Gender and Regional Differences in Internal and International Migration of Scholars Worldwide

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The literature on international scholarly migration shows that women are less mobile and move over shorter distances. We extend this literature by using data from Scopus on over 29 million publications by over 18 million scholars worldwide, and simultaneously focus on internal and international movements. We find that women are also less mobile in internal migration. However, the gender gap is smaller and less prevalent gender gap than in international migration. We decompose the gender differences in migration between the contribution of the specific migration rates specific by field of science and composition. The differences in rates contribute to most of the gap in both internal and international migration in all periods and regions, except for internal migration in Latin America and the Caribbean. The field of science composition has different contributions for internal and international migration. In internal migration, the gap would be bigger in some regions if men and women had the same field of science composition. Our results have implications for promoting more equitable science by showing that there is a cumulative gender gap in migration of scientists, with men being more mobile both internationally and internally.

Migration of scholars | Gender differences | Internal migration | International migration | Bibliometric data

Migration is more common among some sub-populations. For instance, the share of international migrants among scholars, about 9% in 2014, is more than three times that of the general population, roughly 3% since the 1960s (1). While good quality data about migration of the general population is rare (2), this lack is also present in the case of high-skilled population and scholars (3). This lack makes it difficult to advance our understanding of the migration patterns of this specific subgroup and how they differ from the pattern observed for the overall population. Previous studies have addressed this lack by re-purposing bibliometric data to estimate migration based on changes in scholars' affiliation addresses (3–5). There is a promising future in demographic research using bibliometric data due to new services accumulating metadata of scientific publications and innovative methods to prepare cleaner data which is openly accessible for research. It aids in addressing crucial scientific and policy-relevant questions that would have been impossible to answer otherwise (6).

Gender inequalities are particularly pronounced in academic migration (5). Women in academia often face unique challenges, including but not limited to gender bias, less access to networking opportunities (7), and a disproportionate parenting penalty due to unequal distribution of household responsibilities (8–10). These factors contribute to different international migration patterns among women compared to men (5). The intersection of gender with other social and professional factors —such as regional differences between the Global North and Global South— creates a complex landscape of inequality, influencing the decision to enter, remain, migrate, or exit academia (7, 11).

Inequalities in science are also evident when analyzed from a global perspective (12). Scholars from different regions experience varied productivity levels and exposure to international collaborations (13). However, the idea that some countries form the core of the global science and others constitute its peripheries has been criticized in recent studies (14). One of the criticisms of the center-periphery model is the increase in collaboration between scholars from the global periphery compared to center-center and center-periphery collaborations (15). In addition, recent decades have seen an increase in China's share of global scientific production and the emergence of strong scientific systems in countries such as India, Iran, South Korea, and Brazil (15).

The inequalities between regions can also be identified in the internal migration of scholars. Some countries with large science systems are able to hire and promote

Significance Statement

A scientist's mobility can advance their career by providing access to resources, collaborators, and research opportunities. Previous studies have shown that women tend to migrate less frequently and over shorter distances. However, little is known about internal migration. Using bibliometric data, we estimated the gender gap in both types of migration simultaneously. We found that women are also less mobile at the subnational level, though the gender difference is smaller. Additionally, we demonstrated that the distribution of women and men across fields of science accounts for only a small part of the gender gap in international migration. In internal migration, in almost all regions, the gender gap would be even smaller if men and women were equally distributed across fields.

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scholars for permanent positions, making internal migration more frequent and relevant than international migration (16). This relationship between internal and international migration aligns with the integrated methodology suggested by (17). Throughout their academic careers, scientists are likely to move between institutions for training and take up research positions that are scattered across different locations. To some extent, it can be argued that all researchers are mobile, but what varies is the scale (7). Since women migrate less internationally, the difference may be smaller internally or even in favor of women. Consequently, examining internal and international migration simultaneously is essential to gaining a comprehensive understanding of the gender gap in the migration of scholars.

