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Abstract[*]

Studying and working abroad, internationally mobile scientists meet foreign scientists and become carriers of knowledge. The benefits of international scientific mobility might extend to nonmobile colleagues who collaborate with mobile scientists. In this paper, we investigate the role played by Brazilian and Colombian scientists who are mobile in connecting nonmobile scientists with foreign scientists. We combine publicly available data from online curriculum vitae (CVs), scholarship programs, and publications in OpenAlex. We analyze a large sample covering approximately 70 percent of scientists for both countries and their coauthorship networks between 1990 and 2021, combining panel estimations and a difference-in-differences (DiD) event study. We find that nonmobile scientists who coauthor with mobile scientists coauthor more publications with foreign scientists. The number of collaborations by nonmobile scientists with foreign scientists increases with the number of unique mobile scientists the nonmobile scientists interact with. This is because the effect of collaborating with a unique mobile scientist is short-lived. Results suggest that mobile scientists who stay abroad more (diaspora) may be the most effective in creating connections with foreign scientists. Our paper contributes to the literature on scientific mobility and brain drain. We provide first insights into the spillover generated by mobility experiences in connecting nonmobile scientists with foreign scientists. Our results indicate a need to increase brain gain and reduce brain drain from home countries by increasing the links between mobile scientists and nonmobile scientists.

JEL codes: O15, O3, D83
Keywords: international scientific mobility, coauthorship networks, social capital spillovers, Colombia, Brazil

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List of Abbreviations

BrazilDB	database of Brazilian researchers
CAPES	Coordenação de Aperfeiçoamento de Pessoal de Nível Superior or Coordination for the Improvement of Higher Education Personnel
CGEE, Brazil	Centro de Gestão e Estudos Estratégicos
CNPq, Brazil	National Council for Scientific and Technological Development
Colciencias, Colombia	Administrative Department of Science, Technology, and Innovation
ColDB	database of Colombian researchers Colfuturo in Colombia, the Foundation for the Future of Colombia
CV	curriculum vitae
CvLAC	platform in Colombia for scientific CVs
DiD	difference-in-differences
DOI	Digital Object Identifier
FOS	field(s) of study; used to refer to disciplines or fields of science. The fields of studies classification used in this study was originally produced by Microsoft Academic Graph (MAG), and continued by OpenAlex.
ISSN	International Standard Serial Number
CvLattes	"Currículo Lattes" platform in Brazil for scientific CVs
LPM	linear probability model
OA	OpenAlex
OLS	ordinary least squares
ORCID	Open Researcher and Contributor Identifier
SciELO	SciELO-Brazil database
SNA	social network analysis
SNIES, Colombia	Sistema Nacional de Información de la Educación Superior
SSH	social science and humanities
STEM	science, technology, engineering, and mathematics
STHC	Scientific and Technical Human Capital model

1. Introduction

As knowledge has become a critical economic asset in today's world, creating new knowledge is vital to countries' socioeconomic development (Romer, 1990). Given that old knowledge is the main input to new knowledge (Jones, 2009) and that creation is often a form of recombination, knowledge creation can be perceived essentially as a network process in which agents share resources, cooperate, and learn from each other to advance science (Nowotny, Scott, and Gibbons. 2003). Recombination is more successful if agents have access to diverse knowledge sources, implying links between different parts of the knowledge network could be important (Mohnen, 2022). Scientists and policymakers understand this network feature, which duly appears in different mechanisms and policies to promote it. One recurring mechanism is international scientific mobility: by crossing borders, scientists access novel ideas, obtain different types of training, and diversify their professional networks. Upon returning to their home countries, they bring back novel knowledge that can be applied to socioeconomic issues (Cañibano, 2017).

In the last decades, governments in high- and low-income countries have been promoting policies to support the training of students and scientists abroad (Baruffaldi, Marino, and Visentin, 2020; Jonkers and Tijssen, 2008). Academic and policy actors worldwide recognize the role of international mobility in fostering knowledge creation and diffusion, which contribute to economic growth (Baruffaldi and Landoni, 2012; Cañibano, 2017; OECD, 2018). Internationally mobile scientists and students who spend time abroad absorb tacit knowledge through face-to-face interactions, access scientific infrastructures, and expand their social capital (Bozeman, Dietz, and Gaughan, 2001). For internationally mobile scientists themselves, periods abroad improve their research productivity (Netz, Hampel, and Aman, 2020). For the countries of origin of those mobile scientists, benefits arise when sojourners return, carrying with them knowledge that can be applied both to research on local socioeconomic needs and training new students and scientists (Cañibano, 2017; Trippl, 2013).

Mobile scientists may also contribute to the internationalization of their home country's scientific systems by connecting the local scientific community to the global community (Velema, 2012). Empirical studies demonstrate that time spent abroad to do research leads internationally mobile scientists (henceforth "mobile scientists") to have larger international coauthorship networks than scientists who spend their careers in their home countries (henceforth "nonmobile scientists") (Aykac, 2021; Cao, Baas, Wagner, and Jonkers, 2020; Gibson and McKenzie, 2014; Jonkers and Cruz-Castro, 2013).[1] Many studies suggest that, given their larger stock of international coauthors, mobile scientists may benefit nonmobile scientists from their country of origin by connecting them to foreign scientists (Gibson and McKenzie, 2014; Netz, Hampel, and Aman, 2020). However, these studies rarely analyze whether and how nonmobile scientists establish ties with foreign scientists through mobile scientists. As such, the literature is not clear on the extent to which mobile scientists are an essential resource for nonmobile scientists to form foreign ties.

This paper addresses this gap by investigating the extent to which collaborating with mobile scientists affects the probability that a nonmobile scientist collaborates with foreign scientists located abroad. Specifically, it examines whether nonmobile scientists copublishing with mobile scientists increases the nonmobile scientists' number of publications with foreign scientists. The research focuses on the intensive and extensive margin,[2] distinguishing between fields of study (FOS) grouped as science, technology, engineering, and mathematics (STEM) and social science and humanities (SSH). Because mobility patterns may influence both the likelihood that nonmobile scientists form ties with mobile scientists, and the foreign networks of the mobile scientists, we distinguish between three types of mobile scientists: diaspora (who never return to their country of origin), returnees (who return indefinitely to their country of origin), and intermittent (who work for part of their academic career in their country of origin). We also ask about the effect of repeated collaborations with mobile scientists. A single collaboration by a nonmobile scientist with a mobile scientist might introduce a nonmobile scientist to a foreign collaborator. We ask whether that event has a long-lasting effect or whether sustained interactions with foreigners must be supported by

[1] In this working paper, we focus on international mobility rather than mobility within home countries. For simplicity, we will refer to mobile and nonmobile only in the context of international mobility.
[2] In this working paper, we examine two aspects of collaboration with mobile scientists. First, we explore the intensive margin by estimating the likelihood that a nonmobile scientist will copublish with a foreign scientist conditional on copublishing with at least one mobile scientist. Second, we investigate the extensive margin by estimating the total number of publications of nonmobile scientists coauthored with foreign scientists conditional on the number of mobile scientists with whom they copublish.

repeated interactions with mobile scientists. To identify a causal impact of mobile scientists on the foreign collaborations of nonmobile scientists, we conduct an event study.

Our work studies scientists from Colombia and Brazil. In recent decades, both the Brazilian and Colombian governments have established standardized scientific CV platforms to track the careers of their scientists. These platforms are unique scientific databases with information on different aspects of a scientist's career trajectory, including academic and biographical background and publications. We rely on these databases to identify mobile and nonmobile scientists using information about the locations of their higher education and work after the PhD. Because some scientists might not update their CVs after they move abroad, we combine the CV data with scholarship data. We merge CVs data with bibliometric data from OpenAlex to complement the information on the scientists' publications and all their coauthors, and to complement the information on mobility through information about academic affiliations.

Our findings show that a nonmobile scientist's interactions with a mobile scientist positively correlate with more publications coauthored with foreign scientists. The share of publications coauthored with foreign scientists also increases, indicating that nonmobile scientists also shift their research portfolio toward international collaborations. These results also hold when we control for the nonmobile scientist's productivity and visibility (publications and citations) and past stock of collaborations with foreign scientists. Increasing the number of unique mobile scientists with whom the nonmobile scientists copublish is associated with nonmobile scientists increasing collaborations with foreign scientists.

Not all mobile scientists are equal in their impact on nonmobile colleagues' collaborations with foreign scientists. Their relevance to increasing the international collaborations of nonmobile colleagues is inversely proportional to the average time they spend in their home countries, roughly speaking. That is, of types of mobile scientists, diaspora and intermittent scientists have a greater impact than returnees on the number of collaborations nonmobile scientists have with foreign scientists.

We also find that not all nonmobile scientists benefit equally. In Colombia, nonmobile scientists in STEM may benefit less from coauthoring with mobile scientists than scientists in SSH. This is probably because nonmobile scientists in STEM have a higher propensity for being included in international teams by the nature of their work (e.g., to run experiments in local contexts) regardless of their interactions with mobile colleagues. In the case of Brazil, the country has a large infrastructure in which STEM scientists can conduct research in local collaborations.

The difference-in-differences (DiD) event study results confirm that nonmobile scientists who coauthor with a mobile scientist publish more with foreign colleagues than their Brazilian or Colombian peers who do not coauthor with mobile scientists. The more mobile scientists the nonmobile scientists coauthor with, the more their work includes foreign scientists over the years. Before the event of coauthoring with a mobile scientist, nonmobile scientists show no significant difference in the number of publications coauthored with foreign scientists. In the year in which nonmobile scientists coauthor with mobile scientists, the number of their publications with foreign scientists increases by 20 percent over their other nonmobile colleagues. However, this positive effect is due to the nonmobile scientist joining a research team including both mobile and foreign scientists. In both Brazil and Colombia, the benefit to the nonmobile scientist of a single collaboration with a mobile scientist quickly goes to zero. The nonmobile scientist who collaborates with only one or two unique mobile scientists experiences this benefit only for the year of the collaboration. However, with three or more such collaborations, the effect is longer-lived, but it is sustained by the continuous interactions with mobile scientists. When we remove the publications that include the mobile scientists as coauthors, the number of publications with foreign coauthors is hardly different for nonmobile scientists who collaborate with mobile scientists and for those who do not. To sustain a higher rate of publication with foreign scientists, the nonmobile scientists must continue to collaborate with mobile scientists. In other words, mobile scientists connect the nonmobile scientists to foreign scientists, but mobile scientists retain the role of obligatory gateways for further connections.

Results from the DiD event study are similar for STEM and SSH. One interesting difference is that, in Colombia, nonmobile scientists in SSH need to collaborate with more mobile scientists to maintain their connections to foreign scientists than do nonmobile scientists in STEM. DiD results also confirm that mobile scientists who return to their home countries (returnees) and those who stay abroad for a while (intermittent) or forever (diaspora) have a different effect, but only in the case of Brazilian scientists. In Brazil, the impact of returnees in connecting nonmobile scientists with foreign scientists lasts only the year of the first collaboration with a returnee mobile scientist, whereas the impact of the collaboration with intermittent and diaspora mobile scientists lasts for the five years that follow the first collaboration. Again, in most cases this effect is significant only when the nonmobile scientist maintains active collaborations with several diaspora or intermittent scientists who act as gatekeepers, but not when we remove the publications that also include mobile scientists.

Our analysis of two home countries that are very different in terms of size, scientific and education systems, geography, and history shows remarkably similar results. This lends further credibility to our results and their generalizability to other middle-income countries, which can use them to think about their education and research policies concerning mobility, improving collaborations, and the potential implications for brain drain and brain gain.

The rest of this paper is structured as follows. Section 2 examines the main findings from the literature on international scientific mobility and on the peer effect of forming new professional ties through scientific interactions. Section 3 explains the relevance of focusing on Colombia and Brazil. Section 4 explains the data and the empirical strategy. Section 5 presents our main results for the ordinary least squares (OLS) panel regressions. Section 6 documents the methods and results of the DiD event study. Section 7 concludes the paper with some policy recommendations.

2. Literature Review

2.1 International Scientific Mobility

The idea that international scientific mobility affects the scientific performance of scientists' home countries has been in the literature for several years.[3] Many of these studies build on ideas implicit in the concept of the Scientific and Technical Human Capital model (STHC) (Bozeman, Dietz, and Gaughan, 2001). First, an experience abroad is likely to increase a scientist's human capital (e.g., knowledge, skills, and abilities) by allowing the scientist to tap into novel knowledge, absorb tacit knowledge, and access infrastructure. Second, an experience abroad may enlarge personal and professional networks. Together, these imply that international mobility should be positively associated with a scientist having higher research capacity and social capital (see Edler, Fier, and Grimpe, 2011; Jonkers and Cruz-Castro, 2013; Liang, Gu, and Nyland, 2022). Starting with the idea that mobility may increase a scientist's STHC, studies primarily focus on demonstrating the positive impact of mobility on a scientist's performance and network.

A first group of studies investigates the scientific performance of mobile scientists, concluding that mobile scientists have higher performance than scientists without foreign experience (nonmobile scientists) across different scientific fields and countries. For example, relying on bibliometric data for 124 Argentinean scientists in the life sciences, Jonkers and Cruz-Castro (2013) find that mobile scientists have more international copublications than nonmobile scientists. Relatedly, Aykac (2021) documents that Turkish mobile scientists with research stays in the United States obtain more citations than nonmobile scientists without foreign experience. Combining bibliometric and survey data on 47,000 scientists from 16 countries, Franzoni, Scellato, and Stephan (2014) find that international mobility increases the number of articles that scientists publish in high-impact journals.

[3] See for example: Baruffaldi et al. (2020); Edler, Fier, and Grimpe (2011); Franzoni, Scellato, and Stephan (2014); Jonkers and Cruz-Castro (2013); Jonkers and Tijssen (2008); Netz et al. (2020); Scellato, Franzoni, and Stephan (2015); Wang et al. (2019).

The second group of studies investigates scientists' social capital by testing whether mobile scientists have more extensive coauthorship networks—a proxy for professional networks—than nonmobile scientists (Gibson and McKenzie, 2014; Jonkers and Tijssen, 2008; Petersen, 2018; Scellato, Franzoni, and Stephan, 2015). A recurring finding is that mobile scientists display more coauthors than nonmobile scientists (Gibson and McKenzie, 2014; Petersen, 2018). But studies also tend to agree that collaboration with host-country scientists falls when mobile scientists return to their home countries (Jonkers and Tijssen, 2008; Kahn and MacGarvie, 2012). Despite the reduction in international collaborations after they return home, mobile scientists collaborate more with foreign scientists and have larger foreign capital than nonmobile scientists in the home country (Wang et al. 2019).

A third group of studies compares the performance of different categories of scientists: diaspora, returnees, and nonmobile scientists (Cao et al. 2020; Scellato et al. 2015; Velema, 2012).[4] Several studies report that diaspora scientists have a higher performance (e.g., they publish more articles and receive more citations) and have more extensive networks (number of foreign coauthors) than the other two types of scientists (Aykac, 2021). Generally, diaspora scientists tend to have a certain level of both expertise and networks, which allow them to remain at highly competitive institutions abroad. Additionally, these scientists usually work in environments with high-quality infrastructures, leading researchers, and more funding opportunities (Liang et al. 2022; Velema, 2012). Hence, diaspora scientists access resources that are scarcer in their home countries, which enables the diaspora scientists to conduct research at the scientific frontier. Studies also recount that nonmobile scientists cite returnees more frequently and coauthor more with returnees than with diaspora scientists. Geographical proximity and returnees' willingness to align their research agenda to topics investigated in their home countries explain this latter finding (Kahn and MacGarvie, 2012, 2016; Trippl, 2013).

[4] Diaspora includes scientists who moved abroad to work or study and never returned to their home country to work in a research organization (Trippl, 2013; Turpin et al. 2008). Returnees are scientists who have had a stay abroad to work or study in a research organization and returned to their home countries (Jonkers and Tijssen, 2008; Liang et al. 2022; Velema, 2012). Nonmobile scientists include scientists without experience working or studying in a research organization abroad (Gibson and McKenzie, 2014; Jonkers and Tijssen, 2008). There is a less-explored group of mobile scientists in the literature, which we call intermittent scientists. These are scientists who split their career since earning their PhD between their home country and abroad.

2.2 Cooperation in Science

It is a commonplace now that science is a cooperative endeavor. Between 2000 and 2009, the proportion of publications in the Web of Science repository with multiple authors rose from 69 to 78 percent (Gazni Gazni, Sugimoto, and Didegah, 2012). Similarly, the number of authors per publication rose from 3.3 to 4.1 on average. Driving this may be the importance of interpersonal ties for knowledge flows (e.g., Breschi and Lissoni, 2006, or Singh, 2005) and increased specialization. Thus, making links with collaborators becomes part of the scientific process. Trust (cohesiveness), similarity (homophily), and structural position have all been found to explain tie formation in general (Abbasi, 2016), and these factors have been found to be present in tie formation among scientists (Dahlander and McFarland, 2013; Rivera León, Cowan, and Müller, 2016).

Less studied than tie formation is how the non-network properties of a scientist might affect the performance or the formation of new ties for scientists in the same network. For example, Mohnen (2022) investigates the structural position of star medical scientists in a coauthorship network. She finds that scientists who connect scientists from different scientific communities have a stronger impact on the scientific output of their peers. However, Yang, Cai, and Li (2022) investigate the peer effect of Chinese returnee scientists and find that returnees do not increase their peers' international collaborations. Müller, Cowan, and Barnard (2023) find different results; while investigating whether there is a social capital spillover among South African scientists, the authors find that scientists with accumulated foreign social capital help other scientists to form foreign ties. Our paper builds on Müller, Cowan, and Barnard (2023) and asks whether the foreign social (scientific) capital of mobile scientists facilitates the link formation with foreign scientists for nonmobile colleagues.

2.3 Mobility, Cooperation, and Tie Formation

Different studies suggest that mobile scientists make connections between the science systems in their home countries and those countries in which they have sojourned (Gibson and McKenzie, 2014; Jöns, 2009). Based on the premise that mobile scientists have greater foreign social capital, these studies argue that mobile scientists, especially returnees, serve as bridges between the local and global scientific systems. To a great extent, though, these studies focus on “first order effects.” That is, they compare the properties of various types of mobile scientists with those of nonmobile scientists. Trippl (2013), for example, shows that mobile star scientists retain links of different kinds (including coauthorship) with other scientists. Gibson and McKenzie (2014) find, for three small Pacific Island countries, that mobile scientists (diaspora or returnees) have more international coauthors than nonmobile scientists. Scellato et al. (2015) show that, in general, mobile scientists have more internationally focused collaboration networks than nonmobile scientists.

These studies all show that mobile scientists may serve to connect the science system in home countries to the wider world of science. And they can do so in various ways. What is not explicitly addressed in these studies, however, is whether mobile scientists assist nonmobile scientists in forming international connections. That is, does a mobile scientist provide a conduit through which a nonmobile scientist can interact directly with scientists in the rest of the world, or more specifically, does coauthorship with a mobile scientist lead a nonmobile scientist to coauthorship with foreign scientists?

The literature on social capital and social network research has particularly emphasized the implications of that latter question: how do outsiders benefit and behave when they are offered access to social capital by brokers? Burt (1998; 2000; 2007) provides several answers. First, the author argues that often outsiders benefit from borrowing social capital instead of building their own. In this sense, nodes in a network (e.g., a person or an organization) that act as brokers offer access to social capital and legitimacy. Second, Burt coins the concept of “second-hand brokerage” to state that outsiders connected via a broker can benefit from the same resources that a broker has.

To our knowledge, only two empirical studies provide some evidence on the brokerage role of mobile scientists in connecting nonmobile scientists (Müller, Cowan, and Barnard, 2023; Fry, 2023). Nevertheless, these studies consider only returnees and nonmobile scientists, neglecting the role of the diaspora scientists and scientists who return only for short periods. We extend their work to analyze the complete set of scientists, including diaspora scientists and scientists who return only temporarily (i.e., intermittent scientists) to serve as brokers. Studies also tend to acknowledge that, to a lesser extent, the diaspora collaborates with home scientists and connects them to foreign scientists (Saxenian, 2005; Scellato et al. 2015; Trippl, 2013). For example, in a study on star scientists, Trippl (2013) identifies that diaspora scientists foster knowledge flow channels (e.g., research cooperation and staff exchange) between home and foreign scientists. Despite acknowledging the role mobile scientists play in connecting scientific systems, studies generally investigate these scientists' coauthors' share of international copublications,[5] number of international copublications, or modes of knowledge transfer, but not the spillover of mobile scientists' foreign social capital. As such, whether a nonmobile scientist forms new ties by being close to mobile scientists and benefiting from the spillover of these mobile scientists' foreign social capital is still barely explored in the literature about international scientific mobility.

Different scientific fields, including social network analysis (SNA) and the economics of science, have long explored tie formation and peer effects. For instance, Barabási and Albert (1999) argue that one factor in explaining tie formation is preferential attachment: agents prefer to connect to agents who already have many ties. Other studies have acknowledged that trust (cohesiveness), similarity (homophily), and structural position also explain tie formation (Abbasi, 2016). Empirical studies have tested these multiple factors in different networks, including networks of scientists (Dahlander and McFarland, 2013; Rivera León, Cowan, and Müller, 2016).

Another group of studies focuses on the peer effect among scientists, particularly knowledge spillover and impact on peers' productivity. Sharing a similar argument raised by Bramoullé, Djebbari, and Fortin, "individuals interact in groups" (2009, p. 42), studies have claimed that scientists' mean characteristics and outcomes might influence the outcomes of other scientists (Azoulay, Graff Zivin, and Wang, 2010; Waldinger, 2012). These studies show how peers can affect the productivity of other scientists and the role of knowledge spillover.

[5]For instance, Gibson and McKenzie (2014, p. 1493) write, "instead it is return migrants who are the link between researchers in the source country and those located abroad; the returnees have significantly more international co-authors than do never-migrants but are at least as active in publishing with co-authors from different countries as are the current migrants."

2. National Context: Brazil and Colombia

To investigate the role that mobile scientists play in connecting nonmobile scientists with foreign ones, we focus on Brazil and Colombia as countries of origin. Brazil has the largest scientific system in Latin America, with 4,560 graduate programs, world-leading research institutes (e.g., Oswaldo Cruz Foundation and Embrapa), and federal and regional funding agencies supporting science (Academia Brasileira de Ciências, 2021; Negri, 2018). Brazil ranks as the country with the highest share of scientific publications in Latin America and the 13th position relative to the world, with 370,00 articles indexed on the Web of Science between 2015 and 2020, representing 3.2 percent of the world's scientific publications (Centro de Gestão e Estudos Estratégicos, 2021).

Colombia ranks 5th in Latin America in terms of publication counts. The country has been recently upgrading its scientific system. For instance, Colombia has increased the number of graduate programs by 500 percent in 10 years and established a ministry overseeing science, technology, and innovation matters (Observatorio Colombiano de Ciencia y Tecnología, 2021). The number of Colombian publications in top journals displays exponential growth (Lemarchand, 2012).

Despite recent improvements in their scientific systems, Brazil and Colombia are not as productive as high-income countries in producing knowledge outputs. One policy adopted by these countries to promote scientific productivity is the PhD training of citizens abroad. In Brazil, the Coordination for the Improvement of Higher Education Personnel (CAPES) and the National Council for Scientific and Technological Development (CNPq) have opened funding lines supporting Brazilian citizens to obtain a PhD abroad. In Colombia, the Administrative Department of Science, Technology, and Innovation (Colciencias) and the Foundation for the Future of Colombia (Colfuturo) have sponsored Colombian citizens to conduct doctoral training overseas. We identified 3,425 persons sponsored by these Colombian institutions, an increase from only nine persons in 1992. Hence, Brazil and Colombia are noteworthy examples of countries with developing scientific systems, where the national government supports international scientific mobility from the PhD stage.

Given that national governments from Brazil and Colombia have invested extensively in mobility programs for citizens to obtain a PhD abroad, we investigate the impact of mobility experiences in the two countries. Because the impact at the individual level has been broadly researched in the literature, we have opted to investigate the externalities (if any) in terms of creating channels to connect the country of origin with foreign scientists.

4. Data and Empirical Strategy

4.1 Data

4.1.1 Sources

This study combines data on CVs, PhD scholarships, and scientific publications for a large sample of scientists in Colombia and Brazil. Colombian and Brazilian governments have established public CV platforms to track the progress of national researchers and to standardize recruitment in research and teaching positions. In Brazil, CNPq has developed the Currículo CvLattes platform (CvLattes), and in Colombia, the Colombian national government has developed the CvLAC platform. Governments, universities, and scientific institutions in Brazil and Colombia use CvLattes and CvLAC to recruit scientists, allocate grants and scholarships, and decide on promotions.

CvLattes and CvLAC are unique datasets with detailed, self-reported information on scientists' academic backgrounds, publications, and careers. We use these sources to extract information on: (i) the nationality of researchers, to distinguish Colombian and Brazilian scientists at home and abroad from non-Colombian/non-Brazilian scientists;[6] (ii) academic background information to identify whether a scientist has conducted a full PhD abroad; and (iii) a set of self-reported publications to improve the matching with bibliometric data. We extracted these data from CvLattes and CvLAC by accessing

[6] This is an attribute that is not identified in all other studies that rely only on bibliometric data.

available governmental open data repositories.[7] In the case of Brazil, we used Mena-Chalco and Junior's dataset (2009).[8]

Since not all mobile scientists have an incentive to update their CVs on CvLattes and CvLAC when moving abroad to study, we also retrieved data on scholarship holders from the main Brazilian and Colombian funding agencies' web pages to improve the data on mobile scientists. For Brazil, we obtained data from CNPq and CAPES. For Colombia, we obtained data from the official lists published by the Ministry of Science, the Colfuturo Foundation, and Fulbright Colombia.[9] We extracted information on the names of the scholarship holders, the PhD starting date for each, disciplines, and the countries to which they applied.

To understand the mobility patterns and coauthorship networks of Brazilian and Colombian scientists, we retrieved bibliometric data from OpenAlex, a global open-access database with more than 200 million scientific publications, which builds on Microsoft Academic Graph and is regularly updated using several sources (Singh Chawla, 2022).[10] We use the bibliometric data to determine the publication records of the Brazilian and Colombian scientists retrieved from CvLattes and CvLAC and compute: (i) their mobility patterns based on country of affiliation; (ii) their coauthorship networks (including with foreign scientists); (iii) academic seniority, and (iv) scientific productivity.

[7] The main URL for Lattes is https://lattes.cnpq.br/ and for CvLAC the main URL is https://minciencias.gov.co/scienti. The Colombian government makes some of the data available through https://datos.gov.co/. The Brazilian government allows access to Lattes to Brazilian institutions through an application programming interface (API). Although publicly available, the collection of these data is challenging as there is no structured relational database available. We merged information from different web sites and then parsed files in a variety of formats such as JavaScript Object Notation (JSON) and unstructured markup languages such as HyperText Markup Language (HTML) to build a workable relational database.

8Data from the API was collected by Jesús P. Mena-Chalco, who generously allowed us to use the data for the purposes of Rodrigo's PhD research, which contributes to this research.

9 The main URL for Colombia's Ministry of Science (Minciencias) is https://minciencias.gov.co/transparencia-accesoainformacionpublica, for Colfuturo Foundation is https://www.colfuturo.org/beneficiarios/beneficiarios, and for Fulbright Colombia is https://fulbright.edu.co/.

[10] OpenAlex provides more extensive bibliometric data than traditional, nonpublic, academic repositories (e.g., Scopus and Web of Science), including publications in different languages than English, and from working paper repositories such as arXiv (Visser, van Eck, and Waltman 2021).

