to the control group in the absence of treatment in the post-treatment period (Angrist, 2008).

We ended up with a final sample of 3,833 individuals, of whom 2,532 co-authored with at least one foreign researcher.

Appendix B – Spanish publications

Table 5 presents extra analysis conducted in our study to investigate the effects of collaborating with foreign-educated researchers on non-mobile researchers' share of Spanish publications. The result in column 1 shows that non-mobile researchers in the treatment group tend to publish more in English while decreasing their output in Spanish.

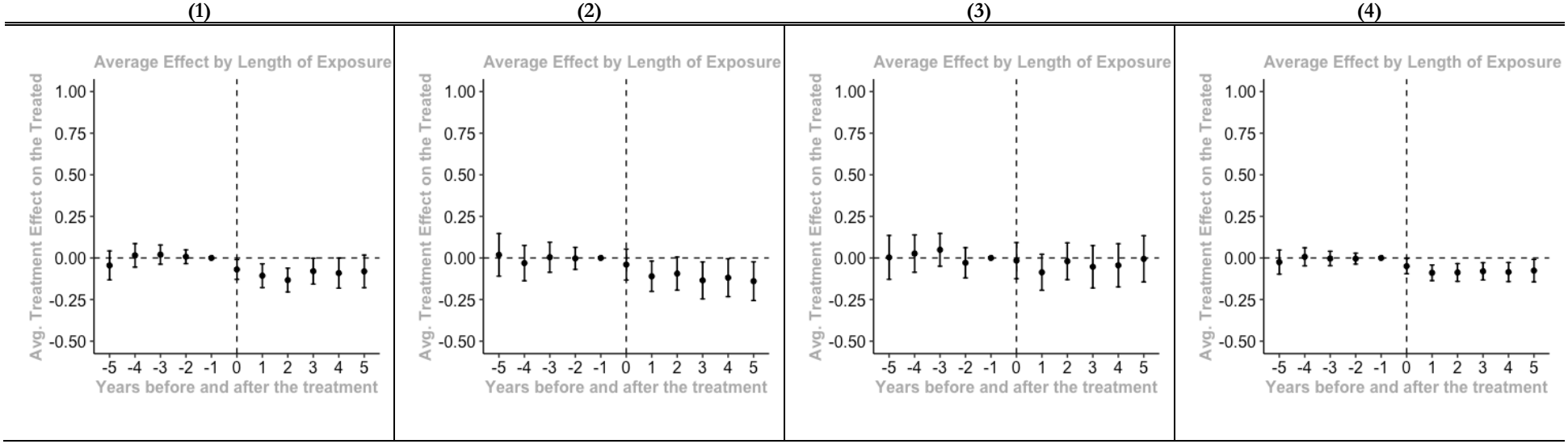
Table 5 – Additional aggregate results: Non-mobile researchers' performance

	Share of Spanish publications
	(1)
Co-authoring with foreign-educated researchers	-0.0778*
	(0.0172)
Observations	16,866
N non-mobile researchers	1,656

Notes: This table provides point estimates for additional performance indicators. In column 1, the data show that non-mobile researchers experience a 8 percentage-point decrease in the share of Spanish publications after co-authoring with foreign-educated researchers. The level of statistical significance is at $^{*}p < 0.05$. Standard errors in parentheses are clustered at the individual level.

Figure 6 illustrates the event study of non-mobile researchers' share of Spanish publications. It shows a discernible pattern: as non-mobile researchers co-author with foreign-educated researchers, there is a decrease in Spanish publications and an increase in English Publications (see Figure 4).

Figure 6 - Effects of co-authoring with foreign-educated researchers on non-mobile researchers' share of Spanish publications