In this study, we use bibliometric data from more than 29 million publications by more than 18 million scholars worldwide to extend the literature on gender differences and study it in internal and international scholarly migration. We present gender differences in migration rates and show how these differences vary by global region. We also decompose these differences to determine the extent to which they are due to differences in the composition of fields of science between men and women.

Results

At the country level, the gender gap in international migration is larger and more prevalent than internal migration. We used the female-to-male ratio of migration rates to assess the gender gap in migration. We referred to the female-to-male ratio as the Migration Gender Parity Index (mGPI), since a value of one represents parity between men and women in migration, controlling for differences in parity in the overall population of scholars. An mGPI greater than one indicates that women migrate proportionally more than men, while an mGPI lower than one indicates that men migrate more than women. We estimated the mGPI using 2,000 random posterior samples, and the uncertainty intervals correspond to the respectives percentiles of the results. The mGPI was estimated at the country level by Field of Science (FOS) and aggregated by country using the mean weighted by the proportion of scholars in each field. In Figure 1, the maps show, for the latest period (2013-2017), the size of the gender gap in international and internal migration, along with the level of uncertainty used to assess the presence of a difference. The sankeys plots in the same figure show how countries in each gender gap category for international migration are classified for internal migration. The sankey plot for the latest period helps interpret and compare the international and internal migration maps.

Gender differences favoring men in international migration were prevalent at the country level, which is consistent with previous studies (5, 7). We found a gender gap favoring men in international migration in more than 80% of countries in all periods. Although the proportion of countries with a gender gap has remained relatively stable over time, the proportion of countries with a migration rate for men that is more than 25% higher than for women has increased from 27% in the first period (1998-2002) to 42% in the latest period (2013-2017).

The gender gap in internal migration was less prevalent than in international migration, and, when present, it was usually smaller. While a gender gap in international migration was identified in more than 80% of countries in every period, this proportion varied from 59% in the first period to 47% in the most recent period for internal migration. In addition to fewer countries having gender differences in migration, the number of countries with a difference greater than 25% in internal migration decreased from 27% to 6%. The decrease in countries with higher differences is the opposite of what was observed with international migration.

In most countries, migration rates for men were higher than for women, but there were a few exceptions where women's rates were higher. In the most recent period, only Uganda and Sri Lanka, women's migration rates were higher than men's migration rates. However, we did not find a difference in the international migration rates of women in two or more periods for the same country. When a consistent difference in international migration over time was identified, it was always in favor of men. Countries with higher rates of internal migration for women were more common than those with higher rates of international migration for women, but they were still exceptions. In the latest period, five countries had higher women's internal migration rates than men's internal migration: Spain, the Netherlands, China, Jordan, and Qatar. However, only the differences in the Netherlands and China were consistent over time. Since 2003-2007, women in the Netherlands have been more internally mobile than men, and since 2008-2012, women in China have been more internally mobile than men.

Our results indicate that when a difference is present in international migration, it does not necessarily extend to internal migration. However, the opposite is true. In other words, a gender gap in internal migration is generally accompanied by a gender gap in international migration. This pattern is evident in Fig. 1's Sankey plot, where the left bars are frequently linked to the yellow bars on the right, but the green bars on the left are almost exclusively linked to other green bars on the right. For example, in 2013-2017, Japan and Kenya were the only two exceptions. In these two countries, there was no difference in international migration rates, but internal migration rates for men were higher than for women. In the case of Japan, although no difference was identified for international migration, the internal migration rate for men was more than 25% higher than the rate for women.