4.1.2 Data matching

To build our database, for each scientist in CvLattes and CvLAC, we matched information from the scholarship and bibliometric data. First, we matched the scholarship lists to CvLattes and CvLAC using fuzzy matching of names, disciplines, and institutions. We manually checked the results.

Second, we matched all scientists in CvLattes and CvLAC with their publications in OpenAlex using disambiguation procedures developed in the scientometrics literature (D'Angelo and van Eck, 2020).[11] We combined the following information: author names (fuzzy matching), Open Researcher and Contributor Identifier (ORCID IDs), title of publications, other bibliographic metadata (e.g., International Standard Serial Number or ISSN; Digital Object Identifier or DOI; year; volume), and self-citations. To maximize precision and recall, we defined several selection criteria based on the above data. The complete procedure to construct the dataset is explained in Appendix 1. The initial number of scientists in Brazil (accessed from CvLattes) is 139,655, and in Colombia (accessed from CvLAC) is 28,729. We matched with high precision a large sample of 102,422 (73 percent) scientists in Brazil and 19,661 (68 percent) in Colombia.

4.2 Definition of Mobility Patterns and Foreign Collaborations

This analysis distinguishes between three main groups of scientists: mobile, nonmobile, and foreigner. Following the literature, we define mobile scientists as those who have moved abroad to obtain their full doctoral training (Brazil and Colombia) or moved abroad after their PhD (Brazil only) (Kahn and MacGarvie, 2012; Liang et al. 2022; Turpin, Woolley, Marceau, and Hill, 2008).[12]

We define nonmobile scientists as those who have done graduate training in Brazil or Colombia and never moved to a foreign country for more than 11 months to work in

[11] Despite the growth in the use of unique identifiers such as ORCID, it is estimated that only 45 percent of Brazilian authors and 50 percent of Colombian authors use it (Porter, 2022, p. 6). Because of this, homonyms are a source of inaccuracy.

[12] Brazil has a well-established national doctoral system, and most PhDs graduate in the country. Because focusing on scientists that do a PhD abroad would leave out most of the mobile scientists, we account for all scientists that spend part of their career abroad, irrespective of where they obtain their PhD. In the case of Colombia, most PhDs have obtained their PhDs abroad. For this reason, we focus on mobile scientists as only those who have moved abroad to obtain full doctoral training.

academia, based on their CV or publication records. We focus on researchers registered in CvLattes and CvLAC with a PhD in progress or completed, or listed as grantees of scholarships to study abroad. Because in Colombia it is possible to access academic careers without holding a PhD,[13] we extended our definition of nonmobile scientists to those with a master's degree and with at least three publications.

We further divide mobile scientists into three types that may have different patterns of interaction with nonmobile scientists and different connectivity to foreign scientists: returnees (R), diaspora (D), and intermittent (I). Returnees are scientists who have returned home indefinitely no more than one year after their period abroad and never spent more than one year abroad over the rest of their career, until the last year of observation (i.e., they have no foreign affiliations noted among their publications since their return). Diaspora are scientists who never returned home to work in academia after spending a period abroad (i.e., they have no Colombian/Brazilian affiliation noted among their publications).[14] Intermittent are scientists who returned home to work for at least one year and worked abroad for at least one year.

We followed the strategy used by Müller, Cowan, and Barnard (2023) to identify foreign collaborators of the nonmobile Colombian and Brazilian scientists. We identified as foreigners all coauthors not present in CvLattes and CvLAC. Because scientists may migrate before their PhD, or obtain a foreign scholarship, some of the scientists not registered in CvLattes or CvLAC may be Colombian or Brazilian. Identifying them as foreigners would overestimate collaborations with foreign scientists and underestimate collaborations with mobile scientists. To avoid this bias, we isolate Colombian and Brazilian mobile scientists in OpenAlex who do not appear in CvLattes and CvLAC in three steps. First, we created a list of common Brazilian or Colombian name and surname combinations from the most frequent combinations in CvLAC and CvLattes databases, and from the national registries of names in Colombia and Brazil. Second, we matched common name and surname combinations with the foreign coauthors

[13] For instance, the academic staff of the largest public university in Colombia is composed of 42 percent holders of PhDs, 38 percent holders of masters degrees, and 20 percent holders of bachelor's degrees (SNIES, 2022).

[14] The period abroad for these two mobility patterns must be at the beginning of their scientific career. In the case of Colombia, this is always the case, as we focus on mobile PhD students.

identified in OpenAlex. Third, we redefined as mobile the matched authors who have published only in national journals[15] or who were affiliated only with national organizations throughout their careers, based on OpenAlex. All other coauthors were defined as foreigners.

4.3 Database Description

In this section, we describe the composition of the matched sample of Brazilian and Colombian scientists and their patterns of mobility and coauthorship. Our sample initially included 102,422 Brazilian scientists with a PhD (73 percent of CvLattes) and 19,661 Colombian scientists with a PhD or master's degree (68 percent of CvLAC) who published between 1990 and 2021. We removed 5,478 Brazilian and 22 Colombian scientists for whom we could not identify the mobility pattern and 481 Colombian scientists who moved abroad after their PhD.[16] Next, we kept only nonmobile scientists that have at least three publications, reducing our final sample to 88,380 Brazilian scientists and 15,101 Colombian scientists. Figures A11 and A12, in Appendix 3, present a summary.

Among the 88,380 Brazilian scientists in our sample, 70 percent are nonmobile and 30 percent are mobile, with mobile scientists categorized as 11 percent returnee, 83 percent intermittent, and 5 percent diaspora (Table 1, column 3). Among the 15,101 Colombian scientists in our sample, 44 percent are nonmobile scientists and 57 percent are mobile. Among the mobile, 46 percent of scientists are returnees, 42 percent intermittent, and 12 percent diaspora. Considering both countries, mobility, and gender, 56 percent of the Brazilian mobile scientists and 63 percent of the Colombian mobile scientists are male (Tables A1 and A2, in Appendix 3). Regarding nonmobile scientists, 46 percent of nonmobile scientists in Brazil and 58 percent of nonmobile scientists in Colombia are male (Tables A1 and A2, in Appendix 3). For reasons discussed earlier, in Colombia, we also include nonmobile scientists with a master's degree (Table A2 in Appendix 3).

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[15] To identify local journals, we used the SciELO-Brazil database for Brazil and the Publindex database for Colombia.
[16] We do not remove them in the Brazilian case because the share of scientists who take their PhD in Brazil and move abroad afterward is too large to ignore their role in connecting nonmobile scientists to foreign scientists.

The vast majority of Brazilian and Colombian scientists publish in collaboration with foreign coauthors (Table 1, columns 5-6). As expected, mobile scientists show a higher percentage of foreign collaborations than nonmobile scientists, and the difference is greater in Colombia. Among Brazilian scientists, 97.3 percent of mobile scientists and 92 percent of nonmobile scientists have coauthored with a foreign scientist at least once. Among Colombian scientists, 89.6 percent of mobile scientists and 82 percent of nonmobile scientists have coauthored with a foreign scientist at least once. The number of international coauthors range from a median of 5 foreign coauthors for nonmobile Colombian scientists to 33 for intermittent mobile Brazilian scientists (Table 1, column 7).[17]

Table 1. Distribution of Brazilian and Colombian Scientists by Mobility Pattern and Coauthorship With Foreign Scientists

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Country of origin	Mobility pattern	Scientists (#)	Scientists with foreign coauthors (#)	Scientists with foreign coauthors (%)	Foreign coauthors (total #)	Foreign coauthors (median # per mobility category)
Brazil	Diaspora	1,396	1,351	97%	73,384	10
	Intermittent	22,128	21,955	99%	1,211,259	33
	Returnee	3,025	2,896	96%	15,083	12
	Nonmobile	61,831	56,825	92%	1,058,962	10
Colombia	Diaspora	1,045	956	91%	64,462	16
	Intermittent	3,581	3,250	91%	230,302	12
	Returnee	3,866	3,370	87%	112,172	6
	Nonmobile	6,609	5,457	82%	143,722	5

Source: Authors' elaboration based on CvLattes, CvLAC, and OpenAlex.
Notes: Column 1: country of analysis. Column 2: mobility patterns of national researchers from Brazil and Colombia (in the Colombian case, we excluded scientists that move abroad after the PhD); Tables A1 and A2 further elaborate on the numbers, percentages, and education levels. Column 3: total number of scientists for each mobility pattern. Column 4 and 5: number and percentage of scientists who have coauthored with foreigners. Column 6: number of unique foreign coauthors of each group of mobility pattern. Column 7: median number of foreign coauthors per scientist.

[17] The distribution is highly skewed.

Fewer nonmobile scientists have coauthored with mobile scientists than with foreign scientists: 82 percent in Brazil and 80 percent in Colombia (Table 2). In Brazil, the share differs substantially between STEM (92 percent) and SSH (62 percent).[18] The average number of years for a nonmobile scientist to coauthor with a mobile scientist since their first publication is four in Brazil and three in Colombia (Table 2). We registered a greater number of coauthorships in the later years of our analysis, as the average year of coauthorship between a nonmobile and a mobile is 2010 in Brazil and 2011 in Colombia.

Table 2. Patterns of Brazilian and Colombian Nonmobile Scientists to Coauthor With Mobile Scientists, by groups of fields of study

Country of origin		Groups of fields		Total
		STEM	SSH	
Brazil	Nonmobile scientists who coauthor with a mobile scientist (#)	38,028	12,941	50,969
	Nonmobile scientists who coauthor with a mobile scientist (%)	92%	62%	82%
	Average time to coauthor with the first mobile (in years)	3.53	5.28	3.97
	Average year of coauthorship	2009	2012	2010
Colombia	Nonmobile scientists who coauthor with a mobile scientist (#)	2,856	2,452	5,308
	Nonmobile scientists who coauthor with a mobile scientist (%)	82%	77%	80%
	Average time to coauthor with the first mobile (in years)	2.6	3.2	2.9
	Average year of coauthorship	2010	2012	2011

Source: Authors' own elaboration based on CvLattes, CvLAC, and OpenAlex.
Notes: The statistics presented in this analysis are based on coauthorship between nonmobile and mobile scientists. The number of years since publication was calculated as the difference between the year of the nonmobile scientist's first publication and the year of the coauthored publication.

In Brazil, nonmobile scientists tend to coauthor first with intermittent scientists, especially within STEM (Table 3). Fewer nonmobile scientists coauthor first with a returnee, especially within STEM. In Colombia, the first coauthored publication with a mobile is with either returnees or intermittent scientists, both within STEM and SSH. Less common in both countries of origin and groups of fields is that the first mobile coauthor is a diaspora type.

[18] For a detailed distribution of scientists by fields of study and STEM and SSH, see Table A3 and A4 in Appendix 3.

Table 3. First Coauthorship by Brazilian or Colombian Nonmobile Scientists With Mobile Scientists by Mobility Pattern and group of fields of study

Country of origin	First coauthorship for nonmobile scientists with mobile scientists	Groups of fields		Total
		STEM	SSH	
Brazil	Only returnee	3,219	2,000	5,219
	Only intermittent	32,723	10,024	42,747
	Only diaspora	160	193	353
	Returnee and intermittent	1,743	605	2,348
	Returnee and diaspora	4	16	20
	Intermittent and diaspora	148	90	238
	All three mobile types	31	13	44
	Total	38,028	12,941	50,969
Colombia	Only returnee	1,118	984	2,102
	Only intermittent	1,258	1,036	2,294
	Only diaspora	80	74	154
	Returnee and intermittent	331	287	618
	Returnee and diaspora	16	12	28
	Intermittent and diaspora	37	21	58
	All three mobile types	16	38	54
	Total	2,856	2,452	5,308

Source: Authors' elaboration based on CvLattes, CvLAC, and OpenAlex.
Notes: The statistics are based on nonmobile scientists who coauthor with mobile scientists. The first coauthorship between the two was calculated after a scientist becomes mobile. Each category was noted separately if a scientist had multiple collaborations with individuals from different mobility categories each year.

Table 4 reports the differences in the number of publications for nonmobile scientists who coauthor with foreign scientists (columns 1-2) and the average yearly number of foreign coauthors (columns 3-4) between nonmobile scientists who coauthor with mobile scientists and those who do not (columns 1 and 3), before and after coauthoring with a mobile scientist (columns 2 and 4).

On average, nonmobile scientists who coauthor with at least one mobile scientist have a higher number of foreign publications and coauthors both in STEM and SSH compared to those who did not (column 1). In Brazil, the average number of publications is 1.76 times higher in STEM and 1.63 times higher in SSH. In Colombia, the average number of publications is 1.37 times higher in STEM and 1.49 times higher in SSH. In Brazil, the average yearly number of foreign coauthors for nonmobile scientists who coauthor with mobiles in STEM is about four times higher than without a mobile coauthor, and the number is about three times higher in SSH (column 3). In Colombia, the difference is about three times for both STEM and SSH.

A large part of the above difference for nonmobile scientists arises after collaborating with mobile scientists. After nonmobile scientists coauthor with mobile scientists, their average yearly number of publications with foreign scientists increases, ranging from 1.5 to 1.7 times higher for both STEM and SSH in Brazil and Colombia (column 2). The average number of foreign coauthors increases after coauthoring with a mobile scientist by 1.7 to 2.6 for STEM and SSH nonmobile scientists in Brazil and Colombia (column 4).

Table 4. Nonmobile Scientists' Average Number of Publications Coauthored With Foreign Scientists and Number of Foreign Coauthors (Brazil and Colombia)

		(1)			(2)			(3)			(4)		
Country of origin	Groups of fields	Average yearly number of publications of nonmobile scientists with foreign scientists			Average yearly number of publications of nonmobile scientists with foreign scientists, before and after coauthoring with mobile scientists			Average yearly number of foreign coauthors of nonmobile scientists			Average yearly number of foreign coauthors of nonmobile scientists before and after coauthoring with mobile scientists		
		With no mobile coauthors	With mobile coauthors	Overall	Before	After	Overall	With no mobile coauthors	With mobile coauthor	Overall	Before	After	Overall
Brazil	STEM	0.74	1.30	1.27	0.83	1.45	1.30	1.4	5.6	5.4	2.5	6.6	5.6
	SSH	0.63	1.03	0.91	0.79	1.18	1.03	1.1	3.2	2.5	2.2	3.8	3.2
	Overall	0.66	1.24	1.16	0.81	1.40	1.24	1.2	5.0	4.6	2.4	6.1	5.0
Colombia	STEM	0.98	1.34	1.28	0.9	1.6	1.3	4.2	13.8	12.2	6.6	17.3	13.8
	SSH	0.63	0.94	0.87	0.6	1.1	0.9	1.2	4.3	3.6	1.7	6.1	4.3
	Overall	0.80	1.17	1.10	0.8	1.4	1.1	2.6	9.8	8.5	4.3	12.9	9.8

Source: Authors' elaboration based on CvLattes, CvLAC, and OpenAlex.

Notes: In columns 1 and 3, "With no mobile coauthors" refers to nonmobile scientists who did not collaborate on any documents with mobile scientists in our sample. "Coauthored with a mobile" refers to nonmobile scientists who have collaborated at least once with mobile scientists. In columns 2 and 4, we only consider nonmobile scientists who have coauthored with a mobile scientist. In columns 2 and 4, "before" refers to all observations made before the year in which the nonmobile scientist coauthors with a mobile scientist, while "after" refers to all observations made in or after that year. The term "overall" refers to the general averages across all observations. We aggregated publications and the number of foreign coauthors at the nonmobile scientist's level and divided by their year of activity.

4.4 Empirical Strategy

Our objective is to study whether the collaboration between Brazilian and Colombian nonmobile scientists with foreign scientists is influenced by their collaboration with mobile scientists. In other words, does collaborating with mobile scientists connect the nonmobile scientists with foreign scientists and thus increase the chances of further collaboration with them? We identify a collaboration as a coauthorship. First, we investigate the probability that a nonmobile scientist collaborates with any number of foreign scientists as a function of collaborating with mobile scientists. Second, we estimate the number and share of collaborations of nonmobile scientists with foreign scientists as a function of collaborating with mobile scientists. In both cases, we investigate both the extensive margins (any number of collaborations with mobile scientists) and intensive margins (the number of unique mobile scientists with whom they collaborate). Third, we explore how results differ for different groups of scientists. We explore field heterogeneity and ask whether nonmobile scientists in STEM gain more or less from collaborations with mobile scientists relative to scientists in SSH. We also distinguish between different types of mobile scientists (returnees, intermittent, and diaspora).

In practice, we estimate separately for Brazil and Colombia. For the probability of collaborating with foreign scientists, we use OLS and estimate the following linear probability model (LPM):[19]

$$y_{it} = \beta_0 + \beta_1 X_{i,t} + \beta_2 STEM_i + \beta_3 STEM_i * X_{i,t} + \Gamma \ \Xi_{i,t-1} + \epsilon_{i,t} \quad (1)$$

where y_{it} is a binary variable indicating whether a nonmobile scientist collaborates at least once with a foreign scientist (at least one coauthored publication); $X_{i,t}$ is our main variable of interest, which measures the collaborations of nonmobile scientists with mobile scientists using two different specifications: a dummy variable equal to 1 if the nonmobile scientist has collaborated with at least one mobile scientist ($X_{i,t} = AMM_{i,t}$) (extensive margin), or the cumulative sum of unique mobile scientists with whom they have collaborated ($X_{i,t} = StkMobSciEncou_{i,t}$) (intensive margin); $STEM_i$ is a dummy

[19] We use LPM instead of a Probit for easier comparison between the intensive and extensive margin results.

variable equal to 1 for nonmobile scientists in the STEM fields; $\Xi_{i,t-1}$ is a set of control variables (see Table 5);[20] ($AvPub_{i,t-1}$) is the logarithm of the Lagged value of average annual publications of the nonmobile scientist over the years since first publication, to control for productivity; ($AvCit_{i,t-1}$) measures the logarithm of the Lagged average of citations over the years since first publication to control for the nonmobile scientist i's visibility; ($StkFRGN_{i,t-1}$) is the logarithm of the nonmobile scientist i's past stock of foreign coauthors to control for existing networks of foreign scientist; ($YrSinFP_{i,t}$) is the years of experience of the nonmobile scientist measured as the number of years since the first publication; ($Gender_i$) takes the value of 1 for male nonmobile scientists. In this first specification, all observations are pooled in one single period, such that a nonmobile scientist who appears in more than one year is considered as a different person.

For the number/share of publications with foreign scientists, we use a panel model with fixed effects as defined in Equation 2:

$$y_{it} = \beta_0 + \beta_1 X_{i,t} + \beta_2 STEM_i + \beta_3 STEM_i * X_{i,t} + \Gamma \; \Xi_{i,t-1} + \varphi_i + \psi_i + \gamma_t + \epsilon_{i,t} \quad (2)$$

where y_{it} can be one of the following outputs: (i) share of publications with foreign coauthors, and (ii) the logarithm of number of foreign coauthors;[21] $X_{i,t}$ is our main variable of interest, which measures the collaborations of nonmobile with mobile scientists using two different specifications: a dummy variable equal to 1 if the nonmobile scientist has collaborated with at least one mobile scientist ($X_{i,t} = AMM_{i,t}$) (extensive margin), or the cumulative sum of unique mobile scientists with whom the nonmobile scientist has collaborated ($X_{i,t} = StkMobSciEncou_{i,t}$) (intensive margin); $STEM_i$ is a dummy variable equal to 1 for nonmobile scientists in the STEM fields; $\Xi_{i,t-1}$ is the set of control variables described above and in Table 5; $\varphi_i + \psi_i + \gamma_t$ are, respectively, FOS, nonmobile scientist, and time-fixed effects. Table 5 summarizes all variables.[22] Table 6 presents the descriptive statistics for Brazilian and Colombian nonmobile scientists. We observe a sample of 68,494 nonmobile scientists among both countries,

[20]Please refer to Appendix 6 for the correlation matrix between the control variables.
[21] To smooth yearly fluctuations, we calculate these variables as the average between values in years t-1, t, and t+1.
[22] Appendix 5 explains the construction of the variables.

61,831 Brazilian and 6,663 Colombian, after removing any nonmobile scientist with fewer than three publications over their career.

Table 5. Variables Summary

Variable name	Description	Mathematical symbol	Associated coefficient
	Dependent variables ($y_{i,t}$)		
Foreign collaboration	Equal 1 if a nonmobile scientist has copublished with a foreign scientist in year t	y_{it}	
Average # of foreign copublications	Rolling average of the number of copublications with foreign coauthors in years t-1, t, and t+1	y_{it}	
Average share of foreign copublications	Rolling average of the share of copublications with foreign coauthors in years t-1, t, and t+1	y_{it}	
	Independent variables		
After coauthoring with the first mobile scientist	Equal 1 in the years after a nonmobile scientist coauthors with a foreign scientist (including year of copublication)	$AMM_{i,t}$	β_1
Stock of mobile scientists	Cumulative sum of unique mobile scientists that a scientist i has in year t	$StkMobSciEncou_{i,t}$	β_1
STEM	Equal 1 if a scientist i belongs to any STEM field of study (FOS)	$STEM_i$	β_2
	Control variables		
Lagged average of publications	Average of scientist i's total number of publications by the years of experience until year t-1	$AvPub_{i,t-1}$	γ_1
Lagged average of citations	Average of scientist i's total number of citations by the years of experience until year t-1	$AvCit_{i,t-1}$	γ_2
Stock of foreign coauthors	Cumulated sum of scientist i's foreign coauthors until year t	$StkFRGN_{i,t-1}$	γ_3
Years of experience	Total number of years of experience. We proxy experience by using the number of years since first publication	$YrSinFP_{i,t}$	γ_4
Gender	Equal 1 if a scientist is a male	$Gender_i$	γ_5

Source: Authors' own elaboration.
Notes: This table displays the number of the variables we use in the OLS models, their description, mathematical symbol and associated coefficients.

Table 6. Variables Descriptive Statistics

Country of origin	Variables	N	Mean	Median	SD	Min	Max
Brazil	Foreign collaboration	61,831	0.38	0	0.48	0	1
	Average foreign publication	61,831	0.78	0.33	1.57	0	202
	Average share foreign publication	61,831	0.25	0.18	0.26	0	1
	After coauthoring with the first mobile scientist	61,831	0.54	1	0.5	0	1
	Stock of mobile scientists	61,831	2.37	1	4.77	0	185
	STEM	61,831	0.7	1	0.46	0	1
	Average publication	61,831	1.51	1	1.62	0.04	182
	Average citation	61,831	4.16	0.5	19.44	0	4,173
	Stock of foreign coauthors	61,831	20.10	4	500.95	0	127,958
	Years since first publication	61,831	8.44	7	6.49	0	31
Colombia	Foreign collaboration	6,609	0.295	0	0.456	0	1
	Average foreign publication	6,609	0.62	0.333	1.944	0	125.33
	Average share foreign publication	6,609	0.23	0.061	0.291	0	1
	After coauthoring with the first mobile scientist	6,609	0.484	0	.5	0	1
	Stock of mobile scientists	6,609	1.57	1	2.398	0	46
	STEM	6,609	0.541	1	0.498	0	1
	Average publication	6,609	1.281	1	1.463	0.04	66.5
	Average citation	6,609	3.13	0.2	36.545	0	3182.23
	Stock of foreign coauthors	6,609	19.383	2	330.059	0	22,272

	Years since first publication	6,609	6.694	6	5.425	0	31

Source: Authors own elaboration based on CvLattes, CvLAC, and OpenAlex.
Notes: This table presents the summary statistics of the variables used in the OLS models. We have included mean, median, standard deviation, minimum and maximum statistics. N corresponds to the number of nonmobile scientists in our analysis. It is important to notice that the number of nonmobile scientists who coauthored with a foreign scientists differs from Table 1 as here we have calculated the yearly average collaborations with foreign scientists.

5. Results

In this section, we report results based on the LPM and panel fixed effects estimation using Equations 1 and 2. Results are presented in pairs of tables, with each table A for Colombia, and each table B for Brazil. There are three pairs of tables presenting regression results. In each table, the unit of observation is nonmobile scientists, and the key independent variable is either having coauthored with a mobile scientist or the number of mobile scientists with whom the nonmobile scientist has coauthored. The three pairs of tables differ regarding the dependent variables: for Tables 7A and B (Equation 1), it is the probability of coauthoring with at least one foreign scientist; for Tables 8A and B (Equation 2), it is the annual average share of publications having foreign coauthors; for Tables 9A and B, it is number of publications with foreign coauthors. Finally, Tables 10A and B differentiate among the three types of mobile scientists (returnee, diaspora, and intermittent).

5.1. Probability of Nonmobile Scientists Collaborating With at Least One Foreign Coauthor

Tables 7A and B report results from Equation 1, estimating the probability that a nonmobile scientist coauthors with at least one foreign scientist if they have coauthored with any number of mobile scientists. In columns 1 to 4, the key independent variable is a dummy variable taking the value 1 if the nonmobile scientist has had at least one coauthorship with a mobile scientist. In columns 5 to 8, the key independent variable is the total number of unique mobile scientists with whom the nonmobile scientist has coauthored.

Tables 7A and B show that collaborating at least once with a mobile scientist (column 1) is related to a 24 percentage points higher probability of collaborating with a foreign scientist in Colombia and 27 percentage points in Brazil. These values fall to 12 and 10 percentage points for Colombia and Brazil, respectively, when we add the controls (columns 2, 3, and 4). Nonetheless, the results remain highly significant at 0.01 percent for both countries. This implies that, once we control for observable features that influence the probability of foreign coauthorship (including previous experience of coauthoring with foreign scientists), scientists who have spent their entire careers in the home country increase the probability by 12 percentage points (for Colombia) or 10 percentage points (for Brazil).

As the number of collaborations with mobile scientists increases, the probability of collaborating with a foreign scientist also increases (columns 5-8). Regarding Colombia, Table 7A, column 6 shows that a 10 percent increase in the stock of mobile scientists with whom the nonmobile collaborates is related to an increase of 8 percentage points in the probability of having a foreign coauthor. Similarly, in the Brazilian case, Table 7B shows a 10 percent increase is associated with an increase of 5 percentage points in the probability of having a foreign coauthor.

The drop in the coefficient when adding controls shows that past performance of a nonmobile scientist is correlated with collaborating with both mobile and foreign scientists. The estimates for the coefficients of the controls are intuitively appealing and in concord with results in the literature. In columns 2 and 6, we find that an increase of 10 percent in the average number of past publications is related to a 12 percentage point positive change in the probability of having a foreign coauthor for Colombian scientists, and to around 17 percentage points change for Brazilian scientists. In columns 3, 4, 7, and 8, we find that scientists' visibility measured by the average number of past citations is statistically and positively correlated with coauthoring with a foreign scientist. Finally, having coauthored in the past with foreign scientists is also related to a higher likelihood of coauthoring with foreign scientists in the future (Lagged stock of foreign coauthors).

Gender and seniority also correlate to the probability of having foreign collaboration. We observe a gender bias: a male nonmobile scientist is more likely to have a foreign coauthor than is a female nonmobile scientist, after controlling for all other observable characteristics. Additionally, in columns 3, 4, 7, and 8, we find that seniority is negatively correlated with the likelihood that nonmobile scientists coauthor with foreign scientists, especially in Colombia (although the coefficient is rather small).

Results suggest a difference between STEM and SSH fields (columns 4 and 8), following different patterns in Colombia and Brazil. First, Colombian nonmobile STEM scientists are 1 to 4 percentage points more likely to have at least a foreign coauthor, whereas in Brazil they are 1 to 2 percentage points less likely to have at least a foreign coauthor.

