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Brain drain or brain gain? Evidence from a developing country

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Luciana Méndez[1] and Mariana Rodríguez-Vivas[2]

Abstract

We contribute to the economic literature by addressing a historical concern regarding the international migration of highly skilled workers, specifically, researchers holding a doctorate degree. We analyze whether a developing country such as Uruguay experiences brain gain or brain drain by exploring a theoretical channel through which a country can benefit from emigration: return migration.

By exploiting a novel database, we build on previous literature and account for endogeneity issues due to selectivity biases that are likely to arise due to individuals' multiple migration' and occupational choices.

Our findings stress that the largest gains from migration are accrued to the migrants themselves. Uruguayan emigrants obtain higher labor income, increases in their productivity, and have a more heterogeneous network in terms of co-authorships, relatively more from foreign institutions and relatively less from Uruguayan ones. Therefore, the country could benefit from emigration if policies fostering international collaboration between Uruguayan researchers are implemented.

Keywords: brain drain, brain gain, developing country, migration, human capital, occupational choice

JEL Classification: F22, J24, J61, O15

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Brain drain or brain gain? Evidence from a developing country

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Resumen

Contribuimos a la literatura económica abordando una preocupación histórica respecto a la emigración internacional de trabajadores altamente calificados, en concreto, de investigadores con título de doctor. Analizamos si un país en vías de desarrollo como Uruguay experimenta ganancia o fuga de cerebros explorando un canal teórico a través del cual un país puede beneficiarse de la emigración: la migración de retorno.

Mediante la explotación de una base de datos novedosa, nos basamos en la literatura previa y tenemos en cuenta los problemas de endogeneidad debidos a los sesgos de selección que probablemente surgen por las múltiples opciones migratorias y ocupacionales de los individuos.

Nuestros resultados subrayan que los mayores beneficios de la migración los obtienen los propios emigrantes. Los emigrantes uruguayos obtienen mayores ingresos laborales, aumentos en su productividad y tienen una red más heterogénea en términos de coautorías, relativamente más de instituciones extranjeras y relativamente menos de uruguayas. Por lo tanto, el país podría beneficiarse de la emigración si se aplican políticas que fomenten la colaboración internacional entre investigadores uruguayos.

Palabras clave: fuga de cerebros, ganancia de cerebros, país en desarrollo, migración, capital humano, elección ocupacional

Código JEL: F22, J24, J61, O15

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1. Introduction

The age-old debate over whether highly skilled migration from developing to developed countries has negative effects on the sending countries –brain drain–[1] has received renewed attention in recent decades; a wave of theoretical literature identifies potential channels as drivers of brain gain: human capital formation, remittances, return migration, and diasporas (Docquier and Rapoport, 2009, 2012; Stark et al., 1998; Beine et al., 2001).

Empirically, there have been no conclusive results on this question. Evidence suggests some positive effects of emigration on human capital accumulation for the sending country (Docquier and Rapoport, 2012); positive effects of technological diasporas[2] in India, China and Singapore (Basri and Box, 2010); but non-significant effect of remittances on the source country (Batista et al., 2007; Bredtmann et al., 2019; Gibson and McKenzie, 2011; Kangasniemi et al., 2007). In turn, some studies suggest that return migration may benefit developing countries: individuals returning with physical and human capital that they acquired abroad are more productive (Dustmann and Kirchkamp, 2002; Mesnard, 2004). However, if unsuccessful immigrants are more likely to leave the host country as compared to more successful counterparts, or if those returning home are mismatched in the local labor market, the effect of return migration on the host country is not so clear (Wahba, 2015).

The lack of robust evidence limits our understanding on the effects of highly skilled international migration; the question of whether a country might experience brain drain or brain gain remains unanswered.

In this respect, the literature has been silent regarding the international migration of individuals holding a doctorate degree, the highest educational level attainable (Jewell and Kazakis, 2021). Specifically, individuals with a PhD and involved in research activities – scientists and academics– play a key role in economic development as they are drivers of innovation, technological advancement, and are key in the generation and dissemination of knowledge (Bender and Heywood, 2006; Kifle and Hailemariam, 2012). Researchers are a relatively more mobile group as compared to other skilled workers; they are also often driven by non-economic factors like access to technology, infrastructure, inclusion in transnational elite scientific networks (Cañibano et al., 2017), recognition by peers, intellectual challenge, among others (Jewell and Kazakis, 2021). These features make the factors driving researchers' international migration a compelling issue worthy of further study.

This article examines whether Uruguay experiences 'brain gain' or 'brain drain' by analyzing the economic consequences of high-skilled migration. It evaluates how different migration statuses (never migrated for study, returned after a PhD, or residing abroad) relate to individual gains (measured by labor income) and social gains (if those who return are more productive in terms of publications in academic journals). Additionally, it explores the factors influencing migration choices, to better understand why some skilled individuals leave while others stay (Gibson and McKenzie, 2011).

By analyzing migration choices and their associated benefits, this study directly examines, at the micro level, the channels through which high-skilled emigration affects the sending country. As pointed out by Gibson and McKenzie (2012) "ignoring the impact on the migrants themselves will lead to a distorted view of the economic benefits and

[1] See Bhagwati and Hamada (1974) and Mountford and Rapoport (2011)

[2] The population of people born in a country and living in another one (Beine et al., 2011).

costs of migration for source countries, as the most major effect could be to make natives of these source countries considerably better off. Ignoring migrants can also give biased measures of the living standards of the best and brightest from developing countries" (p346). In turn, social gains are proxied by publications in academic journals as a means to generate greater knowledge in the origin country.

Therefore, analyzing the factors that influence individuals' decisions to emigrate or return can shed light on a key mechanism identified in the literature through which a country may experience brain drain or brain gain. We exclude other channels through which emigration might benefit the home country, such as remittances and diasporas, as existing international evidence has found no significant effects of highly skilled emigration in these areas (Bredtmann et al., 2019; Docquier and Rapoport, 2012; Faini et al., 1997; Gibson and McKenzie, 2012; Lucas and Stark, 1985).

Uruguay is an interesting case study due to its large tradition of migration, with significant emigration flows throughout the twentieth century, including both economic migration and involuntary or forced movements. Around 13.6% of its population resides abroad, a figure even higher than that of traditionally high-emigration countries like Mexico (10%).[3] Additionally, one in three Uruguayan PhD holders lives abroad, according to Méndez et al. (2019).

In addition to the above, the relatively small proportion of highly-educated Uruguayans living in the country (only 29% of those aged 29 and older have completed university education), and the high proportion of youngsters reporting migration intentions (Méndez, 2020), aligns with factors highlighted in the literature that suggest 'brain drain' is a significant concern for developing countries (Bredtmann et al., 2019).

We exploit a unique dataset of Uruguayans who hold a doctorate degree and reside in Uruguay or abroad, the First Census of Uruguayan Doctorate-holders (PCDUY: *Primer Censo de Personas con título de Doctorado en Uruguay*). The PCDUY contains detailed information on emigrants, returnees, and non-migrant Uruguayan doctorate holders and allows us to explore differentials in terms of labor income. We merge the PCDUY with the SCOPUS database to proxy productivity by academic publications, and elaborate researchers' networks measures through co-authorships.

We estimate Seemingly Unrelated Equation System (SURE) with instrumental variable (IV) analysis to better account for endogeneity issues that could arise in this study due to selection in migration (Wahba, 2015) and unobservable individual characteristics, i.e. abilities that can influence on people's wage and productivity (Borjas, 1994; Gibson and McKenzie, 2012; Grogger and Hanson, 2011).

We find that emigrant researchers holding a PhD obtain higher labor income and higher productivity (in terms of academic publications) than their peers residing in Uruguay. Among researchers living in Uruguay, returnees have higher income and productivity than those who never left. Overall, our results stress that, although the country experiences brain gain through return migration, brain drain is also experienced as researchers residing abroad have higher productivity in terms of academic publications. Therefore, there is still room for policy interventions to attract researchers residing abroad, and to foster international cooperation between researchers in Uruguay and those residing abroad.

[3] Cabella and Pellegrino (2005).

We contribute to the literature on highly skilled migration in multiple ways. First, we exploit a unique dataset that allows us to overcome data limitations prevalent in international migration studies that could not track individuals after they left the country; this gap in the data had previously generated an incomplete picture of scientists' migration patterns (Franzoni et al., 2012).

Second, we build upon previous literature by studying the international migration of PhD holders across different fields of study and involved in research activities. So far, the empirical literature on return among highly skilled workers focuses on individuals from selected professions (Gibson and McKenzie, 2012); or provides descriptive evidence on highly skilled returnees (Cañibano et al., 2017). Thus, we build on previous literature as we focus on a particular population group of highly skilled workers that is relatively less addressed.

Finally, we overcome challenges faced in previous literature by taking proper account of endogeneity issues that are likely to arise in these types of studies. So far, the existing evidence is descriptive and scarce; although there are some studies on return migration, these are centered on the host country and not the origin country. Bijwaard and Wang (2016), for example, assess the return of immigrant students in the Netherlands; Franzoni et al. (2014) analyze differences in productivity across migrants and non-migrant scientists for a sample of 16 developed countries. In sum, the empirical evidence is mixed (Cañibano et al., 2017) and little is known about how the trade-offs faced by skilled migration play out empirically (Gaulé, 2014).

The rest of the article proceeds as follows. Section 2 reviews the related literature. Section 3 describes the dataset and the methodology used. Section 4 presents the results. The last section concludes.

2. Related literature

There is a sizable economic literature that analyzes the effects of highly skilled emigration on sending countries. From a historical perspective, the literature has moved from highlighting the negative effects of skilled migration in the 1960s to evaluating the potential benefits for countries of origin.[4]

In particular, since the 1990s, this new literature has developed theoretical models assessing the potential channels through which a sending country could experience brain gain; these are summarized in Docquier and Rapoport (2012) as follows. The first channel refers to human capital accumulation in the sending country. Due to emigration intentions, people invest more in education; however, because not all individuals actually emigrate, human capital accumulation in the home country increases. The second channel underlines the role of remittances which favor consumption and investment in the country of origin. The third channel stresses that diasporas foster international trade, foreign investment, transfer of knowledge, and reduce transaction costs between the sending and receiving countries. The fourth channel refers to return migration, benefiting the origin country as returnees had acquired human capital abroad.