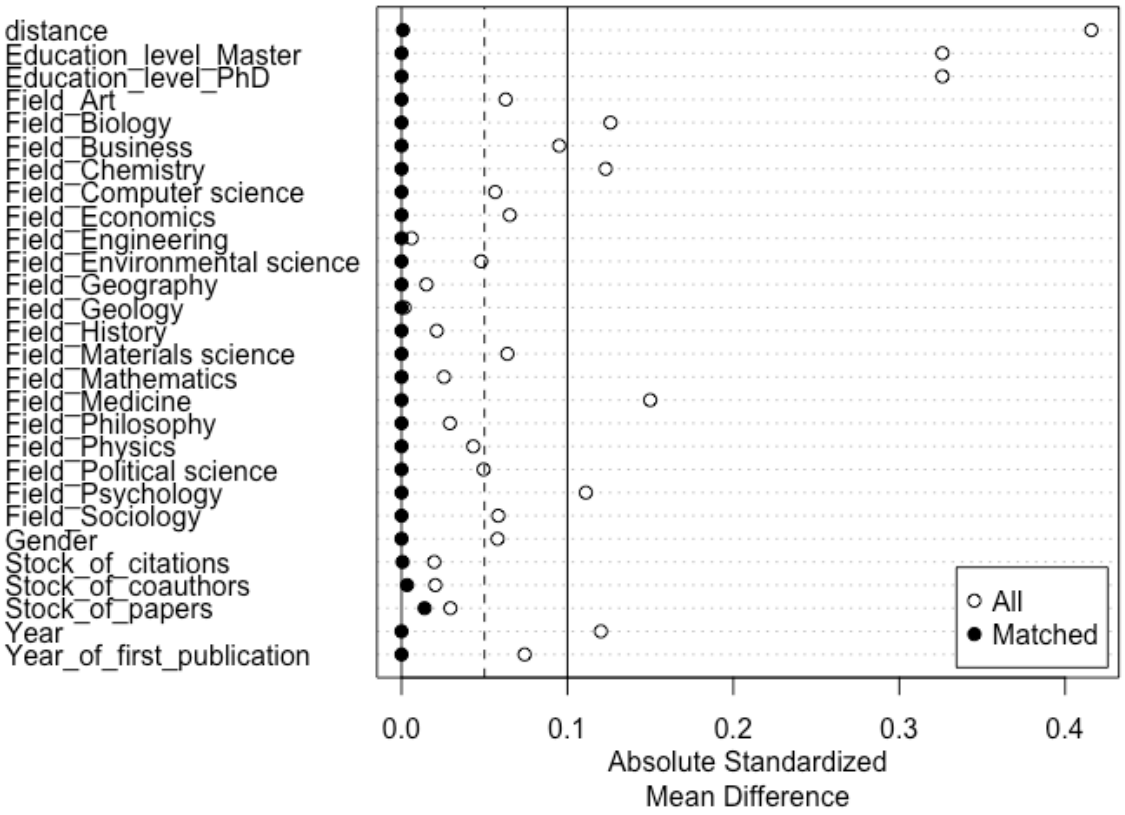


Notes: This figure demonstrates the dynamic effects on non-mobile researchers' share of Spanish publications after co-authoring with one (panel 1), two (panel 2), three (panel 3), and (any) foreign-educated researchers (panel 4). The panels indicate a decrease in the share of Spanish publications after co-authoring with foreign-educated researchers. The only exception is panel 3, where, despite negative point estimates, the results are not statistically insignificant. The bars indicate 95% confidence intervals. Standard errors are clustered at the individual level.

Appendix C – Covariate balance plot

Figure 7 visually represents the Standardized Mean Difference columns from Table 1. The white dots in the figure represent the Standardized Mean Difference in baseline covariates between the treatment and control groups before matching. On the other hand, the black dots represent the mean differences after the matching. Notably, the figure shows that nearly all covariates' Absolute Standardized Mean Differences are near zero following the matching. This indicates that treatment and control groups are well-matched based on the covariates.

Figure 7 – Covariate balance plot



Notes: This figure demonstrates the balance of covariates graphically before and after the matching. Before widmatching, the white dots are highly dispersed, indicating that the covariates between the treatment and control groups are unbalanced. After the matching, the black dots are close to zero, showing that the covariates are well-balanced between the groups.

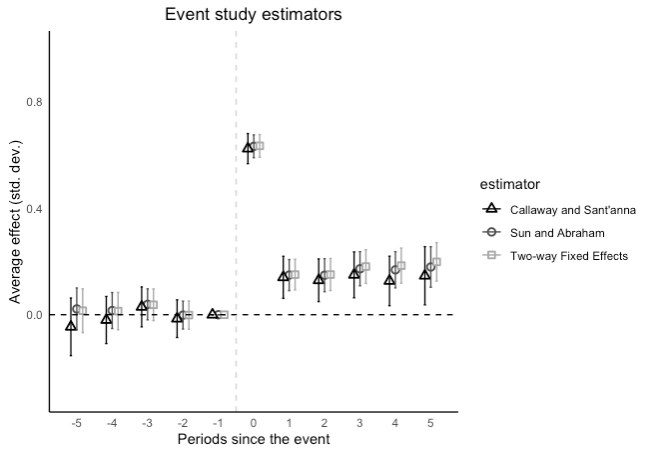
Appendix D – Different Difference-in-Differences Estimators

We rely on several Difference-in-Differences estimators to investigate the consistency of our point estimates, given that these estimators have different assumptions and methods (Callaway & Sant'Anna, 2021; Sun & Abraham, 2020; Two-way Fixed Effects). For example, the Two-way Fixed Effect estimator assumes a strong assumption of homogenous treatment effects (Callaway, 2020), and the Sun & Abraham (2021) estimator relies on the Ordinary Least Squares regressions with many interaction terms for its estimation. Given these differences, relying on a range of estimators is important to ensure robust results (Freedman et al., 2023).