Second, in both Colombia and Brazil, the gain from collaboration with more mobile scientists is slightly smaller in STEM than it is in SSH. The probability of coauthoring with a foreign scientist for a 100 percent increase in mobile coauthors decreases from 10 percent (for SSH) to 7 percent (for STEM) in Colombia and from 8 percent (for SSH) to 7 percent (for STEM) in Brazil (column 8).

Table 7A. Probability of Coauthoring with Foreign Scientists Given Coauthorship with Mobile Scientists, Colombia

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
					Foreign collaborations			
After coauthoring with the first mobile scientist	0.236***	0.121***	0.129***	0.126***				
	(0.00330)	(0.00367)	(0.00356)	(0.00481)				
Stock of mobile scientists					0.188***	0.0844***	0.0892***	0.104***
					(0.00251)	(0.00295)	(0.00289)	(0.00388)
Lagged average of publications		0.119***				0.123***		
		(0.00449)				(0.00449)		
Lagged stock of foreign coauthors		0.104***	0.0924***	0.0920***		0.0993***	0.0885***	0.0874***
		(0.00187)	(0.00209)	(0.00210)		(0.00189)	(0.00211)	(0.00211)
Years since first publication		0.00203***	-0.00213***	-0.00206***		0.00212***	-0.00208***	-0.00194***
		(0.000407)	(0.000386)	(0.000387)		(0.000406)	(0.000386)	(0.000386)
Gender (Male: 1)		0.0153***	0.0186***	0.0181***		0.0150***	0.0184***	0.0174***
		(0.00320)	(0.00320)	(0.00320)		(0.00321)	(0.00321)	(0.00295)
Lagged average of citations			0.0743***	0.0736***			0.0739***	0.0739***
			(0.00292)	(0.00293)			(0.00294)	(0.00295)
STEM				0.00985*				0.0359***
				(0.00396)				(0.00426)
Stock of mobile scientist x STEM								-0.0276***
								(0.00490)
After coauthoring with the first mobile scientist x STEM				0.00484				
				(0.00631)				
_cons	0.160***	-0.0205***	0.0584***	0.0545***	0.149***	-0.0148*	0.0673***	0.0508***
	(0.00206)	(0.00614)	(0.00558)	(0.00580)	(0.00224)	(0.00617)	(0.00561)	(0.00649)
N	67,661	67,661	67,661	67,661	67,661	67,661	67,661	67,661
R^2	0.068	0.170	0.171	0.171	0.079	0.168	0.167	0.168

Source: Authors own elaboration based on CvLattes, CvLAC, and OpenAlex.

Notes: LPM estimating the probability that nonmobile scientist interacts with at least one foreign scientist, when that they coauthor with mobile scientists (Equation 1). Columns 1-4: the main independent variable is a dummy variable that turns to 1 after coauthoring with at least 1 mobile scientist. Columns 5-8: the main independent variable is the stock of unique mobile scientists with whom a nonmobile scientist has collaborated. Columns 1 and 5: no controls. Columns 2-3 and 6-7: controlling for gender, years since first publication, number of previous collaborations with foreign scientist, and number of past yearly publications (columns 2, 6) or citations (columns 3, 7). Columns 4 and 8: displays results when adding an interaction between the main dependent variable and a dummy variable for STEM nonmobile scientists. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 7B. Probability of Coauthoring with Foreign Scientists Given Coauthorship with Mobile Scientists, Brazil

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Foreign collaborations							
After coauthoring with the first mobile scientist	0.266***	0.0993***	0.118***	0.109***				
	(0.000985)	(0.00115)	(0.00117)	(0.00191)				
Stock of mobile scientists					0.142***	0.0527***	0.0737***	0.0826***
					(0.000424)	(0.000612)	(0.000684)	(0.00116)
Lagged average of publications		0.184***				0.166***		
		(0.00137)				(0.00145)		
Lagged stock of foreign coauthors		0.0769***	0.108***	0.108***		0.0733***	0.104***	0.103***
		(0.000587)	(0.000541)	(0.000541)		(0.000594)	(0.000549)	(0.000550)
Years since first publication		0.00220***	-0.00294***	-0.00306***		0.00136***	-0.00292***	-0.00312***
		(0.000104)	(0.000102)	(0.000103)		(0.000107)	(0.000102)	(0.000102)
Gender (Male: 1)		0.0143***	0.0174***	0.0181***		0.0144***	0.0169***	0.0177***
		(0.000962)	(0.000970)	(0.000971)		(0.000962)	(0.000969)	(0.000970)
Lagged average of citations			0.0361***	0.0370***			0.00912***	0.0111***
			(0.000683)	(0.000699)			(0.000790)	(0.000802)
STEM				-0.0216***				-0.0163***
				(0.00135)				(0.00133)
Stock of mobile scientists x STEM								-0.00797***
								(0.00119)
After coauthoring with the first mobile scientist x STEM				0.0163***				
				(0.00220)				
constant	0.218***	0.0181***	0.118***	0.130***	0.203***	0.0412***	0.127***	0.136***
	(0.000687)	(0.00111)	(0.000939)	(0.00121)	(0.000669)	(0.00114)	(0.000929)	(0.00122)
N	862,551	862,551	862,551	862,551	862,551	862,551	862,551	862,551
R^2	0.074	0.168	0.153	0.153	0.108	0.168	0.155	0.156

Source: Authors own elaboration based on CvLattes, CvLAC, and OpenAlex.
Notes: LPM estimating the probability that nonmobile scientist interacts with at least one foreign scientist, when that they coauthor with mobile scientists (Equation 1). Columns 1-4: the main independent variable is a dummy variable that turns to 1 after coauthoring with at least a mobile scientist. Columns 5-8: the main independent variable is the stock of unique mobile scientists with whom a nonmobile scientist has collaborated. Columns 1 and 5: no controls. Columns 2-3 and 6-7: controlling for gender, years since first publication, number of previous collaborations with foreign scientist, and number of past yearly publications (columns 2 and 6) or citations (columns 3 and 7). Columns 4 and 8: display results when adding an interaction between the main dependent variable and a dummy variable for STEM nonmobile scientists.

5.2. Share of Publications With Foreign Coauthors

Tables 8A and B display results for the yearly average share of publications with foreign coauthors (over total publications of a nonmobile scientist), including scientific field (columns 1 and 4) or individual fixed effects (columns 3 and 6) and time-fixed effects to control for unobserved characteristics that vary across disciplines or scientists, and changes over time. We report the results for both independent variable specifications: coauthoring with any number of mobile scientists (columns 1-3), and the number of mobile scientists with whom the nonmobile coauthors (columns 4-6).

After controlling for the nonmobile scientist's visibility (citations) and stock of foreign coauthors, nonmobile scientists interacting with a mobile scientist is positively associated with the share of publications with foreign coauthors. The magnitude of the main independent variable coefficient in column 1 with field fixed effects suggests that coauthoring with at least one mobile scientist is associated with an increase in the share of publications with foreign coauthors by 3.3 percentage points for Colombian scientists and 2.9 percentage points for Brazilian scientists. In the case of Colombia, the coefficient increases for the individual scientist (when we include individual fixed effects): after a nonmobile scientist coauthors with a mobile scientist, they increase their share of publications with foreign coauthors by 5.5 percentage points. This suggests that, in the Colombian case, collaborations with a mobile scientist are more relevant to explain an increase in collaborations with foreign authors before and after the collaboration for the same scientist than when comparing nonmobile scientists who collaborate with mobile scientists and those who do not. This is not the case in Brazil though: when controlling for individual fixed effects the coefficient is smaller. Nonobservable differences among scientists explain part of the different propensity to coauthor with foreign scientists, when measured with the share of publications.

When we use a count of collaborations with mobile scientists (columns 4-6) rather than a binary indicator, results differ for Colombia and Brazil. The individual fixed effects estimates for Colombia (Table 8A, column 6) indicate that the elasticity of increasing the number of mobile collaborators on the share of publications coauthored with a foreign scientist among nonmobile scientists is about 3.9. In Brazil, instead, the number of collaborations with mobile scientists has a smaller coefficient and is not statistically significant on the share of publications with foreign scientists when we control for nonobservable differences among the nonmobile scientists. However, this can be driven by the total number of publications being relatively higher for nonmobile scientists who collaborate with mobile ones, reducing the share of foreign publications.

When individual fixed effects are included, we observe no significant differences between mobile scientists from different groups of fields (STEM or SSH) in the impact of collaborating with mobile scientists on foreign collaboration patterns. However, when groups of fields are treated specifically (excluding individual effects), we see that Colombian STEM scientists are more international than are SSH scientists (column 5). At the same time, though, in Colombia but not in Brazil, field interacts with the main effect of interest. On average, the elasticity of an increase in the number of mobile interactions is about 0.03. However, the interaction between STEM and number of interactions is about -0.025. This suggests that the net effect of increasing interactions with mobile scientists for a Colombian STEM scientist is close to zero.

Table 8A. Average Share of Publications Having Foreign Coauthors Given Coauthorship With Mobile Scientists, Colombia

	(1)	(2)	(3)	(4)	(5)	(6)
	Average share of foreign copublications					
After coauthoring with the first mobile scientist	0.0329***	0.0482***	0.0544***			
	(0.00499)	(0.00447)	(0.00750)			
Stock of mobile scientists				0.00240	0.0306***	0.0388***
				(0.00398)	(0.00434)	(0.00939)
Lagged stock of foreign coauthors	0.119***	0.113***	0.0772***	0.119***	0.112***	0.0767***
	(0.00469)	(0.00503)	(0.00527)	(0.00489)	(0.00511)	(0.00562)
Lagged average of publications	0.0377***			0.0463***		
	(0.00786)			(0.00750)		
Years since first publication	-0.00771***	-0.00581***		-0.00695***	-0.00521***	
	(0.000881)	(0.000770)		(0.000818)	(0.000660)	
Gender (Male: 1)	0.0104***	0.00744		0.0102***	0.00725	
	(0.00233)	(0.00390)		(0.00218)	(0.00381)	
Lagged average of citations		0.0354***	-0.0386***		0.0393***	-0.0436***
		(0.00330)	(0.00551)		(0.00379)	(0.00535)
STEM		0.0141***			0.0331***	
		(0.00249)			(0.00498)	
Stock of mobile scientists x STEM					-0.0250***	-0.00309
					(0.00563)	(0.00987)
After coauthoring with the first mobile scientist x STEM		-0.00176	0.0119			
		(0.00723)	(0.00911)			
_cons	0.101***	0.0877***	0.129***	0.105***	0.0858***	0.138***
	(0.00931)	(0.00489)	(0.00494)	(0.00893)	(0.00473)	(0.00551)
Field FE	YES	NO	NO	YES	NO	NO
Individual FE	NO	NO	YES	NO	NO	YES
Time FE	YES	NO	YES	YES	NO	YES
N	67,661	67,661	67,661	67,661	67,661	67,661
R^2	0.306	0.283	0.567	0.303	0.280	0.565

Source: Authors own elaboration based on CvLattes, CvLAC, and OpenAlex.
Notes: OLS regressions estimating the yearly average share of nonmobile scientists' publications with foreign coauthors (Equation 2). Columns 1-3: the main independent variable is a dummy variable that turns to 1 after coauthoring with at least one mobile scientist. Columns 4-6: the main independent variable is the stock of unique mobile scientists with whom a nonmobile scientist has collaborated. Columns 1 and 4: controlling for field and time-fixed effects. Columns 2 and 5: displays results when adding an interaction between the main dependent variable and a dummy variable for STEM nonmobile scientists. Columns 3 and 6: controlling for individual and time-fixed effects. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 8B. Average Share of Publications Having Foreign Coauthors Given Coauthorship With Mobile Scientists, Brazil

	(1)	(2)	(3)	(4)	(5)	(6)
	Average share of foreign copublications					
After coauthoring with the first mobile scientist	0.0294***	0.0228**	0.0200**			
	(0.00585)	(0.00635)	(0.00571)			
Stock of mobile scientists				0.00181	0.00820	0.0120
				(0.00238)	(0.00538)	(0.00677)
Lagged stock of foreign coauthors	0.0936***	0.0986***	0.0471***	0.0946***	0.0988***	0.0473***
	(0.00247)	(0.00228)	(0.00247)	(0.00243)	(0.00234)	(0.00234)
Lagged average of publications	-0.0114*			-0.00591		
	(0.00430)			(0.00489)		
Years since first publication	-0.00760***	-0.00577***		-0.00727***	-0.00560***	
	(0.000330)	(0.000313)		(0.000366)	(0.000325)	
Gender (Male: 1)	0.00738*	0.00849**		0.00732*	0.00822**	
	(0.00306)	(0.00223)		(0.00303)	(0.00224)	
Lagged average of citations		-0.0167***	-0.0419***		-0.0183***	-0.0523***
		(0.00119)	(0.00179)		(0.00150)	(0.00259)
STEM		0.00275			0.0103*	
		(0.00419)			(0.00418)	
Stock of mobile scientists x STEM					0.00640	0.0146*
					(0.00520)	(0.00676)
After coauthoring with the first mobile scientist x STEM		0.0241**	0.0384***			
		(0.00672)	(0.00661)			
_cons	0.149***	0.119***	0.171***	0.155***	0.121***	0.180***
	(0.00354)	(0.00362)	(0.00409)	(0.00397)	(0.00387)	(0.00411)
Field FE	YES	NO	NO	YES	NO	NO
Individual FE	NO	NO	YES	NO	NO	YES
Time FE	YES	NO	YES	YES	NO	YES
N	862,551	862,551	862,551	862,551	862,551	862,551
R^2	0.202	0.195	0.412	0.200	0.192	0.410

Source: Authors own elaboration based on CvLattes, CvLAC, and OpenAlex.
Notes: OLS regressions estimating the yearly average share of nonmobile scientists' publications with foreign coauthors (Equation 2). Columns 1-3: the main independent variable is a dummy variable that turns to 1 after coauthoring with at least one mobile scientist. Columns 4-6: the main independent variable is the stock of unique mobile scientists with whom a nonmobile scientist has collaborated. Columns 1 and 4: controlling for field and time-fixed effects. Column 2 and 5: displays results when adding an interaction between the main dependent variable and a dummy variable for STEM nonmobile scientists. Columns 3 and 6: controlling for individual and time-fixed effects. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

5.3. Number of Publications With Foreign Coauthors

The share of publications with foreign coauthors (Tables 8A and B) is affected by overall productivity of the nonmobile scientist. Interaction with a mobile scientist may have two effects: change the total number of publications or change the extent of "internationality" of a scientist's coauthors (i.e., publications with foreign scientists). Thus an increase in the proportion of "foreign" publications may be affected by a reduction in the number of "domestic" publications rather than an increase in publications with foreign authors. To address this, we report results for the number of publications with foreign coauthors in Tables 9A (Colombia) and 9B (Brazil) for at least one collaboration with mobile scientists (in columns 1-3), and for the stock of collaborations with mobile scientists (in columns 4-6).

Results are overall similar to those discussed in Section 5.2 with reference to Tables 8A and B, suggesting that the higher share of publications with foreign coauthors following collaboration with mobile scientists is driven by an increase in the number of publications with foreign coauthors rather than a decrease in purely "domestic" publications. For nonmobile scientists from both countries, collaborating with a mobile scientist is associated with an increase by 6.5 percent (in Colombia) and 6.9 percent (in Brazil) in the number of publications with foreign coauthors (column 2 in a log-log specification). When we control for individual and time-fixed effects, the magnitude of the coefficient is 8 percent for Colombia and 6.6 percent for Brazil (column 3). This finding corroborates the previous results: for a nonmobile scientist, collaborating with a mobile scientist may be important in a strategy to increase foreign collaborators.

The coefficients regarding the stock of unique mobile scientists with whom the nonmobile scientists collaborate (in log) in the last three columns (columns 4-6) show that an increase in mobile scientists' collaborators is positively related to an increase in the average number of publications with foreign scientists. For example, in column 6 (with individual and time-fixed effects), the elasticity of foreign publication with regard to the number of unique mobile scientists with whom nonmobile collaborate is 0.09 for Colombia and 0.12 for Brazil. So, a doubling in the stock of mobile collaborators in a nonmobile scientist's career is related to a 9 percent increase in the number of publications with foreign coauthors in the case of Colombia and 12 percent in the case of Brazil. Comparing Table 9B and 8B shows that the small coefficients in Table 8B are due to Brazilian scientists increasing publication with and without foreign collaborators at the same rate; when they coauthor with mobile scientists, the number of foreign collaborations increase, but not the share.

Table 9A. Average Number of Publications With Foreign Coauthors Given Coauthorship With Mobile Scientists, Colombia

	(1)	(2)	(3)	(4)	(5)	(6)
	Average number of foreign copublications					
After coauthoring with the first mobile scientist	0.0558***	0.0654***	0.0770***			
	(0.00637)	(0.00573)	(0.0105)			
Stock of mobile scientists				0.0389***	0.0583***	0.0964***
				(0.00660)	(0.00729)	(0.0130)
Lagged stock of foreign coauthors	0.167***	0.165***	0.121***	0.166***	0.162***	0.114***
	(0.00423)	(0.00439)	(0.00696)	(0.00458)	(0.00473)	(0.00780)
Years since first publication	-0.0115***	-0.00947***		-0.0115***	-0.00949***	
	(0.000828)	(0.000759)		(0.000892)	(0.000746)	
Gender (Male: 1)	0.0306***	0.0287***		0.0303***	0.0283***	
	(0.00562)	(0.00607)		(0.00560)	(0.00615)	
STEM		0.00342			0.0188*	
		(0.00506)			(0.00761)	
After coauthoring with the first mobile scientist x STEM		0.000260	0.0288*			
		(0.00875)	(0.0110)			
Stock of mobile scientists x STEM					-0.0188*	0.0319*
					(0.00803)	(0.0125)
Lagged average of citations	0.140***	0.147***	0.0311**	0.139***	0.147***	0.0145
	(0.00690)	(0.00640)	(0.00935)	(0.00728)	(0.00636)	(0.00908)
_cons	0.110***	0.0898***	0.134***	0.114***	0.0841***	0.117***
	(0.00854)	(0.00619)	(0.00793)	(0.00780)	(0.00674)	(0.00793)
Field FE	YES	NO	NO	YES	NO	NO
Individual FE	NO	NO	YES	NO	NO	YES
Time FE	YES	NO	YES	YES	NO	YES
N	67,661	67,661	67,661	67,661	67,661	67,661
R^2	0.394	0.387	0.630	0.394	0.387	0.631

Source: Authors own elaboration based on CvLattes, CvLAC, and OpenAlex.
Notes: OLS regressions estimating the yearly average number of nonmobile scientists' publications with foreign coauthors (three-year rolling average) (Equation 2). Columns 1-3: the main independent variable is a dummy variable that turns to 1 after coauthoring with at least 1 mobile. Columns 4-6: the main independent variable is the stock of unique mobile scientists with whom a nonmobile scientist has collaborated. Columns 1 and 4: controlling for field and time-fixed effects. Column 2 and 5: displays results when adding an interaction between the main dependent variable and a dummy variable for STEM nonmobile scientists. Columns 3 and 6: controlling for individual and time-fixed effects. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 9B. Average Number of Publications With Foreign Coauthors Given Coauthorship With Mobile Scientists, Brazil

	(1)	(2)	(3)	(4)	(5)	(6)
	Average number of foreign copublications					
After coauthoring with the first mobile scientist	0.0653***	0.0694***	0.0669***			
	(0.00559)	(0.00657)	(0.00813)			
Stock of mobile scientists				0.0636***	0.0651***	0.122***
				(0.00507)	(0.00594)	(0.0119)
Lagged stock of foreign coauthors	0.199***	0.203***	0.125***	0.194***	0.197***	0.111***
	(0.00473)	(0.00476)	(0.00566)	(0.00465)	(0.00478)	(0.00515)
Years since first publication	-0.0110*** (0.000620)	-0.0102*** (0.000734)		-0.0112*** (0.000656)	-0.0106*** (0.000830)	
Gender (Male: 1)	0.0266**	0.0280**		0.0258**	0.0281**	
	(0.00692)	(0.00847)		(0.00685)	(0.00854)	
STEM		-0.0163**			-0.0271***	
		(0.00560)			(0.00677)	
After coauthoring with the first mobile scientist x STEM		-0.000128	0.0291*			
		(0.0112)	(0.0122)			
Stock of mobile scientists x STEM					-0.00141	0.00719
					(0.00717)	(0.00975)
Lagged average of citations	0.0632***	0.0616***	-0.00195	0.0368***	0.0360***	-0.0556***
	(0.00506)	(0.00689)	(0.00324)	(0.00563)	(0.00620)	(0.00582)
_cons	0.114***	0.101***	0.186***	0.109***	0.116***	0.152***
	(0.00861)	(0.00828)	(0.0110)	(0.00759)	(0.00819)	(0.0149)
Field FE	YES	NO	NO	YES	NO	NO
Individual FE	NO	NO	YES	NO	NO	YES
Time FE	YES	NO	YES	YES	NO	YES
N	862,551	862,551	862,551	862,551	862,551	862,551
R^2	0.359	0.354	0.568	0.365	0.360	0.575

Source: Authors own elaboration based on CvLattes, CvLAC, and OpenAlex.
Notes: OLS regressions estimating the yearly average number of nonmobile scientists' publications with foreign coauthors (three years rolling average) (Equation 2). Columns 1-3: the main independent variable is a dummy variable that turns to 1 after coauthoring with at least 1 mobile. Columns 4-6: the main independent variable is the stock of unique mobile scientists with whom a nonmobile scientist has collaborated. Columns 1 and 4: controlling for field and time-fixed effects. Column 2 and 5: displays results when adding an interaction between the main dependent variable and a dummy variable for STEM nonmobile scientists. Columns 3 and 6: controlling for individual and time-fixed effects. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

5.4. The Role of Different Types of Mobile Scientists

Finally, we separate mobile scientists by types (returnee, diaspora, and intermittent) (Tables 10A and B) for both the share of publications (columns 1-5) and the number of publications (columns 6-8) with foreign scientists. In column 1, we report results without controls. In the case of Colombia, collaborating with a higher stock of diaspora and intermittent mobile scientists is associated with an increase in the share of publications with foreign coauthors (with respect to the average nonmobile scientist) that is three times as large as that of increasing the stock of returnee mobile scientists. When we add controls and field fixed effects (columns 2 and 3), we find that for the Colombian case an increase in the number of collaborations with returnees is not associated with a significant increase for nonmobile scientists in the share of publications with foreign coauthors. On the contrary, we find a small negative coefficient when including time and field fixed effects. Similar results are found in the Brazilian case, where diaspora and intermittent mobile scientists have an almost three times higher positive correlation with the share of publications with foreign coauthors than returnee mobile scientists (column 1).

In column 4, we see that the large difference of the role of different types of mobile scientists in Colombia arises partly in STEM. For all non-STEM nonmobile scientists, the correlation between coauthoring with returnees and the share of publications with foreign coauthors is positive and significant even when controlling for observable features. However, for STEM scientists collaborating with mobile returnees, it is negative.

Because STEM nonmobile scientists are more likely to coauthor with foreign scientists than SSH scientists, this result suggests that, in Colombia, returnees substitute for foreign scientists: nonmobile STEM scientists collaborate with either returnees or with foreign coauthors, but not with both. Once more, results are different with individual fixed effects, suggesting a positive association for all scientists, when assessing the role of returnees over their careers.

Results are similar for the number of publications with foreign scientists (columns 6-8), although here we notice no difference between STEM and SSH. This suggests that the negative impact on the share of publications with foreign scientists for STEM was driven by a higher number of publications with no foreigners than with foreigners, for nonmobile researchers that publish with a higher number of returnee mobile scientists.

In the Brazilian case (column 4), we find no differences between STEM and SSH. As noted above, when controlling for individual and time-fixed effects, we observe no relation between an increase in the number of mobile coauthors (of any type) and the share of foreign publication (column 4) because the number of collaborations with foreign and national scientists increase at the same rate. The relationship is positive for the total number of publications with foreigners (column 8), and the difference with respect to the average nonmobile scientists is twice as large for those who collaborate with diaspora and intermittent than for those who collaborate with returnees.

Table 10A. Average Share and Number of Publications With Foreign Coauthors Given Coauthorship With Mobile Scientists by Mobility Categories, Colombia

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Average share of foreign copublications					Average number of foreign copublications		
Stock of returnee scientists	0.0418***	-0.00265	-0.0144**	0.0136**	0.0170*	0.0560***	0.0331***	0.0534***
	(0.00767)	(0.00544)	(0.00469)	(0.00363)	(0.00627)	(0.0118)	(0.00672)	(0.0135)
Typical of diaspora and intermittent scientists	0.115***	0.0259***	0.0169**	0.0336***	0.0418***	0.107***	0.0615***	0.0902***
	(0.00669)	(0.00502)	(0.00481)	(0.00555)	(0.0105)	(0.0101)	(0.00744)	(0.0107)
Lagged average of citations		0.0392***	0.0304***	0.0392***	-0.0451***	0.0131	0.146***	0.0106
		(0.00396)	(0.00326)	(0.00383)	(0.00553)	(0.00945)	(0.00637)	(0.00932)
Lagged stock of foreign coauthors		0.112***	0.113***	0.111***	0.0760***	0.112***	0.160***	0.112***
		(0.00513)	(0.00469)	(0.00514)	(0.00560)	(0.00798)	(0.00481)	(0.00797)
Years since first publication		-0.00522***	-0.00844***	-0.00509***			-0.00949***	
		(0.000657)	(0.000679)	(0.000623)			(0.000743)	
Gender (male: 1)		0.00879*	0.0116***	0.00772			0.0288***	
		(0.00350)	(0.00237)	(0.00374)			(0.00608)	
STEM				0.0341***			0.0212*	
				(0.00499)			(0.00748)	
Stock of returnees x STEM				-0.0299***	-0.00861		-0.0225*	0.00702
				(0.00707)	(0.0107)		(0.0105)	(0.0185)
Stock of diaspora and intermittent x STEM				-0.0141	0.000816		-0.0135	0.0325
				(0.00790)	(0.0137)		(0.00956)	(0.0171)
_cons	0.161***	0.104***	0.138***	0.0874***	0.143***	0.133***	0.0874***	0.132***
	(0.0115)	(0.00680)	(0.00620)	(0.00466)	(0.00495)	(0.00935)	(0.00681)	(0.00733)
Field FE	NO	NO	YES	NO	NO	YES	NO	NO
Individual FE	NO	NO	NO	NO	YES	NO	NO	YES
Time FE	NO	NO	YES	NO	YES	YES	NO	YES
N	67,661	67,661	67,661	67,661	67,661	67,661	67,661	67,661
R^2	0.070	0.279	0.305	0.281	0.565	0.632	0.388	0.632

Source: Authors own elaboration based on CvLattes, CvLAC, and OpenAlex.
Notes: OLS regressions estimating the yearly average yearly average share (columns 1-5) and number (columns 6-8) of nonmobile scientists' publications with foreign coauthors (three years rolling average) (Equation 2). The main independent variable is the stock of unique mobile scientists with whom a nonmobile scientist has collaborated. Column 1: no controls. Columns 2: all controls included: gender, years since first publications, past citations, and foreign collaborations. Columns 3 and 6: controlling for field and time-fixed effects. Columns 4, 5, 7 and 8: Including an interaction between the main dependent variable and a dummy variable for STEM nonmobile scientists. Columns 5 and 8: controlling for individual and time-fixed effects. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 10B. Average Share and Number of Publication With Foreign Coauthors Given Coauthorship With Mobile Scientists by Mobility Categories, Brazil

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Average share of foreign copublications					Average number of foreign copublications		
Stock of returnee scientists	0.0191**	0.00123	-0.00165	0.00541	0.000453	0.0570***	0.0450***	0.0566***
	(0.00490)	(0.00221)	(0.00132)	(0.00331)	(0.00533)	(0.00766)	(0.00335)	(0.00780)
Stock of diaspora and intermittent scientists	0.0531***	0.0143***	0.00906**	0.00677	0.0108	0.121***	0.0620***	0.114***
	(0.00328)	(0.00220)	(0.00257)	(0.00539)	(0.00687)	(0.0104)	(0.00596)	(0.0119)
Lagged average of citations		-0.0165***	-0.0192***	-0.0179***	-0.0517***	-0.0583***	0.0337***	-0.0592***
		(0.00211)	(0.00204)	(0.00149)	(0.00271)	(0.00537)	(0.00624)	(0.00563)
Lagged stock of foreign coauthors		0.0986***	0.0972***	0.0989***	0.0477***	0.111***	0.196***	0.111***
		(0.00225)	(0.00234)	(0.00238)	(0.00244)	(0.00514)	(0.00483)	(0.00521)
Years since first publication		-0.00570***	-0.00674***	-0.00557***			-0.0107***	
		(0.000284)	(0.000271)	(0.000319)			(0.000826)	
Gender (male: 1)		0.00896**	0.00735*	0.00838**			0.0272**	
		(0.00255)	(0.00286)	(0.00221)			(0.00844)	
STEM				0.0114*			-0.0260***	
				(0.00418)			(0.00660)	
Stock of returnees x STEM				-0.00489	-0.00509		-0.00101	0.000876
				(0.00423)	(0.00607)		(0.00615)	(0.0144)
Stock of diaspora and intermittent x STEM				0.00700	0.0149*		-0.00171	0.00739
				(0.00522)	(0.00685)		(0.00796)	(0.00985)
_cons	0.181***	0.128***	0.149***	0.121***	0.182***	0.163***	0.120***	0.163***
	(0.00559)	(0.00371)	(0.00315)	(0.00387)	(0.00400)	(0.0159)	(0.00772)	(0.0154)
Field FE	NO	NO	YES	NO	NO	YES	NO	NO
Individual FE	NO	NO	NO	NO	YES	NO	NO	YES
Time FE	NO	NO	YES	NO	YES	YES	NO	YES
N	862,551	862,551	862,551	862,551	862,551	862,551	862,551	862,551
R^2	0.060	0.191	0.202	0.191	0.410	0.575	0.361	0.575

Source: Authors own elaboration based on CvLattes, CvLAC, and OpenAlex.