Over time, the gender gap in internal migration either decreased or remained stable in nearly all regions. This resulted in a greater difference between internal and international gaps. To assess trends over time and differences between regions, we aggregated the migration rates for men and women using UN-M49 regions, and estimated the mGPI for each region. The regional rate was aggregated using the mean of the countries rates weighted by the population of scholars. Due to the number of countries with data, we combined some of the UN-M49 regions. Figure 2 shows the internal and international mGPI by period for each UN-49 region. The gender gap in migration is equal to the difference between the mGPI and one (represented in red line). The internal migration gender gap was smaller than the international one in all periods for regions in the Global North and in most periods for regions in the Global South. Regions in the Global North showed a consistent trend of decreasing

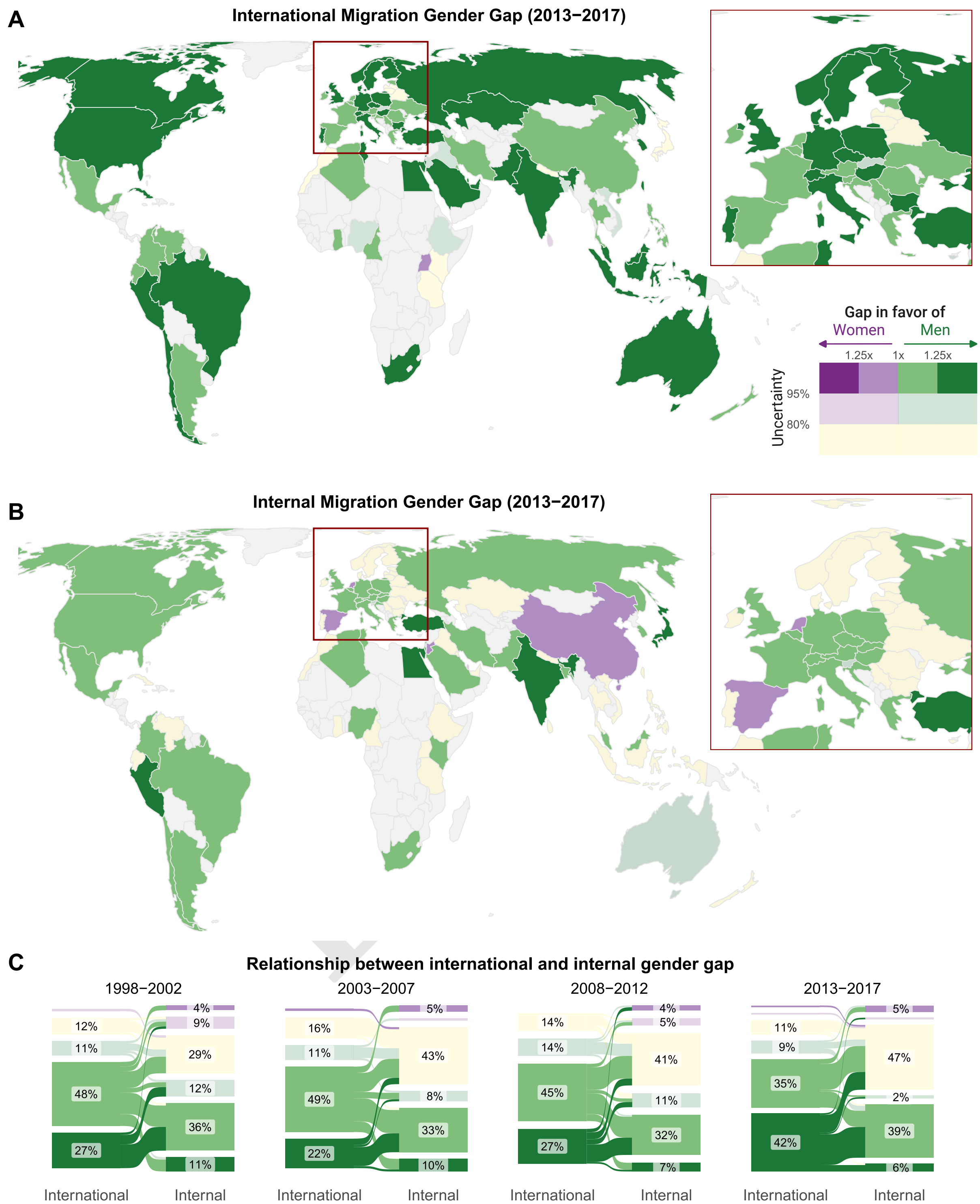

Fig. 1. Distribution of countries by migration gender gap classification. **A and B** present the international (A) and internal (B) migration gender gaps in the most recent period (2013-2017). A country is classified with a gender gap for women if the migration Gender Parity Index (mGPI) is bigger than one considering the uncertainty interval, for men if the mGPI is smaller than one and not identified if the uncertainty interval (UI) includes one (see methods section for details). A gender gap in favor of women is represented by purple, while a gap in favor of men is represented by green. The brightness of the color indicates the size of the gap and the level of uncertainty used to identify it. For example, dark green indicates that men's migration rates are more than 25% higher than women's, and a 95% uncertainty interval does not include one. Second darkest green indicates that the mGPI is smaller than one when using a 95% uncertainty interval, but men's rates are up to 25% higher than women's. The lightest green indicates that the male migration rate is higher than the female migration rate, but since the uncertainty interval used is high, we do not represent the size of the difference. mGPIs that are not different