Empirical studies on these different channels are scarce and have mixed results (Gibson and McKenzie, 2012). Evidence on human capital accumulation in the sending country is provided in Docquier and Rapoport (2012) for three case studies: Cape Verde, Tonga, and Papua New Guinea, and the Pacific region. Conversely, null effects are found in

[4] Docquier and Rapoport (2012) extensively review this literature from a historical perspective.

Kangasniemi et al. (2007) who analyze the effect of foreign doctors in the UK on their origin countries. Regarding remittances, the evidence shows a non-significant effect on the source country (Batista et al., 2007; Bredtmann et al., 2019b; Gibson and McKenzie, 2011; Kangasniemi et al., 2007). In turn, evidence shows positive effects of technological diasporas in India, China, and Singapore (Basri and Box, 2010).

Regarding return migration, the literature focuses on the return of workers in general rather than specifically on the highly educated (Gibson and McKenzie, 2012). For the most skilled workers, migration seems to be mostly driven by non-monetary factors. Specifically, descriptive evidence shows that return migration of scientists and researchers is positively associated to family and personal motives, the feeling of national identity and home attachment, and the existence of collaborative ties with the country of origin; motives, that is to say, are not strictly related to research or career (Cañibano et al., 2017). Also, Gibson and McKenzie (2011) point out that the main determinants of return for many highly skilled migrants are family and lifestyle rather than employment opportunity. Highly skilled migrants may be prepared to return to a lower income after experiencing some time abroad in order to be near aging parents or to be able to raise their children in their home culture.

Gibson and McKenzie (2012) study the economic effects of highly skilled migration for five countries: Ghana, New Zealand, Micronesia, Tonga, and Papua New Guinea. The study is based on surveys conducted among top academic performers in each country at the time of their high school graduation; it is then tracked wherever they currently live in the world. The authors formed counterfactuals for what these individuals would be doing at home by also surveying academically similar non-migrants and return migrants, and through direct questions. Their results show that the largest gains from migration are accrued by the migrants themselves; migrants obtain higher wages, increase their human capital, and more study and work opportunities abroad. However, no evidence of net knowledge transfers to home governments or business is found.

In turn, Monteleone and Torrisi (2010) study the propensity to return among highly qualified Italian emigrants and assess the factors that foster return migration. The authors contacted 350 Italian researchers (assistant professors) and professors employed in different universities around the world. Based on OLS and GLM model regressions, they find that Italian researchers have a low intention to return. More opportunities for research and higher perception of quality of life abroad decrease individuals' intention to return to Italy.

Güngor and Tansel (2008) address the intention to return among Turkish students at the undergraduate or graduate level enrolled at foreign higher education institutions. The data used comes from an internet survey that reached students in the US and UK. Their findings stress that better pay and lifestyle in the host country decreased the probability of return to their home countries. Also, the longer the migrants remained abroad, the lower their intention to return. Conversely, individuals with prior return intentions, with family support in Turkey, or individuals with government scholarships (with compulsory service required) were more likely to report return intentions.

Rather than focusing analysis on the home country, Bijwaard and Wang (2016) study the return of immigrant students to the Netherlands. After controlling for correlated unobserved heterogeneity across migration, labor, and marriage formation processes, the authors find that when students become unemployed, they are more likely to leave the host country. Also, marriage in the Netherlands makes the students more likely to stay there.

Besides the analysis of the factors influencing scientists and researchers regarding their return to their home country, the literature explores the effect of international mobility on productivity as a means to generate greater knowledge in the origin country. For instance, Franzoni et al. (2014) show that, for a sample of 16 developed countries, migrant scientists are more productive (proxied by academic publications) than non-migrant scientists. However, when focusing the analysis on the sending country, empirical evidence is scant and descriptive.

In this regard, Cañibano et al. (2017) review studies that address the effect of return migration and use bibliometric information to proxy productivity (publications and citation impact) to compare performance of returnees, emigrants, and non-emigrant researchers. Their review shows mixed results; some studies find that returnees and emigrants perform similarly in terms of academic production, have higher publication productivity than non-migrant researchers and larger networks of co-authors; others show that emigrants perform better in terms of publications and citation impact; and a third set report no correlation or a negative association between international mobility and productivity. Cañibano et al. (2017) conclude that returnees are as productive as non-returnees in terms of research results, but returnees perceive a deterioration in working conditions in terms of recognition, wages, and future promotion opportunities.

In turn, Gibson and McKenzie (2012) argue that if return migrants are more productive than non-migrants (either as entrepreneurs or in wage jobs) it would be expected that they earn higher incomes. However, when comparing the income gain estimated relative to non-migrants for Ghana, New Zealand, Micronesia, Tonga, and Papua New Guinea, Gibson and McKenzie (2012) find non-significant gains in any country.

Finally, Gaulé (2014) assesses return decisions among immigrant scientists and engineers with a doctorate degree obtained in the US, with a non-US undergraduate degree, and registered in the American Chemistry Society (ACS) directory of graduate research. The author distinguishes between those who returned to their home country, moved to a third country, or moved to a US job outside the academy, and matches scientists to their publication records in Scopus; computing, for every individual-year, the average productivity, from the time of initial faculty appointment to the current year. Gaulé (2014) shows that individuals who have been particularly productive during their US appointments are more likely to return; although, stresses that this result is sensitive to alternative ways of measuring and defining ability. Overall, he concludes that the balance of evidence is more consistent with positive rather than negative selection into return migration.

3. Methodological framework

3.1. Data and descriptive analysis

We use a unique dataset obtained from the First Census of Doctorate holders in Uruguay and Uruguayans living abroad (PCDUY: *Primer Censo de Personas con título de Doctorado en Uruguay*). This census was carried out in 2017 by the Migration Studies Group of the Universidad de la República (UDELAR), and had a response rate of 86% (Méndez et al., 2019).

The PCDUY dataset contains 2,098 observations. We restrict our sample to those individuals who completed the online survey (1877) and whose country of origin is

Uruguay, as immigrants in Uruguay could have different motivations for international migration.[5] Once these restrictions are made, our database ends up with 1,763 observations.

Uruguayan PhD holders report different migration trajectories. We particularly focus on two individuals' migration decisions: whether to enroll in a Uruguayan doctorate program or in a foreign university; and the actual country of residence, Uruguay or abroad. Then, we classify PhD holders into three groups: never migrated for PhD enrollment and actually reside in Uruguay (*never moved*);[6] resided abroad while enrolled in a foreign doctorate program but currently reside in Uruguay (*returnees*); residing abroad (*emigrants*), regardless the country of PhD enrollment.

Figure 1. PhD holders' migratory paths

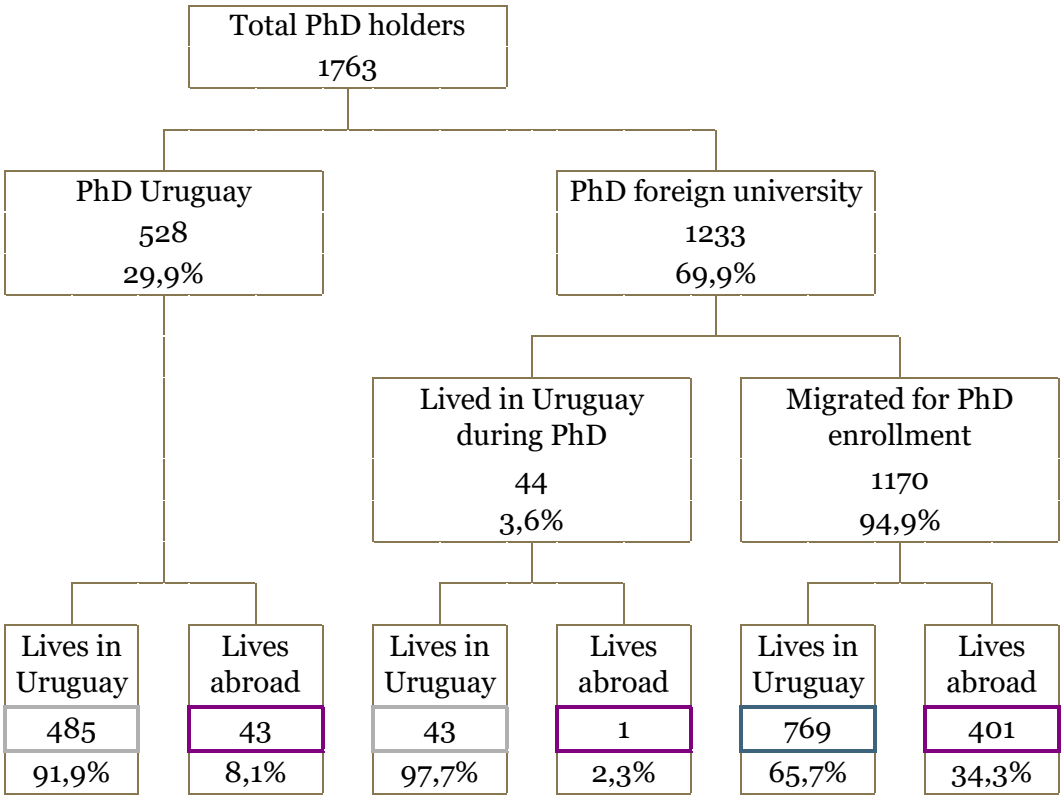


Figure 1 describes individuals' migration path in detail. Almost 70% of Uruguayan PhD holders graduated from a foreign university. Within these, a small percentage resided in Uruguay while being enrolled in a foreign PhD program (3.6%).[7] Also, of those residing abroad while enrolled in the doctorate program, 65.7% returned to Uruguay.
In turn, PhD holders residing abroad are 25% of the sample, a large proportion of them studied abroad (90%), showing a large persistence between having migrated for PhD studies and being an emigrant.