Notes: OLS regressions estimating the yearly average yearly average share (columns 1-5) and number (columns 6-8) of nonmobile scientists' publications with foreign coauthors (three years rolling average) (Equation 2). The main independent variable is the stock of unique mobile scientists with whom a nonmobile scientist has collaborated. Column 1: no controls. Columns 2: all controls included: gender, years since first publications, past citations, and foreign collaborations. Columns 3 and 6: controlling for field and time-fixed effects. Columns 4, 5, 7 and 8: Including an interaction between the main dependent variable and a dummy variable for STEM nonmobile scientists. Columns 5 and 8: controlling for individual and time-fixed effects. Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

6. Difference-in-Differences Event Study

6.1. Empirical Strategy

Coauthoring with mobile scientists does not occur randomly. The opportunity for nonmobile scientists to meet with colleagues who have studied or worked abroad depends on their academic careers. Mobile scientists may seek to collaborate with nonmobile scientists based on observable characteristics (e.g., past publications) and nonobservable characteristics (e.g., social skills). Results presented in Section 5 control for several of the observable characteristics that may influence the coauthorship patterns of nonmobile scientists with mobile scientists and foreign scientists: academic tenure, gender, FOS, and past publications, citations, and coauthored publications with foreign scientists. Yet, there may be other, nonobservable characteristics of nonmobile scientists that influence the probability of their coauthoring with foreign and mobile colleagues, and which may overestimate the role of mobile scientists in connecting them with foreign scientists. For instance, a higher propensity to participate in national and international conferences, writing and other communication skills, or where they have studied during their undergraduate or master's degrees, and the connections they formed then. Additionally, nonmobile scientists may collaborate with mobile scientists at different points in time over their careers, on different topics, in different capacities, and in different research projects.

To identify the causal effect of coauthoring with mobile scientists on the number of publications that nonmobile scientists coauthor with foreign scientists, we rely on a DiD event study design (Borusyak et al. 2021). We use the DiD estimator with treatment over multiple periods developed by Callaway and Sant'Anna (2021) to estimate the average treatment effect on the treated for nonmobile scientists who are treated in different years. This setup follows a staggered treatment. In this study, the treatment group is formed by Brazilian and Colombian nonmobile scientists who have coauthored with mobile scientists at least once during the period in which we observe them. The control group is formed by all other nonmobile Brazilian and Colombian scientists who have never coauthored with a mobile scientist (but who may coauthor with foreign scientists).[23] The estimated outcome is an indicator of the intensity of coauthoring with foreign scientists. To simplify, here we use the number of publications coauthored with foreign scientists.[24]

Formally, our DiD specification is then expressed as in Equation 3:

$$Y_{i,t} = \alpha_1^{g,t} + \alpha_2^{g,t} G_g + \alpha_3^{g,t} 1\{T = t\} + \beta \left(G_g . 1\{T = t\}\right) + x_i' \theta + \varepsilon_{it} \quad (3)$$

where $Y_{i,t}$ is the (log-transformed) number of publications coauthored with foreign scientists by the nonmobile scientist i in year t; G_g is a binary variable that equals 1 if a nonmobile scientist belongs to the treatment group and becomes first treated in year g and equals 0 for the control group; $\alpha_2^{g,t}$ is the coefficient for the treatment group dummy variable; β represents the average treatment effect; $\alpha_3^{g,t}$ represents the coefficient for the post-treatment dummy variable; x_i' represents a vector of control variables that are not influenced by the treatment: tenure (years since first publication) and gender.[25] We have checked that there is no statistically significant difference for observable features that can be endogenous and influenced by the treatment (publications and citations) before the treatment between treated and nontreated nonmobile scientists (see Appendix 4). Following the recommendations of Callaway and Sant'Anna (2021) and Abadie, Athey, Imbens, and Wooldridge (2023), we clustered standard errors at the individual level.[26]

As observed in Section 4, throughout their career nonmobile scientists may coauthor with more than one mobile scientist, in one or more years.[27] This means that some of the nonmobile scientists are treated more than once. To distinguish the effect of one versus multiple treatments, we split the sample according to the number of unique

[23] Table A5 (for Colombia) and A6 (for Brazil) in Appendix 4 display the number of scientists in the treatment and control groups according to different specifications.
[24] Results using the share of publications coauthored with foreign scientists are similar.
[25] Results are robust to the inclusion of main field of study. For Colombia, we have also added the education level as a control because, in our sample, we include nonmobile scientists with a master's degree or a PhD. Because of the inclusion of scholars with a master's degree, to focus on researching active scholars, we include only nonmobile scientists that have at least three publications (like in the OLS regressions).
[26] Results are robust to clustering at both individual and discipline level.
[27] We observe nonmobile Brazilian and Colombian scientists throughout their academic careers between 1990 and 2021, which lasts between the first and last year of publication that was retrieved from OpenAlex or from the online CV.

mobile scientists with whom a nonmobile scientist has coauthored. We consider the treatment to be the year of the first coauthored publication because our research question is about the effect of the interaction with a mobile scientist, which does not exclude that the interaction can last for more than one period (although this occurs in a minority of cases in our data, as shown in Section 4). Future research may distinguish different types of more- or less-stable collaborations. Thus this paper estimates the impact of the first coauthorship with a mobile scientist on the number of coauthored publications with foreign authors for the following samples: (i) nonmobile scientists who have coauthored with one unique mobile scientist; (ii) nonmobile scientists who have coauthored with two unique mobile scientists; (iii) nonmobile scientists who have coauthored with three unique mobile scientists; and (iv) nonmobile scientists who have coauthored with any number of mobile scientists (i.e., all collaborations).[28] We analyze the Colombian and the Brazilian samples separately.

6.2. Results

In this section, we present the results of the DiD event study, separately for Colombia and Brazil. Each figure has four panels for: (i) nonmobile scientists who coauthored with one unique mobile scientist; (ii) nonmobile scientists who coauthored with two unique mobile scientists; (iii) nonmobile scientists who coauthored with three unique mobile scientists; and (iv) nonmobile scientists who coauthored with any number of unique mobile scientists. Figures 1 and 2 report the estimated effect of nonmobile Colombian and Brazilian scientists coauthoring with mobile scientists on the number of publications the nonmobiles coauthored with foreign scientists for the full sample.

First, we note that, in the five years before coauthoring with a mobile scientist, treated and nontreated nonmobile scientists do not differ significantly in the number of publications that they coauthor with foreign scientists, regardless of the number of unique mobile coauthors (panels 1-4).

[28] Please note that we consider multiple treatment only when a nonmobile scientist coauthors with multiple mobile scientists. Most nonmobile scientists coauthor with the same mobile scientist only in one year (Section 4), but some of them publish with the same mobile scientists more than once, in different years.

Second, we find that an average Colombian nonmobile scientist, publishes approximately 20 percent more publications coauthored with a foreign scientist than a Colombian nonmobile scientist who has never coauthored with a mobile scientist. In Brazil, the difference can be as high as 28 percent. This is a large effect. The difference is always largest in the year of first copublication with the mobile scientist.

Unfortunately, this "mechanical" effect tends not to be sustained over time—that is, nonmobile Colombian and Brazilian scientists do not remain connected to the foreign scientists more than their untreated peers beyond that first copublication, which also involved the mobile scientists. We observe this in Figures 1 and 2, panels 1-2. Colombian and Brazilian nonmobile scientists who coauthor with only one or two unique mobile scientists are not more likely to coauthor with foreign scientists in the following years than their untreated peers. Only nonmobile scientists who coauthor with at least three different mobile scientists (in one or multiple years) see a positive effect still after two or three years. But this effect is because, in each of these three years, they have a higher probability of copublishing with the foreign coauthors and the mobile scientists, rather than independently of the mobile scientists. In other words, nonmobile scientists, on average, need to be reconnected every time by a mobile colleague to foreign scientists to continue collaborating with foreigners.

Fourth and related, in panel 4 there is a significant drop in the probability of foreign collaboration from year 0 (the year of first collaboration with a mobile scientist) and year 1 (the first year after). When we consider publishing with any number of mobile coauthors (panel 4), the difference between treated and nontreated drops to around 10 percent in the first year after the first copublication with a mobile scientist. This again suggests that the mechanism connecting a nonmobile scientist to foreign scientists is a joint publication by nonmobile, mobile, and foreign coauthors.

Fifth, the DiD event study results confirm that increasing the number of unique mobile coauthors positively affects the number of publications coauthored with foreign scientists, as discussed in the OLS regressions (Tables 9A and 9B). However, the DiD event study results also qualify the OLS results, showing that most of that effect is explained by the inclusion of nonmobile scientists in publications that the mobile coauthors with the foreign scientists. While that copublication may have other positive impacts, there is weak evidence that it helps establish long-lasting links between the nonmobile Colombian or Brazilian scientists and foreign scientists.

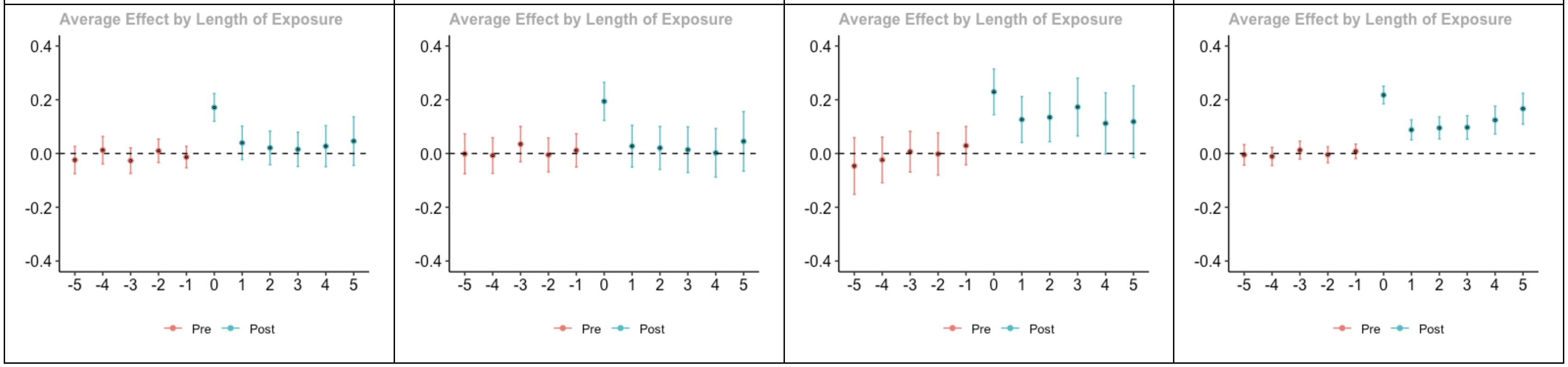
To test if the increase in the number of publications coauthored with foreign scientists increases only as a result of the mechanical effect of coauthoring also with the mobile scientists, we remove publications with mobile scientists from the stock of nonmobile scientists' publications. That is, we test if the number of publications with foreign authors alone (excluding mobile scientists) also increases after coauthoring with mobile scientists. Figures 3 (Colombia) and 4 (Brazil) show that, in general, the point estimates drop to very small effects, which are not statistically significant. Only in the case of Brazil, with continuous collaborations with different mobile scientists (more than three), do we find a very small, and barely significant effect.

The results suggest that nonmobile scientists benefit from the social capital of mobile scientists while working with them, as they are included in publications with foreign scientists, but nonmobile scientists do not build social capital of their own with foreigners. These results are in line with Burt's (1998, 2000, 2007) suggestions that outsiders may borrow social capital instead of building their own.

In sum, these results suggest that interacting with several mobile scientists can benefit nonmobile scientists by expanding their portfolio of publications with foreign coauthors: as nonmobile scientists diversify their network of mobile scientists, the number of foreign publications increases. Nonetheless, although mobile scientists play a role in nonmobile scientists' internationalization process, nonmobile scientists need mobile scientists to reconnect them to foreign scientists.

Figure 1. Number of Publications With Foreign Coauthors (Log) Five Years Before and After First Treatment, Colombia

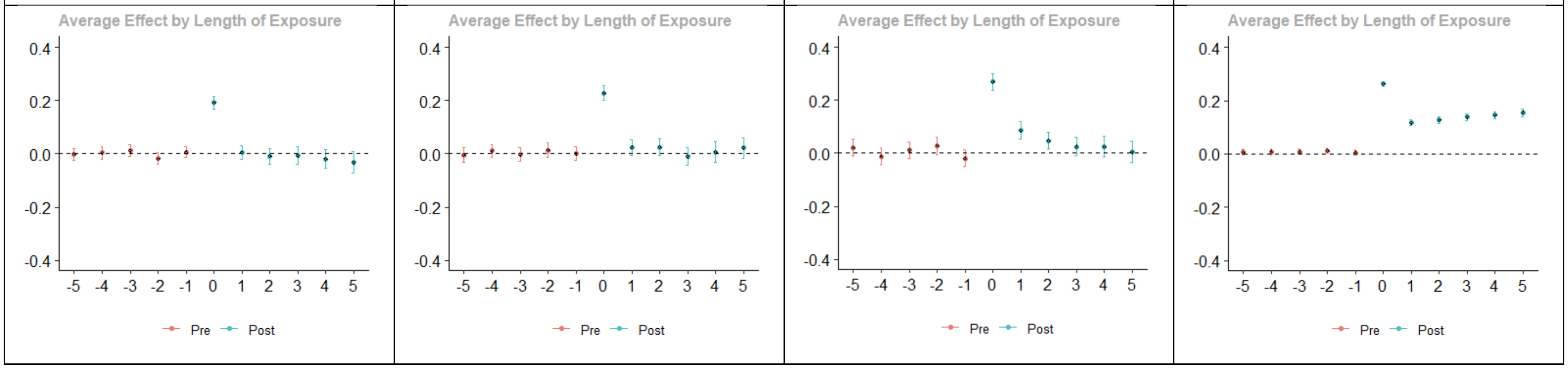
(1) Coauthoring with one unique mobile scientist	(2) Coauthoring with two unique mobile scientists	(3) Coauthoring with three unique mobile scientists	(4) Coauthoring with any number of unique mobile scientist



Notes: Results of a DiD analysis with multiple time periods (Equation 3). We investigate the impact of mobile scientists coauthoring with nonmobile scientists on the additional number of publications they coauthor with one or more foreign scientist. The dependent variable is the nonmobile scientist's yearly average number of publications coauthored with foreign scientists. Controls include education level, gender, and years since first publication. We cluster standard errors at the individual level. The treatment group consists of nonmobile scientists who coauthored with mobile scientists. The treatment effect is estimated to occur after coauthoring with the first mobile scientist at time 0. Time 0 is when we observe the first coauthored publication between the nonmobile and the mobile scientist. Each panel in the figure reports results for different numbers of unique mobile scientists with whom a nonmobile scientist coauthors with throughout their entire career, up to the point of data collection: only one (panel 1); exactly two (panel 2); exactly three (panel 3); and all of them (panel 4).
Source: Authors' own elaboration based on CvLattes, CvLAC, and OpenAlex.

Figure 2. Number of Publications With Foreign Coauthors (Log) Five Years Before and After First Treatment, Brazil

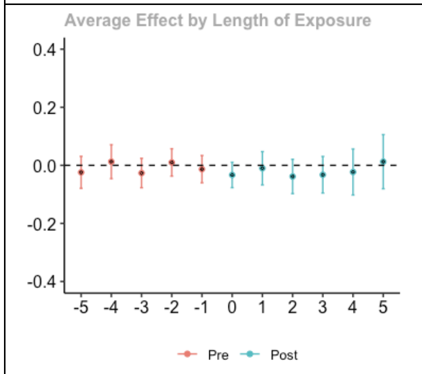
(1) Coauthoring with one unique mobile scientist	(2) Coauthoring with two unique mobile scientists	(3) Coauthoring with three unique mobile scientists	(4) Coauthoring with any number of unique mobile scientist

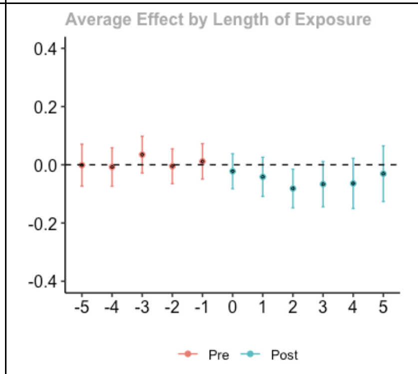


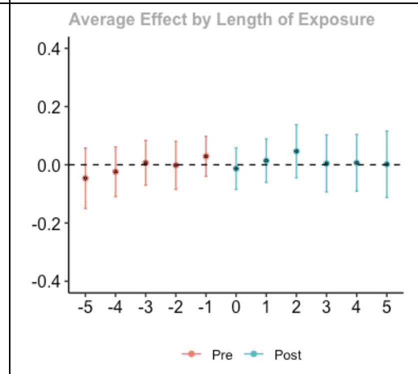
Notes: Results of a DiD analysis with multiple time periods (Equation 3). We investigate the impact of mobile scientists coauthoring with nonmobile scientists on the additional number of publications they coauthor with foreign scientists. The dependent variable is the nonmobile scientist's yearly average number of publications coauthored with foreign scientists. Controls include education level, gender, and years since first publication. We cluster standard errors at the individual level. The treatment group consists of nonmobile scientists who coauthored with mobile scientists. The treatment effect is estimated to occur after coauthoring with the first mobile scientist at time 0. Time 0 is when we observe the first coauthored publication between the nonmobile and the mobile scientist. Each panel in the figure reports results for different numbers of unique mobile scientists with whom a nonmobile scientist coauthors throughout their entire career, up to the point of data collection: only one (panel 1); exactly two (panel 2); exactly three (panel 3); and all of them (panel 4).
Source: Authors' own elaboration based on CvLattes, CvLAC, and OpenAlex.

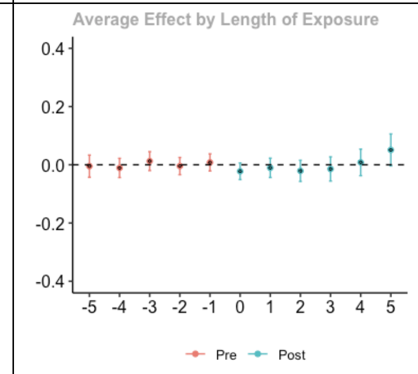
Figure 3. Number of Publications With Foreign Coauthors (Log) Five Years Before and After First Treatment, Excluding Publications With Mobile, Colombia

(1) Coauthoring with one unique mobile scientist	(2) Coauthoring with two unique mobile scientists	(3) Coauthoring with three unique mobile scientists	(4) Coauthoring with any number of unique mobile scientist





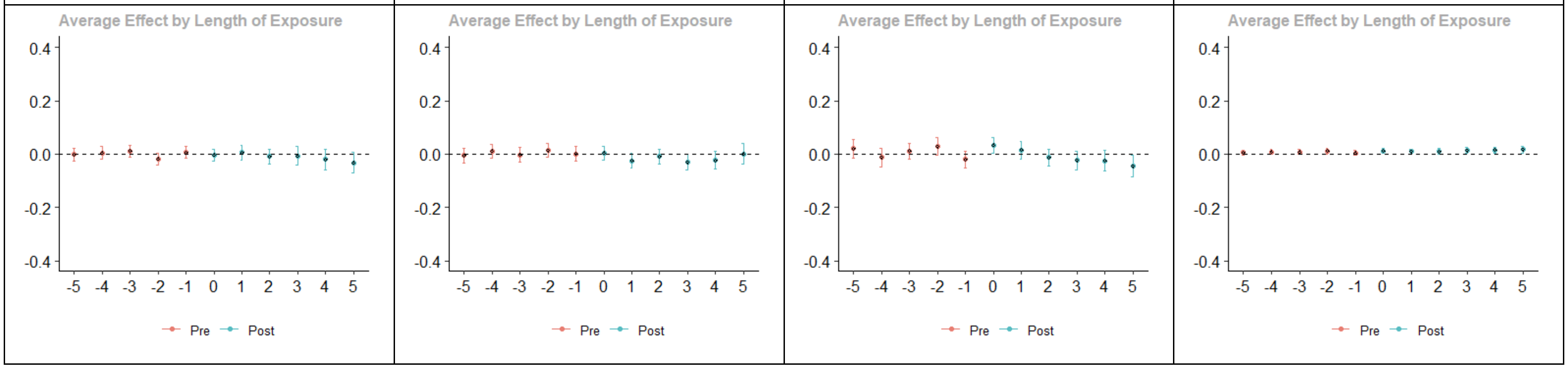




Notes: Results of a DiD analysis with multiple time periods (Equation 3). We investigate the impact of mobile scientists coauthoring with nonmobile scientists on the additional number of publications they coauthor with foreign scientists. The dependent variable is the nonmobile scientist's yearly average number of publications coauthored with foreign scientists, but without mobile scientists. Controls include education level, gender, and years since first publication. We cluster standard errors at the individual level. The treatment group consists of nonmobile scientists who coauthored with mobile scientists. The treatment effect is estimated to occur after coauthoring with the first mobile scientist at time 0. Time 0 is when we observe the first coauthored publication between the nonmobile scientist and the mobile scientist. Each panel in the figure reports results for different numbers of unique mobile scientists with whom a nonmobile scientist coauthors throughout their entire career, up to the point of data collection: only one (panel 1); exactly two (panel 2); exactly three (panel 3); and all of them (panel 4).
Source: Authors' own elaboration based on CvLattes, CvLAC, and OpenAlex.

Figure 4. Number of Publications With Foreign Coauthors (Log) Five Years Before and After First Treatment, Excluding Publications With Mobile, Brazil

(1) Coauthoring with one unique mobile scientist	(2) Coauthoring with two unique mobile scientists	(3) Coauthoring with three unique mobile scientists	(4) Coauthoring with any number of unique mobile scientist



Notes: Results of a DiD analysis with multiple time periods (Equation 3). We investigate the impact of mobile scientists coauthoring with nonmobile scientists on the additional number of publications the nonmobile scientists coauthor with foreign scientists. The dependent variable is the nonmobile scientist's yearly average number of publications coauthored with foreign scientists, but without mobile scientists. Controls include education level, gender, and years since first publication. We cluster standard errors at the individual level. The treatment group consists of nonmobile scientists who coauthored with mobile scientists. The treatment effect is estimated to occur after coauthoring with the first mobile scientist at time 0. Time 0 is when we observe the first coauthored publication between the nonmobile scientist and the mobile scientist. Each panel in the figure reports results for different numbers of unique mobile scientists with whom a nonmobile scientist coauthors with throughout their entire career, up to the point of data collection: only one (panel 1); exactly two (panel 2); exactly three (panel 3); and all numbers (panel 4).
Source: Authors' own elaboration based on CvLattes, CvLAC, and OpenAlex.

We next examine whether these effects change for different groups of nonmobile and mobile scientists. We first split nonmobile scientists between STEM and SSH. Figures 5 and 6 compare results for both subsamples, for Colombia and Brazil respectively.

We observe small differences between the two groups of fields or with respect to the average effects in Figures 5 and 6. In neither case is there a significant persistent effect in the years following the "mechanical" increases in publications with foreign coauthors in the year in which nonmobile scientists coauthor with the mobile scientists. However, the effect on STEM nonmobile scientists tends to be larger in the case of coauthoring with any number of mobile scientists both in Brazil and Colombia (panel 4).

When we remove the publications with mobile scientists and foreign coauthors (Figures 7 and 8), the positive effect of collaborating with at least one mobile scientist disappears, with the exception of SSH Brazilian scientists who collaborate with a large number of mobile scientists. The effect is very small though: SSH nonmobile Brazilian scientists publish 1-2 percent more publications with foreign authors (and no mobile coauthors) when they coauthor with more than three unique mobile scientists.

Next, we split mobile scientists into two groups: (i) intermittent and diaspora, and (ii) returnees.[29] We study the heterogeneous effect of nonmobile scientists coauthoring with the two different groups of mobile scientists on coauthoring with foreign scientists. Figures 9 and 10 compare results for Colombia and Brazil, respectively. As suggested by the OLS results, it is diaspora and intermittent mobile scientists who have a positive impact on the number of publications that nonmobile scientists publish with foreign scientists over time beyond the first year.

