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Intra-regional mobility of PhD students in the European Union: the outcomes of region-making policy?

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ABSTRACT

This paper examines the flow of intra-European Union (EU) students for doctoral (PhD) studies to identify reasons for differences in international student mobility and migration (ISM) among member states. Rather than conceptualising intra-EU PhD student ISM only through push–pull forces, we theorise the intra-EU PhD ISM is associated with relative levels of national resources or levels of capital. We investigate the intra-EU PhD ISM through dyadic country pairings allowing the use of Gravity models to estimate the effect of variables associated with stocks of capital ascribed to a country to the change in the number of PhD students. The findings of this study indicate while there is asymmetry among EU member states, investment in strengthening the higher education systems within individual EU countries can strengthen the overall cohesion and competitiveness of the EU in the global science competition. Thus, policy focused on enhancing developing national higher education systems can pay dividends throughout the EU.

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International student mobility and migration; PhD students; European Union; gravity model

Introduction

The movement of researchers across national borders increased markedly since the 1990s. Europe experienced considerable intra-regional mobility, both following global trends and reflecting policies designed to encourage mobility. Regional mobility to support the European Higher Education Area (EHEA) is central to the Bologna Process (Bergan and Deca 2018). Policymakers anticipated free movement within the region would push European universities in improving the attractiveness of their teaching and research environments to attract students and staff from across the region (Van Bouwel and Veugelaers 2013). The successive policy frameworks encouraged the circulation of people, ideas, and educational practices to promote competition among European universities for the best students, while increasing the overall quality (Eurydice 2010). In summary, a number of policies and initiatives aimed to increase student mobility and create a harmonised exchange of students and academic staff among European countries.

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Doctoral education is a topic of interest to European higher education policy harmonisation. The Bologna Process additionally encouraged European higher education systems to adopt three-year doctoral programs as a means of harmonising advanced education and research (Sadlak 2004). Bologna supported harmonisation is buttressed by isomorphic tendencies associated with globalisation of post-secondary education whereby doctoral programs adopt increasingly similar structures across countries both within and beyond Europe (Nerad 2020; Nearad and Heggelund 2011; Shin, Postiglione, and Ho 2018). As part of the Bologna Processes, the European University Association (EUA) established the Salzburg Principles in 2005, a set of 10 principles about the purpose, organisation, experience, and content of doctoral education. The principles were established to strengthen doctoral education in the region. In 2010, the principles resulted in a set of recommendations for doctoral education reform that stressed the importance of the doctoral degree as rooted in original research, provided a set of recommendations on best practices for organising doctoral programs, and addressing challenges to implementing the principles in practice (EUA 2010). European funding has directly and indirectly supported doctoral education through research funding and mobility programs. Harmonisation, mobility, and funding created a European space for doctoral education that reduced the friction associated from moving from one country to another within the region to pursue a doctoral degree.

Harmonisation, including the adoption of the Salzburg Principles, has helped usher in a European standard for doctoral education but it has not standardised doctoral education in the region; national, institutional, and disciplinary differences endure (Shin, Khem, and Jones 2018). Even where integration is extensive, harmonisation of advanced education and research has not been fully realised. Some dynamics remain contained in national borders, and power imbalances means integration occurs asymmetrically (Cantwell and Grimm 2018; Kweik 2019; Marginson 2021). Doctoral student mobility provides a window into the integration and imbalances of advanced education and research in the region. Consistent with the Salzburg Principles, those undertaking doctoral programs in Europe are generally considered early career researchers. While doctoral researchers are trainees, they are critical members of the scientific workforce (Shin, Khem, and Jones 2018). Policymakers understand regionally mobile doctoral students are important in supporting Europe's national and regional goals to increase competitiveness in the global knowledge economy (Slaughter and Cantwell 2012; Khem 2009). Given the global, regional, and national importance of doctoral education, understanding doctoral exchange patterns remains a question of theoretic and practical significance. Several studies examine intra-European credit mobility (Souto-Otero 2008; Souto-Otero et al. 2013; Van Mol 2013; Van Mol and Timmerman 2014) and a limited number on intra-European degree mobility (Ovchinnikova, Van Mol, and Jones 2022; Rachaniotis, Kotsi, and Agiomirgianakis 2013; Van Bouwel and Veugelers 2013). However, to our knowledge, there are no longitudinal, macro-level (between countries) studies on doctoral student mobility within Europe.

Study purpose

This paper seeks to understand how international mobility of doctoral students works within the policy framework of Europe. Our study centres individual nation states, and

the exchange of students among them, as the unit of analysis. Specifically, we examine the flow of intra-European Union (EU) students for doctoral (PhD) studies to identify reasons for differences in international student mobility and migration (ISM). While the EU is not the EHEA, all EU nation states are EHEA members and subject to not only EHEA policy (e.g. Bologna) but also EU policy (note: UK was a member of the EU until 2020 and is still currently an EHEA member). We chose to focus on intra-EU mobility in large part due to EU treaties allowing EU citizens the right to reside, look for work, and in general, enjoy equal treatment (employment/working conditions as well as all other social and tax advantages) as nationals within another EU country. In short, international students from EU countries within another EU country have roughly similar rights and opportunities as nationals. Our aim is to offer a macro-level account identifying drivers of intra-EU PhD ISM. Because our study addresses the flow of students' between-nation states, we focus on national-level variables that explain the flows. The European context stands as the backdrop to the study, which itself reveals national-level drivers of ISM. The study does not directly assess how the policies and processes emanating from the European Commission and EU directly affect ISM. Instead, we see the EU context as ideas for studying doctoral ISM because the regions education systems are more integrated than in most other regions and because the barriers to mobility are relatively low. Thus, we are able to focus how the differences between nations may contribute to ISM imbalances. Even though we do not focus on EU-specific policy or interventions, understanding the drivers of intra-EU PhD ISM provides a window into scientific and academic integration and asymmetry within the EU. The significance of the study is three-fold.

First, the findings are relevant to regional and national policy. Mobility is a key plank of the educational and economic agendas of the European community (Teichler 2017); a better understanding of the national dynamics of intra-EU PhD ISM can help inform policymakers seeking to steer intra-regional mobility and migration. This is a key point as, in general, PhD degrees are currently less regulated compared to master and bachelor degrees in harmonisation efforts. And because national governments, along with the European Commission (EC), seek to leverage higher education in the knowledge economy (Slaughter and Cantwell 2012), the findings of this study will likely support innovation policy.