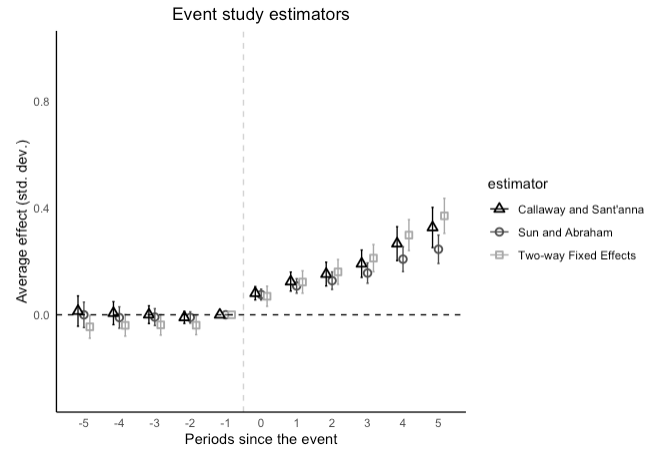
Figure 8 presents the event study graphs for all four performance indicators in the scenario in which non-mobile researchers co-author with (any number of) foreign-educated researchers. Across all four graphs, the parallel trends assumption holds: regardless of the estimator used, the point estimates are consistently near zero, indicating no divergent trends in the pre-treatment years. Different estimators provide similar point estimates in all four graphs during the treatment year and subsequent periods, reinforcing the robustness of our findings.

Figure 8 – Effects of co-authoring with foreign-educated researchers on the performance of non-mobile researchers over time

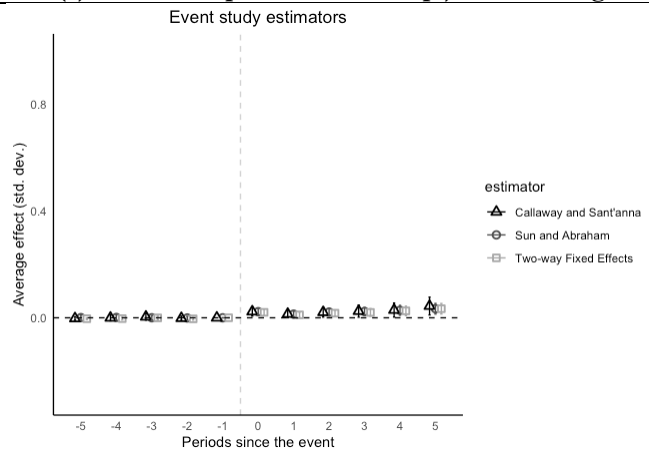
(1) Number of publications in log



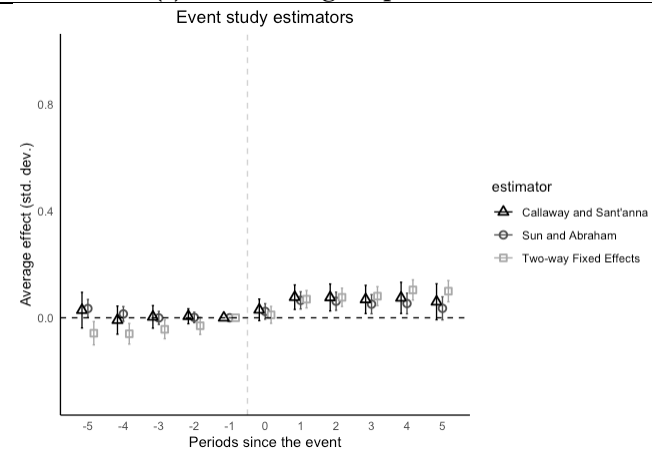
(2) Cumulative number of citations per publications in log