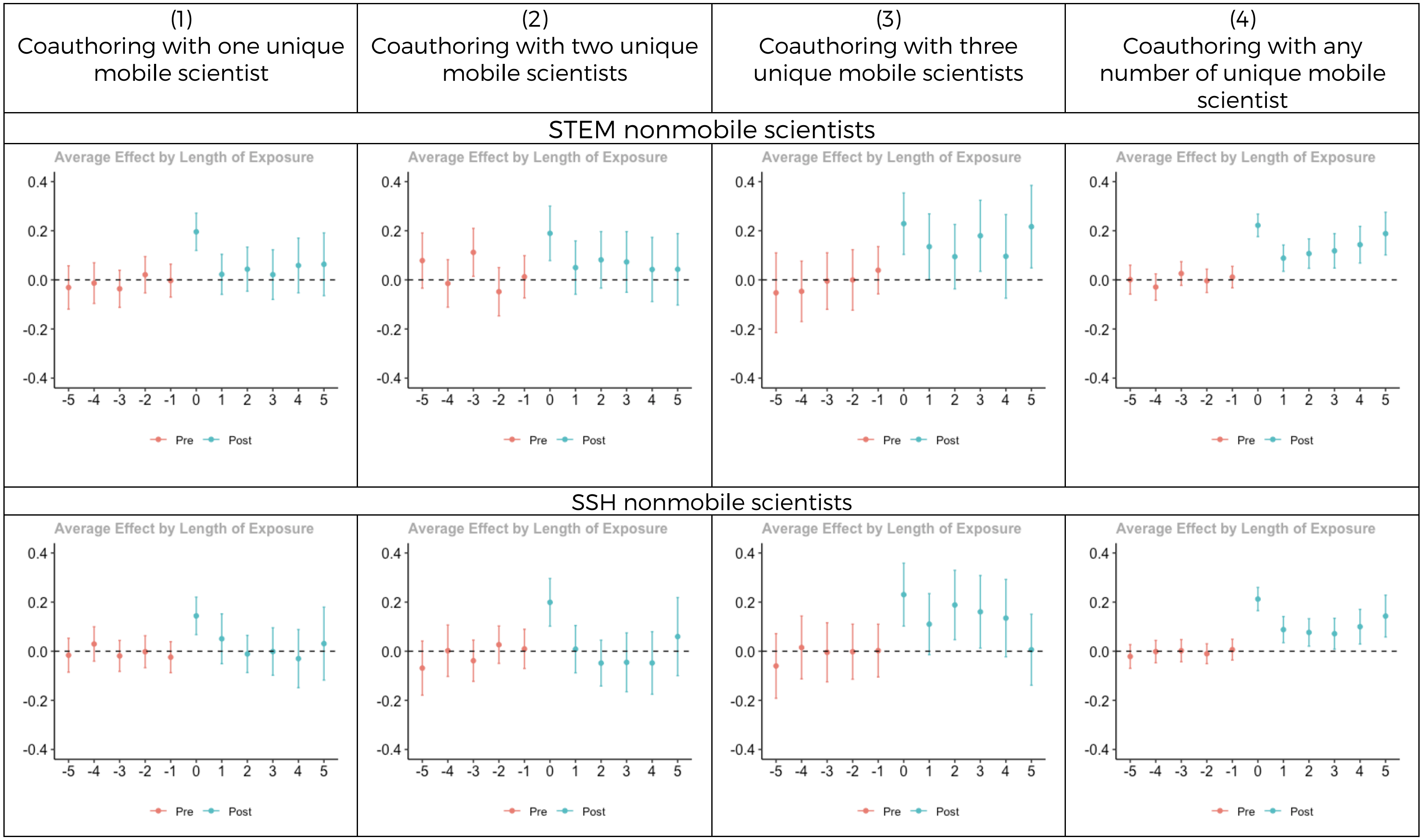
In the case of Colombia (Figure 9), because of the smaller sample size, the impact is not significant every year, although the probability of coauthoring more publications with foreign scientists is always positive when nonmobile scientists coauthor with multiple diaspora and intermittent mobile scientists.

[29] The number of mobile scientists in the diaspora group is too small to run DiD with only this sample.

In the case of Brazil (Figure 10), the difference in the impact of the two groups of mobile scientists on nonmobile scientists' collaborations with foreign scientists is more visible. Point estimates are in general higher for nonmobile scientists who coauthor with diaspora and intermittent mobile scientists (top panels) than for those who coauthor with returnee mobile scientists (bottom panel). Collaboration with diaspora and intermittent mobile scientists has also a more persistent effect over time than collaborations with returnee mobile scientists. When a nonmobile scientist coauthors with several unique mobile scientists who work abroad (for at least part of their time), they publish more with foreign scientists also in the five years following the first collaboration. When a nonmobile scientist coauthors with several unique mobile scientists who have come back to Brazil, they do not establish more collaborations with foreign scientists than the control group after the first year since coauthoring with the first mobile.

As such, there is no impact on the number of publications that a nonmobile scientist coauthors with foreign scientists, irrespective of the type of the mobile scientist with whom they coauthor once we remove the publications with the mobile scientists from the portfolio of the publications of nonmobile scientists with the foreign scientists (Figures 11 and 12). Nonmobile scientists may publish more papers in collaboration with foreign scientists than their nonmobile peers, and those who coauthor with returnees, but only when they join publications with diaspora and intermittent scientists coauthors.

Figure 5. Number of Publications With Foreign Coauthors (Log) Five Years Before and After First Treatment –STEM and SSH, Colombia



Notes: Results of a DiD analysis with multiple time periods (Equation 3). We investigate the impact of mobile scientists coauthoring with nonmobile scientists on the additional number of publications the nonmobile scientists coauthor with foreign scientists. We distinguish between STEM (top panels) and SSH (bottom panels) scientists. The dependent variable is the nonmobile scientist's yearly average number of publications coauthored with foreign scientists. Controls include education level, gender, and years since first publication. We cluster standard errors at the individual level. The treatment group consists of nonmobile scientists who coauthored with mobile scientists. The treatment effect is estimated to occur after coauthoring with the first mobile scientist at time 0. Time 0 is when we observe the first coauthored publication between the nonmobile and the mobile scientist. Each row panel in the figure reports results for different numbers of unique mobile scientists with whom a nonmobile scientist coauthors with throughout their entire career, up to the point of data collection: only one (panel 1); exactly two (panel 2); exactly three (panel 3); and all numbers (panel 4).
Source: Authors' own elaboration based on CvLattes, CvLAC, and OpenAlex.

Figure 6. Number of Publications With Foreign Coauthors (Log) Five Years Before and After First Treatment, STEM and SSH, Brazil

<table>
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Coauthoring with one unique mobile scientist</th><th>(2)
Coauthoring with two unique mobile scientists</th><th>(3)
Coauthoring with three unique mobile scientists</th><th>(4)
Coauthoring with any number of unique mobile scientist</th></tr>
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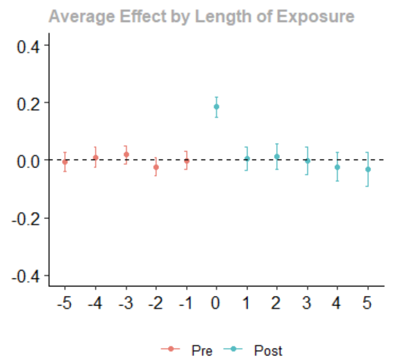
<td>
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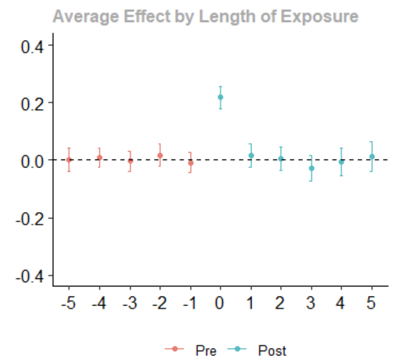
<td>
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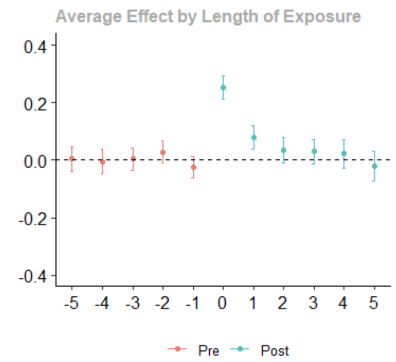
<td>
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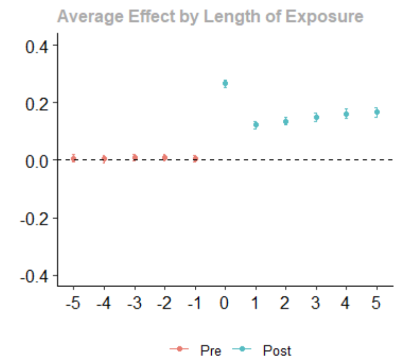
<td>
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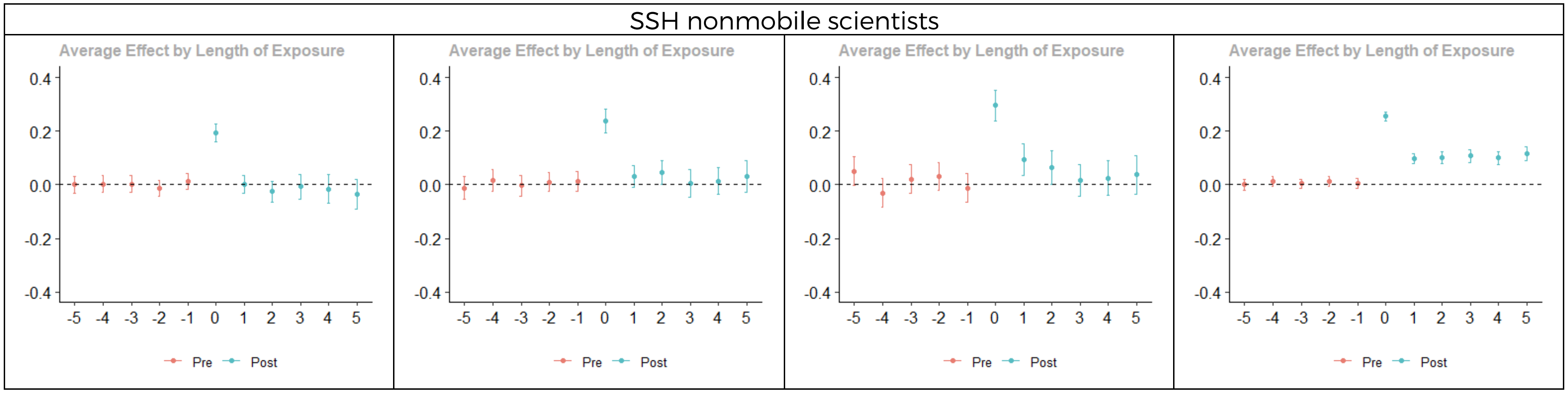
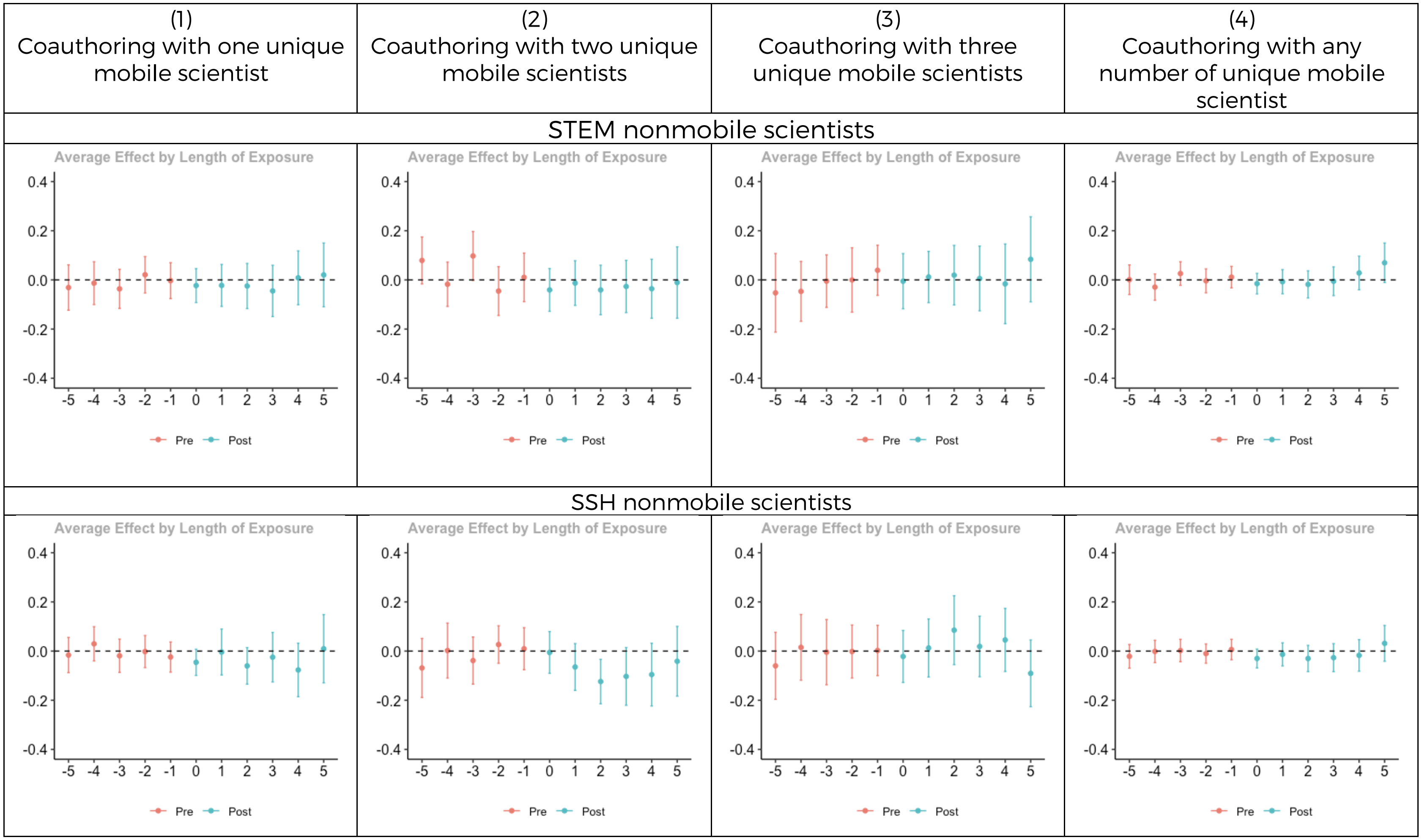


Notes: Results of a DiD analysis with multiple time periods (Equation 3). We investigate the impact of mobile scientists coauthoring with nonmobile scientists on the additional number of publications they coauthor with foreign scientists. We distinguish between STEM (top panels) and SSH (bottom panels) scientists. The dependent variable is the nonmobile scientist's yearly average number of publications coauthored with foreign scientists. Controls include education level, gender, and years since first publication. We cluster standard errors at the individual level. The treatment group consists of nonmobile scientists who coauthored with mobile scientists. The treatment effect is estimated to occur after coauthoring with the first mobile scientist at time 0. Time 0 is when we observe the first coauthored publication between the nonmobile and the mobile scientist. Each row panel in the figure reports results for different numbers of unique mobile scientists with whom a nonmobile scientist coauthors with throughout their entire career, up to the point of data collection: only one (panel 1); exactly two (panel 2); exactly three (panel 3); and all numbers (panel 4).
Source: Authors' own elaboration based on CvLattes, CvLAC, and OpenAlex.

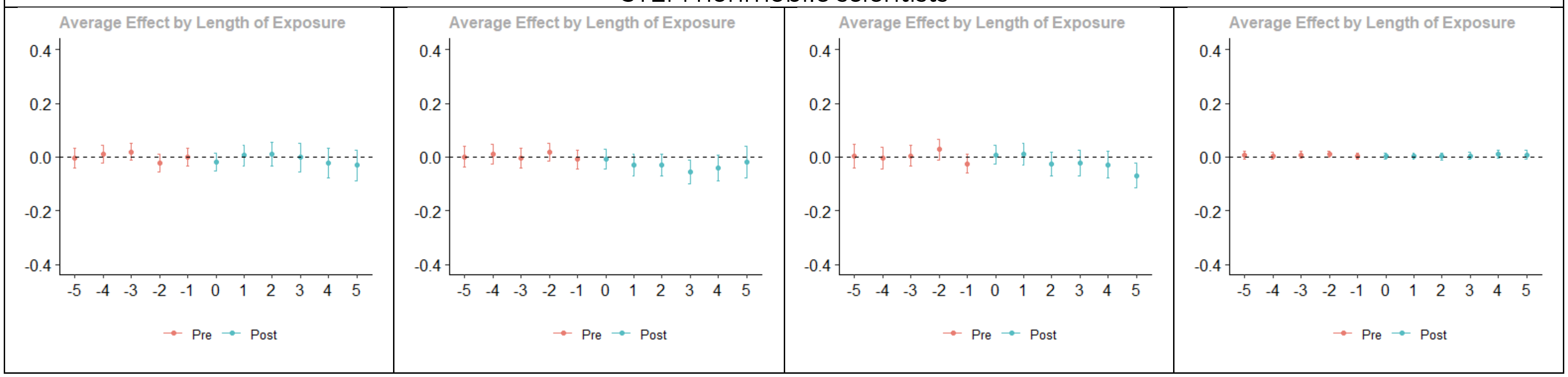
Figure 7. Number of Publications With Foreign Coauthors (Log) Five Years Before and After First Treatment, Excluding Publications With Mobile, STEM and SSH, Colombia



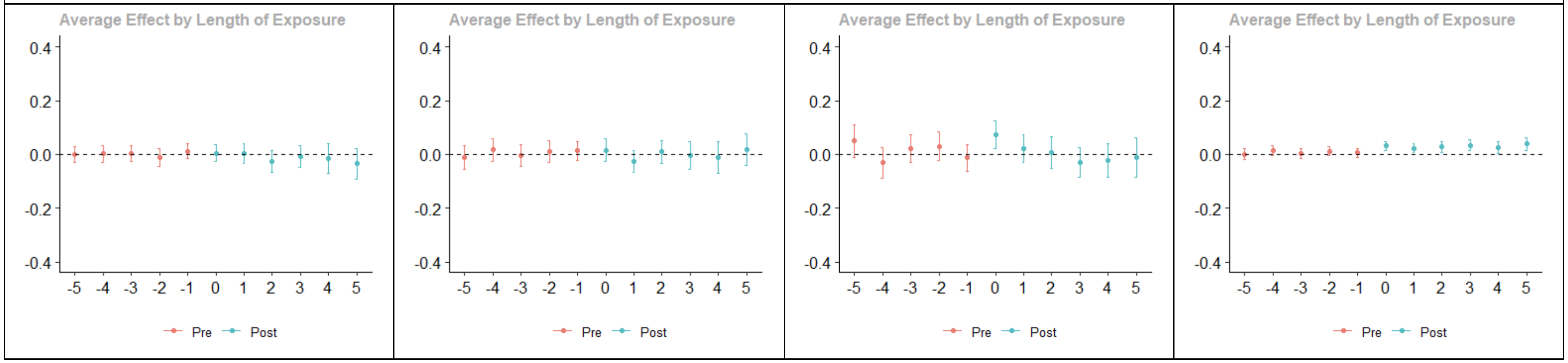
Notes: Results of a DiD analysis with multiple time periods (Equation 3). We investigate the impact of mobile scientists coauthoring with nonmobile scientists on the additional number of publications they coauthor with foreign scientists. We distinguish between STEM (top panels) and SSH (bottom panels) scientists. The dependent variable is the nonmobile scientist's yearly average number of publications coauthored with foreign scientists, but without mobile scientists. Controls include education level, gender, and years since first publication. We cluster standard errors at the individual level. The treatment group consists of nonmobile scientists who coauthored with mobile scientists. The treatment effect is estimated to occur after coauthoring with the first mobile scientist at time 0. Time 0 is when we observe the first coauthored publication between the nonmobile scientist and the mobile scientist. Each panel in the figure reports results for different numbers of unique mobile scientists with whom a nonmobile scientist coauthors with throughout their entire career, up to the point of data collection: only one (panel 1); exactly two (panel 2); exactly three (panel 3); and all numbers (panel 4).
Source: Author's own elaboration based on CvLattes, CvLAC, and OpenAlex.

Figure 8. Number of Publications With Foreign Coauthors (Log) Five Years Before and After First Treatment, Excluding Publications With Mobile, STEM and SSH, Brazil

(1) Coauthoring with one unique mobile scientist	(2) Coauthoring with two unique mobile scientists	(3) Coauthoring with three unique mobile scientists	(4) Coauthoring with any number of unique mobile scientist
STEM nonmobile scientists			

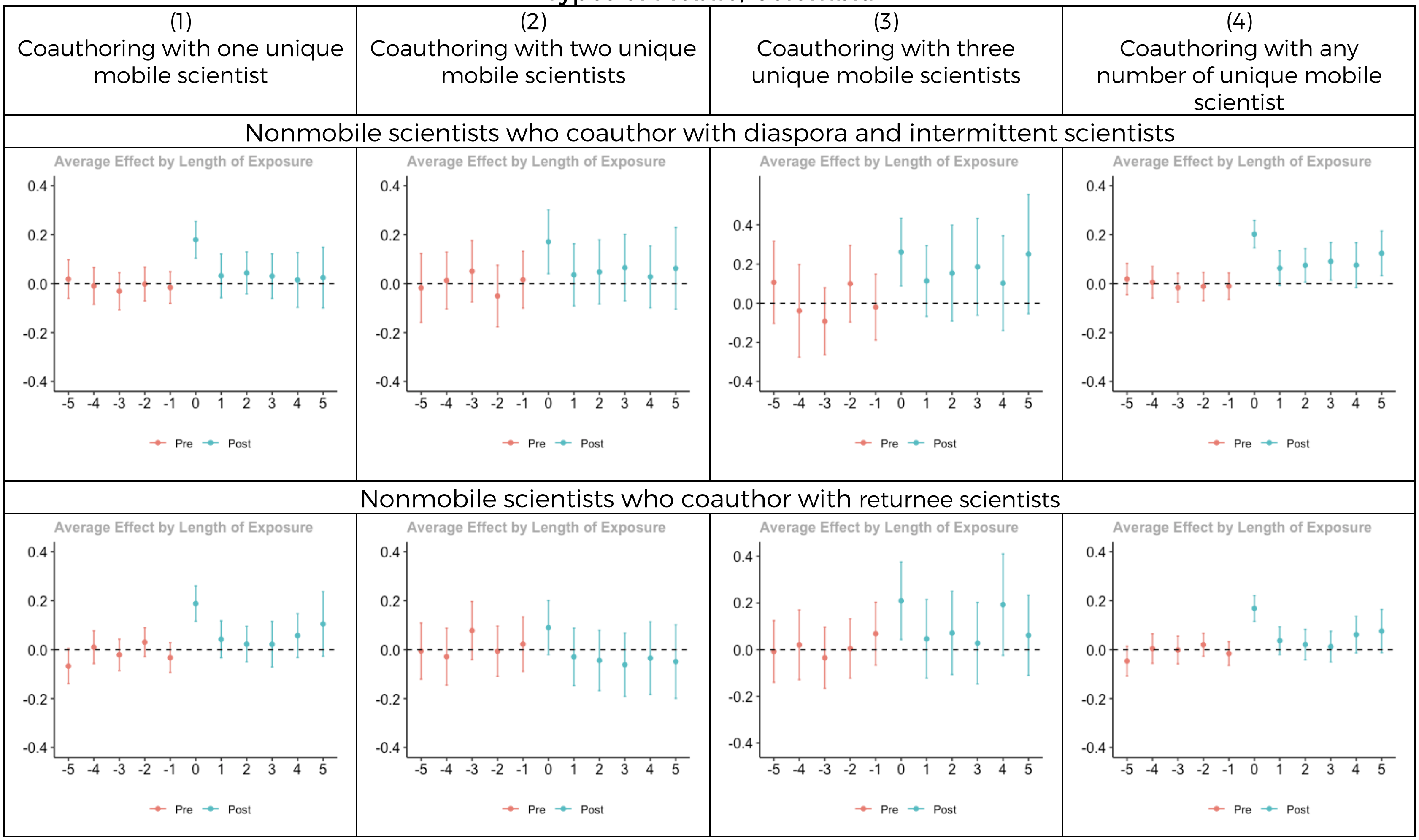


SSH nonmobile scientists



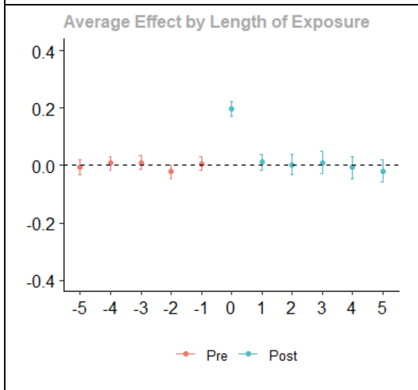
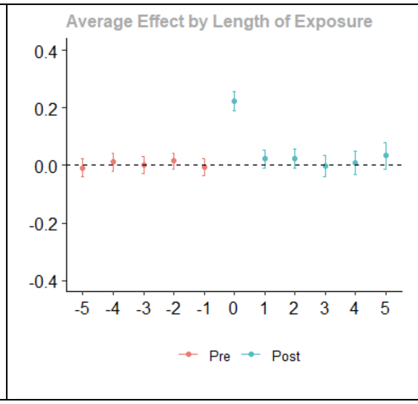
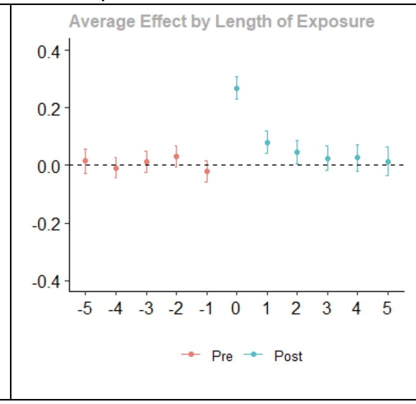
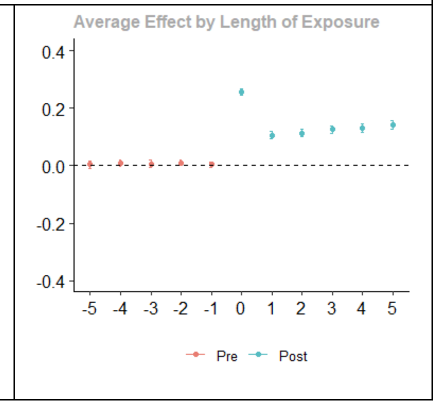
Notes: Results of a DiD analysis with multiple time periods (Equation 3). We investigate the impact of mobile scientists coauthoring with nonmobile scientists on the additional number of publications they coauthor with foreign scientists. We distinguish between STEM (top panels) and SSH (bottom panels) scientists. The dependent variable is the nonmobile scientist's yearly average number of publications coauthored with foreign scientists, but without mobile scientists. Controls include education level, gender, and years since first publication. We cluster standard errors at the individual level. The treatment group consists of nonmobile scientists who coauthored with mobile scientists. The treatment effect is estimated to occur after coauthoring with the first mobile scientist at time 0. Time 0 is when we observe the first coauthored publication between the nonmobile scientist and the mobile scientist. Each panel in the figure reports results for different numbers of unique mobile scientists with whom a nonmobile scientist coauthors with throughout their entire career, up to the point of data collection: only one (panel 1); exactly two (panel 2); exactly three (panel 3); and all numbers (panel 4).
Source: Authors' own elaboration based on CvLattes, CvLAC, and OpenAlex.