from one when an 80% interval is used are represented by light yellow. To assess the relationship between internal and international gender gap, **C** presents the cross-classification of gender gap by type of migration of each period. For example, a flow from a green color to a purple color in the right indicates that a country with a gender gap in favor of men in international migration has a gender gap in favor of women in internal migration in the same period.

internal gender gaps and relatively stable international gender gaps. In contrast, regions in the Global South experienced heterogeneous trends.

The five regions in the Global South presented different patterns. Central and Southern Asia experienced an increase in the international gender gap, followed by a decrease in the internal gender gap. This pattern is similar to that observed in Eastern and Southern Asia, except for the first period. Despite this similar trend, the gender gap was smaller in Eastern and Southeastern Asia than in Central and Southern Asia. In Latin America and the Caribbean, both internal and international gender gaps remained stable, with smaller disparities in internal migration. The North Africa and Western Asia region had a stable internal gender gap and an increasing international gender gap. The largest gender gap was observed in this region for international migration, with a rate that was 64% [57%, 70%] higher for men than for women. Sub-Saharan Africa was the only region with a clear increase in the internal gender gap, and, during the 2008–2013 period, it was also the only region in which no difference was identified between the gender gaps in international and internal migration. In all other regions, the gender gap was larger for international migration than for internal migration.

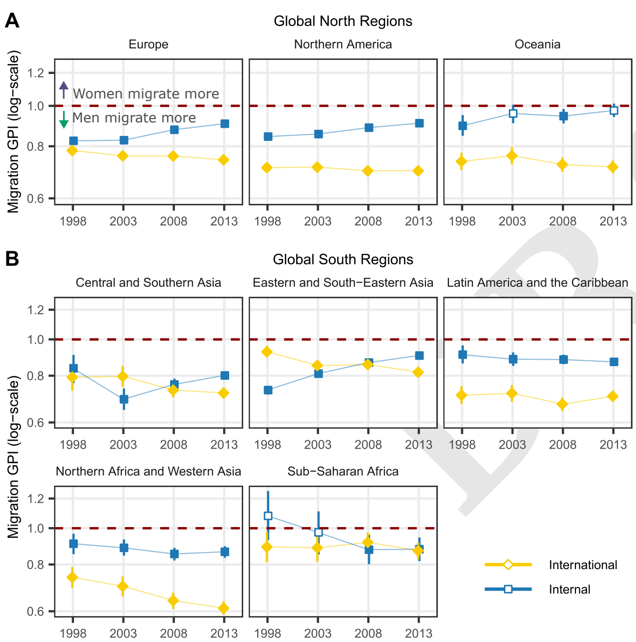

Fig. 2. Migration Gender Parity Index (mGPI) for international (yellow diamonds) and internal (blue squares) out-migration by 5-year period (only the beginning year of the interval is printed on the x-axis) for (A) the UN M49 regions classified as the Global North and (B) the UN M49 regions classified as the Global South. The markers are filled with white when the 95% uncertainty interval includes one.