[5] We define Uruguay as the country of origin if the individual was born in Uruguay, or attended at least one of the three educational levels in the country, and have an undergraduate degree in Uruguay.
[6] This category groups individuals who were enrolled in a Uruguayan doctorate program with those who graduated from a foreign university but did not migrate for enrollment. Those individuals with migration experience but not for study motives are also considered in this group.
[7] 95% of those with a foreign degree resided abroad for at least one year.

As we are interested in labor differentials across migration status, we restrict our sample to employed PhD holders younger than 65 years old at the time of the survey. We also left out individuals who were living in Uruguay while enrolled in a foreign doctorate program. This is due to the fact that, although they were enrolled in a foreign program, they were not exposed to the same treatment as those who were living abroad.[8] Overall, our final sample comprises 1520 observations.

Table 1 presents the main descriptive statistics separately for individuals' migration status (never migrated, returnees and emigrants), and the mean tests. Almost half of the Uruguayan PhD holders are women, over-represented in the non-migrant group and underrepresented in the returnee and emigrants' groups.

In comparison to those who never migrated or those who returned after PhD completion, emigrants are younger. Also, a smaller proportion of them had children at the time of the survey. Emigrants and returnees are from better-off parental educational backgrounds than those who never left Uruguay. As expected, individuals with previous migration experience are more likely to live abroad (37% for emigrants versus 23% for returnees, and 16% for those who did not leave Uruguay).

Table 1. Mean test between groups by trajectory paths

	Never moved (NM)	Returnees (R)	Emigrants (E)	Total	tt- Diff. E - R	tt- Diff. E - NM	tt-Diff. R - NM
Sociodem.							
Age	47,24	48,92	45,65	47,60	-3,268***	-1,587***	1,681***
Female	0,59	0,47	0,43	0,50	-0,037	-0,158***	-0,121***
Children	0,77	0,72	0,60	0,70	-0,118***	-0,169***	-0,052*
Education							
Age ends PhD	38,18	38,04	34,64	37,22	-3,400***	-3,546***	-0,147
Gap PhD-Bachelor	6,98	7,08	4,49	6,41	-2,588***	-2,491***	0,097
Field							
Agricultural sciences	0,04	0,15	0,08	0,10	-0,062***	0,042**	0,105***
Medical and Health sciences	0,20	0,07	0,12	0,12	0,043**	-0,083***	-0,126***
Natural sciences	0,58	0,28	0,36	0,39	0,075**	-0,227***	-0,302***
Social sciences	0,06	0,29	0,24	0,21	-0,047	0,178***	0,225***
Humanities	0,00	0,11	0,08	0,07	-0,032*	0,071***	0,103***
Engineering and technology	0,11	0,10	0,13	0,11	0,024	0,018	-0,005
Post Doctorate	0,23	0,28	0,65	0,36	0,368***	0,418***	0,050*
Background							
University parents	0,37	0,44	0,49	0,43	0,052	0,125***	0,073**
Lived abroad before PhD	0,16	0,23	0,37	0,24	0,140***	0,212***	0,073***
Private high school	0,41	0,42	0,46	0,43	0,046	0,050	0,004
Labor before PhD							
Research before PhD	0,95	0,88	0,85	0,89	-0,034	-0,104***	-0,070***
Employment sector before PhD							
University	0,77	0,70	0,59	0,70	-0,102***	-0,176***	-0,074***
Research center	0,12	0,10	0,13	0,11	0,030	0,006	-0,023
Other	0,11	0,20	0,28	0,19	0,073**	0,170***	0,097***
Actual job							
Researcher	0,91	0,85	0,86	0,87	0,012	-0,046**	-0,058***

[8] We also ran our estimations including individuals graduated from a foreign doctorate program but resided in Uruguay all years of PhD enrollment, and results remain the same.

SNI	0,58	0,49	0,04	0,40	-0,450***	-0,540***	-0,090***
Private employee	0,08	0,15	0,29	0,17	0,147***	0,213***	0,067***
Public employee	0,80	0,72	0,52	0,69	-0,200***	-0,284***	-0,084***
Self-employed	0,03	0,04	0,03	0,03	-0,013	-0,001	0,013
RDT	0,74	0,64	0,83	0,72	0,186***	0,092***	-0,093***
Employment sector							
University	0,78	0,77	0,69	0,77	-0,082*	-0,092**	-0,010
Research center	0,14	0,10	0,17	0,12	0,074**	0,030	-0,044**
Other	0,08	0,13	0,14	0,11	0,008	0,062**	0,054***
Observations	445	691	384	1520			

A large proportion of participants are individuals from natural sciences (39%), and a smaller portion are from the humanities (7%). Within fields of knowledge, we observe differences in migration status; i.e. humanities and social sciences are more likely to return than to emigrate; and a greater number of those who have never emigrated are from the natural sciences and medical and health sciences.

Emigrants were more likely to enroll in a doctorate degree sooner after completing their bachelor's degree (two years before than those who never moved or those who returned) and to graduate at a younger age (34 versus 38 years old for returnees and non-migrants).

Notice that 65% of emigrants had a postdoctoral position, more than doubling individuals with a postdoctoral position in Uruguay. This suggests that the relatively large supply of postdoctoral positions abroad in comparison to the local supply is an important pull factor for Uruguayans after PhD graduation.

Next, we examined individuals' labor experience prior to PhD enrollment. First, individuals with a foreign PhD were, on average, less involved in research than those who studied in Uruguay. In turn, a higher proportion of non-migrants and returnees were employed at the university before PhD enrollment.

Regarding individuals' labor conditions at the time of the survey, a large segment of the sample was employed as researchers as their primary occupation (87%); this number is significantly higher for those who did their PhD in Uruguay as compared to those who studied abroad. On average, those residing in Uruguay are more likely to be part of a National Research System (SNI) than emigrants. Emigrants are, on average, more likely to have full-time job dedication (RDT). Notice that, although the public sector is the main employer for PhD holders, this percentage decreases from 80% for non-migrants to 52% for emigrants. This could be reflecting different opportunities in the local job market, which is in line with the employment sector distribution across migration status, and is greater in the university sector among those residing in Uruguay.

The key variables of this study are PhD holders' gains proxied by the monthly hourly labor income (in logarithm) and their academic publications. Income in the main occupation is self-reported by individuals surveyed in the PCDUY and corrected by Purchasing Power Parity (PPP) in order to make comparable incomes across countries.[9]

[9] For researchers working at the public university with missing information, wages were imputed according to their reported rank, worked hours and years in the institution. This is possible because wages at the public university are flat.

Figure 2. Differences in labor income by migratory status

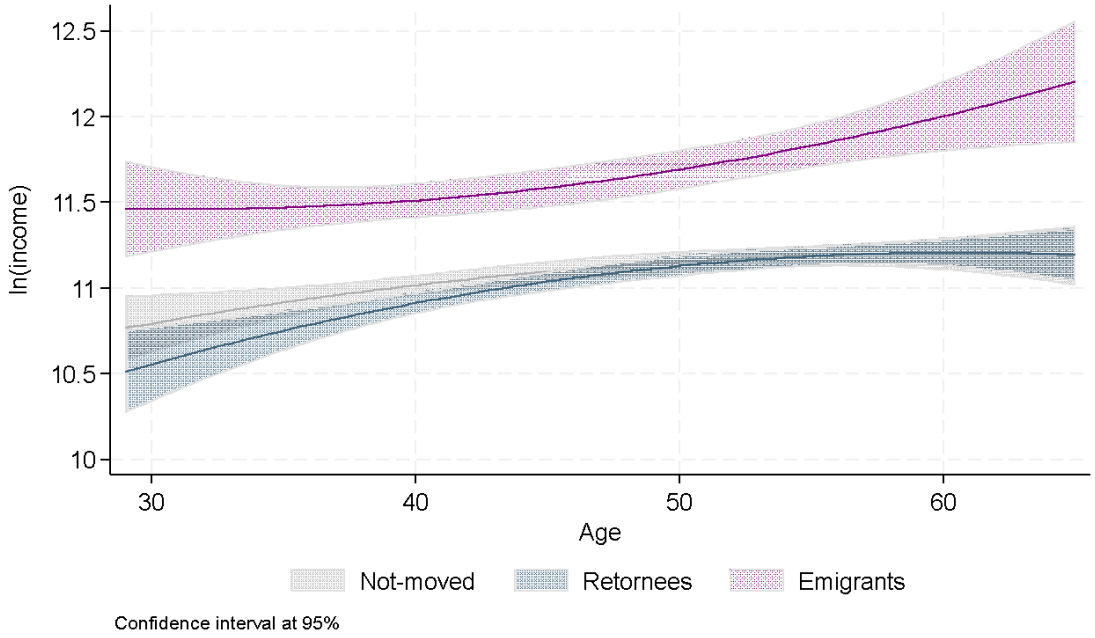
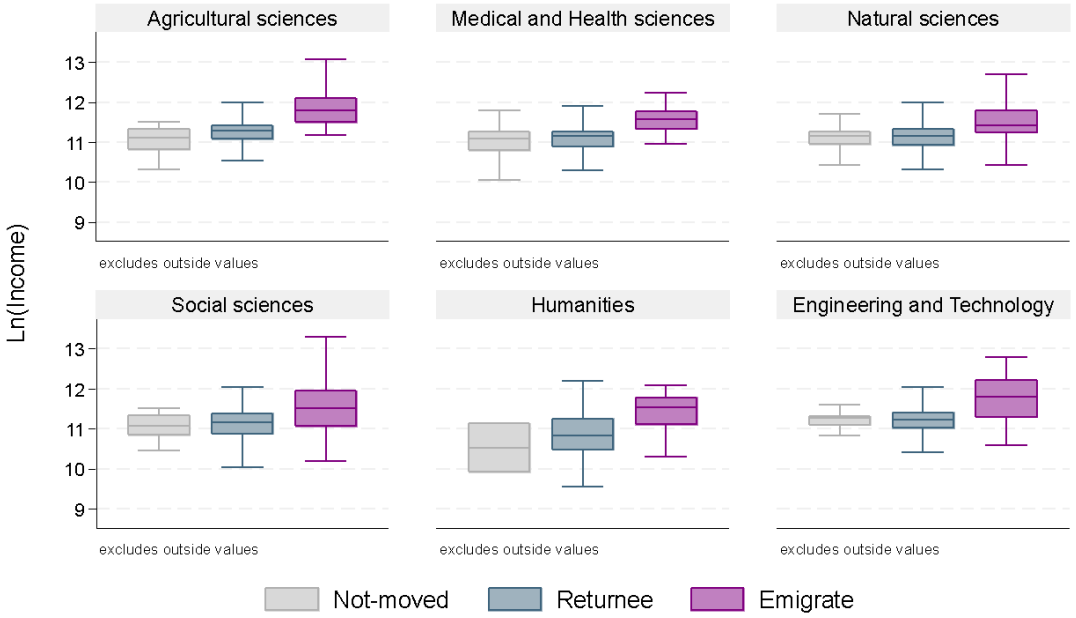