Figure 9. Number of Publications With Foreign Coauthors (Log) Five Years Before and After First Treatment, Different Types of Mobile, Colombia

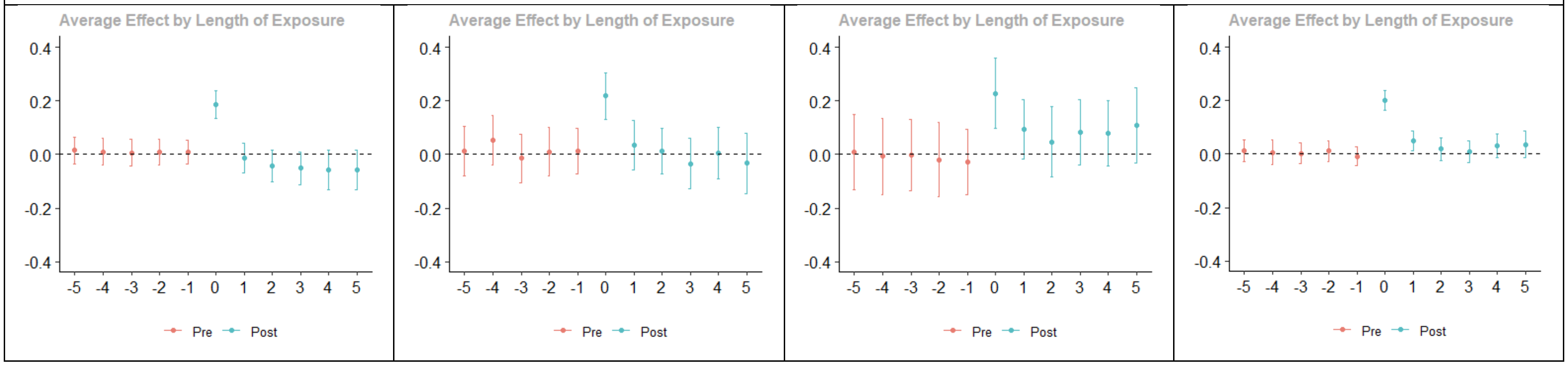


Notes: Results of a DiD analysis with multiple time periods (Equation 3). We investigate the impact of mobile scientists coauthoring with nonmobile scientists on the additional number of publications they coauthor with foreign scientists. We distinguish between nonmobile scientists who coauthor only with diaspora and intermittent mobile scientists (top panels) and only with returnee mobile scientists (bottom panels). The dependent variable is the nonmobile scientist's yearly average number of publications coauthored with foreign scientists. Controls include education level, gender, and years since first publication. We cluster standard errors at the individual level. The treatment group consists of nonmobile scientists who coauthored with mobile scientists. The treatment effect is estimated to occur after coauthoring with the first mobile scientist at time 0. Time 0 is when we observe the first coauthored publication between the nonmobile and the mobile scientist. Each panel in the figure reports results for different numbers of unique mobile scientists with whom a nonmobile scientist coauthors throughout their entire career, up to the point of data collection: only one (panel 1); exactly two (panel 2); exactly three (panel 3); and all numbers (panel 4).
Source: Authors' own elaboration based on CvLattes, CvLAC, and OpenAlex.

Figure 10. Number of Publications With Foreign Coauthors (Log) Five Years Before and After First Treatment, Different Types of Mobile, Brazil

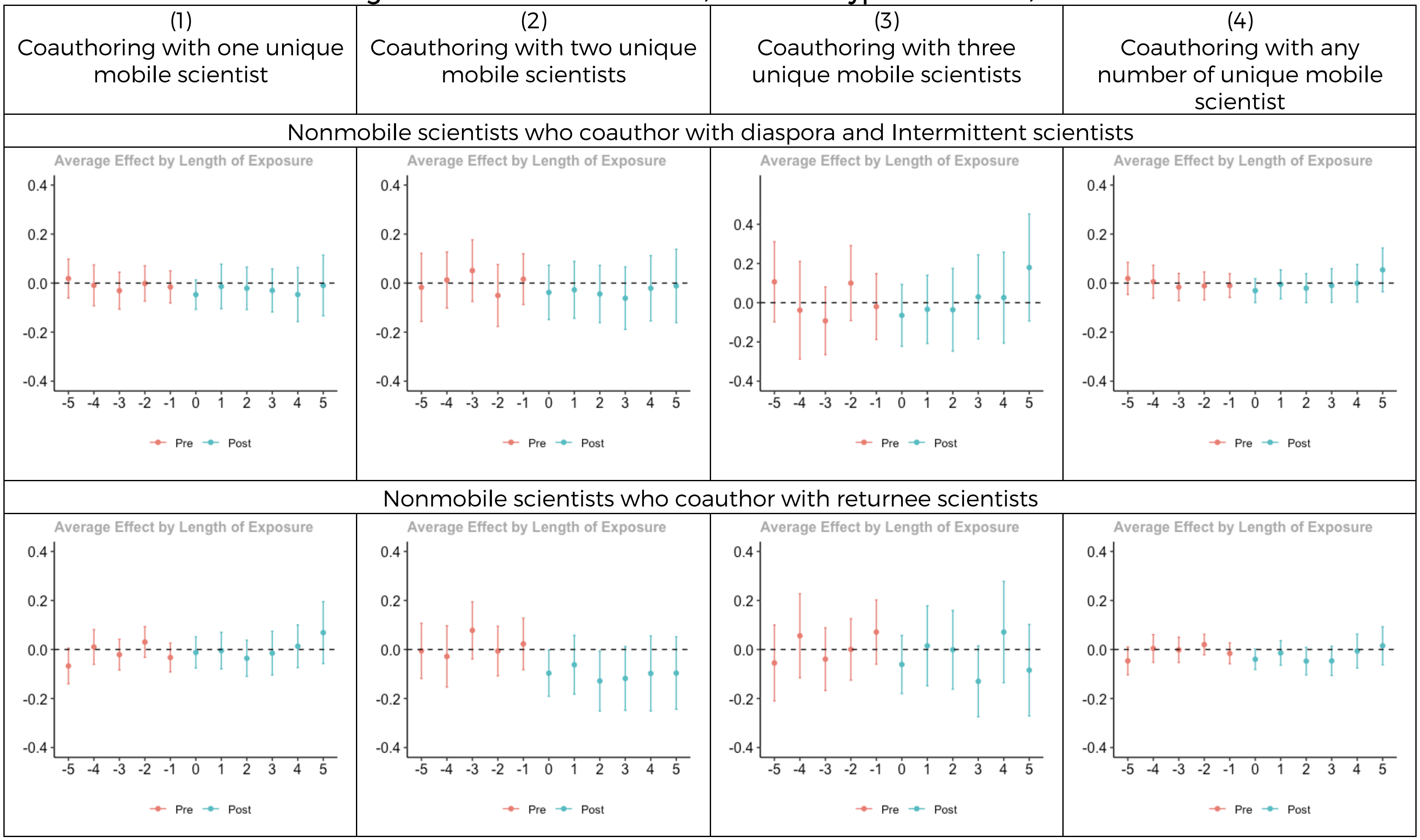
(1) Coauthoring with one unique mobile scientist	(2) Coauthoring with two unique mobile scientists	(3) Coauthoring with three unique mobile scientists	(4) Coauthoring with any number of unique mobile scientist
Nonmobile scientists who coauthor with diaspora and Intermittent scientists			
			

Nonmobile scientists who coauthor with returnee scientists



Notes: Results of a DiD analysis with multiple time periods (Equation 3). We investigate the impact of mobile scientists coauthoring with nonmobile scientists on the additional number of publications the nonmobile scientists coauthor with foreign scientists. We distinguish between scientists who coauthor only with diaspora and intermittent mobile (top panels) and only with returnee mobiles (bottom panels) scientists. The dependent variable is the nonmobile scientist's yearly average number of publications coauthored with foreign scientists. Controls include education level, gender, and years since first publication. We cluster standard errors at the individual level. The treatment group consists of nonmobile scientists who coauthored with mobile scientists. The treatment effect is estimated to occur after coauthoring with the first mobile scientist at time 0. Time 0 is when we observe the first coauthored publication between the nonmobile and the mobile scientist. Each panel in the figure reports results for different numbers of unique mobile scientists with whom a nonmobile scientist coauthors throughout their entire career, up to the point of data collection: only one (panel 1); exactly two (panel 2); exactly three (panel 3); and all numbers (panel 4).
Source: Authors' own elaboration based on CvLattes, CvLAC, and OpenAlex.

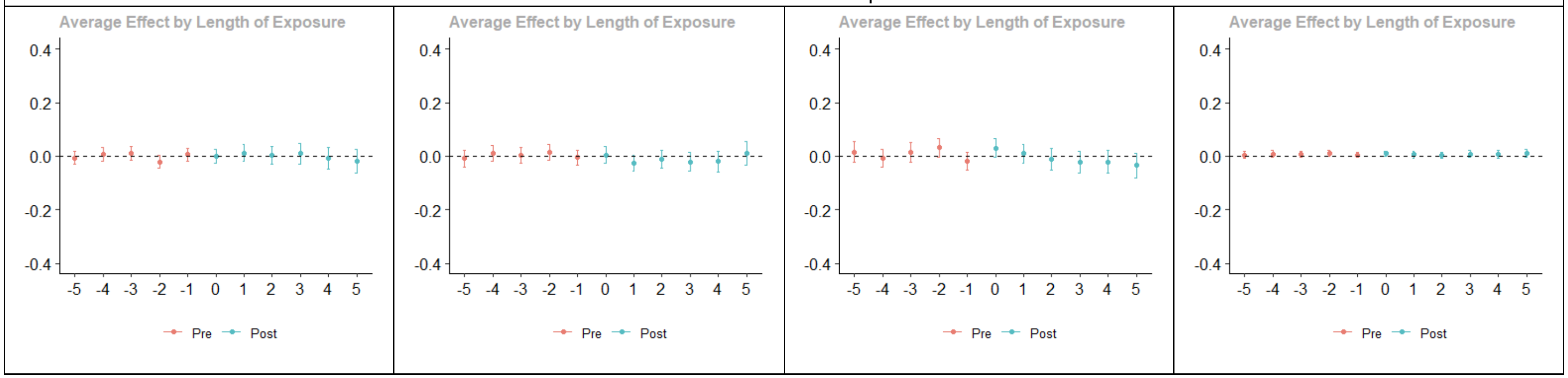
Figure 11. Number of Publications With Foreign Coauthors (Log) Five Years Before and After First Treatment, Excluding Publications With Mobile, Different Types of Mobile, Colombia

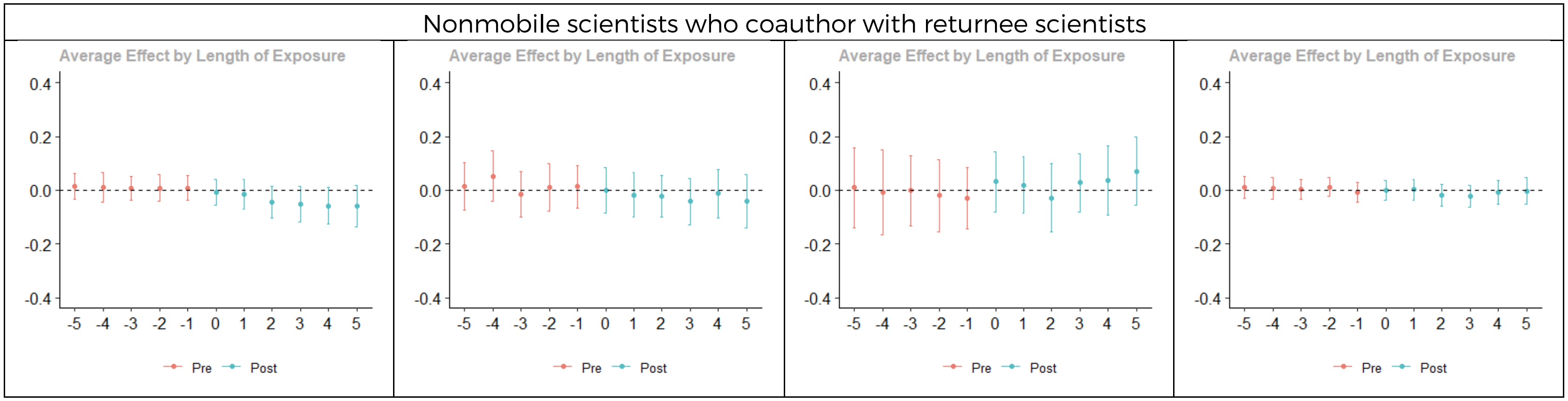


Notes: Results of a DiD analysis with multiple time periods (Equation 3). We investigate the impact of mobile scientists coauthoring with nonmobile scientists on the additional number of publications the nonmobile scientists coauthor with foreign scientists. We distinguish between scientists who coauthor only with diaspora and intermittent mobile scientists (top panels) and only with returnee mobile scientists (bottom panels). The dependent variable is the nonmobile scientist's yearly average number of publications coauthored with foreign scientists. Controls include education level, gender, and years since first publication. We cluster standard errors at the individual level. The treatment group consists of nonmobile scientists who coauthored with mobile scientists. The treatment effect is estimated to occur after coauthoring with the first mobile scientist at time 0. Time 0 is when we observe the first coauthored publication between the nonmobile and the mobile scientist. Each panel in the figure reports results for different numbers of unique mobile scientists with whom a nonmobile scientist coauthors throughout their entire career, up to the point of data collection: only one (panel 1); exactly two (panel 2); exactly three (panel 3); and all numbers (panel 4).
Source: Authors' own elaboration based on CvLattes, CvLAC, and OpenAlex.

Figure 12. Number of Publications With Foreign Coauthors (Log) Five Years Before and After First Treatment, Excluding Publications With Mobile, Different Types of Mobile, Brazil

(1) Coauthoring with one unique mobile scientist	(2) Coauthoring with two unique mobile scientists	(3) Coauthoring with three unique mobile scientists	(4) Coauthoring with any number of unique mobile scientist
Nonmobile scientists who coauthor with diaspora and Intermittent scientists			





Notes: Results of a DiD analysis with multiple time periods (Equation 3). We investigate the impact of mobile scientists coauthoring with nonmobile scientists on the additional number of publications they coauthor with foreign scientists. We distinguish between scientists who coauthor only with diaspora and intermittent mobile scientists (top panels) and only with returnee mobile scientists (bottom panels). The dependent variable is the nonmobile scientist's yearly average number of publications coauthored with foreign scientists. Controls include education level, gender, and years since first publication. We cluster standard errors at the individual level. The treatment group consists of nonmobile scientists who coauthored with mobile scientists. The treatment effect is estimated to occur after coauthoring with the first mobile scientist at time 0. Time 0 is when we observe the first coauthored publication between the nonmobile and the mobile scientist. Each panel in the figure reports results for different numbers of unique mobile scientists with whom a nonmobile scientist coauthors throughout their entire career, up to the point of data collection: only one (panel 1); exactly two (panel 2); exactly 3 (panel 3); and all numbers (panel 4).
Source: Authors' own elaboration based on CvLattes, CvLAC, and OpenAlex.

7. Discussion and Conclusions

In this paper, we have matched unprecedented (publicly available) Brazilian and Colombian data from CVs, scholarships, and scientific publications to study a simple question for which no evidence yet exists in the literature: do mobile scientists connect nonmobile scientists from their country of origin to foreign scientists located abroad? We use panel fixed effects estimations, controlling for a large number of observable characteristics that influence collaborations between nonmobile and foreign scientists. To further isolate the effect of the mobile scientists, we use an event study approach. Our results are consistent throughout: increasing the number of mobile scientists with whom nonmobile scientists copublish increases the number (and share) of publications that nonmobile scientists coauthor with foreign scientists. Results are remarkably similar for Brazil and Colombia.

First, the average nonmobile scientist from Brazil and Colombia is more likely to coauthor a publication with a foreign scientist if they have published at least once with a mobile scientist from their country of origin. As the number of unique mobile scientists with whom nonmobile scientists coauthor increases, the probability of coauthoring with foreign scientists also rises. Second, the number of collaborations by nonmobile scientists with mobile scientists is positively associated with the share and number of publications that nonmobile scientists coauthor with foreign scientists. The association is higher when controlling for individual fixed effects. On average, nonmobile scientists from Colombia and Brazil increase by 10 percent and 12 percent, respectively, the number of their publications coauthored with foreign scholars when the number of mobile scientists with whom they collaborate doubles. Nonmobile scientists in STEM gain slightly less from the interaction with mobile scientists, but only in Colombia and only when we do not control for nonobservable characteristics of the nonmobile scientists. This suggests that (in Colombia) STEM nonmobile scientists' larger international network of foreign coauthors is to some extent independent from the collaboration with mobile scientists.

Mobile scientists can be grouped as diaspora, intermittent, and returnees, and their impact on nonmobile scientists varies by these groups. Coefficients are significantly larger for diaspora and intermittent scientists than they are for returnees. This result contributes to the debate on brain drain: scientists who work abroad may be more beneficial to their country of origin than returnees are, at least in terms of increasing the number of publications of nonmobile scientists with foreign scientists. This result is likely due to the larger network of foreign collaborators that Colombian and Brazilian scientists abroad maintain with the foreign scientists.

Our DiD event study identification strategy confirms the OLS results. However, they qualify these results, raising a concern. The effects on "internationalization" of nonmobile scientists from a small number of collaborations with mobile scientists are short-lived. The benefits are strongly localized in precisely the period in which the mobile and nonmobile scientists collaborate. We show that the positive effect of collaborating with mobile scientists is the result of a collaboration among mobile, nonmobile, and foreign scientists as coauthors of the same publication(s). The impact remains statistically significant beyond the first year only for nonmobile scientists who diversify their network of mobile scientists (at least three) with whom they coauthor. However, this is the case only because nonmobile scientists participate in projects and publications with mobile scientists and foreign scientists also in the following year, not because they extend their network of foreign collaborators more than their peers do.

Our overarching message is that mobile scientists play a relevant role in the internationalization of middle-income countries' scientific systems. Our results contribute to the literature regarding international scientific mobility by showing a strong pattern of mobile scientists from Brazil and Colombia serving as bridges connecting home and foreign scientific systems. Also, adding to the "brain drain versus brain circulation" debate, we show that sending and having scientists abroad may not necessarily be harmful to the home countries sending them but rather may positively impact nonmobile scientists of a country. However, our results suggest that positive results are rather short term and depend on a regular interaction between nonmobile scientists and their mobile peers, which raises the question of whether steps can be taken to extend their effects.

Results point to some policy recommendations that, given the robustness of our results across two very dissimilar countries, are likely to be generalizable across middle-income countries. First, sponsoring mobility schemes is important as the mobility of some scientists also allows their nonmobile peers to connect to international research. Second, the conditions that a home country applies to mobile scientists returning from a PhD abroad may need to be more flexible, as diaspora and intermittent scientists play a larger role in connecting nonmobile scientists to foreign scientists and other countries (in Brazil). Nonetheless, it is also imperative that national governments engage their scientific communities abroad, to increase the role of mobile scientists. For example, national governments can create funding lines to bring back their mobile scientists from abroad for short periods. For instance, these mobile scientists could offer workshops or become involved in research.

This paper has several limitations that need to be addressed in future research. First, we do not capture short visiting periods that scientists spend abroad. Second, we are not able to identify all mobile scientists who never returned to academic life in Brazil or Colombia. Third, the bibliometric data used do not capture the entire portfolio of many scientists. Given that many Brazilian and Colombian scientists publish in local journals that are not indexed in OpenAlex, we miss some of their publications. Fourth, Brazil and Colombia have different graduate systems. While Brazil has a well-established doctoral program system, Colombia is still building up its system. As a consequence, mobility programs tend to be different in these two countries: Colombia emphasizes more full doctoral programs, while Brazil focuses on short visits during PhD programs. For future studies including other countries in Latin America, it is fundamental to consider the types of mobility policies given the structure of the graduate system in the home countries. Fifth, along the same lines, home countries with a well-established PhD system within the country might face some of their trained researchers moving abroad after the doctoral training, thus it would be interesting to investigate the effects of mobile scientists who obtained a PhD abroad versus those who were awarded the PhD in the home country and moved abroad after doctoral training. Finally, an interesting extension of our study would be to investigate the impacts of increased access to foreign collaboration for the nonmobile scientists and the national science system at large.

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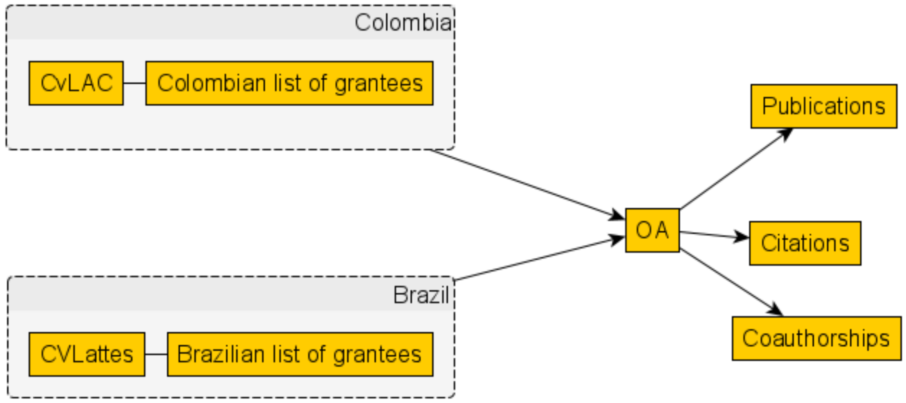
Appendix 1. Database Construction Procedure

To assemble our database for analysis, we integrated two CV databases: CvLattes for Brazil and CvLAC for Colombia, lists of students granted scholarships for PhDs abroad, and OpenAlex. CvLattes is the official Brazilian database of researchers, managed by Brazil's National Council for Scientific and Technological Development (CNPq), and CvLAC is the official Colombian database of researchers, managed by the Ministry of Science. These databases incorporate information on education history, employment history, projects, and self-reported publications. As some researchers who do their PhD abroad and do not go back to their country of origin are unlikely to fill in their CVs in CvLattes and CvLAC, we also identified grantees of PhD scholarships to study abroad from the CNPq and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) in Brazil, and the Ministry of Science, Colfuturo, and Fulbright in Colombia. These were matched or added to CvLattes and CvLAC by using fuzzy matching of names of researchers and manual checks. Finally, OpenAlex (noted in the figures as OA) is a global bibliographic database with a coverage of 211 million research documents to May 2022. We use OpenAlex instead of self-reported publications in CvLattes and CvLAC to validate the information in the CVs with an external source, and to be able to identify the network of coauthorships that is absent in CvLattes, in CvLAC, and in the lists of grantees. Figures A1 to A10 show an overview of our procedure. Figure A11 and A12 further illustrate an overview of database construction.

Figure A1. Overview of Databases Used for Our Analysis



The aim of our procedure was to correctly identify each person in our databases of Brazilian (BrazilDB) and Colombian researchers (ColDB) with a person in OpenAlex (OA). BrazilDB organizes the names of Brazilian PhD holders and students (with or without scholarship), and ColDB organizes the names of Colombian PhD holders, PhD students (with or without scholarship), and nonPhD holders with at least three publications in CvLAC. The initial number of persons in BrazilDB is 139,655 and in ColDB 28,729.[30] While in BrazilDB and ColDB, each person has a unique identifier, OpenAlex is more focused on the lists of publications and does not have a reliable way to identify an author. This means that an author can have different identifiers, even though the different identifiers are the same person. This poses a big challenge when trying to match a set of names in BrazilDB and ColDB because we cannot rely on OpenAlex's own identifiers. To circumvent this problem, we had to follow a set of author name disambiguation strategies. They are as follows

1. Author name fuzzy match
2. ORCID match
3. Title fuzzy match
4. Bibliographic information match
5. DOI match
6. Selection of matches based on quality

[30] These represent the number of scientists identified in CvLAC, Lattes, and scholarship lists before the matching in OpenAlex.

7. Additional search of records for quality matches based on self-citations, common coauthors, ORCIDs, and same title
8. Extract the records from OpenAlex
9. Build sample for analysis

Figures A2 and A3 show the whole procedure for Brazil and Colombia. The metadata available for Colombia was larger than for Brazil. For this reason, we performed more types of searches. We explain each step of the process in the following subsections.