Second, mapping intra-EU PhD ISM adds to our understanding of European integration in higher education, both regionally and globally. The EU, as a large part of the EHEA, is the most integrated higher education region in the world. As Marginson (2021) argues, science exists on two registers, global and national. Global science is the near-universal conversation, conducted primarily in English and in the natural sciences, in which networked participants add value to the system by contributing to rapidly advancing bodies of knowledge. National science, on the other hand, is contained within states, conducted in national and local languages and is heterogeneous in values and organisation. Regions, such as the EU and EHEA intermediate between social activity – such as higher education and science – that simultaneously occur on national and global scales. The variegated regionalism concept, or the 'resilient differences in the organization and trajectories of the regimes, institutions, ideas, and practices that shape regional projects and processes' (Robertson 2018, 115) – helps us to identify intra-regional ISM as an empirical marker that shows the contours of the region as well as a region making processes. Empirical findings on regional integration are, useful then, for further developing

concepts of national, regional, and global higher education and specifically for understanding how the EU, as a region, interfaces globally.

Third, the study makes empirical advances in studying ISM. One challenge to studying ISM in general, and intra-EU movement specifically, is inconsistent data collection when patching together national sources (Rachaniotis, Kotsi, and Agiomirgianakis 2013). By primarily using a single data source (with a few noted exceptions), we attempt to overcome the issues Rachaniotis, Kotsi, and Agiomirgianakis (2013) identify. Furthermore, research on ISM is currently dominated by a single or a small number of country studies that often focus on Anglophone or highly economically developed (e.g. OECD member) countries. Understanding the drivers of intra-EU PhD ISM provides a window into the exchanges within the EU. This is significant as both national and regional (EU) governments seek to leverage higher education in the knowledge economy. Though PhD students contribute and advance global research and innovation systems, they are an under-researched topic (Bloch, Gravarsen, and Pedersen 2015). We take a new approach to measuring ISM through dyadic pairing of EU countries. By examining mobility between EU country pairs, we conceptualise mobility being shaped by resource differentials between EU nation states. Our assumption is that student flows are asymmetrical and reflect unequal social, economic, and academic conditions within the EU. We test that assumption empirically using descriptive statistics and two gravity econometric models which were originally designed to study international trade among nation states.

Background literature and conceptual framing

Since the 1980s, the number of individuals holding and seeking doctoral degrees increased considerably, with growth concentrated in high-income countries (Auriol, Misu, and Freeman 2013; Boosten and Vandeveld 2014; Cyranoski et al. 2011; Gokhberg, Shmatko, and Auriol 2016). The growth in doctoral degrees, on a percent change basis, is larger than any other degree type (Auriol 2016). The main reasons cited for growth in PhDs are tied to the importance of knowledge-intensive industries within knowledge economies and increasing need of highly educated workers (see Bryan and Guccione 2018; Pedersen 2014). Highly educated workers are crucial for economic growth in industrialised countries (Cyranoski et al. 2011), though there is limited evidence on which specific economic sectors require PhD graduates (Pedersen 2014).

As doctoral education expands, it is also internationalising. The current OECD average share of 25–64-year-olds with a PhD is around 1%. If current trends continue, roughly 2.3% of today's young adults (18–29 years old) will enter doctoral studies at some point in their life (OECD 2019). A high share of doctoral students come from abroad as roughly one-quarter (25%) of all enrolled PhDs students are international (OECD 2019).

Researchers have long understood ISM as reflective of political, economic, and social conditions (see Chen and Barnett 2000; Mathies and Karhunen 2021a, 2021b; McMahon 1992; Riaño and Piguet 2016; Van Mol 2013). The literature on international students and their mobility and migration patterns is large and growing. ISM has grown rapidly over the past decades and currently, international students are currently the fastest growing group of all international migrants (Czaika 2018). This is even when compared to labour migrants, family migrants, and refugees (Riaño and Piguet 2016). Overall, ISM grew at a constant average annual rate of around 6% between 1998 and 2017 (OECD 2019).

That said, much of the ISM literature focuses on undergraduate students. Consistent with higher education research overall, PhD students are less often studied and remain an under-research topic (Bloch, Graversen, and Pedersen 2015). The globalisation of science generally and specifically of doctoral education, couples with national and regional policies promoting early career mobility contextualises ISM at the PhD level. The intention to create ‘brain gain’, in terms of attracting future PhD students, international academics and students who could contribute to the future work force in a host country is a highly cited reason for ISM. Revenue generation is the least often stated reason, whereas altruistic motives – for example, for development or international cooperation – still play a role (Wächter and Maiworm 2014). The sharpening of the international profile of institutions also plays a role; not just for fostering partnerships with institutions from other countries but also for host institutions improving their profile in comparison with other institutions within their own country.

International doctoral education in Europe

Member states of the EU have integrated their national higher education systems more deeply than any other multinational region. Guided by the conviction that ISM is beneficial for the global competitiveness of the EU, ISM within the EHEA has been strongly promoted through European policy (e.g. The Bologna Process, The Lisbon Agreement) and mobility programs, such as ERASMUS+, helped establish the EHEA (de Wit 2018; Shields 2016). The result is research and development (R&D) and graduate education domains are perhaps the most integrated parts of the EHEA.

While each member country maintains an independent and sovereign higher education system, integration and harmonisation among member systems have produced a single area of social activity. Substantial integration though has not erased the salience of national borders and national systems of higher education. Students remain more likely to undertake a PhD in their own country as the average share in OECD countries is roughly 75% of PhD students are domestic (OECD 2019). Asymmetries among EU countries though endure and remain a barrier to integration (Maricut and Puetter 2018; Ruhs and Palme 2018; Scharpf 2010). Movement of doctoral students among any two countries in the EU occurs with few if any legal barriers but is not a fully ‘level playing field.’ We cannot assume that any two countries in the EU are alike in terms levels of economic, social, and academic resources relative to one another. Even with few structural barriers for mobility, some countries are net senders while others are net receivers of European PhDs, meaning that some countries send more students than they receive.