Most of the gender gap is due to differences in field-specific migration rates, except for internal migration in Latin America and the Caribbean. Men and Women have different FOS composition. From 2012 to 2017, 61% of men were in agricultural, engineering, and natural sciences; 31% were in medical and health sciences; and 7% were in humanities and social sciences. During the same period, women were less concentrated in agriculture, engineering, and natural sciences (48%) than men, and, consequently, more concentrated in medical and health sciences (41%), and in humanities and social sciences (11%). These percentages vary by time and region, but the overall pattern remains consistent. Due to the international nature of some fields, scholars are more likely to migrate internationally in those fields than in others (7). Therefore, part of the observed gender gap could be attributed to the difference in FOS composition by gender. To assess the extent to which the difference in FOS composition contributes to the difference in migration rates between men and women, we used a Kitagawa decomposition (18). We decomposed the total gender difference in migration rate between FOS-specific migration rates and FOS composition.

The contribution of FOS composition to gender differences in international migration is higher in regions of the Global North than in the Global South. Considering only the points with a difference found using a 95% uncertainty interval, the contribution of the FOS composition ranged from 16% for Europe (1998–2003) to 27% for North America (2013–2017) in the Global North. In the Global South, the range was from -6% for Sub-Saharan Africa (2003–2007) to 14% for Northern Africa and Western Asia (1998–2002). The negative contribution indicates that the observed gender gap would be 6% larger if men and women had an FOS composition equal to the mean for both genders. In both the Global North and the Global South, FOS composition only contributes a small part to the observed gender gap. However, the highest contribution observed in Global South regions was smaller than the lowest value observed in Global North regions.

In the case of internal migration, the FOS composition contributed negatively or nearly zero to the gender gap in all regions of the Global North and most regions of the Global South. While scholars from the fields of agriculture, engineering, and natural sciences had higher international migration rates than scholars from other fields, scholars from medical and health sciences migrated with similar or greater intensity in internal migration. These differences in migration rates by field led to different contributions to the observed gender gap in internal and international migration. The Latin America and the Caribbean region was an exception with the composition contribution varying from 73% of the total gender difference in 1998-2002 to 50% in 2013-2018. Unlike in all other regions, scholars from the Medical and Health Sciences did not show an equal or higher rate than scholars from the Agricultural, Engineering, and Natural Sciences. The latter had a rate twice as high as the former.

Discussion

Our aim was to analyze differences between genders in the migration of scholars by focusing simultaneously on internal and international migration. We demonstrated that a gender gap also exists in the internal migration of scholars, though it is smaller than the gap observed in international migration. Women cannot make up for lower international mobility by moving more internally, which increases inequality in access to opportunities for career advancement. Decomposing the differences between rates and composition contributions revealed that the effects of differences in FOS composition on internal and international migration were different. Therefore, field-specific interventions to promote mobility may have different effects on internal and international gender gaps.