Figure A2. Database Construction Procedure for Brazil

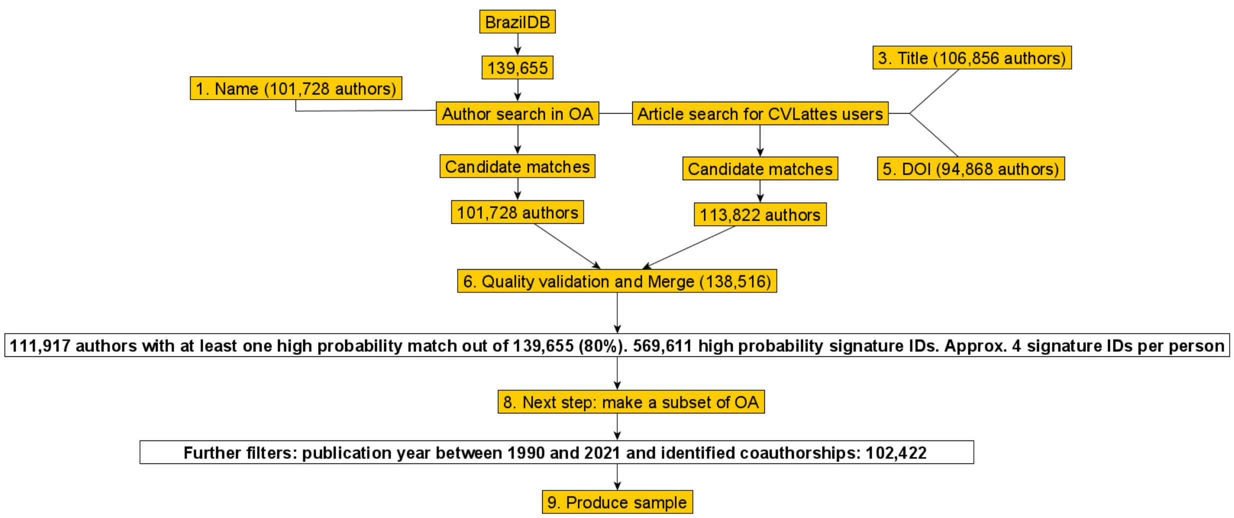
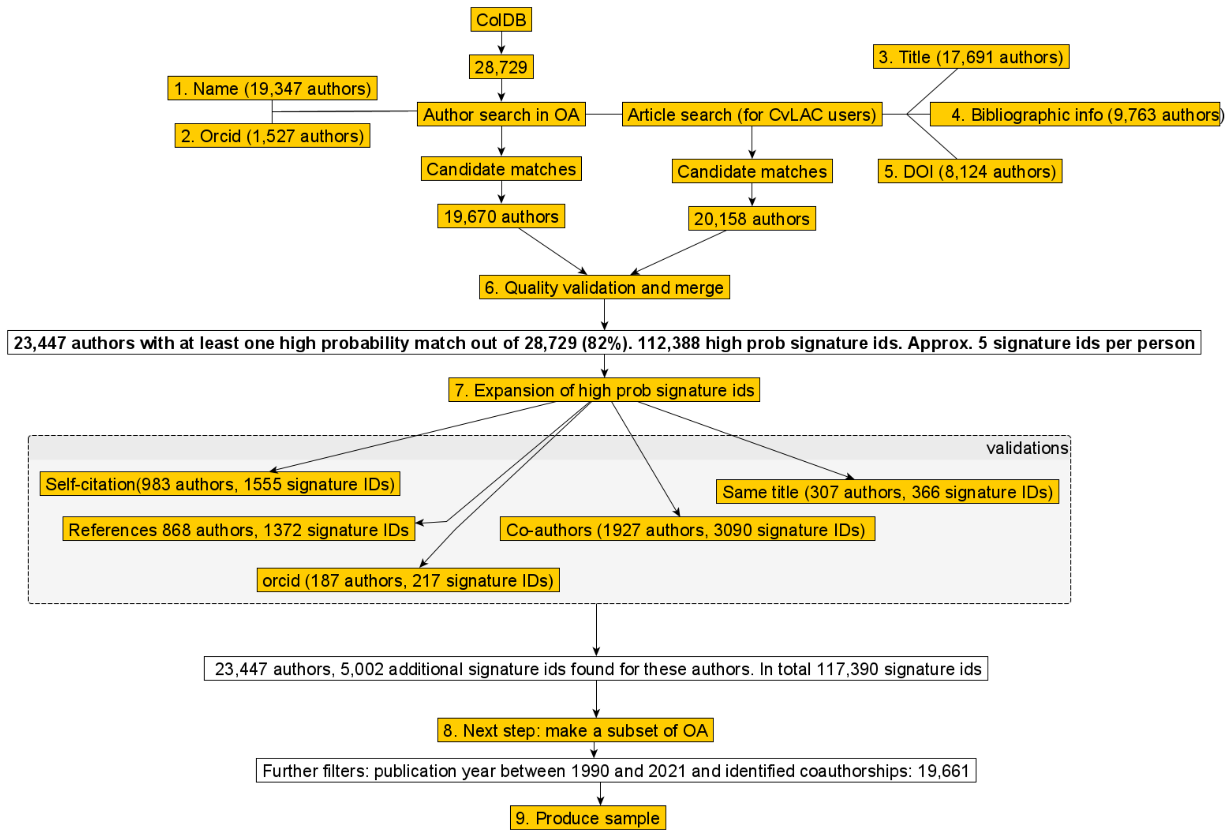


Figure A3. Database Construction Procedure for Colombia

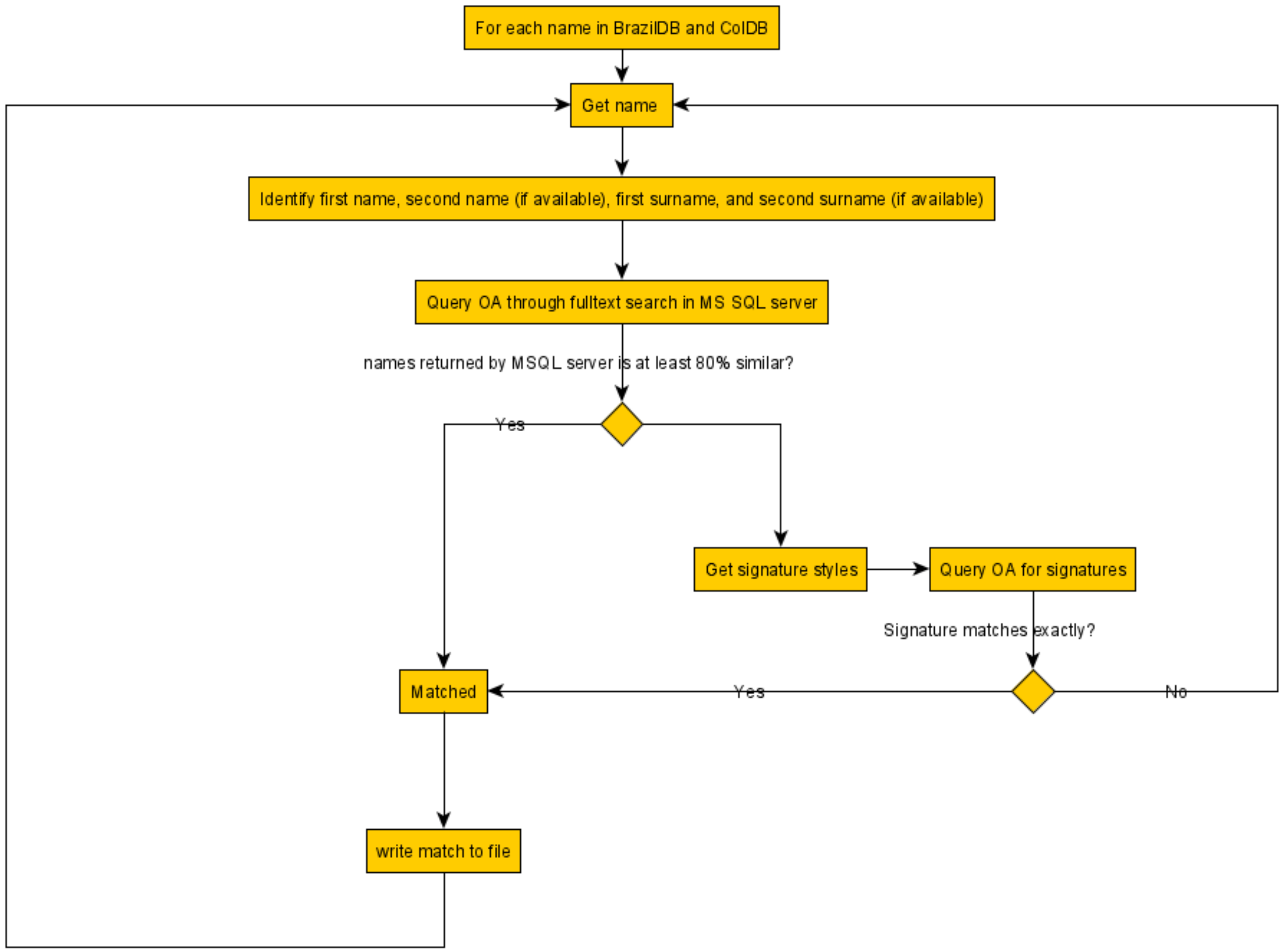


Author Name Match

The databases BrazilDB and ColDB were matched to OpenAlex author names. The algorithm used fuzzy match and exact match of different ways in which names can appear. We identified variations of a name, as it is common to find different ways to report a name in the affiliation field of OpenAlex. We call these different ways to write a name a "signature." For instance, the hypothetical researcher Rodrigo Jiménez Caijiao can be found as R. Jiménez Caijiao or R. J. Caijiao, among other variations. We consider each variation of the name a signature. Because signatures are abbreviations of the names, we only considered exact matches of signatures where the signature was composed of at least four words and did the match word by word. Afterward we merged all unique signatures found and selected the records in OpenAlex for those authors. In many cases, different signatures are identified by OpenAlex as different authors, and thus OpenAlex assigns a different author id. Our aim to identify the different signatures that belong to the same author but have different author ids was to overcome this limitation of OpenAlex.

In the fuzzy match case, we set a threshold of 80 percent or more similarity of full names. In the exact match of signatures, we included 30 possible combinations of name signatures: complete name as it appears in BrazilDB and ColDB, and different signature styles such as full first name and full first surname, initial of first name and full surname, and so on. The algorithm is as follows:

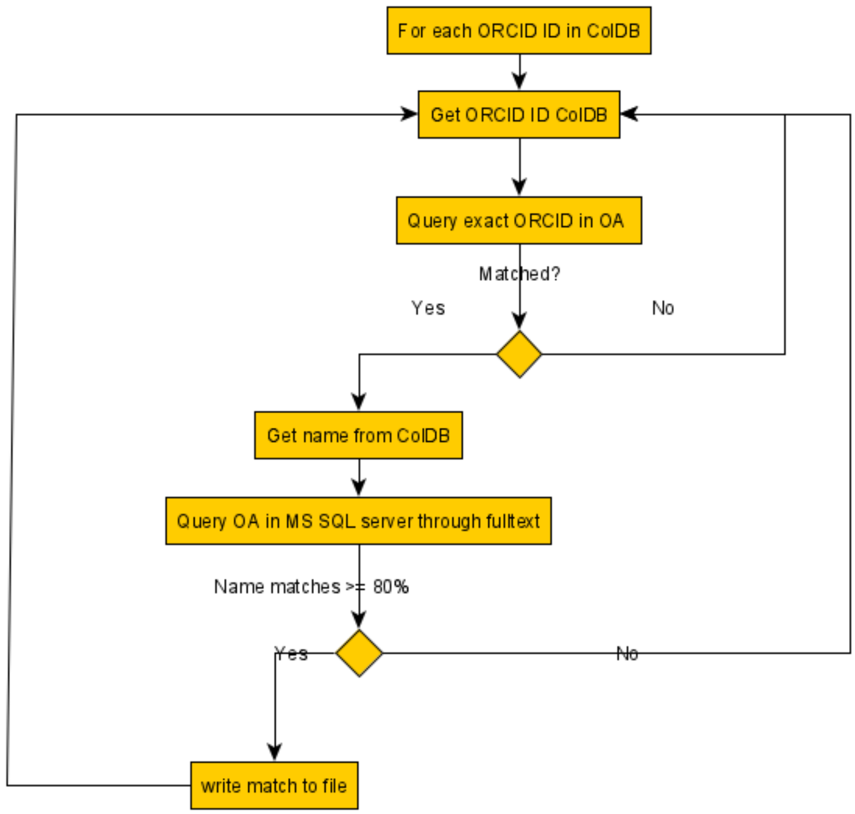
Figure A4. Algorithm for Name Match



ORCID Exact Match

Records with an ORCID identifier were matched against OpenAlex. We performed an exact match of ORCIDs, but because ORCIDs can be either wrongly assigned or mistyped, we also checked that the ORCIDs in ColDB and OpenAlex were at least 80 percent similar. This was only performed for Colombia as the information was not available for Brazil. The algorithm is as follows:

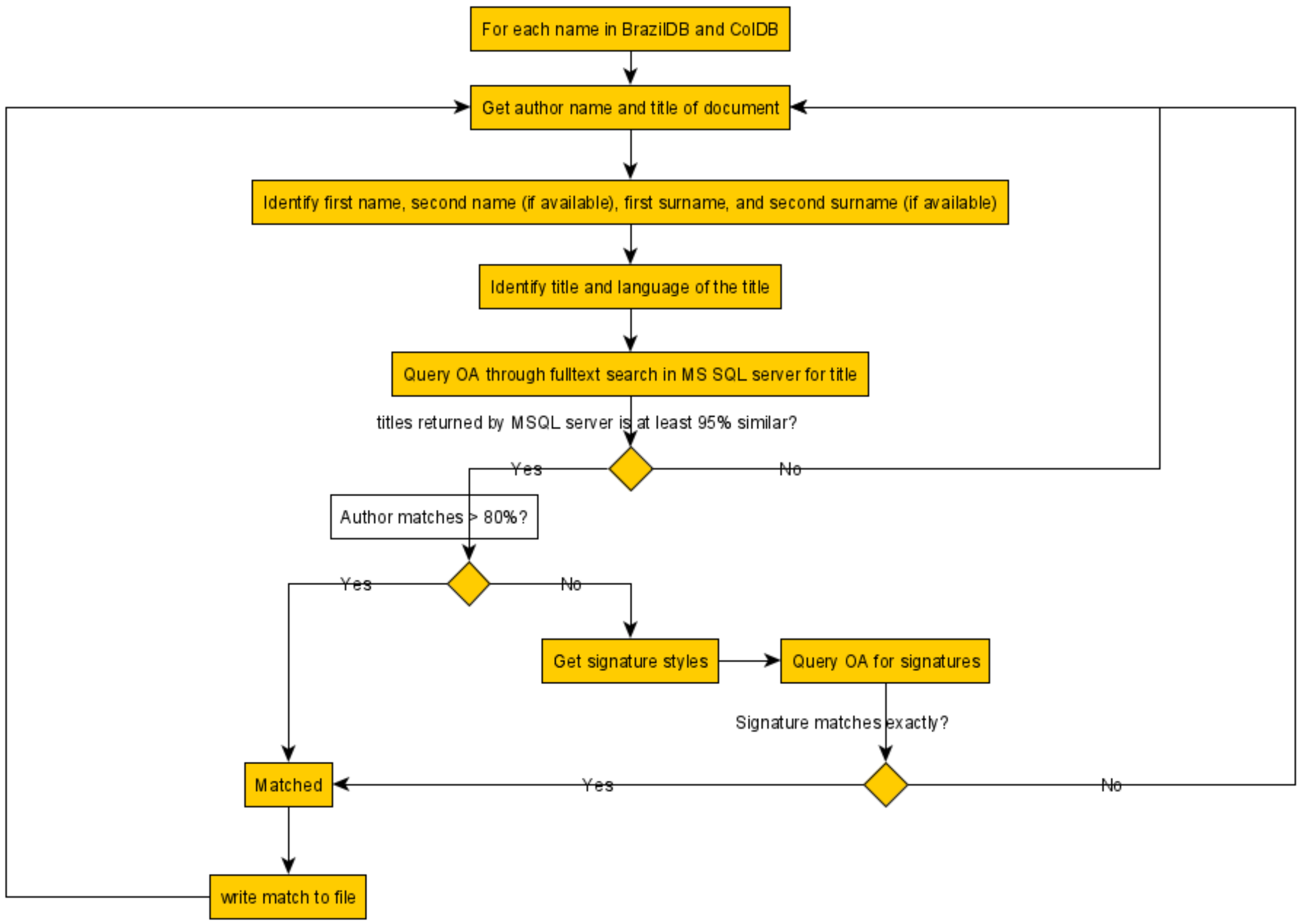
Figure A5. Algorithm for ORCID Match*



Title Match

The main idea in using titles to match persons in BrazilDB and ColDB with OpenAlex is to use the self-reported information on publications to disambiguate names in OpenAlex. The title of each publication in CvLAC or CvLattes was matched with titles in OpenAlex, and author names were checked. Additionally, as publications can be written in different languages, we identified the language of the publication and queried OpenAlex using full-text queries in that specific language. After that, we performed a similarity check of titles retrieved and author names and signature styles.

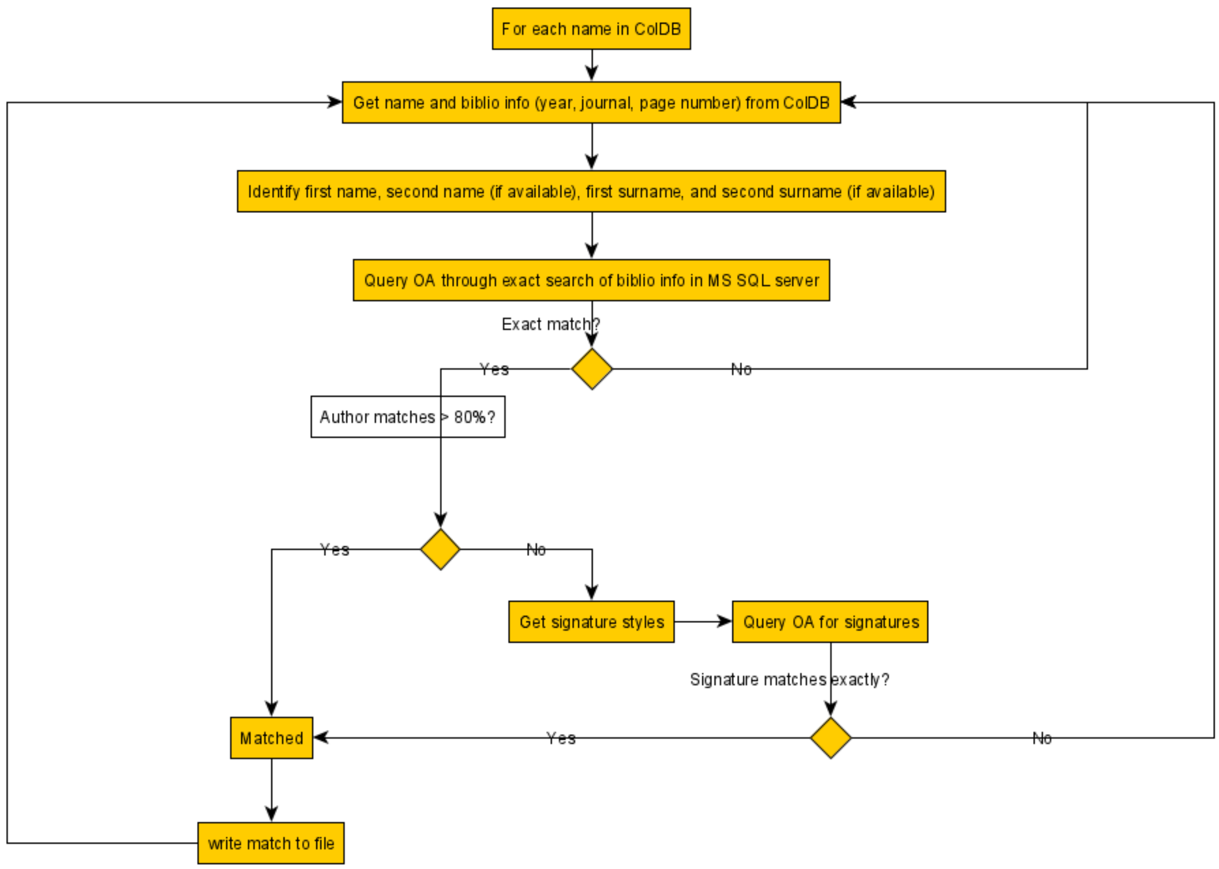
Figure A6. Algorithm for Title Match



Bibliographic Information Match

To search for those publications that have titles translated into English in OpenAlex and titles that may be short and for that reason any typographical error can produce a great percentage of dissimilarity when compared to titles in CvLAC or CvLattes, we also searched for bibliographic information that could help us to identify the publications regardless of their titles. We used journal title, year, and beginning page number for this purpose. This was only performed for Colombia because of information availability. Additionally, we checked that the author in CvLAC or CvLattes was in the list of authors in OpenAlex. The algorithm is as follows:

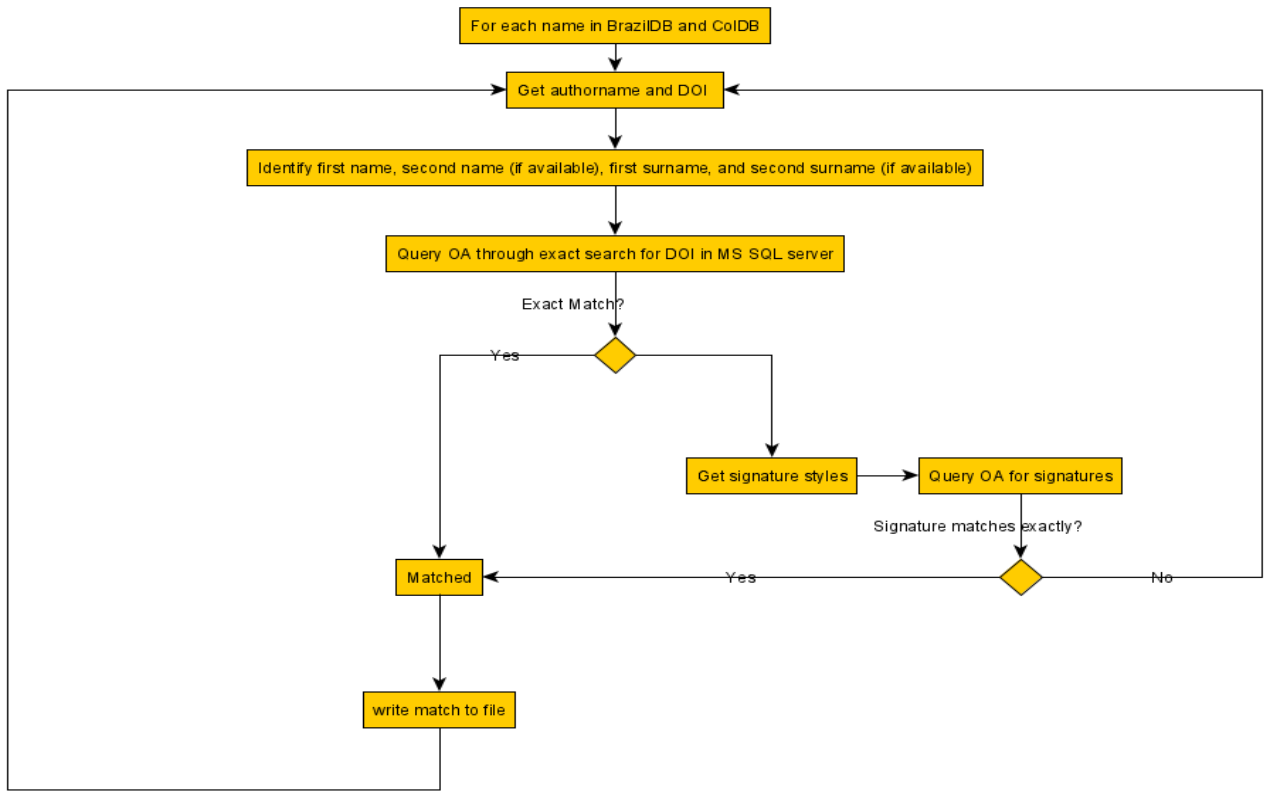
Figure A7. Algorithm for Bibliographic Information Match



DOI Match

This match is based on the Digital Object Identifier (DOI), and additionally it checks that the author in CvLAC and CvLattes is in the list of authors in OpenAlex.

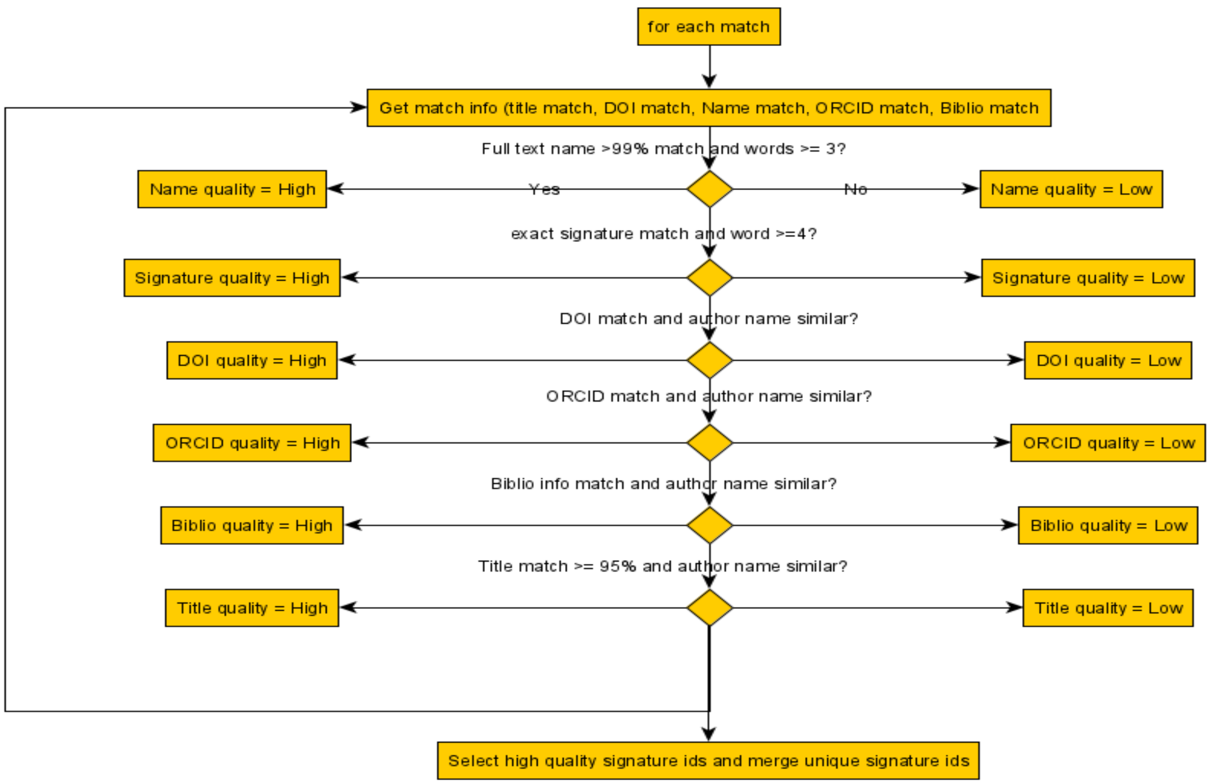
Figure A8. Algorithm for DOI Match



Selection of Matches Based on Quality

The previous algorithms produced different sets of authors' signature identifications in OpenAlex. However, some of these matches can be false positives. To reduce the probability of false positives, we classified each match as high quality or low quality. Matches based on unique identifiers such as DOI and ORCID have the highest quality. Then, for titles, only those that matched more than 95 percent and had a match with an author were considered high quality. For bibliographic information, publications matching exactly those which had a match with an author were considered high quality. Finally, for author names, we only considered either a 99 percent or higher match of author names that were composed of at least three names. This was done letter by letter. Additionally, as noted earlier for Author Name matches, we identified variations of names, called "signatures," and addressed those variations.

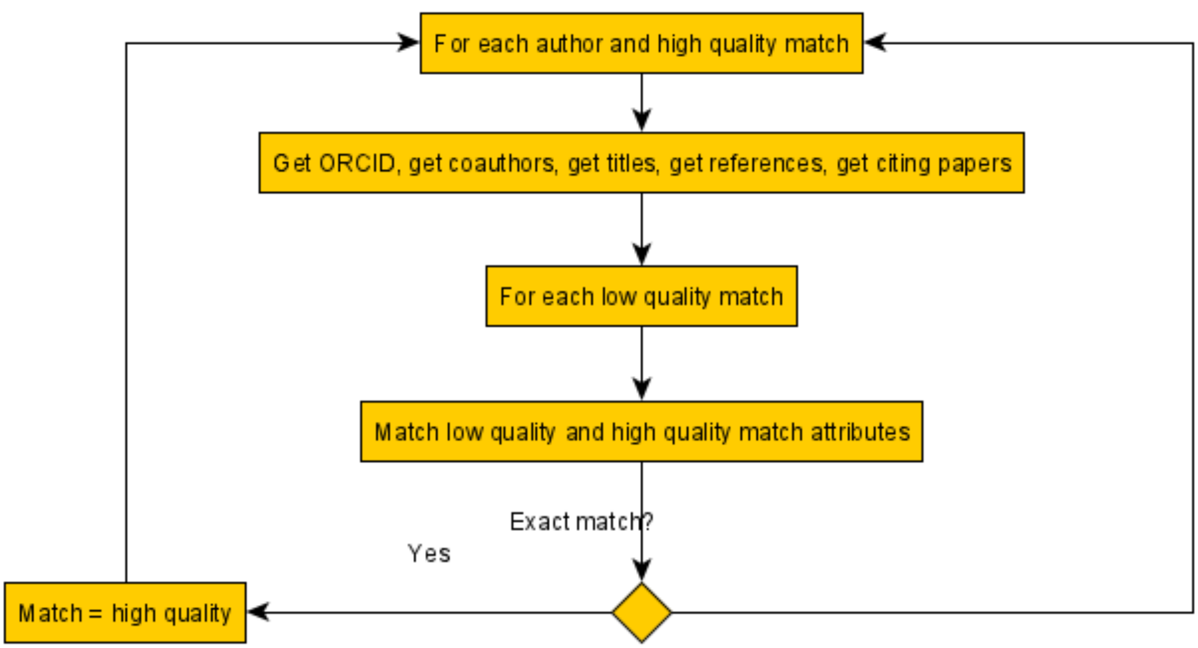
Figure A9. Algorithm for Selection Based on Quality of Matches



Additional Search of Records for Quality Matches

We used the attributes of high-quality matches for each author to identify more signatures in their low-quality matches. The aim was to expand the identification of publications of people based on their high-quality matches, to validate those cases in which the names did not reach more than 99 percent similarity. For those cases in which the name is similar but not exact, we used: self-citations, titles that match exactly but with an author name match below 99 percent, ORCIDs found through 100 percent name matches, and lists of coauthors. This was only performed for Colombia. The algorithm is as follows:

Figure A10. Algorithm for Expansion of High Quality of Matches



Subset of OpenAlex

The author name disambiguation and matching process allowed us to identify the Brazilian and Colombian scientists in OpenAlex and collect their bibliometric information. This information was used to build datasets containing titles of academic publications, the OpenAlex author and document unique identifiers (IDs), coauthors, and citations. Also, to identify the scientists' FOS, we used the bibliometric information on the fields assigned to academic publications. For those scientists with publications in different fields, we assumed their fields by observing the field in which they had the highest share of publications.