Conceptual Framing and research questions

Oftentimes, studies on ISM are framed through the push–pull framework that assumes a student’s location of study is a function of forces that ‘push’ away from the home country, and ‘pull’ to a host country (Gesing and Glass 2019; Li and Bray 2007; Mazzarol and Soutar 2002; Maringe and Carter 2007; Souto-Otero et al. 2013). It is implicitly based on a broader centre–periphery model of development, under which flows of students are largely mono-directional from the periphery to the core (Altbach 2007). Push–pull models view mobility being determined by the interaction of relative deprivation in a student’s

home country with opportunity and resources in the host country (e.g. Mazzarol and Soutar 2002; Maringe and Carter 2007; Souto-Otero et al. 2013). Deprivation, in ISM context, includes limited program offerings, poor facilities, inadequate funding, and limited access to expert supervisors. Opportunity, by contrast, refers to strong programs, expert supervisors, funding availability, and well-resourced facilities. Some push–pull studies consider macro-social conditions such as political stability and social development as key elements influencing ISM (Gesing and Glass 2019). Other studies find the quality of academic conditions influencing ISM (Beine, Noël, and Ragot 2014; Van Bouwel and Veugeliers 2013). Economic factors are consistently identified as strong influences in shaping ISM (Beine, Noël, and Ragot 2014; Hawthorne 2018; Mathies and Karhunen 2021a, 2021b).

While the push–pull model is widely applied, it may work less well in regional higher education systems defined by the free movement of citizens (students) and that either does not have a clear centre and a clear periphery, or at exhibit substantial centre–periphery ambiguity (Cantwell 2021). The nation state lies at an intersection of numerous strands of empirical and normative discourses and policies impacting the conditions of lives of the people who inhabit it (Piattoni 2010). In Europe, the role of the nation state is being challenged as new actors are pursuing and enacting strategies at both subnational and super-national (regional) levels (Piattoni 2010). Much of these changes are due to European integration and this in turn, this is redefining the ‘very notions of ‘centre’ and ‘periphery’ of European policy and discourse (Piattoni 2010, 36). So, while our study accepts nation states as the unit for measuring ISM flows, we acknowledge that conventional assumptions about state independence may not fully apply in the EU context.

To partially address the EU context, rather than conceptualising intra-EU PhD student mobility only through push–pull forces, we theorise the intra-EU PhD exchange is associated with relative levels of national resources or levels of capital. Previous research shows higher education is stratified due to concentration of resources (Slaughter and Cantwell 2012), which influences collaboration and exchange patterns (Kweik 2019). Kauppinen, Mathies, and Weimer (2014) conceptualise an international student market where the more capital an actor (nation state, university, or individual) has, the better they can participate. This argument, grounded theoretically through the commodification of knowledge, conceptualises national levels of resources as stocks of different forms of capital. Studies of domestic students’ educational choice, enrolment, and attainment commonly use the concepts of capital and the same conceptions can be applied to international students (Waters 2006). Within an international student market, the type of capital influencing student mobility comes in multiple forms, but the main groupings are academic, economic, and social/cultural (Kauppinen, Mathies, and Weimer 2014); this is in-line with previous studies push–pull grounded ISM studies which use academic, economic, and social or cultural factors (see Beine, Noël, and Ragot 2014; Gesing and Glass 2019; Li and Bray 2007; Souto-Otero et al. 2013; Van Bouwel and Veugeliers 2013).

For this study we operationalise economic capital as the relative wealth of EU member countries and their citizens. Academic capital as the relative size, resource level, and status of national higher education systems. Social capital as the relative wellbeing and equity enjoyed by residents of an EU member country. Operationalising this way frames the economic, academic, and social conditions of an EU member state as either ‘pushing’ a PhD student out (domestically) or ‘pulling’ them in (from abroad). In short, it argues

the various stocks of capital held by countries influence the ways in which member states participate in intra-EU PhD ISM.

We have three sets of research questions. The first research question is on the EU-level trends in intra-EU PhD ISM over time.

- RQ1: What is the total level of intra-EU PhD ISM and how did ISM (exchange) levels change over the observed period?

The second set of research questions focuses on comparisons of intra-EU PhD ISM among the EU member states over time. There are three subset questions in this section operationalised as:

- RQ2.1: Who were the leading intra-EU sending countries for PhDs?
- RQ2.2: Who were the leading intra-EU hosting countries for PhDs?
- RQ2.3: Who were the net sending/host countries of intra-EU PhD ISM?

The third research question examines dyadic country pair mobility (exchanges) of intra-EU PhD ISM and is operationalised as:

- RQ3.1: What is the association between the change in capital with the change in dyadic pairs that pushes students out?
- RQ3.2: What is the association between the change in capital with the change in dyadic pairs that pulls students in?

Methods

For the first two research questions (RQ1 and RQ2), we use descriptive statistics to examine the level of intra-EU PhD ISM trends and changes over a seven-year period (2013–2019). As noted previously, the movement within EU-states is not as simple, or direct, due to the various EU-level regulations and lack of a clearly defined ‘centre-periphery’ in the movement of international students. As such, to investigate the intra-EU PhD ISM, we do so through dyadic country pairs (RQ3). Each case within the model represents a dyadic pairing of PhD students’ mobility, in both directions, between two EU countries. For example, one dyadic pair is the mobility of PhD students between Germany and France.

We use two gravity models in our analysis for RQ3. One for push, controlling for conditions in sending country and one for pull, controlling for conditions in host countries. Gravity models are useful in analysing the exchange of services, capital, and people between countries (Ramos 2016) and have been used previously in studies on ISM (See Beine, Noël, and Ragot 2014; Barrioluengo and Flisi 2017; Kritz and Gurak 2018; Ovchinnikova, Van Mol, and Jones 2022; Van Bouwel and Veugelers 2013). As we set the models as the dyadic exchanges between EU member state, they provide each EU member country 27 exchange partners (EU-28, prior to Brexit) or cases each year. This provides 756 cases a year and 5292 cases across 7 years (2013–2019) of panel data.