Figure 2 presents the quadratic estimation for income in logarithm by age and migratory status. We observe that differences in labor income become significant when we consider the actual place of residence: emigrants have higher incomes than researchers living in Uruguay. There are slight –non-significant– differences in income between returnees and non-emigrants. Difference in income persists when we consider individuals in different fields of knowledge: emigrants earn higher incomes than their peers in Uruguay (Figure 3).

Figure 3. Income by migratory paths and field



Our second variable of interest is PhD holders' productivity proxied by academic publications in peer-reviewed journals. To construct this variable, we first match researchers in the PCDUY to their publication records in the SCOPUS database.[10]

The Scopus database contains information regarding an article's identification, the journal in which it is published, year of publication, and co-authors' information — including names, Scopus identifier, institutional affiliation, country, and city of the institution. We also consider the Scopus journal information, which contains several reputation metrics for each journal by year, including Scimago Journal Ranking (SJR).

We adapt strategies of earlier works (Anderson and Richards-Shubik, 2022; Franzoni et al., 2014; Gaulé, 2014; Scellato et al., 2015) and compute the number of published papers weighed by the journal's ranking, for each year. Our productivity measure is the average of weighted publications in different periods in time: before PhD enrollment, during PhD, and after completing PhD (and until the time of the survey).

Note that our measure of productivity is biased to those fields of knowledge in which peer-reviewed articles are a common form of written production. Fields in which books, chapters, essays, or not peer-reviewed articles dominate are less represented as they are not indexed in Scopus.[11] Despite this limitation, the literature is confident in using publications in peer-reviewed articles as a good proxy for productivity (Anderson and Richards-Shubik, 2022; Franzoni et al., 2014; Scellato et al., 2015).[12]

Figure 4. Distribution of number of articles, mean SJR and productivity after PhD completion, by migration status

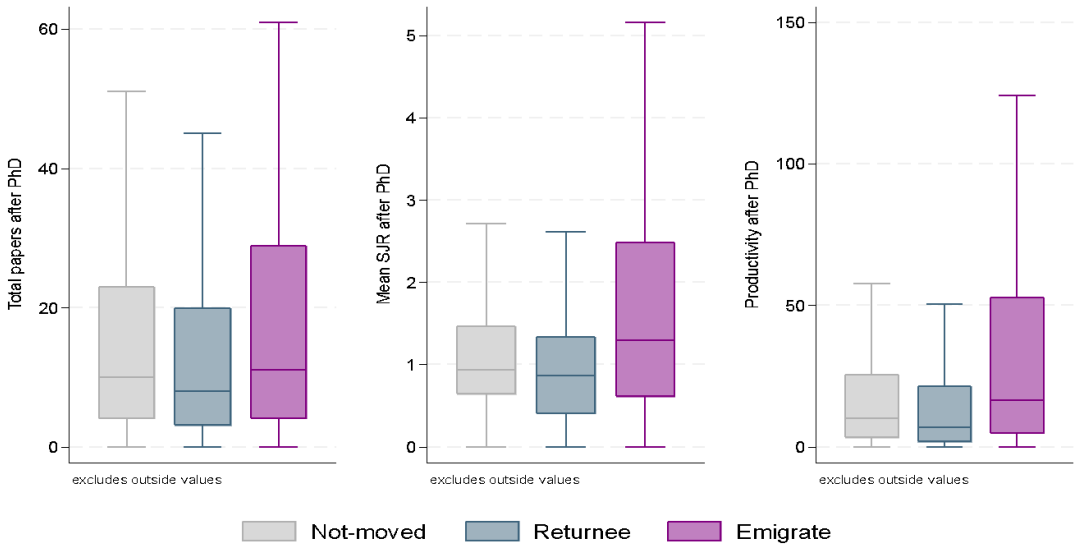


Figure 4 presents the distribution of individuals' published articles, the mean of the SJR, and productivity after PhD completion by migration status. Emigrants publish relatively

[10] Almost 84% of the individuals were matched (93.3% of non-emigrants, 76% of returnees, and 86.7% of emigrants).

[11] Based on information in the researchers' curriculum vitae in the Uruguayan Research and Innovation Agency (*Agencia Nacional de Investigación e Innovación*), peer-reviewed articles represent 65.2% of the written production, but with differences across fields of study. Specifically, while it represents more than 80% for Natural and Medical and Health sciences, it decreases to 31% for Social Sciences and Humanities. In turn, books represent 53% of the written production in Humanities and 41.4% in Social Sciences.

[12] By adding fixed effects one could control for differences across fields of knowledge.

more than non-emigrants and returnees. Notice that these gaps increase when publications are weighted by the journal's impact factor. Emigrants publish more articles and in more prestigious journals.

We consider individuals' network composition because when the individual has a larger and a more diverse network, productivity likely improves (Scellato et al., 2015). We define researchers' network composition as the proportion of co-authors in Uruguay, other Latin American and Caribbean countries, Europe, North America, or other regions; this calculation is made for three periods in time: before PhD enrollment, during PhD enrollment, and after graduation.

Figure 5. Composition of the coauthors' network, by migration status and PhD stage

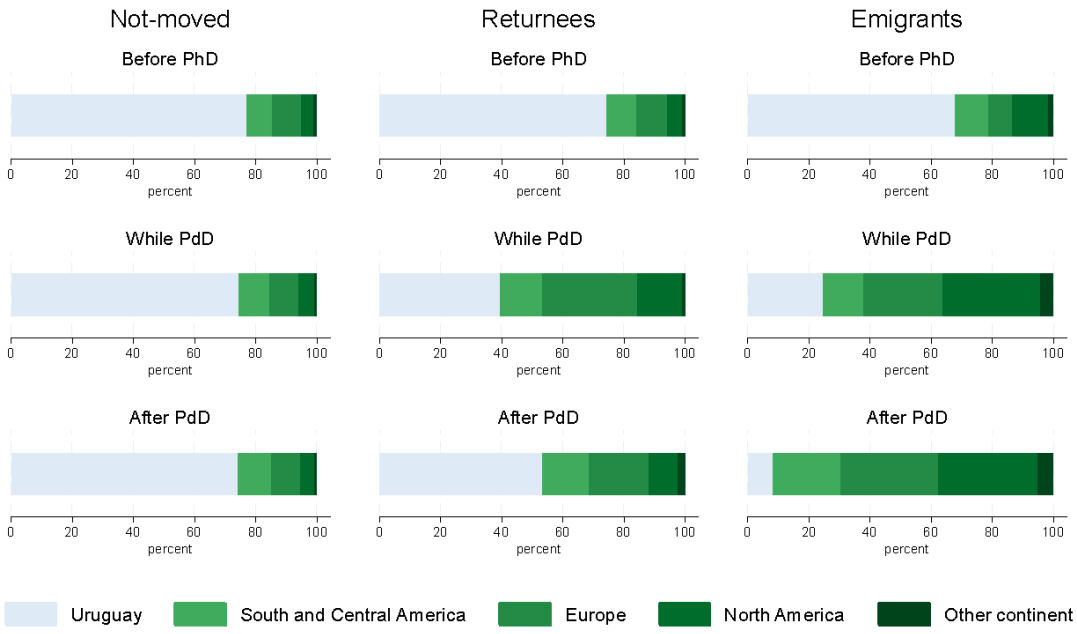


Figure 5 shows the coauthor network structure by migration status at three points in time. Researchers who did not emigrate maintain a stable network, with about 75% of their coauthors being Uruguayan.

Returnees' networks shift over time: before PhD enrollment, 71.3% of their publications include Uruguayan coauthors, dropping to 53% after graduation likely due to greater exposure to international academia. After completing the PhD, their share of foreign coauthors decreases from 60% to 47%.

Emigrants have the lowest proportion of Uruguayan coauthors (67.8% vs. 75% for non-emigrants and 71.8% for returnees pre-PhD). Their networks become more international, with foreign coauthors increasing from 32% to 75% during the PhD and 92% after graduation. Cooperation with Uruguayan coauthors declines, and 57% of emigrants with post-PhD publications have no Uruguayan coauthors in Uruguay.

3.2. Empirical strategy

To assess whether individual and social *gains* (labor income and productivity proxied by academic publications, respectively) are affected by researchers' migration status, we model gains as follows:

$$gains = \beta_1' dem + \beta_2' res * enrol + \beta_3' labor + \beta_4' prod + \beta_5' coaut + \varepsilon_1 \quad (1)$$

Our key independent variable, an individual migration status (never migrated, returned, or emigrated) is defined as the interaction between the actual place of residence (res equal to 1 if the individual lives in Uruguay, and 0 abroad) and the location of PhD enrolment ($enrol$, equal to 1 if studied in Uruguay, 0 id abroad). Then, β_2 captures gain differences across individuals' migration status; those who never moved (res=1 and $enrol$=1), those who migrated for PhD enrollment and returned to Uruguay (res=1 and $enrol$=0), those who studied abroad and reside abroad (res=0 and $enrol$=0), those who reside abroad but graduated in Uruguay (res=0 and $enrol$=1).