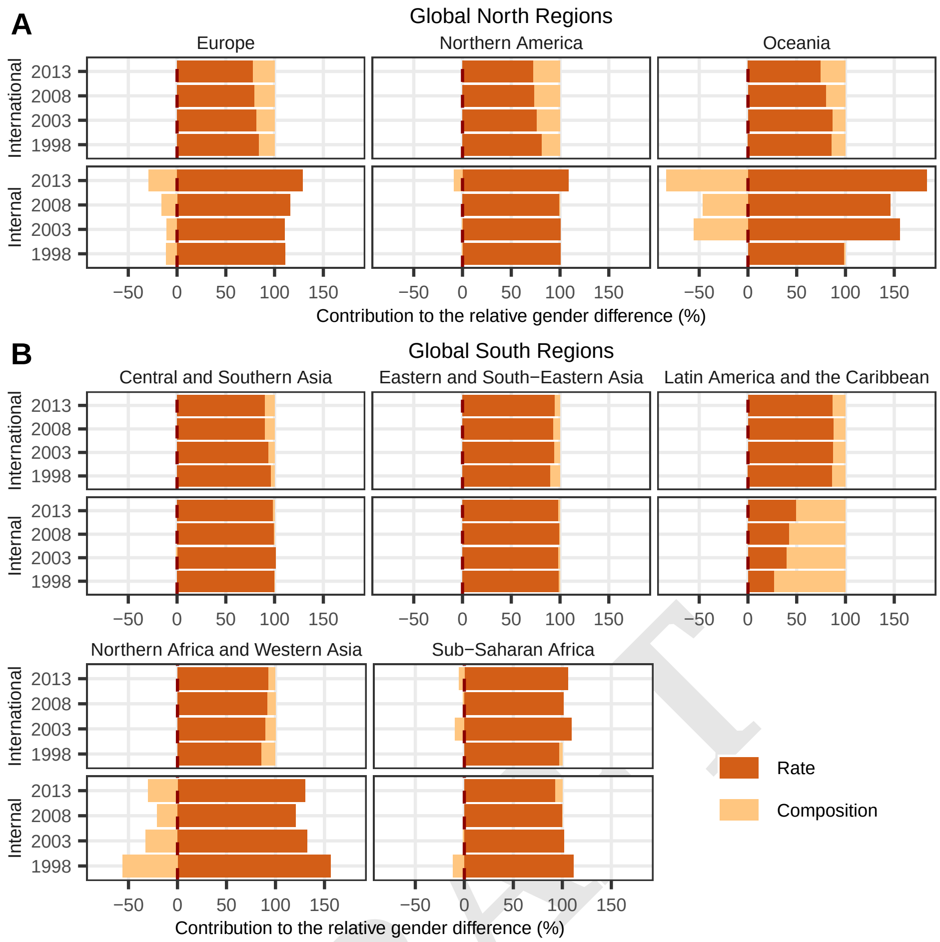

Fig. 3. Contribution of the differences in field-specific out-migration rates (dark orange) and field composition (light orange) to the total difference between female and male out-migration rates for international and internal migration by 5-year period for (A) the UN M49 regions classified as the Global North and (B) the UN M49 regions classified as the Global South.

Using bibliometric data has allowed us to study the internal migration of researchers worldwide simultaneously, but these data also have limitations present in our study. A limitation is related to the gender information. The gender of authors was inferred by an algorithm with different accuracy between countries and reduced to a binary gender classification without taking into account more diverse gender identities. Another limitation is that Elsevier's 2020 Scopus snapshot data mainly included English-language publications that undercover countries and regions, mostly from the Global South.

Analyzing the mechanisms that explain the gender differences in scholars' migration was beyond the scope of our work. The data used allows for longitudinal tracking of each scholar over the years, and future studies could use this feature to investigate how internal and international migration interact at the micro level, whether they complement, substitute, or precede each other. Another challenge for future studies would be to combine these data with other databases that allow us to study the mechanisms at work in the inequalities described in this study.

Materials and Methods

We use 29+ million "articles" and "reviews" by 18+ million authors indexed in Elsevier's 2020 Scopus snapshot provided to us by the German Competence Network for Bibliometrics (19) through the Max Planck Digital Library. Since bibliometric data have not been collected to study the migration of scholars, some pre-processing steps and assumptions are necessary to re-purpose the data (3, 6).

Pre-processing and variables. The first necessary step is to do the author name disambiguation, i.e, identify and link all papers of each unique author. For this step, we use the identification numbers provided by Scopus. The Scopus author name disambiguation algorithm identifies all publications of a single author in 94.4% of the cases and incorrectly merges by mistake the publications of two different authors in the same author id in only 1.9% of the cases (20).

The second necessary step is to disambiguate and geolocate affiliations at the subnational level. We used the data after disambiguation and geolocation of the authors' affiliation addresses at the subnational level, as described by Akbaritabar (21). In the analysis, we only considered authors whose affiliation location was identified at a subnational level and excluded those affiliation addresses that could not be geocoded.

After author and affiliation disambiguation, it is possible to identify the migration events. We use the change in the modal region of affiliation for each year to identify migration events. This strategy was found to be most suitable for analyzing scholars' migration with bibliometric data. A more detailed description of the migration identification process can be found in Akbaritabar *et al.* (3).