(3) Number of publications in top journals in log



(4) Share of English publications



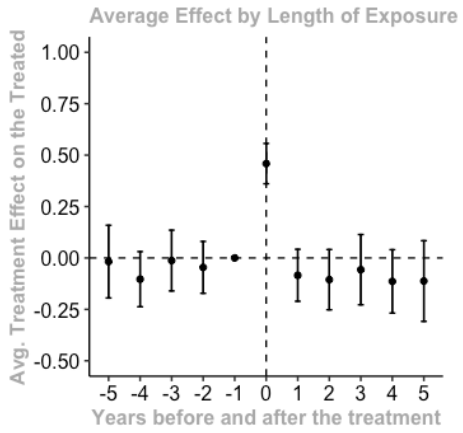
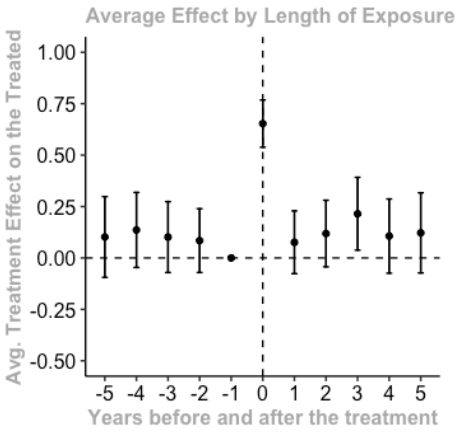
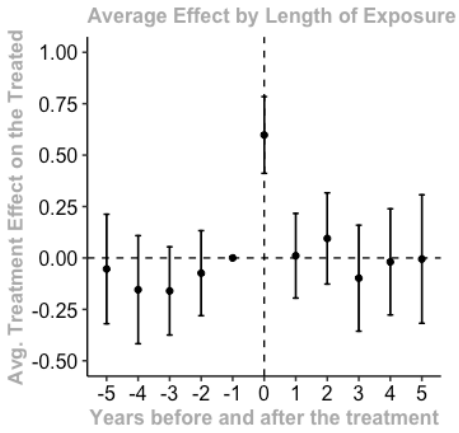
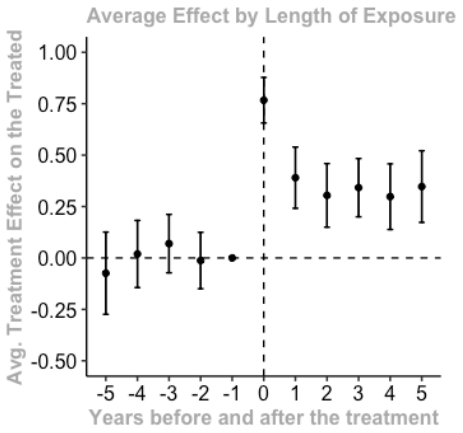
Notes: This figure presents the Event Study plots on performance indicators following co-authoring with (any) number of foreign-educated researchers, employing multiple Difference-in-Differences estimators (Callaway & Sant'Anna, 2021; Sun & Abraham, 2020; Two-way Fixed Effects). Panel 1, on the number of publications (in log), shows a notable peak in the year of the treatment. Although the point estimates decrease in the following years, they remain stable, positive, and statistically significant. Panel 2 shows that treated researchers steadily increase the cumulative number of citations per publication following the treatment. Panel 3 shows that co-authoring with foreign-educated researchers has a slight yet positive and stable impact on the number of publications in top journals over time. Panel 4 demonstrates a stable yet upward shift in the share of English publications. It indicates that non-mobile researchers who co-authored with foreign-educated researchers shifted the language of their publications towards English more than those in the control group. In the four panels, we use different estimators to indicate robustness and to test for parallel trends during pre-treatment periods. The bars indicate 95% confidence intervals. Standard errors are clustered at the individual level.

Appendix E – Robustness check: treatment intensity

In our study, we adopt a staggered setup: once treated, a researcher remains treated throughout the study period. We also allocate non-mobile researchers to subgroups based on the number of foreign-educated collaborators in each subgroup. This can raise two concerns. First, the collaboration with a mobile researcher can be localized in the treatment year or spread across time. Second, a treated non-mobile researcher might collaborate with a mobile co-author in the treatment year and, in subsequent years, with other foreign-educated researchers.

To verify the robustness of our results, we investigate the treatment intensity in Figure 9. In other words, we split the treated non-mobile researchers by the number of joint publications with foreign-educated researchers in the first 6 years (the year of first collaboration and the following 5 years): 1 (panel 1), 2 (panel 2), 3 (panel 3), and more than 3 (panel 4) joint publications. The Event Studies in Figure 9 indicate that the surge in the number of joint publications is directly related to an increasing performance of the treated non-mobile researchers.

Figure 9 - Treatment Intensity

(1)	(2)	(3)	(4)
			

Notes: This figure demonstrates the dynamic effects on Colombian non-mobile researchers' number of publications (in log) according to the number of joint publications with mobile researchers: 1 (panel 1), two (panel 2), 3 (panel 3), and more than 3 joint publications (panel 4). Across all panels, the figures indicate that the effects on the number of publications are positive and sustained as treated non-mobile researchers co-author joint publications with mobile researchers. The bars indicate 95% confidence intervals. Standard errors are clustered at the individual level.