Other control variables commonly considered are a set of sociodemographic variables (dem) such as gender, age cohort, and educational choice variables, including the period taken to PhD graduation, and the field of knowledge. We also control for current labor conditions ($labor$) like length of time at current institution and in current position; sector of employment (university, research center, other); occupational category (public, private, self-employed, other); whether individuals are employed full time or not (RDT); and if they are recipients of National Researchers Systems (SNI).

We include individuals' past productivity proxied by weighted publications in two points in time: before and during PhD enrollment ($prod$); and a proxy for researchers' co-authorship network ($coaut$) as the number of co-authors in their academic publications before PhD enrollment and during PhD.

Previous literature stresses that researchers are likely to be a non-random sample of doctorate holders. Specifically, individuals' enjoyment of scientific activities, autonomy for choosing research projects, opportunities for publishing, and interactions with the scientific community, are denoted as relevant factors that could influence an individual's decision to work as a researcher (Di Paolo, 2016; Roach & Sauermann, 2010). Therefore, if unobserved characteristics such as individuals' personality traits and preferences affect their choices regarding whether to be a researcher or not, could in turn affect their gains. Then, the estimation of equation (1) with ordinary least squares (OLS) may be biased if self-selection is not accounted for.

Therefore, an individual's occupational choice is modelled as follows:

$$researcher = \gamma_1' dem + \gamma_2' res + \gamma_3' enrol + \gamma_4' fund + \gamma_5' Z_{resch} + \varepsilon_2 \quad (2)$$

Equation 2 includes similar control variables as equation 1 (individuals' demographic characteristics, educational choices, residential choices and PhD enrollment). Following previous literature, we add PhD funding source ($fund$) as a determinant for occupational choices (Di Paolo, 2016; Horta et al., 2018; Nisticò, 2018). Specifically, empirical studies show that PhD students with scholarships are more likely to pursue a research career as funding may induce them to increase time dedicated to study and reduce time devoted to work. Also, financed students may invest more in related research-oriented activities, such as attending workshops, visiting programs, etc. The less doctorate students are exposed to non-research work during PhD enrollment, the more likely they are to pursue a research-career after PhD graduation. In this sense, previous labor experience can also affect individuals' likelihood to be a researcher.

Therefore, we add a set of instrumental variables (Z_{resch}) that accounts for individuals' labor experience before PhD enrollment and immediately after graduation (such as being involved in research activities and the employment sector), and the elapsed time between undergraduate degree completion and PhD enrollment (as in Di Paolo, 2016). Section 3.3. describes in detail the instrumental variables used in this analysis.

In turn, productivity gaps (income, publications) between individuals may depend on their residential choices: actual country of residence (Uruguay or not), and PhD

enrollment (Uruguay or abroad). As individuals self-select in migration based on their preferences and personality traits (Wahba, 2015), it can affect the estimation of equation (1).

Then, we model a first decision on whether to enroll in a Uruguayan doctorate program or to emigrate for PhD enrollment ($enrol$) as a probit model as follows.

$$enrol = \delta_1' dem + \delta_2' mig + \delta_3' ed_p + \delta_4' prod_b + \delta_5' coaut_b + \delta_6' Z_E + \varepsilon_3 \quad (3)$$

Equation 3 includes similar controls as equation 2 and adds year of PhD enrollment in the set of sociodemographic variables (dem). Based on previous literature, we consider whether the individual has previous migration experience before PhD enrollment (mig), as it can increase individuals' probability of future migration (Franzoni et al., 2014).[13]

In turn, we control for parental education (ed_p), as more educated parents are likely to have explicit strategies for preparing their children for emigration, such as investing in a foreign language skill; influencing on individuals' preferences, tastes, and personality traits (i.e., openness to experience or extraversion), more experience travelling and higher (unobserved) innate ability, both of which might affect their emigration intention (Ivlevs, 2015).

Past performance proxied by weighted academic publications and researchers' co-authorship network before PhD enrollment ($prod_b$ and $coaut_b$, respectively) can also affect individuals' PhD enrollment decision.[14]

To control for endogeneity issues, we add a set of instrumental variables (Z_E). First, we consider whether the individual had children before deciding to enroll in Uruguay or abroad, as family ties can be expected to affect migration decisions (Cañibano et al., 2017; Gibson and McKenzie, 2011). Second, we include motives for PhD enrollment, a set of retrospective variables accounting for individuals' reasons for selecting a specific program. These include factors such as university or advisor reputation, availability of scholarships or financial aid, and local PhD program offerings.[15] Finally, drawing on literature emphasizing the role of personal contacts in PhD program selection, we introduce a second proxy for individuals' social networks: the average number of PhD graduates in the same field who previously earned their degree from a foreign university. Section 3.3 provides further details on the selected instrumental variable (IV).

Then, we model individuals' residential choice (res) as follows:

$$res = \tau_1' dem + \tau_2' enrol + \tau_3' mig + \tau_4' ed_p + \tau_5' fund + \tau_6' prod + \tau_7' coaut + \tau_8' Z_R + \varepsilon_4 \quad (4)$$

Note that equation 4 is similar to equation 3 in terms of controls for sociodemographic characteristics, educational choices, migration experience, and parental educational background. We consider PhD funding as a potential factor influencing on residential choices, such as the compulsory service requirements tied to government scholarships (Güngör and Tansel, 2008). Additionally, we account for individuals' past productivity, as self-selection based on unobserved abilities may occur. We include $coaut$ as researchers' co-authorship networks are important channels through which job information can flow.

[13] Note that migration experience excludes migration for study motives.

[14] Past performance can be used by universities for students' admission in doctorate programs, signaling abilities. Individuals' networks can provide information regarding PhD programs.

[15] Estimations with or without these retrospective variables report very similar results.

Z_R denotes for a set of instrumental variables (Z_R). First, we include a dummy variable indicating whether the individual had a child born during PhD enrollment, as family ties influence on individuals' residential choices (Cañibano et al., 2017; Gibson and McKenzie 2011). Second, we consider whether the individual was a public employee in Uruguay before PhD enrollment; in such a case, she would likely have committed to return following graduation.

Overall, in order to control for multiple endogeneity issues, we model strategies used by earlier literature (Burone and Méndez, 2022; Roach and Sauermann, 2010) and estimate Seemingly Unrelated Equation Systems (SURE) with IVs for each outcome of interest: labor income and performance in terms of academic publications,

$$\begin{cases} gains = \beta_1' dem + \beta_2' res * enrol + \beta_3' labor + \beta_4' prod + \beta_5' coaut + \varepsilon_1 & (1) \\ researcher = \gamma_1' dem + \gamma_2' res + \gamma_3' enrol + \gamma_4' fund + \gamma_5' Z_{resch} + \varepsilon_2 & (2) \\ enrol = \delta_1' dem + \delta_2' mig + \delta_3' ed_p + \delta_4' prod_b + \delta_5' coaut_b + \delta_6' Z_E + \varepsilon_3 & (3) \\ res = \tau_1' dem + \tau_2' enrol + \tau_3' mig + \tau_4' ed_p + \tau_5' fund + \tau_6' prod + \tau_7' coaut + \tau_8' Z_R + \varepsilon_4 & (4) \end{cases}$$

where $\varepsilon = (\varepsilon_1, \varepsilon_2, \varepsilon_3, \varepsilon_4)' \sim N(0, \Sigma)$, in which the main diagonal of the correlation matrix Σ is 1, and out of the main diagonal $\rho_{12}, \rho_{13}, \rho_{C14}, \rho_{23}, \rho_{24}, \rho_{34}$.

The next sub-section describes the exclusion restrictions of this study in detail.

3.3. Exclusion restrictions

As previously underlined, endogeneity issues are likely to arise in these types of studies. First, unobserved factors like an individual's personality traits, preferences, and tastes, could affect migration choices (i.e. actual place of residence and past residence for doctorate enrollment) and productivity (Collischon, 2020; Fouarge et al., 2019; Rohrbach-Schmidt, 2020). For example, extroversion may influence individuals' migration decisions (Fouarge et al., 2019), and the ability to negotiate higher wages (Collischon, 2020; Rohrbach-Schmidt, 2020). Second, PhD holders self-select in research activities (Di Paolo, 2016; Roach and Sauermann, 2010). Additionally, reverse causality between individuals' career choices and place of residence can bias the results if not properly addressed.

To account for endogeneity, we use different instrumental variables (IV) as in Burone and Méndez (2022); Di Paolo (2016); Roach and Sauermann (2010). Equation 2 models individuals' selection in research controlling for a set of IV (Z_{inv}) that are likely to influence career choice, but do not directly affect individuals' gains. This set of variables includes individuals' labor experience before PhD enrollment and immediately after graduation (such as being involved in research activities and the employment sector). The more the individuals were exposed to research work in the past (before PhD enrollment and immediately after PhD graduation), the more likely they are to pursue a research career at the time of the survey (Roach and Sauermann, 2010). We also consider the elapsed time between PhD enrollment and the completion of the undergraduate degree in line with Di Paolo (2016), with the understanding that each additional year between the undergraduate degree and PhD enrollment represents more exposure to the labor market, increasing the chances of finding a job outside the academia.

Next, equation 3 denotes whether the individual chooses to enroll in a Uruguayan doctorate program or a foreign one. For this decision to be made, the individual considers her family ties as well as different aspects of the PhD program. A first IV considers

individuals' reported reasons for choosing a PhD program: university or thesis supervisor's prestige; scholarship availability; local supply, family ties, and desire to stay in Uruguay. A second IV is whether the individual had children before PhD enrollment, a likely factor in the decision to stay or to leave.