We use the United Nations' "Standard Country or Area Codes for Statistical Use" (UN-M49) to group countries. Additionally, we grouped the UN-M49 regions "Europe," "North America," and "Oceania" into the "Global North" and the remaining regions into the "Global South." This division is similar to the "More developed regions" category in the UN Human Development Index (excluding Japan) and is also consistent with the WEIRD*/non-WEIRD categories. However, the Global North and Global South classifications are more appropriate for studying the migration of scholars because these categories reflect country characteristics that have influenced the historical development of the social sciences as a whole (22).

We use gender data inferred from authors' names by a character-based neural network model. The model was trained using a Wikidata-dump containing approximately 4.3 million names, each with an assigned gender. Of those names, 870,000 were female. The model was trained using 80% of randomly chosen 870,000 male and 870,000 female names and validated using the remaining 20%. The model's overall accuracy was 93.5%. However, we acknowledge that this algorithmic gender labeling, despite being scalable to large-scale data such as ours, is binary and neglects more diverse gender identities.

We assign each author in the database a Field of Science (FOS). We define an author's FOS as a time-invariant variable based on their entire career. The assignment of an FOS consists of two steps. First, we assign an FOS to each publication. Then, we select the FOS with the highest proportion for each author. We use the OECD FOS classification (23), which has six major fields. We aggregate the six major fields into three groups: 1) Agricultural, Engineering, and Natural Sciences; 2) Humanities and Social Sciences; and 3) Medical and Health Sciences.

Statistical model. We use a Bayesian hierarchical model to estimate the gender and FOS-specific internal and international in- and out-migration rates at the country level. Due to the size of the exposure in some countries, we grouped the data into four periods of five years: 1998-2002, 2003-2007, 2008-2012, and 2013-2017. Additionally, we grouped countries with fewer than ten thousand person-years in a given period. We fit the same model twice: one for out-migration and one for in-migration.

We assume that y^g_{it} – the number of observed in- and out-migrants for a gender, country, and field in a 5-year period – follows a Poisson distribution with an expected unobserved value μ^g_{it}. In this notation, g represents the gender, i represents the combination of country and field, and t represents the five-year period.

$$\mathrm{y}^g_{it} \sim \mathrm{Poisson}(\mu^g_{it}) \tag{1}$$

We model the gender and FOS-specific log-migration rates m_{it} hierarchically. We reparameterize our hierarchical model using non-centered priors to avoid convergence issues (24).

$$\ln(\mu^g_{it}) = m^g_{it} + \ln(P^g_{it}) \tag{2}$$

$$m^g_{it} = \overline{m}_{r^g_{it}} + \sigma_{r^g_{it}} \cdot z^g_{it} \tag{3}$$

Where, P^g_{it} is the number of person-years, $\overline{m}^g_{r_{it}}$ is the gender- and FOS-specific mean log-rate of the UN-M49 region of the country, $\sigma^g_{r_{it}}$ is the standard deviation of the UN-M49 region.

We use weakly informative priors chosen by a prior predictive check as suggested by Gelman et al. (25).

$$\begin{aligned} z^g_{it} &\sim \mathcal{N}(0,1) \\ \overline{m}_{r^g_{it}} &\sim \mathcal{N}(-3, 0.1) \\ \sigma_{r^g_{it}} &\sim \mathcal{N}^+(0, 0.3) \end{aligned}$$

Here, $\mathcal{N}^+(0,\sigma)$ denotes a half-normal distribution, i.e., a normal distribution truncated at zero to ensure non-negativity.

*Western, Educated, Industrial, Rich, and Democratic (WEIRD)

We implement the model in Stan v2.36.0 (26) and R v4.4.3 (27). We fit the model with 4 chains for 4,000 iterations and 2,000 warm-up iterations. We evaluate the convergence of the model by checking the estimated R-hat criterion and visually checking the rank plots (28).

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