Gravity models are common in international trade studies, though in the last two decades they have increasingly been applied in migration studies as well. We focus on

the influences on the mobility of international PhD students from one country and to another, so our dependent variable is the number of PhD students moving from one country (sending) to another country (hosting). From here, we create two models, one for push and another for pull factors. Gravity models are often grouped as ‘supply-side’ or ‘demand-side’ and for this study, we include measures capturing factors that are sending country (push as supply-side) and host country (pull as demand-side) specific. As such, we include the characteristics (values) of sending (push model) country and hosting (pull model) country as controls (independent variables) in the respective models. Additionally, as gravity models assume the movement between two countries directly relates to their characteristics often in the form of distance between and size (see Ramos 2016), we include population, distance between capital cities, and whether countries share a border (contiguous) and official languages as additional controls. We log (ln) all continuous variables as the coefficients in gravity models ‘are often log linearised in empirical applications’ (Van Bouwel and Veugelers 2013, 176). However, two continuous variables, the dependent variable and number of ranked universities, had values of zero (0) which disallowed logging. As such, we treated these two variables by adding 0.001 to each value to allow the logging of these variables, a common approach to addressing 0 trade flows in gravity models (Martin and Pham 2015). In the end, the implied equation for both models (the independent variables for Academic, Economic, and Social capital switch according to push model or sending country and pull model or host country model) is expressed as:

$$\ln Std_{sh} = \ln AC_c + \ln EC_c + \ln SC_c + \ln GAV_{pair} + e_{sh}$$

With Std_{sh} the number of PhD students (Std) from sending (s) country to hosting (h) country, AC_c the amount (3 variables) of academic capital in a country (c ; s for push model and h for pull model), EC_c the amount (2 variables) of economic capital in a country (c ; s for push model and h for pull model), SC_c the amount (2 variables) of social capital in a country (c ; s for push model and h for pull model), GAV_{pair} the required additional controls (4 variables) for the gravity model for each country pair (note, population is country s for push model and h for pull model), and e_{sh} the error term.

Data

Data was collected for a seven-year period (2013–2019). We use this period for two reasons. First, this period was prior to both COVID and the finalisation of Brexit, which has had a notable impact on intra-EU student mobility (see Papatsiba 2021). Analysis of a relatively stable period allowed us to better understand the basic dynamics of intra-EU ISM among doctoral students. However, it also means that the results do not address recent changes and environment. Second, the period reflects data availability at the time of data collection; 2019 was the most recent year available for several variables while 2013 was the earliest year available for complete PhD student mobility data from Eurostat.

Data for most variables were gathered from Eurostat, with three exceptions. We collected data on university rankings from the Times Higher Education World University Rankings. Due to missing data in Eurostat, the number of EU PhD students in Germany, data on inbound students to Germany, was pulled from the Federal Ministry of Education

and Research (BMBF) which provides data sourced from the Federal Statistical Office of Germany (Destatis).¹ Finally, we include data from the Research and Expertise on the World Economy (CEPII) Gravity database for the distance between countries' capital cities (as a proxy for the distance between countries) and whether countries share a border (contiguous) or an official language. These variables are needed for the chosen (gravity) models for the analysis of RQ3.

The dependent variable for the dyadic pair models is the number of PhD students a country sends to another EU member state in the *Mobile students from abroad enrolled by education level, sex, and country of origin* (EDUC_UOE_MOBS02) Eurostat data table (except for the noted exception of incoming into Germany). There were a few cases of a country pair not having values in all years (dependent and independent variables)²; these were estimated by using the other years' data (in same variable and country) which provided an average (mean) value and were subsequently used. Full listing and documentation of specific tables and estimates for all variable values are available from the authors.

We operationalise the independent variables into three forms of capital (academic, economic, and social). Academic capital is the resource level and status of national higher education systems and is measured by the tertiary attainment ratio (% of population 25–34 who have completed tertiary studies), the share of GDP spent on R&D in the higher education sector only, and the number of universities appearing in the top-400 of the THE world rankings. Economic capital is the wealth of countries and residents and is measured by GDP per capita (at the current market price in year) and personal disposable income (Gini coefficient of the share of population arranged by equivalised income). Social capital includes measures of wellbeing and equity enjoyed by a country's residents and is measured by life expectancy (total number of healthy years expected) and the gender pay gap (difference in average hour earnings, male vs female). As gravity models assume the exchanges between two countries directly relate to their characteristics, often in the form of distance between and size (see Ramos 2016), we include the country's population (Eurostat), distance between capital cities (CEPII), and whether country pairs share a border (contiguous, CEPII) and an official language (CEPII).

Of note, our study does not include data on EU funding for scientific research and EU mobility programs that may influence the results of the study. This is a potential limitation, as unobserved streams of funding could bias results. We acknowledge this limitation but also note that European research funding generally correlates with other measures of national size, wealth, and academic prowess. Between 2014 and 2020, Germany, the UK, and France were the top three nations in terms of Horizon 2020 programme research allocations. Together, these three large nations were allocated nearly 40% of all Horizon 2020 funds (Schiermeier 2020). Given that EU funding allocation patterns appear to track tightly with the national measures included in our model, we are comfortable with the nation state focus of this study.

Findings

Regional findings

To address our first research question, we examined PhD ISM in the region. The intra-EU PhD ISM saw a sharp increase followed by a slight decline over the seven-year period

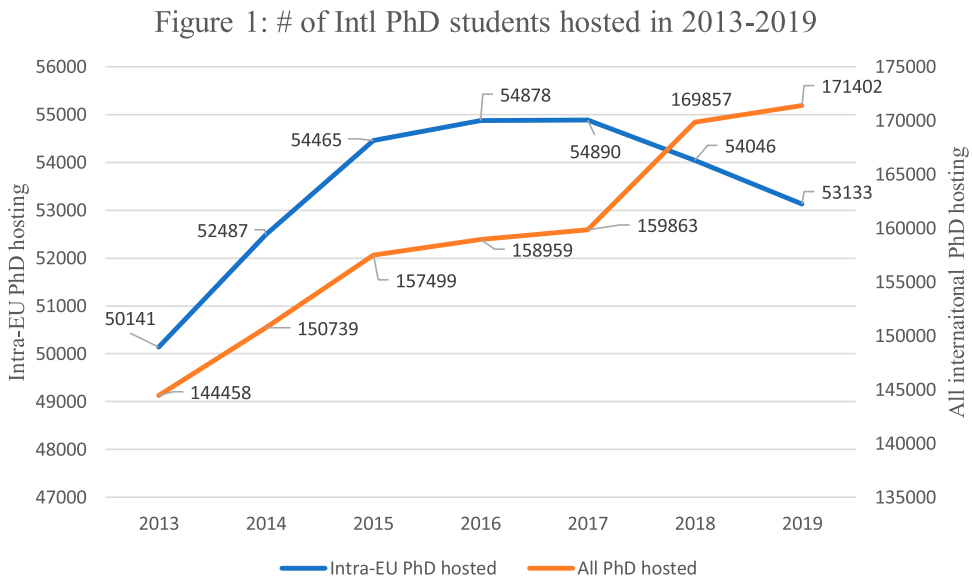


Figure 1. Number of PhD students hosted in EU countries 2013–2019.