Appendix 2. Identifying Nationalities and Mobility Patterns

In the previous step, we identified scientists who were in CvLAC and CvLattes and their coauthors. Nonetheless, we did not have information on the mobility categories and whether their coauthors were locals or foreigners. To tackle this issue, we reconstructed scientists' mobility patterns from their affiliations in their academic publications and/or academic and working background from CvLAC. For the Brazilians, we only had access to OpenAlex data. For the Colombians with a CvLAC, we used information on projects, grants, and teaching courses to determine if the scientists were still working in the country. We also relied on the affiliations in academic publications to check scientists' mobility patterns. For some coauthors, we could not identify their nationalities through CvLattes or CvLAC; we decided to follow two strategies to solve this issue. The first was to use the affiliations in the academic publications. The second was to check whether the names of scientists were in line with the recurring names in Brazil and Colombia.

Appendix 3. Sample for Main Analysis

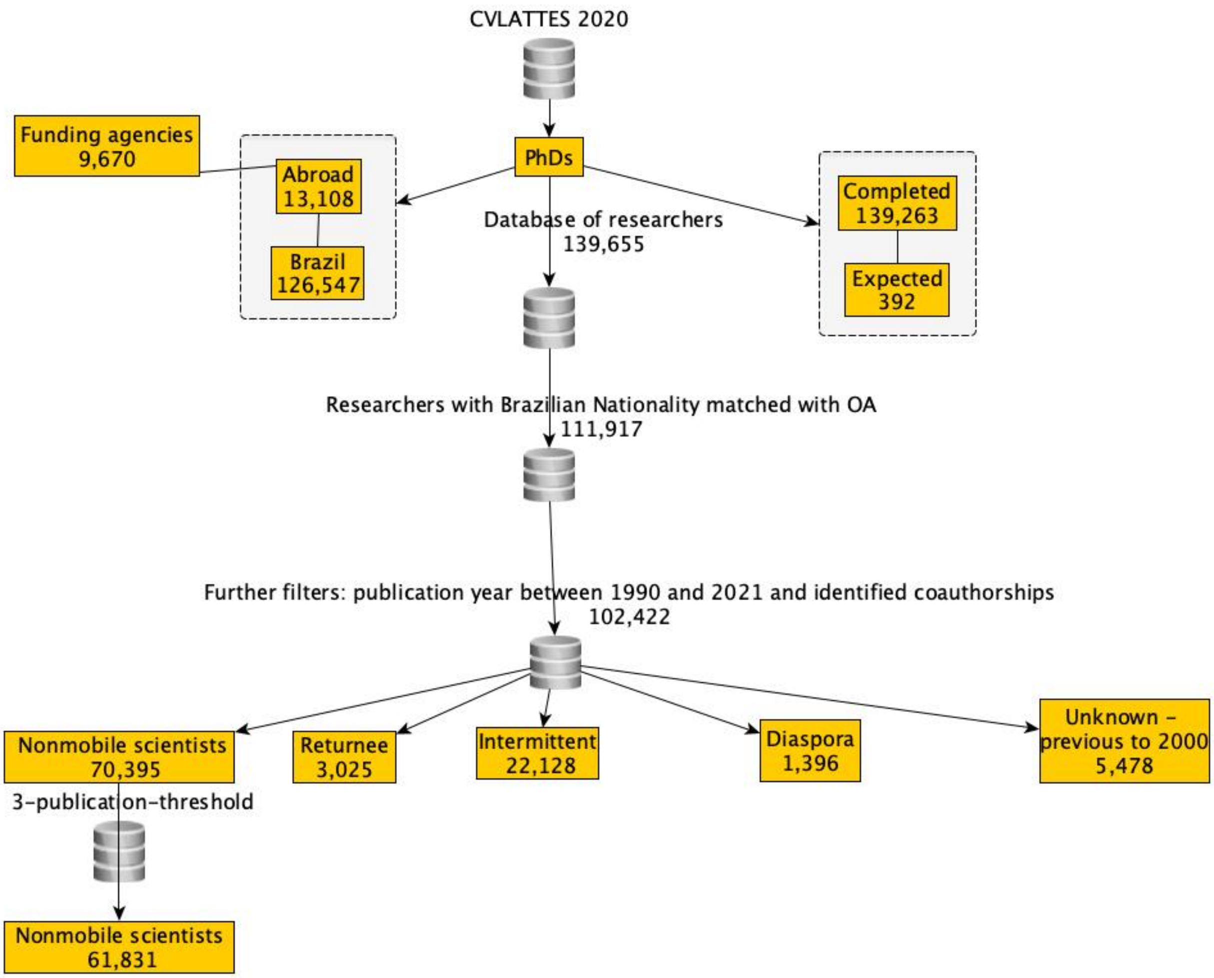
The previous two steps allowed us to identify the Colombian and Brazilian scientists, categorize them and their coauthors, and gather bibliometric information about these scientists and their coauthors. For our third step, we constructed the final datasets for analysis.

Given that the main objective of this paper is to observe whether there is a spillover of foreign scientists from mobile scientists to nonmobile scientists, we needed to observe the number of copublications with foreign scientists before and after the first interaction between mobile and nonmobile scientists. We decided to construct these figures in two forms. First, we determined the total number of foreign scientists before and after, independent of if they are repeated. Second, we determined the total number of foreign scientists before and the number of new scientists after the interaction (in the form of copublication). It is important to mention that we set a time range. We chose the year 1990 as the initial year for the first publication and 2021 for the last year to copublish with a foreign scientist. The reason for 1990 is that our sample concentrated most between 1990 and 2021.

Database Description

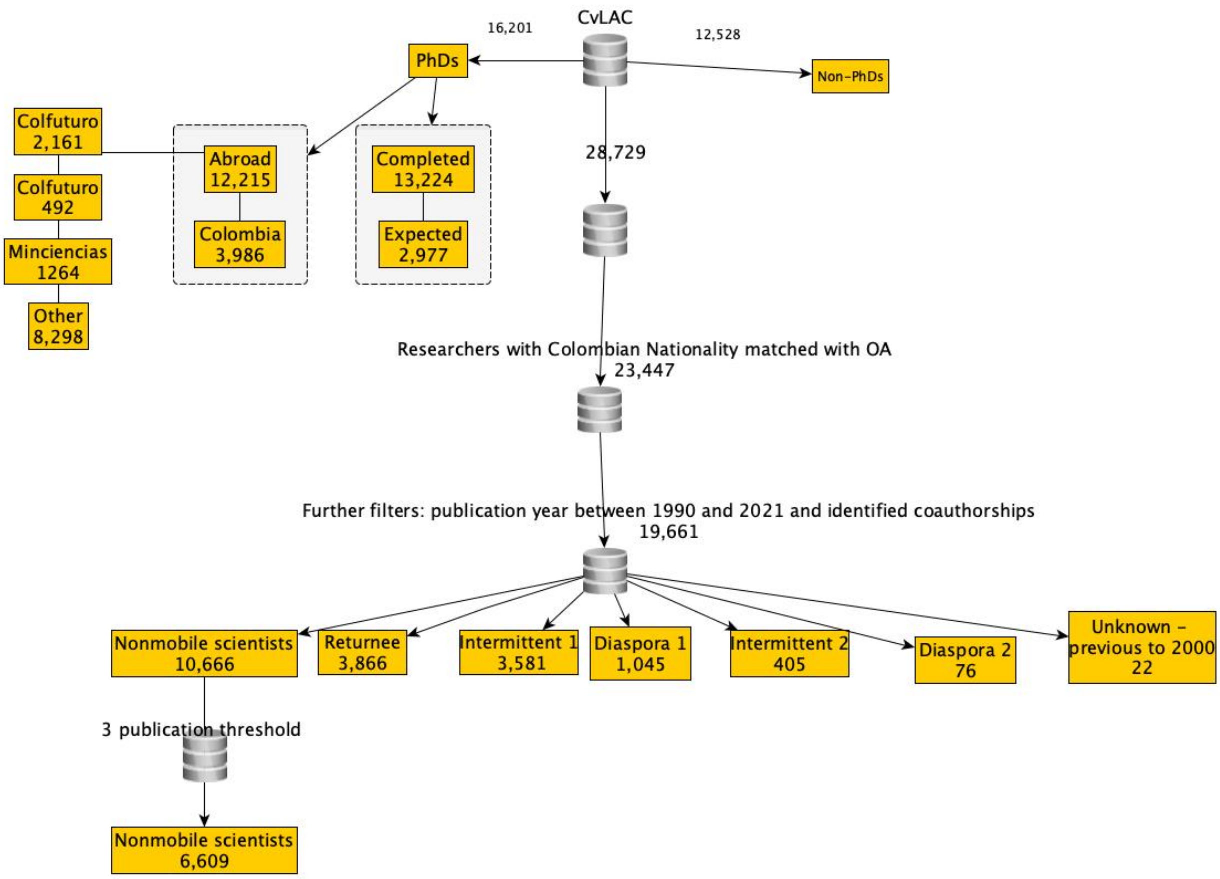
Appendix 1 describes Brazil and Colombia's data cleaning and matching process results. The full process and the final databases are illustrated in Figures A11 and A12. Also, Tables A1 and A2 present the number of scientists by mobility pattern and gender. Tables A3 and A4 present the distribution of scientists by fields and mobility pattern.

Figure A11. Overview of Database Construction for Brazil



Notes: This figure illustrates the sample figures before and after the identification process in OpenAlex, and before selecting the final sample for analysis. Initially, there were 139,655 Brazilian nationals with a PhD (or expected PhD). After the identification process in OpenAlex and further filters (e.g., publications only between 1990 and 2021), we identified 102,422 Brazilian researchers. Out of these, we classified scientists according to the categories of mobile and nonmobile scientists.
Source: Authors' own elaboration.

Figure A12. Overview of Database Construction for Colombia



Notes: This figure illustrates the sample figures before and after the identification process in OpenAlex. Initially, there were 16,201 Colombian nationals with a PhD or a Master's. After the identification process in OpenAlex and further filters (e.g., publications only between 1990 and 2021), we identified 19,661 Colombian researchers. Out of this, we classified scientists according to the categories of mobile and nonmobile scientists. Minciencias refers to the Ministry of Science (Ministerio de Ciencia, Tecnología e Innovación), which was identified in Section 4.1.1, along with Colfuturo.
Source: Authors' own elaboration.

Table A1. Number of Brazilian Scientists Identified in OpenAlex by Mobility Pattern and Gender

(1)		(2)			(3)	(4)
Mobility pattern		Gender			Total	% of Total
		Female	Male	X		
Mobile	Diaspora	675	697	24	1,396	1%
	Intermittent	9,479	12,269	380	22,128	24%
	Returnee	1,113	1,851	61	3,025	3%
Total mobile		11,267	14,817	465	26,549	28%
Nonmobile		32,454	28,234	1,143	61,831	66%
Other	Unknown	29	2,453	125	5,478	6%
Grand total		43,750	45,504	1,733	93,858	100.0%

Notes: Column 1 refers to the distinction between mobile researchers (who work for at least one year abroad) and nonmobile researchers (who completed their PhD in Brazil and did not go abroad during the observed period). All individuals have either completed their PhD or are expected to complete it during the period of observation.
Source: Authors' own elaboration based on CvLattes, scholarship lists, and OpenAlex.

Table A2. Number of Colombian Scientists Identified in OpenAlex by Mobility Pattern, Education Level, and Gender

(1)		(2)	(3)			(4)	(5)
Mobility pattern		Education level	Gender			Total	% of Total
			F	M	X		
Mobile	Diaspora	PhD	417	623	5	1,045	7%
	Intermittent	PhD	1,358	2,223	0	3,581	23%
	Returnee	PhD	1,320	2,546	0	3,866	25%
	Total mobile		3,095	5,392	5	8,492	54%
Nonmobile		PhD	907	1,363	0	2,270	15%
		Master's	1,864	2,475	0	4,339	28%
	Total nonmobile		2,771	3,838	0	6,609	42%
Other	Diaspora2	PhD	28	48	0	76	0%
	Intermittent2	PhD	150	255	0	405	3%
	Unknown	PhD	9	13	0	22	0%
	Total other		187	316	0	503	3%
Grand Total			6,053	9,546	5	15,604	100.0%

Notes: Column 1 differentiates between mobile (those who did their PhD abroad) and nonmobile (those who did their PhD or master's degree in Colombia and reported more than three publications in CvLAC and did not have a foreign affiliation for more than one year in our period of observation). Diaspora2 and Intermittent2 are scientists who did their PhD in Colombia and moved abroad after; we drop these scientists from the analysis in the paper. In column 3, F refers to female, M to male, and X to nonbinary / other.
Source: Authors' own elaboration based on CvLAC, scholarship lists, and OpenAlex.

Table A3. Distribution of Brazilian Scientists by Field and Mobility Pattern

(1)	(2)	(3)			(4)	(5)	(6)	(7)
Groups	Fields	Mobility pattern			Nonmobile	U	Total	% of total
		D	I	R				
STEM	Medicine	259	544	220	12,489	888	14,400	15%
	Biology	284	4,844	371	11,181	760	17,440	19%
	Chemistry	125	2,959	182	6,908	543	10,717	11%
	Computer science	104	1,542	335	3,177	281	5,439	6%
	Materials science	90	1,464	200	3,013	270	5,037	5%
	Environmental science	62	748	145	2,036	162	3,153	3%
	Mathematics	17	282	80	894	79	1,352	1%
	Physics	23	429	50	680	136	1,318	1%
	Geology	12	224	77	643	41	997	1%
	Engineering	4	19	15	117	31	186	0%
	Total STEM	980	17,951	1,675	41,138	3,191	64,935	69%
SSH	Political science	92	911	343	4,727	557	6,630	7%
	Sociology	91	750	269	5,162	479	6,751	7%
	Psychology	56	757	157	3,233	325	4,528	5%
	Geography	90	720	197	2,818	317	4,142	4%
	Art	39	266	138	2,224	271	2,938	3%
	Business	29	509	109	1,443	152	2,242	2%
	Philosophy	8	129	73	723	122	1,055	1%
	Economics	10	135	60	358	31	594	1%
	History	1	0	1	5	2	9	0%
	Total SSH	416	4,177	1,347	20,693	2,256	28,889	31%
Other	Not identified	0	0	3	0	31	34	0%
Grand total		1,396	22,128	3,025	61,831	5,478	93,858	100.0%

Notes: The grouping of FOS is given as well as FOS: Field of Science level 0 (a classification used by Microsoft Research) assigned to the relative majority of publications of a scientist. Mobility pattern: “D”=diaspora, “I”=intermittent, and “R”=returnee. “U” = unknown.
Source: Authors’ own elaboration based on CvLattes, scholarship lists, and OpenAlex.

Table A4. Distribution of Colombian Scientists by Field and Mobility Pattern

(1)	(2)	(3)			(4)	(5)			(6)	(7)
Groups	Fields	Mobile			Nonmobile	Other			Total	% of total
		D1	I1	R		D2	I2	U		
STEM	Biology	171	452	317	771	14	55	3	1783	11%
	Computer science	103	338	403	716	11	41	3	1615	10%
	Medicine	77	228	212	720	5	36	2	1280	8%
	Chemistry	98	293	217	474	10	55	4	1151	7%
	Materials science	58	173	137	209	7	26	0	610	4%
	Environmental science	43	152	147	228	3	12	1	586	4%
	Mathematics	12	97	115	105	2	6	0	337	2%
	Physics	18	76	88	100	2	13	2	299	2%
	Engineering	14	65	80	87	0	8	0	254	2%
	Geology	12	30	31	36	1	3	0	113	1%
	Total STEM	731	2288	2189	3446	60	283	15	9012	58%
SSH	Geography	125	384	442	681	5	28	0	1665	11%
	Political science	79	332	421	725	5	23	2	1587	10%
	Art	59	266	382	432	3	38	0	1180	8%
	Business	72	261	318	391	1	22	3	1068	7%
	Psychology	40	147	181	391	2	8	0	769	5%
	Philosophy	17	135	164	226	2	16	1	561	4%
	Sociology	22	92	127	246	2	11	1	501	3%
	Economics	20	42	64	64	1	3	0	194	1%
	History	5	18	20	7	0	1	0	51	0%
	Total SSH	314	1293	1677	3163	16	122	7	6592	42%
	Grand total	1045	3581	3866	6609	76	405	22	15604	100.0%

Notes: FOS: Field of Science level 0 (a classification used by Microsoft Research) assigned to the relative majority of publications of a scientist. Mobility pattern: “D”=diaspora, “I”=intermittent, “R”=returnee; “D1”=diaspora with a PhD abroad, and “I1”=intermittent with a PhD abroad,“D2”=diaspora with a Colombian PhD, “I2”=intermittent with a Colombian PhD, and U is unknown. Source: Authors’ own elaboration based on scholarship lists and OpenAlex.

Appendix 4. Event Study

To conduct the event study, we have filtered scientists in the treatment group according to characteristics we were investigating in different specifications (e.g., STEM nonmobile scientists with any number of collaborations with mobile scientists). We have also tested the similarity of treatment and control groups before the treatment. The first part of Appendix 4 shows the event study sample figures (Tables A5 and A6) and the second part of Appendix 4. describes the t-tests procedure.

Event Study Samples

Tables A5 and A6 illustrate the number of scientists in the treatment and control groups used in different specifications for Colombia and Brazil, respectively.

Table A5. Colombian Sample in the Event Studies

	(1)	(2)	(3)	(4)
		Sample	Treatment group	Control group
Full sample	Coauthorship with any number of mobile scientists	3,321	2,318	1,003
	Coauthorship with one unique mobile scientist	1,756	753	1,003
	Coauthorship with two unique mobile scientists	1,507	504	1,003
	Coauthorship with three unique mobile scientists	1,314	311	1,003
STEM scientists	Coauthorship with any number of mobile scientists	1,631	1,164	467
	Coauthorship with one unique mobile scientist	861	394	467
	Coauthorship with two unique mobile scientists	711	244	467
	Enc Coauthorship ounter with three unique mobile scientists	631	164	467
SSH scientists	Coauthorship with any number of mobile scientists	1,690	1,154	536
	Coauthorship with one unique mobile scientist	895	359	536
	Coauthorship with two unique mobile scientists	796	260	536
	Coauthorship with three unique mobile scientists	683	147	536
Coauthor with diaspora/intermittent	Coauthorship with any number of mobile scientists	1,876	873	1,003
	Coauthorship with one unique mobile scientist	1,454	451	1,003
	Coauthorship with two unique mobile scientists	1,212	209	1,003
	Coauthorship with three unique mobile scientists	1,094	91	1,003
Coauthor with returnee	Coauthorship with any number of mobile scientists	2,281	1,278	1,003
	Coauthorship with one unique mobile scientist	1,614	611	1,003
	Coauthorship with two unique mobile scientists	1,309	306	1,003
	Coauthorship with three unique mobile scientists	1,153	150	1,003

Notes: This table displays the sample figures in each scenario of the event study. For instance, no restriction; only scientists in STEM fields; only scientists in SSH fields; scientists in the treatment group who have only coauthored with diaspora and intermittent scientists; scientists in the treatment group who have only copublished with returnee scientists. In each scenario, we have subset the sample according to the number of unique mobile scientists a nonmobile has coauthored with: one, two, three, or (any) number of mobile scientists.
Source: Authors' own elaboration based on scholarship lists and OpenAlex.

Table A6. Brazilian Sample in the Event Studies

(1)		(2)	(3)	(4)
		All	Treatment group	Control group
Full sample	Coauthorship with any number of mobile scientists	40,901	30,039	10,862
	Coauthorship with one unique mobile scientist	19,343	8,481	10,862
	Coauthorship with two unique mobile scientists	15,396	4,534	10,862
	Coauthorship with three unique mobile scientists	15,847	4,985	10,862
STEM scientists	Coauthorship with any number of mobile scientists	24,062	20,952	3,110
	Coauthorship with one unique mobile scientist	7,323	4,213	3,110
	Coauthorship with two unique mobile scientists	5,950	2,840	3,110
	Coauthorship with three unique mobile scientists	6,317	3,207	3,110
SSH scientists	Coauthorship with any number of mobile scientists	16,839	9,087	7,752
	Coauthorship with one unique mobile scientist	12,020	4,268	7,752
	Coauthorship with two unique mobile scientists	9,446	1,694	7,752
	Coauthorship with three unique mobile scientists	9,530	1,778	7,752
Coauthor with diaspora/intermittent	Coauthorship with any number of mobile scientists	33,871	23,009	10,862
	Coauthorship with one unique mobile scientist	19,343	8,481	10,862
	Coauthorship with two unique mobile scientists	15,396	4,534	10,862
	Coauthorship with three unique mobile scientists	15,847	4,985	10,862
Coauthor with returnee	Coauthorship with any number of mobile scientists	13,906	3,044	10,862
	Coauthorship with one unique mobile scientist	12,959	2,097	10,862
	Coauthorship with two unique mobile scientists	11,401	539	10,862
	Coauthorship with three unique mobile scientists	11,080	218	10,862

Notes: This table displays the sample figures in each scenario of the Event Study. For instance, no restriction; only scientists in STEM fields; only scientists in SSH fields; scientists in the treatment group who have only coauthored with diaspora and intermittent scientists; scientists in the treatment group who have only copublished with returnee scientists. In each scenario, we have subset the sample according to the number of unique mobile scientists a nonmobile has coauthored with: one, two, three, or (any) number of mobile scientists.
Source: Authors' own elaboration based on scholarship lists and OpenAlex.

T-tests for Pretrends

To conduct our event study, we compare treatment and control groups. Unlike typical experiments and quasi-experiments where both groups apply to the treatment, our study case needs a reference point for the control group since they never interacted with mobile scientists. To address this issue, we employed the following strategy: we measured the time it took for the treatment group to receive the treatment and used this time as a proxy for the control group's seniority. For example, if a scientist started collaborating with a mobile scientist two years after their first publication, we compared their publications and citations to someone with two years of career experience.

We then conducted t-tests to analyze the comparability of treatment and control groups (see Table A7). The treatment and control groups in Brazil did not differ significantly regarding publications, but the treatment group had slightly more citations. There were no significant differences between the treatment and control groups regarding publications or citations in Colombia.

Table A7. T-tests

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Country of origin	Period	Variables	Treatment group	Control group	T-statistic	p-value
Brazil	2 years	Stock of publications	2.223	1.981	1.34	0.182
		Stock of citations	0.641	0.150	1.717	0.089
	3 years	Stock of publications	2.605	2.885	-1.463	0.144
		Stock of citations	0.480	0.387	0.710	0.478
	4 years	Stock of publications	2.969	2.708	1.443	0.150
		Stock of citations	0.911	0.327	4.228	0.000
	5 years	Stock of publications	3.559	3.724	-0.797	0.426
		Stock of citations	1.294	0.663	2.657	0.008
	6 years	Stock of publications	3.581	3.413	0.972	0.331
		Stock of citations	1.720	0.772	3.478	0.001
Colombia	2 years	Stock of publications	1.800	2.891	-4.01	0.000
		Stock of citations	0.950	0.683	-0.652	0.517

	3 years	Stock of publications	1.911	2.616	-2.701	0.008
		Stock of citations	0.778	1.221	-0.663	0.509
	4 years	Stock of publications	2.015	2.245	-1.114	0.267
		Stock of citations	0.746	0.510	0.840	0.403
	5 years	Stock of publications	3.091	3.135	-0.099	0.922
		Stock of citations	1.202	0.875	0.754	0.452
	6 years	Stock of publications	3.412	2.931	1.044	0.298
		Stock of citations	1.216	1.238	-0.047	0.963

Notes: This table shows the results of the t-tests comparing stock of publications and citations of scientists in the treatment and control group with similar seniority.
Source: Authors' own elaboration based on scholarship lists and OpenAlex.

Appendix 5. Variables Construction

In Appendixes 1-3, we have described the database construction, the identification of the Colombian and Brazilian scientists (and their coauthors) in OpenAlex, and their bibliometric information. To run the regressions described in Equations 1-3, we construct a panel dataset with several pieces of information from OpenAlex, including but not limited to the scientist i's number of publications per year, number of foreign publications per year, year of first publication, stock of foreign coauthors, stock of mobile scientists coauthors, and number of citations.

With regard to the dependent variables, for foreign collaboration, we have computed the number of foreign coauthors that a scientist i has in year t. If a scientist i has one or more foreign coauthors in year t, foreign collaboration is 1; and 0 otherwise. The second dependent variable, the average of foreign copublications, was built from calculating the rolling average of the number of foreign coauthors in years t-1, t, and t+1: $Y_{it} = \frac{\sum_{t-1}^{t+1} x_{i,t}}{3}$, where $x_{i,t}$ is the number of publications coauthored with foreign coauthors by nonmbile scientist i. For the third dependent variable, the average share of foreign copublications, we followed two steps to construct this variable. We divided the number of foreign copublications that i has coauthored in year t by their total number of publications in that year. Then we calculated a three-year-window average as for the average of foreign copublications.

With regard to the independent variables, we have used the number of mobile scientists that a scientist i has coauthored with in a year t to build the binary variable of after coauthoring with the first mobile scientist. Since the year in which a nonmobile scientist has at least one mobile coauthor, the binary variable turns to 1 and remains as such for this scientist's later years. The second independent variable, stock of mobile scientists, was built from the number of unique mobile coauthors that a nonmobile scientist i has published with. We calculated the cumulative sum of unique mobile coauthors until and including year t. We relied on the scientists' academic fields and Organization for Economic Co-operation and Development's scientific categories to create the STEM variable, the third independent variable. If a scientist belongs to any of the STEM fields, the binary variable indicates 1; otherwise, the variable is 0.

With regard to the control variables, for the Lagged average of publications and Lagged averages of citations, we calculated the cumulative sum of publications and citations of a nonmobile scientist i until and including year t and divided by the number of years since first publication. For the third control variable, the stock of foreign coauthors, we calculated the cumulative sum of unique foreign coauthors until and including year t. One factor that might affect the number of foreign coauthors and publications is the scientist's years of experience. Given that we did not have information on all scientist's years of experience, we have proxied it using the number of years since first publication. The last control variable is gender: it equals 1 if a scientist is male; and 0 if female.

Appendix 6: Correlation Between Control Variables

Table A8 displays the matrixes of correlation between control variables used in Equations 1 and 2 for Colombia and Brazil. The matrixes show that control variables do not raise issues of multicollinearity.

Table A8. Matrix of Correlations Between Control Variables

Variables	(1)	(2)	(3)	(4)	(5)
Colombia					
(1) Lagged average of publications	1.000				
(2) Lagged average of citations	0.551	1.000			
(3) Stock of foreign coauthors	0.353	0.682	1.000		
(4) Years of experience	-0.034	0.418	0.495	1.000	
(5) Gender	0.060	0.045	0.058	0.023	1.000
Brazil					
(1) Lagged average of publications	1.000				
(2) Lagged average of citations	0.632	1.000			
(3) Stock of foreign coauthors	0.572	0.648	1.000		
(4) Years of experience	0.172	0.519	0.651	1.000	
(5) Gender	0.042	0.027	0.049	0.039	1.000