Finally, equation 4 estimates residential choices at the time of the survey: Uruguay or a foreign country. In this case, we consider if the individual had a child during enrollment in a PhD program or not. We speculate that new family ties (like a newborn child) could affect the individual's residential choices. We also include whether the individual was employed in the public sector before PhD enrollment or not; public employees could have special benefits for study motives, but could also have a commitment to return to the job after PhD completion.

Overall, we are confident that by estimating a SURE with IV analysis, we correctly account for self-selection and reverse causality that may arise in this study; our estimations also suggest researchers' gain differences due to their migration status.

4. Results

This section presents the main findings of our study. Sub-section 4.1 reports the cross-correlation coefficient of the estimated SURE with IV analysis. Sub-sections 4.2 and 4.3 show income and academic publications differentials among researchers with different migration status, respectively. Finally, sub-section 4.4 reports the different factors influencing residential and occupational choices.

4.1. Unobserved heterogeneity and correlations

Table 2 reports cross-correlated coefficients of the estimated SURE with IV. Note that the estimated correlated coefficients of equations 1 and 4 are statistically significant, suggesting that the unobserved individual factors that explain gains (labor income or academic publications) and being a researcher are negatively correlated. In turn, the estimated correlated coefficients of equations 1 and 3 are positive and statistically significant, showing that unobserved factors affect publication and individuals' PhD enrollment choices.

Table 2. Cross-correlation coefficients

	Income		**Publications**	
	Coeff.	**Robust SE**	**Coeff.**	**Robust SE**
ρ_12	0.153	(0.111)	-0.007	(0.095)
ρ_13	0.109	(0.164)	0.226**	(0.097)
ρ_14	-0.163*	(0.084)	-0.503*	(0.268)
ρ_23	-0.154	(0.164)	-0.107	(0.162)
ρ_24	0.024	(0.222)	0.008	(0.229)
ρ_34	-0.060	(0.168)	-0.073	(0.173)
Observations			1527	

* p<0.1, ** p<0.05, *** p<0.01

These results suggest that not accounting for the potential endogeneity resulting from unobserved heterogeneity would lead to biased results, thus giving support to the empirical strategy chosen.

Notably, the IV used are statistically significant in explaining individuals' choices related to migration for PhD enrollment, current residence, and occupational choices (see Panel C in Table 4, columns 1a to 3c); further discussed in section 4.4.

4.2. Labor income differentials across migration status

Table 3, column 1 reports income differentials associated with researchers' migration status. We observe that after controlling for PhD holders' decisions regarding their actual place of residence, previous choices of enrolling in a local or foreign PhD program, and occupational decisions, researchers living in Uruguay experience a penalty in income.

Specifically, researchers with a Uruguayan PhD degree and residing in Uruguay at the time of the survey (never moved for study motives) earn 58% less than those who enrolled in a foreign PhD program and reside abroad. Also, returnees earn 55.5% less than emigrants with a foreign PhD. Notably, there are no significant income differences among emigrants based on their PhD enrollment choice, suggesting that the income gap is primarily driven by place of residence rather than the decision to study abroad. This finding aligns with Gibson and McKenzie (2012), who emphasize that the greatest income gains from migration benefit the migrants themselves.

Regarding the other control variables, women earn 6.5% less than men and younger researchers earn 8.4% less than researchers between 40 to 49 years old. Those from humanities are penalized on income compared to researchers from the agricultural sciences (24.2%). In turn, recently graduated individuals (between 2011 to 2017) are penalized on income (24.1% less than those who obtained their PhD before 1990).

As expected, labor conditions influence income differentials. First, researchers in a national research system (SNI) earn 6.7% more than those who are not. Second, an additional year of experience in the actual institution increases income by 0.07%, while an additional year in the current position reduces income by 0.05%. In turn, researchers employed at the university sector and those employed in the public sector are penalized in income; those with a full time job dedication (RDT) obtain higher income than those without RDT (59%). Note that past productivity and individuals' co-authors network do not affect labor income.

Table 3. Factors affecting labor income and academic publications

	Income (1)		**Publications (2)**	
Sociodemographic characteristics				
Cohort of birth (omitted: less 40)				
40-49	0.084*	(0.045)	0.001	(0.087)
50 or more	0.051	(0.055)	0.033	(0.113)
Women	-0.065**	(0.029)	-0.160***	(0.059)
Migration status (presid#pdoct. Omitted: foreign#foreign)				
Foreign#Uruguay	0.425	(0.348)	-0.002	(0.436)
Uruguay#Foreign	-0.555***	(0.090)	-0.453**	(0.203)
Uruguay#Uruguay	-0.582***	(0.123)	-0.803***	(0.228)
Educational choices				
Field (Omitted: Agricultural sciences)				
Medical and Health sciences	-0.018	(0.080)	0.373**	(0.157)
Natural sciences	-0.117	(0.072)	0.433***	(0.125)
Social sciences	-0.054	(0.062)	-0.993***	(0.123)

Humanities	-0.242***	(0.078)	-1.437***	(0.142)
Engineering and Technology	0.018	(0.073)	-0.078	(0.149)
PhD graduation (Omitted: before 1990)				
1990-2000	-0.019	(0.111)	-0.347*	(0.197)
2001-2010	-0.130	(0.111)	-0.979***	(0.192)
2011-2017	-0.241**	(0.114)	-1.761***	(0.201)
Job characteristics				
1.Belongs to the SNI	0.067**	(0.030)	0.493***	(0.063)
Occupational category (Omitted: private worker)				
Public worker	-0.191***	(0.061)	0.126	(0.101)
Self employed	-0.208	(0.139)	-0.017	(0.278)
Null	-0.132*	(0.075)	-0.091	(0.147)
In RDT	0.587***	(0.042)	0.384***	(0.072)
Sector of activity (Omitted: University)				
Research center	0.047	(0.057)	0.155	(0.103)
Other	0.323***	(0.091)	0.150	(0.162)
Tenure at institution	0.007***	(0.002)	-0.012***	(0.004)
Tenure at job	-0.005*	(0.003)	-0.013**	(0.006)
Production_before	0.013	(0.028)	0.126**	(0.056)
Mean co-authors abroad before PhD	0.025	(0.065)	-0.094	(0.149)
Production_during	0.021	(0.021)	0.410***	(0.048)
Mean co-authors abroad while PhD	-0.014	(0.048)	0.277**	(0.108)
Constant	11.399***	(0.184)	2.947***	(0.314)
Obs.	1526		1526	

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

4.3. Academic publications and migration status

Next, we analyze whether researchers' migration status affects productivity in terms of academic publications. Table 3, column 2 shows that researchers who studied and reside abroad are 45.3% more productive than returnees. In turn, returnees are, on average, more productive than non-emigrants. Then, it can be stated that, although the country experiences brain gain as returnees publish more in comparison to non-emigrants, there is still room for brain gain as more productive researchers remain in a foreign country.

Second, individuals' past performance in terms of weighted academic publications before and during PhD enrollment influence actual performance; researchers who published more before are more likely to perform better. Also, researchers with more foreign co-authors during PhD enrollment are more likely to perform better in terms of publications. Therefore, in line with Scellato et al. (2015) mobility fosters productivity and enhances networks.

With regard to other controls used, we find that women, researchers in humanities and social sciences, and relatively recent graduates, do worse in terms of academic publications. Also, current labor conditions affect researchers' productivity: full-time dedication (RDT) and being part of a National Research System (SNI) increase researchers' productivity. On the contrary, the longer one's tenure in their current job and institution, the less productive they are.

4.4. Individual choices and their effects on productivity

Previous results are conditional on individuals' choices regarding place of residence, doctorate program, and occupation. Therefore, it is important to analyze the factors behind these decisions as indirectly affecting individual gains. As we assess whether Uruguay experiences 'brain drain' or 'brain gain', we are particularly interested in those factors associated with individuals' residential choices (emigrants and returnees).

In what follows, Table 4 presents the average marginal effects (AME) of the SURE for the two outcomes of interest (income and academic publications) for the factors affecting individuals' choices on actual residence (sub-section 4.4.1), PhD enrollment (sub-section 4.4.2), and occupational choice (sub-section 4.4.3). As the estimated coefficients are very similar in both equation systems, we describe the associations between variables for the first equation system (income), keeping in mind that are similar when focusing on academic publications.

Table 4. AME for individuals' choices

	Income						Productivity: academic publications					
Panel A.	**Residence (1a)**		**PhD enrollment (2a)**		**Researcher (3a)**		**Residence (1b)**		**PhD enrollment (2b)**		**Researcher (3b)**	
Sociodemographic vbles												
Birth cohort (Omitted: less 40)												
40-49	0.118***	(0.038)	-0.079***	(0.027)	-0.007	(0.022)	0.117***	(0.039)	-0.077***	(0.026)	-0.010	(0.022)
50 or more	0.181***	(0.041)	-0.055	(0.035)	-0.021	(0.024)	0.181***	(0.042)	-0.053	(0.034)	-0.020	(0.024)
Women	0.008	(0.021)	0.035**	(0.018)	0.029*	(0.016)	0.012	(0.021)	0.034*	(0.018)	0.032*	(0.016)
Country of residence: Uruguay					-0.006	(0.050)					-0.005	(0.051)
Lived abroad before PhD	-0.116***	(0.026)	-0.092***	(0.020)			-0.118***	(0.026)	-0.088***	(0.020)		
Parental education												
<9 yrs	0.008	(0.030)	-0.051*	(0.027)			0.004	(0.030)	-0.054**	(0.026)		
9-12yrs	0.033	(0.031)	-0.014	(0.030)			0.030	(0.032)	-0.020	(0.029)		
13yrs +	-0.012	(0.029)	-0.039	(0.025)			-0.015	(0.030)	-0.044*	(0.025)		
Educational choices												
PhD in Uruguay	0.170***	(0.046)			0.015	(0.037)	0.159***	(0.045)			0.023	(0.037)
Field (Omitted: Agricultural sc.)												
Medical and Health sciences	-0.079*	(0.047)	0.147*	(0.085)	-0.041	(0.035)	-0.077	(0.047)	0.141*	(0.084)	-0.038	(0.035)
Natural sciences	-0.038	(0.036)	0.170***	(0.053)	-0.025	(0.025)	-0.032	(0.036)	0.171***	(0.053)	-0.026	(0.024)
Social sciences	-0.044	(0.035)	-0.060*	(0.034)	-0.038	(0.024)	-0.046	(0.035)	-0.063*	(0.034)	-0.036	(0.024)
Humanities	-0.048	(0.046)	-0.195***	(0.041)	-0.059	(0.037)	-0.047	(0.047)	-0.196***	(0.040)	-0.062*	(0.038)
Engineering and Technology	0.017	(0.039)	0.132***	(0.047)	-0.107***	(0.036)	0.019	(0.039)	0.131***	(0.047)	-0.107***	(0.036)

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

Table 4 (cont.)