(2013–2019) with the high mark coming in 2017. The total number of PhD students moving among the 28 member states of the EU grew each year between 2013 and 2017 (see [Figure 1](#)) from 50,141 to 54,878. However, in 2018 and 2019, there was a decline in Intra-EU PhD students with only 54,046 (2018) and 53,133 (2019) PhD students moving. During the seven-year period of observation, there was a steady growth of all international PhD students in the EU. These represented students from any nationality other than the host country growing from just over 144,000 students in 2013 to more than 171,000 in 2019.

Country level findings

To understand which EU countries were most involved in the intra-EU movement of PhD students (by student numbers), as well as which EU countries sent and hosted the most EU PhD students, we examined both the full sample (2013–2019 combined) as well as the 2019 data, the most recent year in the sample (RQ2.1–RQ2.3). [Table 1](#) (2013–2019) and [Table 2](#) (2019) display each country's total number of students sent, the total number of students hosted, and net sending, the difference between the number of students sent and hosted. Countries were ranked for sending, hosting, and net sending (sending minus hosting). For the entire sample (2013–2019) as well as the last year of the sample (2019), the top five countries involved in Intra-EU PhD ISM (hosting and sending combined) were the same – Germany, UK, Italy, France, and Spain. These top five countries accounted for roughly 57% (56.7% full sample, 57.1% last year) of all the intra-EU PhD ISM. Conversely, the lowest five – Malta, Latvia, Estonia, Slovenia, and Lithuania – were involved in around 2% (1.9% full sample, 2.0% last year) of all intra-EU PhD ISM. These descriptive data show substantial asymmetry in intra-EU PhD ISM among EU member states.

Table 1. Number of students sent, hosted, and net – full sample (2013–2019).

Full sample	# Send	Send rank	#Host	Host rank	Net send #	Net send rank
Austria	14,301	9	29,260	4	-14,959	3
Belgium	7450	15	9577	10	-2127	10
Bulgaria	9283	13	981	21	8302	22
Croatia	7152	16	196	26	6956	21
Cyprus	5162	20	879	22	4283	19
Czech Rep.	5259	19	16,082	7	-10,823	5
Denmark	2724	24	11,350	9	-8626	7
Estonia	2146	26	785	23	1361	12
Finland	2857	23	8168	11	-5311	9
France	24,169	5	35,169	3	-11,000	4
Germany	56,744	2	77,462	2	-20,718	2
Greece	26,627	3	1413	18	25,214	27
Hungary	5852	17	2333	17	3519	18
Ireland	9214	14	5956	13	3258	17
Italy	65,475	1	6948	12	58,527	28
Latvia	1929	27	784	24	1145	11
Lithuania	3400	22	149	27	3251	16
Luxembourg	4428	21	2415	16	2013	15
Malta	1784	28	94	28	1690	13
Netherlands	11,698	11	17,698	6	-6000	8
Poland	19,508	6	1070	20	18,438	26
Portugal	14,577	8	4277	14	10,300	23
Romania	12,974	10	1187	19	11,787	25
Slovakia	15,921	7	4135	15	11,786	24
Slovenia	2551	25	617	25	1934	14
Spain	25,119	4	19,071	5	6048	20
Sweden	5764	18	14,456	8	-8692	6
UK	9972	12	101,528	1	-91,556	1

Table 2. Number of students sent, hosted, and net – 2019 only.

2019 only	# Send	Send rank	#Host	Host rank	Net send #	Net send rank
Austria	2004	9	4457	4	-2453	2
Belgium	1136	14	347	17	789	20
Bulgaria	1126	15	201	21	925	22
Croatia	959	16	41	26	918	21
Cyprus	700	19	241	18	459	19
Czech Rep.	674	20	2482	7	-1808	4
Denmark	430	24	1723	9	-1293	7
Estonia	267	26	149	23	118	12
Finland	398	25	1097	11	-699	9
France	3216	5	4897	3	-1681	5
Germany	8156	2	9975	2	-1819	3
Greece	3782	3	187	22	3595	27
Hungary	819	18	361	16	458	18
Ireland	1160	13	1035	12	125	13
Italy	10,337	1	1184	10	9153	28
Latvia	231	27	114	24	117	11
Lithuania	445	23	21	28	424	16
Luxembourg	625	21	425	15	200	15
Malta	214	28	28	27	186	14
Netherlands	1732	10	2531	6	-799	8
Poland	2180	7	224	20	1956	26
Portugal	2172	8	694	13	1478	24
Romania	1667	11	229	19	1438	23
Slovakia	2221	6	445	14	1776	25
Slovenia	541	22	88	25	453	17
Spain	3600	4	3886	5	-286	10
Sweden	820	17	2131	8	-1311	6
UK	1521	12	13,940	1	-12,419	1

Hosting

Of all the EU PhD students studying in another EU member country, a total of 101,528 across the seven years and 13,940 alone in 2019 studied in the UK (see [Tables 1 and 2](#)). Roughly one out of every four (27.1% full sample, 26.2% 2019) intra-EU PhD students were at UK universities. Germany received the second largest number of inbound intra-EU PhD students, hosting 77,462 across the seven years and 9975 in 2019, or 20.7% (full sample) and 18.8% (2019) respectively. At 35,169 (9.4%) students across the seven years and 4897 (9.2%) in 2019, France was the third largest host. Combined, these three countries hosted over half (57.3% full sample, 54.2% 2019) of all Intra-EU PhD ISM. In 2019, more than half (16) of the 28 EU member states hosted fewer than 1000 EU PhD students with four countries – Slovenia, Croatia, Malta, and Lithuania – hosting fewer than 100 students.

The movement of PhD students is a two-way street. For example, while the UK hosted 13,940 EU PhD students in 2019 (see [Table 2](#)), 1521 UK nationals undertook PhD studies elsewhere in the EU. As a result, the UK was a net host of 12,419 students, the most in the EU (see [Table 1](#)). For both the full sample and 2019 data, only 10 of the 28 EU member states were net hosts of EU PhD students. The 2019 net host countries were the UK (12,419), Austria (2453), Germany (1819), Czech Republic (1808), France (1681), Sweden (1311), Denmark (1293), Netherlands (799), Finland (699), and Spain (286).

Sending

The top sending countries for both the full sample and the last year (2019) were Italy (65,475 or 17.5% full sample, 10,337 or 19.5% 2019), Germany (56,744 or 15.2% full sample, 8156 or 15.4% 2019) and Greece (26,627 or 7.1% full sample, 3782 or 7.1% 2019). Combined, these three countries sent around 40% (39.8% full sample, 41.9% 2019) of all Intra-EU PhD ISM. The lowest sending countries were Malta (1784 or 0.5% full sample, 214 or 0.4% 2019), Latvia (1929 or 0.5% full sample, 231 or 0.4% 2019), and Estonia (2146 or 0.6% full sample, 267 or 0.5% 2019). The lowest sending countries combined for around 1.5% (1.6% full sample, 1.3% 2019) of all Intra-EU PhD ISM.

Majority of EU countries (18) were net senders, meaning they sent a greater number of PhD students to other EU member countries than they hosted. The largest net senders were Italy (58,527 full sample, 9152 in 2019), Greece (25,214 full sample, 3595 in 2019) Poland (18,438 full sample, 1956 in 2019), Romania (11,787 full sample, 1438 in 2019), Slovakia (11,786 full sample, 1776 in 2019), and Portugal (10,300 full sample, 1478 in 2019) (see [Tables 1 and 2](#)).

Dyadic pairing findings

The estimates of dyadic pairing results from the gravity models allow an understanding of the correlates of the movement of PhD students between EU member countries (RQ3). The estimated the effect of variables associated with stocks of capital – or academic, economic, or social measures ascribed to a country, on change in the number of PhD students either pushed out or pulled in for each dyadic country pair. [Table 3](#) presents the results of both gravity models.

Table 3. Dyadic country results – gravity model.

Variables		Push model	Pull model
<i>Academic capital</i>	In R&D expenses as share of GDP	−0.182 (0.186)	0.384** (0.170)
	In tertiary attainment	0.913* (0.523)	−0.358 (0.385)
	In top-400 ranked universities	−0.023 (0.015)	0.041*** (0.015)
<i>Economic capital</i>	In per capita GDP	−0.966*** (0.255)	2.359*** (0.222)
	In disposable income	0.074 (0.937)	0.546 (0.800)
<i>Social capital</i>	In gender pay gap	−0.129 (0.166)	0.299 (0.202)
	In life expectancy	0.949 (0.910)	−1.265 (0.819)
<i>Gravity model</i>	In population	0.654*** (0.092)	0.912*** (0.073)
	In distance (km)	−0.418** (0.205)	−0.365** (0.156)
	Contiguous (Y/N)	1.105*** (0.389)	1.437*** (0.309)
	Common language (Y/N)	2.019*** (0.559)	−0.067 (0.410)
	Number of obs	5292	5292
	Number of dyad groups	756	756
	R^2 within	0.367	0.367
	R^2 between	0.622	0.768
	R^2 overall	0.571	0.700

Robust standard errors in parentheses.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$.

Among academic capital variables, R&D expenses as a share of GDP and having ranked (top-400) universities in the THE were significant and positive influences for the pull model, suggesting when a country invests in research (funding) or has ranked universities, the number of intra-EU PhD students is predicted to increase. For the push model, only the level of tertiary attainment was significant (and positive). This suggests an increase in the relative supply of educated population in an EU country increases the possible candidates who seek further education (PhD studies) abroad in another EU country.

For economic capital, only the per capita GDP was significant for both (push and pull) models. The negative finding for the push model suggests GDP growth for an EU country relative to dyadic pair partner is associated with sending fewer PhD students to the partner. The positive finding for the pull model suggests relative GDP growth relative to dyadic partner is associated with attracting more PhD students (hosting). For social capital, none of the variables were significant for either model. This indicates social conditions were not significant factors (positively or negatively) associated with intra-EU PhD ISM.

Several of the gravity model control variables were significant. Population was significant and positive in both models. The distance between national capitals was a significant negative predictor while sharing a border was a significant positive predictor for both models. The common language variable was significant (and positive) for the push model but was insignificant for the pull model. This suggests international PhD students are likely to go, or are pushed towards, countries where there is a shared common language.

Discussion

The descriptive and gravity model findings offer several insights into Intra-EU PhD ISM. At the European level (RQ1), there was consistent growth in the first five years of observation (2013–2017) with the number of international PhD students from other EU member states

as well as the overall international PhD student numbers, which includes sending countries outside the EU. The early year growth (2013–2017) was consistent with policy efforts to build, expand, and integrate a regional higher education and research area. This also aligns with OECD's (2019) finding of an increasing number of PhD students globally during this time period. Decline in the number of PhD students from the EU countries in the last two years of the sample hints at an emerging shift in PhD ISM in Europe. In 2013, EU PhD students represented 34.7% of all international PhDs in EU member states; this share steadily declined to 31.0% in 2019. While there was overall growth of international PhD students in EU member states, international PhD students in the region increasingly originated from outside the EU.

The decline of Intra-EU PhD students in the last two years of observation likely relates to larger factors impacting the large EU area (e.g. Brexit – vote was June 2016, declining youth population, etc.) as the three largest host countries (UK, Germany, France) of EU PhDs all experienced a decline in hosting EU PhDs. While these larger factors likely do not fully explain why this occurred in the last two years of observation, we note this is consistent with Robertson's (2018) observation about educational regionalism; intra-regional integration appears to be a precursor to an increased global presence of Europe as a region for higher education. Regional mobility is both an end in itself, but also a means to better establishing the EU as an entity for attracting skilled migrants globally. The early success of regional mobility may translate to the relative de-emphasis of the EU recruiting internally and increased emphasis on recruiting externally PhD students.

While the country-level findings (RQ2) do not indicate a clear pattern of movement, they do suggest the ISM of EU PhD students among EU member states is not symmetrical. The asymmetry was clearly observed as most countries were net senders. But some, like the UK, were disproportionately a net host country while others, like Italy, sent far more PhD students than it hosted. Overall, EU member countries fell into different categories of receiving and hosting. For example, the UK was involved in the large share of the overall exchange volume, but primarily in the role of attracting intra-EU PhD students. Germany and France also contributed to a reasonably large share of the volume of movement. While both were net host countries, they were at a much more balanced ratio of sending and hosting. For both Germany and France, fewer than two students were hosted for every single student sent. Italy though, a larger and relatively prosperous country, sent nearly ten students for each student it hosted.