	Income						Productivity: academic publications					
Panel B.	**Residence (1a)**		**PhD enrollment (2a)**		**Researcher (3a)**		**Residence (1b)**		**PhD enrollment (2b)**		**Researcher (3b)**	
PhD cohort start (Omitted: Before 1990)												
1990-2000	0.059	(0.048)	0.072*	(0.037)			0.064	(0.048)	0.081**	(0.037)		
2001-2010	0.094*	(0.051)	0.082**	(0.041)			0.100*	(0.051)	0.099**	(0.042)		
2011-2017	0.114**	(0.058)	0.040	(0.052)			0.116*	(0.061)	0.064	(0.054)		
PhD funding												
Public	0.098***	(0.024)			0.019	(0.018)	0.098***	(0.023)			0.014	(0.019)
Private	0.040	(0.025)			-0.038**	(0.018)	0.037	(0.025)			-0.032*	(0.018)
Other	-0.010	(0.029)			0.026	(0.026)	-0.009	(0.029)			0.027	(0.025)
Co-authors before PhD	0.014	(0.062)	-0.042	(0.041)			0.007	(0.061)	-0.040	(0.040)		
Co-authors while PhD	-0.118***	(0.032)					-0.117***	(0.032)				
Publications before PhD	0.020	(0.025)	0.084***	(0.017)			0.024	(0.026)	0.080***	(0.017)		
Publications while PhD	-0.020	(0.017)					-0.021	(0.017)				

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

Table 4 (cont.)

Panel C.	Residence (1a)		PhD enrollment (2a)		Researcher (3a)		Residence (1b)		PhD enrollment (2b)		Researcher (3b)	
Instrumental variables												
Public employee before PhD	0.050**	(0.025)					0.052**	(0.025)				
Children while PhD	-0.071**	(0.036)					-0.064*	(0.036)				
PhD networks (graduated field)			-0.256*	(0.140)					-0.271*	(0.139)		
Children before PhD			0.097***	(0.023)					0.104***	(0.023)		
Motives for choosing PhD program												
University			-0.257***	(0.023)					-0.252***	(0.023)		
Scholarship			-0.086***	(0.019)					-0.087***	(0.019)		
Local supply			0.260***	(0.020)					0.258***	(0.021)		
Gap PhD-Bachelor					-0.005***	(0.001)					-0.005***	(0.001)
Research experience												
Before PhD					0.012	(0.027)					0.021	(0.028)
After PhD					0.403***	(0.079)					0.386***	(0.081)
Employment sector before PhD (Omitted: university)												
Research center					-0.016	(0.026)					-0.018	(0.026)
Other					-0.139***	(0.030)					-0.135***	(0.029)
Observations	905		905		905		905		905		905	

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

4.4.1. Current place of residence

First, we observe that a prior decision regarding PhD enrollment is important for individuals' current residential choice. When graduating from a local doctorate program, the probability that an individual will live in Uruguay increases by 17 percentage points (pp) (Table 4, column 1a).

Second, the chosen IVs are statistically significant for explaining individuals' actual residential choice. Specifically, those who were public employees before the PhD enrollment are 5pp more likely to reside in Uruguay, while those who had a child born while enrolled in a foreign doctorate program are 7pp less likely to live in Uruguay.

Third, individuals' productivity before and during PhD enrollment does not influence residential choice and demonstrates no selection in terms of productivity. However, as shown in sub-section 4.3, current place of residence impacts individuals' productivity. In turn, individuals more exposed to international networks while enrolled in the doctorate degree (those with more foreign coauthors) are less likely to reside in Uruguay.

Regarding the other control variables, we observe that older individuals are more likely to reside in Uruguay. Conversely, those with previous migration experience (and not for study motives) are 11.6pp less prone to choose Uruguay.

Educational choices like field of knowledge, the period of PhD enrollment, and the PhD's source of funding, are important determinants of the place of residence. Researchers from medical and health sciences are 8pp less likely to live in Uruguay in comparison to those from the agricultural sciences; probably related to local labor market opportunities. Those more recently enrolled in a PhD program and those who funded their PhD with public resources, are more prone to stay in Uruguay; which could be explained by the increasing local supply of doctorate degrees and the increasing public national budget for research activities and PhD scholarships since 2005.[16]

4.4.2. PhD enrollment choices

Next, we explore individuals' migration decisions due to PhD enrollment (column 2a in Table 4). As above, our IVs are statistically significant in explaining people's educational choices. For instance, individuals embedded in larger social networks (measured by the average of PhD holders previously graduated abroad) increase their chances to study in a foreign country in 25.6pp (significant at 90%). Also, family ties affect enrollment choices; individuals with children before PhD enrollment are 9.7pp more prone to study in Uruguay (significant at 99%).

Individuals who place greater value on the prestige of the university or thesis supervisor, as well as the availability of scholarships, are more likely to study abroad, as opposed to those valuing the local supply of doctorate programs. Second, we observe that more productive individuals before PhD enrollment are 8.4pp more likely to stay in Uruguay for doctorate enrollment.

In turn, women and younger individuals choose Uruguay for PhD enrollment, in comparison to men and those aged 40 to 49 years old. As expected, those with migration experience prior to PhD enrollment, are less likely to study in Uruguay.

[16] Méndez et al. (2019) briefly describe the institutional framework for research in Uruguay.

Finally, researchers in the Humanities and Social Sciences are less likely to study in Uruguay than those from other fields. Individuals enrolled in a doctorate program between 2011 and 2017 are more prone to study in Uruguay than older cohorts of students. The gradual expansion of the local supply of doctorate degrees in Uruguay, mostly offered in natural sciences and medical and health sciences in the 1990s to other fields of knowledge in the 2000s could be explaining these results.

4.4.3. Occupational choices

Column 3a in Table 4 shows the AME of the factors associated with individuals' occupational choice. We first observe that our IVs proved to be statistically significant in explaining individual career choices. Specifically, and consistent with previous literature (Di Paolo, 2016), the greater the elapsed time between completion of an undergraduate degree and PhD enrollment, the less likely the individual was to pursue a research career. Also, individuals with previous experience in research were more likely to be researchers at the time of the survey; as well as those previously employed in a university.

In turn, women are 3pp more likely to be researchers than men. Persons in engineering and technology are 10.6pp less prone to be researchers than those from the agricultural sciences. Whether one lives in Uruguay currently or has graduated from a foreign PhD program did not appear to directly affect career choice. Finally, similar to Nisticò (2018) and Horta et al. (2018), we observe that individuals who funded the doctorate degree with private resources are less likely to become researchers.

5. Concluding remarks

This study assessed whether a developing country such as Uruguay experiences 'brain gain' or 'brain drain'. To this end, we explored the extent to which individual and social benefits are derived from international migration choices of Uruguayan researchers holding a doctorate degree; i.e. non-emigrants, emigrants, and returnees.

To undertake this study, we estimated seemingly unrelated equation systems with instrumental variable analysis, which allowed to account for endogeneity issues due to unobservables and reverse causality.

We derive multiple conclusions from our results. First, the largest gains from migration go to migrants themselves. As highlighted in Gibson and McKenzie (2012), not considering the impact on the migrants themselves will lead to a distorted view of the economic benefits and costs of migration for source countries.

Second, in line with Scellato et al. (2015), migration fosters productivity and enhances networks. Uruguayans residing abroad obtain higher income; produce more in terms of academic publications; and have a more heterogeneous network in terms of co-authorships, with more participation of foreign co-authors and relatively less co-authors residing in Uruguay.

Social gains relate to human capital accumulation that returnees with a doctorate degree bring to the country. Until recent years, the local supply of doctorate programs was scarce and more oriented to natural and health sciences. Therefore, the return of individuals holding doctorate degrees within fields of knowledge that were not provided by local universities can be seen as brain gain.

However, the return of researchers seems to be mostly driven by family ties, as stressed by previous literature (Bijwaard & Wang, 2016; Cañibano et al., 2017; Gibson & McKenzie, 2011). The relatively small local labor market and the productive economic structure largely based on the primary sector limits private demand for researchers holding a PhD. In Uruguay; research is mostly driven by the public university, with budget restrictions for hiring and for research. These factors may act as push factors in which emigration is seen as a possible channel for reaping the rewards of the long process of human capital investment.

Overall, we conclude that although there is a high proportion of Uruguayans who return to Uruguay after obtaining the PhD, one out of three do not. Then, although the country benefits from return migration, as long as Uruguayan researchers holding a PhD remains abroad and with scarce collaboration in publications with researchers in Uruguay, brain drain is also experienced.

Finally, our results call for policy interventions so that the country might better benefit from skilled international migration. Specifically, policies aiming to retain researchers in the country, by improving research opportunities (i.e. research funding, salary, infrastructure), increasing budget for PhD funding; and fostering cooperation through complex policies of collaboration with Uruguayan researchers living abroad; could at least partially offset brain drain.