The hierarchy of intra-EU PhD ISM was fairly fixed over time; countries that had high or low levels of sending, hosting, and/or net-sending were essentially the same throughout the seven years of the study (Tables 1 and 2). This suggests, in-line with Lee's (2021) and Waters and Brooks (2021) arguments, the reasons for this asymmetry are embedded in layers of historical, societal, and cultural power structures among countries. The picture that emerges is less of a free market, in which supply and demand are eventually expected to reach equilibrium, than an increased volume of mobility facilitated by policies that reflected prior and enduring differences (Robertson 2018).

To assess the reasons for asymmetrical intra-EU PhD ISM (RQ3), we used a novel dyadic pairing panel gravity model. This approach allows us to understand how differences between countries may contribute to the overall asymmetry of intra-EU PhD ISM in the region. With academic capital indicators, outward mobility (sending) is associated with higher levels of tertiary degree attainment relative to the dyadic partner. Findings

suggested educational development within EU countries spurs individual agency and therefore outward mobility (see Marginson 2021). We found indications that when an EU country directly invests in its higher education system and graduates its younger population at a high rate, other EU countries benefit from an increased reservoir of qualified candidates to draw from to fill their PhD student slots. With hosting, the two academic capital variables tied to research production, research, and development (R&D) as percent of GDP and number of ranked universities in the THE, were positively associated in attracting EU PhD students. This is consistent with Van Bouwel and Veugelers' (2013) finding of increasing the number of ranked universities within a national higher education system had a positive effect on increasing the number of incoming EU PhD students.

While mobility of PhD students between dyadic pair countries was positively associated with strong academic conditions (relative to mobility partner), findings were mixed with economic conditions. Per capita GDP had a negative finding for the push model but was positive for the pull model. This suggests as a country becomes wealthier, relative to its dyadic partner, it will increase in its numbers of inbound EU PhD students while decreasing its outbound. This is consistent with Beine, Noël, and Ragot's (2014) gravity model as well as traditional push–pull explanations of ISM. Our findings though are inconsistent with Kritz and Gurak's (2018) finding of GDP per capita being a positive predictor of outward mobility. Their explanation for their finding is as GDP rises, middle-class households having the ability to afford mobility. Two notable differences from this study to Kritz and Gurak's (2018) is they examined all degree types (bachelor, masters, and PhD) and in 169 countries. Whether these differences account for the difference in findings requires further research. One notable aspect of the EU context is the right to work and reside in any country within the EU. Intra-EU PhD ISM students may choose to study in countries with relatively larger economies and high incomes as they may view this as a pathway to make a career in a more prosperous country (relative to mobility partner).

None of the social capital variables were found to play a significant role in increasing or decreasing intra-EU PhD ISM. As such, the social conditions in an EU country do not appear to play a role in pushing or pulling EU PhD students from another EU country. This finding does not align with previous research. The choice of where to live and study is a conscious decision and is not a one-off act completed on arrival (Benson and O'Reilly 2016; Hoey 2005) and the environment for migrants is considered an influencer in migration decisions; not just where to live but also 'how' or the ability to live within a society (Benson and O'Reilly 2016). Poor health services and quality of life are directly linked to life expectancy and are some of the most often cited rationales 'pushing' individuals to migrant to another country (Castelli 2018). Additionally, gender-equal societies have shown to benefit migrant women, from adapting socially to engaging in the labour market (OCED 2020a). In OECD countries though, many of which are located within the EU, females are less likely to travel abroad for a doctoral degree than men (OCED 2020b).

One of the pillars upon which the EU is built is the diversity of distinct cultural and social traditions of its member states. The lack of significance of the social capital variables is surprising on one hand due to the wide variety of social conditions existing among EU member states. However, perhaps the null finding points to the level of inter-connectedness and the realities of the working conditions in EU science and higher education systems. Concerns over lifestyle and living environments might be less in academia within the EU due to the perception of tightening the availability of permanent academic

jobs (e.g. Afonso 2016). Additionally, the perception that mobility is supported in the region may reduce the influence of country-specific social conditions because one can have a successful career by moving among institutions and systems (countries) within the EU. This latter point is in-line with Robertson's (2018) observation on the extent of integration of the EU's science and higher education systems as a region (i.e. the making of the EU's science and higher education sectors). If academics can demonstrate excellence in their research and teaching, it is transferable to another EU country's academic system. As a result, economic and academic conditions, along with proximity to home, may mean more than social conditions for PhD researchers who expect to move several times in their careers. In the end, even though the majority of PhD students undertake studies in their home country (OECD 2019; Woolston 2019), it appears for those in the EU who go to another EU country is more about getting training (PhD degree) and potentially having a career in academia *somewhere* within the EU rather than where the PhD studies are located within the EU.

The variables included for the gravity models (common language, distance between capitals, sharing a contiguous border, and population of the country) were strong and significant indicators for both the push and the pull model. Similar to Jöns and Deakin (2015), we found shared common language among dyadic pair countries a strong factor in 'pushing' PhD students from one partner country to another, but it did not play a significant role in 'pulling' students into the other pair. This was also consistent with the Beine, Noël, and Ragot (2014) and Ovchinnikova, Van Mol, and Jones (2022) findings of shared common language positively impacted the flow of students. However, this was inconsistent with Van Bouwel and Veugelers (2013) finding of shared common language did not factor in the movement of PhD students across borders in the EHEA. There are two important differences between this study and both Beine, Noël, and Ragot (2014), Ovchinnikova, Van Mol, and Jones (2022) and Van Bouwel and Veugelers (2013) research. One is the time period. Our study uses recent consecutive years (panel data) while the other studies either had a single year or a repeated cross-sectional data collection. Second, this study created two distinct models for 'push' and 'pull' factors. These differences likely account for the variation of the influence of a shared common language in the movement of students across borders. The large-scale adoption of English within EU higher education likely mitigated the role common language played in attracting (pulling) students to a particular country but did not lessen it in terms 'pushing' students out. The end result from this study suggests sharing a common language is a very strong influence for PhD students who leave their home country and where they study, but it did not necessarily play a role in the host country's ability to 'pull' PhD students into it.

The distance between capitals and sharing a (contiguous) border was positive for both the push and the pull models. This finding is consistent with Beine, Noël, and Ragot (2014) and Van Bouwel and Veugelers (2013) studies which found strong relationships between distance and borders; shared borders and shorter distances among pair countries were positive indicators of flows of students. The result from this study seems intuitive as distance, as a variable in a gravity model for ISM, picks up the impact of the transportation, cultural, and the psychological costs and adjustments of studying abroad (Beine, Noël, and Ragot 2014; Van Bouwel and Veugelers 2013). While an EU PhD student can legally go anywhere in the EU to live and study, the findings in this study suggest PhD students are more likely to study in a country that is close to their home country which likely shares

some similar cultural aspects if not language(s). Lastly, the population variable was significant and positive for both models. This suggests growing larger (population) relative to the dyadic partner was associated with a surplus of PhD students to send, as well as an increased capacity to receive.

Taking a step back and looking at the larger picture of all the findings (RQ1 through RQ3), one interpretation is that the EU has a large asymmetry of movement of EU PhD students among its member states. At the intra-regional level and in the context of decades long harmonisation projects, national science and education systems are sufficiently heterogeneous that they unevenly map onto global and regional spaces (Marginson 2021). Regionalism is unable to rapidly displace enduring national differences (Robertson 2018). The internationalisation of higher education is often idealistically portrayed as cooperation among countries; however, neo-liberal agendas have in recent decades emphasised competition over collaboration (Lee 2021). While ISM is consistent with policy objectives in the region, asymmetry may not be an indication of regional cohesion and integration. Further, inequality among EU member states may indicate that some members of the EU are not well positioned to participate in the region's science competition as well as the global science competition.

Our findings indicate traditional factors predict where students go; strong academic, social, and economic conditions are associated with pulling students into a country with weak pushing students out. The observed patterns of intra-EU PhD ISM are consistent with the idea that internationalisation reproduces uneven geo-political and epistemic relations (see Stein and McCartney 2021). On the whole, wealthier countries invest more in research production (seen as R&D as percent of GDP and rankings) which in turn helps them attract more PhD students than they send out. However, when you isolate dyadic pairing of countries and strip out (control for) the economic, distance, language, and size (population) advantages, we find that developing stronger academic systems, operationalised in the form of tertiary graduates, leads to greater outward intra-EU PhD mobility. While seemingly counterintuitive, this indicates net of economic, size, and distance asymmetries, developing and supporting higher education within individual EU countries actually empowers outward mobility of PhD students within the EU as a whole. This promotes the EU's ability, as a region, to develop and compete in the global science network. The conventional framing of differences of academic 'quality' is one of a pull factor to a host country causing brain drain in the sending country. This study's findings indicate building strong academic systems in one country can over time, indirectly increase the cohesion and development of the entire EU's science competitiveness.

Conclusion

The findings from this study are relevant to policy, theoretical, and the empirical study of ISM. Successive education policies in the EU sought to enhance social wellbeing and economic competitiveness of the region through educational development and mobility. Robertson's 'variegated regionalisms' (2018) argues there are different trajectories, forms, and purposes of regions while actors, within individual states and at regional level, have different roles and purposes. Together, they provide distinct arrangements within regional projects, in this case, EU higher education, as individual countries' culture, history, economy, and politics shape it. In other words, even within a region where

there are clearly defined objectives and agreements, individual differences will play a strong role in how each actor, in this case, countries, are able to engage and participate.

While asymmetric differences within the union were expected and revealed by the descriptive findings, we also find national characteristics also play a very strong role in size and direction of intra-EU PhD ISM. The findings of this study indicate while there is asymmetry among EU member states, investment in strengthening the higher education systems within individual EU countries can strengthen the overall cohesion and competitiveness of the EU in the global science competition. Thus, policy focused on enhancing developing national higher education systems can pay dividends throughout the union. But perhaps this is also evidence of the role of the lack of a clear centre-periphery (Cantwell 2021; Piattoni 2010) of the EU. The positive influence of close distance and sharing of language and borders on increasing intra-EU ISM suggest sub-regional aspects, which are likely linked to shared cultural and social values, also play a role in shaping the movement of PhD students within the EU. In this case, national and sub-regional aspects can perhaps mitigate some of the power and influence of the Anglophone model which has long dominated global science (Marginson 2021).

Intra-EU PhD ISM rose and then fell during the period of study, while the number of PhD students from outside the EU increased consistently. Intra-EU PhD ISM was highly asymmetric, all of which supports the idea of variegated regionalism (Robertson 2018) and is consistent with separate development between global and national science. As doctoral education globalises and isomorphic tendencies create international standards and practices, the countries whose institutions are best reflected in global norms appear to attract the most students from abroad. At the same time, intra-regional PhD movement appeared to be a for-runner to the expanded global presence for the EU in higher education and science, as predicted by Robertson (2018).

To our knowledge, our study is the first study to examine intra-EU PhD ISM over an extended time. We believe this is a meaningful empirical contribution, at least in the European context where all EU countries enjoy the same reciprocity and freedom of exchange with all other member states. By assessing dyadic country pairs, we were able to understand how the dynamics of ISM differ from student flows that do not occur within a common education area. Of note, we find that contrary to push-pull theory, development and support of national higher education systems are associated with increases in net mobility outwards. This finding would not have been possible without taking the approach of examining pairs of countries within a larger region.

While this study advances our understanding of PhD-level ISM in the EU, with implications beyond the region, additional research is needed. One limitation of our study is that we do not include measures of EU intervention in the form of research funding and sponsored mobility programmes. Future research should refine our work by specifying the extent to which EU funds either re-enforce or attenuate the between-nation dynamics identified here. Second, given the outsized role of the UK in regional ISM, future research should also address the impact of Brexit on mobility patterns. Third, different methods applied to similar data could produce nuanced understanding. Our dyadic gravity model is, to our knowledge, a novel approach for the ISM literature, but other approaches could also be applied fruitfully. These data, for example, are ripe for network analysis. Finally, we assume that regional and global mobility are related. Future research should examine the relationship between regional and global ISM.

Notes

1. Only total number of students by nationality is included in data from BMBF. We were required to estimate the number of PhD students by taking the total of students of each EU-member state multiplied by the percentage of international students in Germany who are PhD students for each year (between 12.96 and 9.82 for 2013–2019). This percentage is sourced from data provided by the *Wissenschaft Weltoffen* (Science open to the world) project supported by the German Academic Exchange Service (DAAD) and the German Centre for University and Science Research (DZHW).
2. As noted in the text, full documentation of estimated cases and years is available from authors, short overview provided here: Greece 2 times, Spain 2 times, and Slovenia 4 times.

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