References

Anderson, K. A., & Richards-Shubik, S. (2022). Collaborative Production in Science: An Empirical Analysis of Coauthorships in Economics. *The Review of Economics and Statistics*, *104*(6), 1241-1255. https://doi.org/10.1162/rest_a_01025

Basri, E., & Box, S. (2010). International Mobility of the Highly Skilled: Impact and Policy Approaches. En *The innovation for development report 2009-2010: Strengthening innovation for the prosperity of nations*. Palgrave Macmillan Basingstoke. https://doi.org/10.1057/9780230285477

Batista, C., Lacuesta, A., & Vicente, P. C. (2007). Brain Drain or Brain Gain? Micro Evidence from an African Success Story. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1017529

Beine, M., Docquier, F., & Özden, Ç. (2011). Diasporas. *Journal of Development Economics*, *95*(1), 30-41. https://doi.org/10.1016/j.jdeveco.2009.11.004

Beine, M., Docquier, F., & Rapoport, H. (2001). Brain drain and economic growth: Theory and evidence. *Journal of Development Economics*, *64*(1), 275-289. https://doi.org/10.1016/S0304-3878(00)00133-4

Bender, K. A., & Heywood, J. S. (2006). JOB SATISFACTION OF THE HIGHLY EDUCATED: THE ROLE OF GENDER, ACADEMIC TENURE, AND EARNINGS. *Scottish Journal of Political Economy*, *53*(2), 253-279. https://doi.org/10.1111/j.1467-9485.2006.00379.x

Bijwaard, G. E., & Wang, Q. (2016). Return Migration of Foreign Students. *European Journal of Population*, *32*(1), 31-54. https://doi.org/10.1007/s10680-015-9360-2

Borjas, G. J. (1994). The Economics of Immigration. *Journal of Economic Literature*, *32*(4), 1667-1717. JSTOR.

Bredtmann, J., Martínez Flores, F., & Otten, S. (2019). Remittances and the Brain Drain: Evidence from Microdata for Sub-Saharan Africa. *The Journal of Development Studies*, *55*(7), 1455-1476. https://doi.org/10.1080/00220388.2018.1443208

Burone, S., & Méndez, L. (2022). Are women and men equally happy at work? Evidence from PhD holders at a public university in Uruguay. *Journal of Behavioral and Experimental Economics*, *97*, 101821. https://doi.org/10.1016/j.socec.2021.101821

Cañibano, C., Vértesy, D., & Vezzulli, A. (2017). *An inquiry into the return mobility of scientific researchers in Europe*. Publications Office of the European Union. https://data.europa.eu/doi/10.2760/54633

Chen, C., Bernard, A., Rylee, R., & Abel, G. (2022). Brain Circulation: The Educational Profile of Return Migrants. *Population Research and Policy Review*, *41*(1), 387-399. https://doi.org/10.1007/s11113-021-09655-6

Collischon, M. (2020). The Returns to Personality Traits Across the Wage Distribution. *LABOUR*, *34*(1), 48-79. https://doi.org/10.1111/labr.12165

Di Paolo, A. (2016). (Endogenous) occupational choices and job satisfaction among recent Spanish PhD recipients. *International Journal of Manpower*, *37*(3), 511-535. https://doi.org/10.1108/IJM-10-2014-0197

Docquier, F., & Rapoport, H. (2009). Documenting the Brain Drain of "La Crème de la Crème": Three Case-Studies on International Migration at the Upper Tail of the Education Distribution. *Jahrbücher Für Nationalökonomie Und Statistik*, *229*(6), 679-705. https://doi.org/10.1515/jbnst-2009-0603

Docquier, F., & Rapoport, H. (2012). Globalization, Brain Drain, and Development. *Journal of Economic Literature*, *50*(3), 681-730. https://doi.org/10.1257/jel.50.3.681

Dustmann, C., & Kirchkamp, O. (2002). The optimal migration duration and activity choice after re-migration. *Journal of Development Economics*, *67*(2), 351-372. https://doi.org/10.1016/S0304-3878(01)00193-6

Faini, R., Galli, G., Gennari, P., & Rossi, F. (1997). An empirical puzzle: Fallino migration and growing unemployment differentials among Italian regions. *European Economic Review*, *41*, 571-579.

Fouarge, D., Özer, M. N., & Seegers, P. (2019). Personality traits, migration intentions, and cultural distance. *Papers in Regional Science*, *98*(6), 2425-2454. https://doi.org/10.1111/pirs.12468

Franzoni, C., Scellato, G., & Stephan, P. (2012). *Foreign Born Scientists: Mobility Patterns for Sixteen Countries* (w18067; p. w18067). National Bureau of Economic Research. https://doi.org/10.3386/w18067

Franzoni, C., Scellato, G., & Stephan, P. (2014). The mover's advantage: The superior performance of migrant scientists. *Economics Letters*, *122*(1), 89-93. https://doi.org/10.1016/j.econlet.2013.10.040

Gaulé, P. (2014). Who comes back and when? Return migration decisions of academic scientists. *Economics Letters*, *124*(3), 461-464. https://doi.org/10.1016/j.econlet.2014.07.014

Gibson, J., & McKenzie, D. (2011). The microeconomic determinants of emigration and return migration of the best and brightest: Evidence from the Pacific. *Journal of Development Economics*, *95*(1), 18-29. https://doi.org/10.1016/j.jdeveco.2009.11.002

Gibson, J., & McKenzie, D. (2012). The Economic Consequences of 'Brain Drain' of the Best and Brightest: Microeconomic Evidence from Five Countries. *The Economic Journal*, *122*(560), 339-375. https://doi.org/10.1111/j.1468-0297.2012.02498.x

Grogger, J., & Hanson, G. H. (2011). Income maximization and the selection and sorting of international migrants. *Journal of Development Economics*, *95*(1), 42-57. https://doi.org/10.1016/j.jdeveco.2010.06.003

Güngör, N. D., & Tansel, A. (2008). Brain drain from Turkey: An investigation of students' return intentions. *Applied Economics*, *40*(23), 3069-3087. https://doi.org/10.1080/00036840600993999

Horta, H., Cattaneo, M., & Meoli, M. (2018). PhD funding as a determinant of PhD and career research performance. *Studies in Higher Education*, *43*(3), 542-570. https://doi.org/10.1080/03075079.2016.1185406

Ivlevs, A. (2015). Happy Moves? Assessing the Link between Life Satisfaction and Emigration Intentions. *Kyklos*, *68*(3), 335-356. https://doi.org/10.1111/kykl.12086

Jewell, S., & Kazakis, P. (2021). Migration patterns and job satisfaction: Evidence from European doctorate holders. *The Annals of Regional Science*, *66*(2), 359-407. https://doi.org/10.1007/s00168-020-01024-z

Kangasniemi, M., Winters, L. A., & Commander, S. (2007). Is the medical brain drain beneficial? Evidence from overseas doctors in the UK. *Social Science & Medicine*, *65*(5), 915-923. https://doi.org/10.1016/j.socscimed.2007.04.021

Kifle, T., & Hailemariam, I. (2012). Gender Differences in Domains of Job Satisfaction: Evidence from Doctoral Graduates from Australian Universities. *Economic Analysis and Policy*, *42*(3), 319-338. https://doi.org/10.1016/S0313-5926(12)50032-9

Lucas, R. E. B., & Stark, O. (1985). Motivations to Remit: Evidence from Botswana. *Journal of Political Economy*, *93*(5), 901-918.

Méndez, L. (2020). So Dissatisfied to Leave? The Role of Perceptions, Expectations and Beliefs on Youths' Intention to Migrate: Evidence from a Developing Country. *Journal of Happiness Studies*, *21*(8), 2981-3006. https://doi.org/10.1007/s10902-019-00210-x

Méndez, L., Pellegrino, A., Robaina, S., & Vigorito, A. (2019). Primer censo de personas uruguayas e inmigrantes con título de doctorado. Informe de resultados. *Serie Documentos de Trabajo, DT 16/2019. Instituto de Economía, Facultad de Ciencias Económicas y Administración, Universidad de la República, Uruguay*.

Mesnard, A. (2004). Temporary Migration and Capital Market Imperfections. *Oxford Economic Papers*, *56*(2), 242-262. JSTOR.

Monteleone, S., & Torrisi, B. (2010). *A Micro Data Analisys Of Italy's Brain Drain* [MPRA Paper]. University Library of Munich, Germany. https://EconPapers.repec.org/RePEc:pra:mprapa:20995

Mountford, A., & Rapoport, H. (2011). The brain drain and the world distribution of income. *Journal of Development Economics*, *95*(1), 4-17. https://doi.org/10.1016/j.jdeveco.2009.11.005

Nisticò, R. (2018). The Effect of PhD Funding on Postdegree Research Career and Publication Productivity. *Oxford Bulletin of Economics and Statistics*, *80*(5), 931-950. https://doi.org/10.1111/obes.12232

Pellegrino, A., Vigorito, A., & Macadar, D. (2005). *Informe sobre emigración y remesas en Uruguay*. Informe de consultoría realizado para el Banco Interamericano de Desarrollo.

Roach, M., & Sauermann, H. (2010). A taste for science? PhD scientists' academic orientation and self-selection into research careers in industry. *Research Policy*, *39*(3), 422-434. https://doi.org/10.1016/j.respol.2010.01.004

Rohrbach-Schmidt, D. (2020). Licensing, Educational Credentialing, and Wages Among Foreign Skilled Workers in Germany. *Kölner Z. Für Soziologie Und Soz*, *72*, 375-400.

Scellato, G., Franzoni, C., & Stephan, P. (2015). Migrant scientists and international networks. *Research Policy*, *44*(1), 108-120. https://doi.org/10.1016/j.respol.2014.07.014

Stark, O., Helmenstein, C., & Prskawetz, A. (1998). Human capital depletion, human capital formation, and migration: A blessing or a "curse"? *Economics Letters*, *60*(3), 363-367. https://doi.org/10.1016/S0165-1765(98)00125-6

Wahba, J. (2015). Selection, selection, selection: The impact of return migration. *Journal of Population Economics*, *28*(3), 535-563. https://doi.org/10.1007/s00148-015-0541-4