Higher Education (2024) 87:1749–1767
https://doi.org/10.1007/s10734-023-01089-7

Quantifying the mover's advantage: transatlantic migration, employment prestige, and scientific performance

Benjamin C. Holding[1] · **Claudia Acciai**[1] · **Jesper W. Schneider**[2] · **Mathias W. Nielsen**[1]

Accepted: 27 July 2023 / Published online: 24 August 2023
© The Author(s) 2023

Abstract

Research on scientific careers finds a mover's advantage. International migration correlates with increased visibility and productivity. However, if scientists who move internationally, on average, enter into more prestigious employments than they came from, extant research may overestimate the direct performance gains associated with international moves. Building on insights from the sociology of science and studies of international researcher mobility, we examine how changes in employment prestige shape international movers' performance returns to mobility. We follow a cohort of 167,014 European scientists to identify individuals that move to the USA and pair these migrants to non-mobile scientists with identical home institutions, research fields, and genders, giving a final sample of 3978 researchers. Using a difference-in-differences design, we show a substantial increase in the publishing rates and scientific impact of transatlantic migrants, compared to non-mobile scientists. However, most of the movers' mobility-related boost in citation and journal impact is attributable to changes in employment prestige. In contrast, we find limited effects of employment prestige on changes in migrants' publication rates. Overall, our study suggests large variations in the outcomes of transatlantic migration and reaffirms the citation-related "visibility advantage" tied to prestigious institutional locations.

Keywords Researcher mobility · Employment prestige · Performance · Science

Introduction

Transnational mobility benefits science by increasing knowledge diffusion across localized contexts (Appelt et al., 2015; Wagner & Jonkers, 2017). At the individual level, long-distance moves may allow scientists to expand their networks, exposing them to new ideas and approaches (Azoulay et al., 2017). Yet, relocating internationally may also disrupt a

✉ Mathias W. Nielsen
mwn@soc.ku.dk

[1] Department of Sociology, University of Copenhagen, Øster Farimagsgade 5, Copenhagen 1353, Denmark

[2] Danish Centre for Studies in Research and Research Policy, Department of Political Science, Aarhus University, Bartholins Allé 7, 8000 Aarhus C, Denmark

scientist's work routines and impose restrictions on interactions with previous colleagues and collaborators (Tartari et al., 2020).

Despite much talk about the mover's advantage in science, research on the link between transnational mobility and scientific performance is mixed, and attempts to unpack this relationship have been hampered by selection problems (Netz et al., 2020). Another important shortcoming concerns the lack of attention to the indirect effect of employment prestige. Migrating scientists who move upwards in the institutional prestige hierarchy may enter environments that are better endowed and have better research support, equipment, and opportunities for interaction with high-performing colleagues, which in turn may boost their performance gains. While the performance-related benefits of employment prestige are well-established in the sociological literature (Allison & Long, 1990; Long, 1978), the indirect effects of upward institutional mobility on international migrants' scientific achievements remain uncertain. This research question is important, since the performance gains that mobility scholars usually attribute to international moves may in fact be driven by migrating scientists' tendency to move to more prestigious institutions than they came from.

Our study responds to a recent call for more sophisticated estimation techniques and attention to mediating factors in studies of researcher mobility (Netz et al., 2020). We have two overarching objectives: (A) to estimate the performance gains from research migration; and (B) to parcel out the indirect effects of upward institutional mobility on within-level changes in migrants' performance.

We focus on transatlantic migration from Europe to the USA—the historically most desirable and common destination for migrating European scientists (Appelt et al., 2015; Franzoni et al., 2012). Using large-scale bibliometric panel data, we trace the career movements of 167,014 European scientists, and match transatlantic migrants to a sample of active but non-mobile scientists of the same gender, in the same research field and same career year, and with identical institutional affiliations prior to the mobility event. Based on a difference-in-differences design, we compare the within-person changes over time in the publication and citation rates, journal impact scores, and numbers of top-cited and top-journal publications of the matched pairs of migrants and non-mobile scientists.

International mobility has been correlated with many important career outcomes, including international networks, recombination of knowledge, and access to research infrastructures and funds (Netz et al., 2020). We focus on citation and publication related measures due to their scalability (in analyses of thousands of careers) and comparability across geographical contexts. Moreover, publications and citations are important building blocks for status and success in science (Merton, 1988). They are frequently used in tenure, hiring, and funding decisions and correlate with the size of collaboration networks (Abramo et al., 2017), funding rates (Van Leeuwen & Moed, 2012), academic salary levels (Leahey, 2007), and promotions (Lissoni et al., 2011).

International mobility and research performance

International mobility has become a rite of passage in science (Schiermeier, 2011). Early-career researchers are increasingly expected to be on the move, and evaluators in hiring and funding committees see international experience as a signal of ambition and excellence (Ackers, 2008). Ideas from the innovation literature also suggest that international mobility can yield positive performance outcomes. According to knowledge recombination theory, international migration can enhance scientists' performance by allowing them to leverage unique knowledge sets in new contexts, thereby improving their technical skills through knowledge spillover (Franzoni et al., 2014; Hoisl, 2007). Similarly, specialty-matching theory proposes that migration can enhance performance by facilitating a better alignment between the mover's specialized skills and expertise, and the available facilities and complementary skills at the destination institution (Franzoni et al., 2014; Fernandez-Zubieta et al., 2013).

Despite such theoretical predictions, available evidence on the link between international research mobility and performance is inconsistent. According to a recent review article, 19 of 34 studies on research productivity and 15 of 23 studies on citation impact indicate performance gains from international mobility (Netz et al., 2020). However, extant evidence is hampered by selection problems. The vast majority of studies, including highly influential papers, use cross-sectional survey data to compare the publication and citation performance of mobile and non-mobile scientists. For instance, Sugimoto and colleagues' (2017) widely cited cross-sectional study of 14 million papers from 16 million authors suggests that internationally mobile scientists (about 4% of their sample), regardless of destination country, accrue more citations than non-mobile scientists (see also Aksnes et al., 2013; Cruz-Castro & Sanz-Menéndez, 2010; Cañibano et al., 2008; Gibson & McKenzie, 2014). As noted by Netz et al. (2020), such studies tell us little about the effects of mobility, since "those going abroad are not a random selection from the population of scientists regarding their productivity."

A few existing studies have attempted to reduce such endogeneity issues through panel data and quasi-experimental approaches. Dubois et al. (2014) use panel data and regression models with author fixed effects to study the careers of 10,803 mathematicians globally, finding increased productivity returns to international mobility in terms of publication output. Petersen (2018) examines the mobility patterns of 26,170 physicists globally using bibliometric panel data and a matched-pairs analysis based on propensity scores and shows that migrants experience a 9–17% increase in citations compared to non-mobile counterparts. Finally, Franzoni et al. (2014) employ instrumental variable regression (instrumenting migration for work or study by migration in childhood) in a multidisciplinary sample of 14,299 scientists from Western countries and show a positive correlation between international mobility and per-paper journal impact.

As suggested by this summary, empirical studies designed to unpack the direct returns to international mobility all indicate clear gains on impact and productivity-related performance measures. However, none of these studies estimates the potential mediating effect of institutional prestige. This is an important limitation, since the expected performance gains associated with international mobility may vary considerably for migrants who enter destination institutions of higher and lower prestige. If scientists who move internationally, on average, enter more prestigious employments than they came from, extant research may overestimate the direct performance gains associated with international moves.

Indeed, surveys on scientists' motives for moving abroad also highlight institutional reputation and improved work conditions (including better equipment and facilities) as important pull factors (Ivancheva & Gourova, 2011; Schiller & Diez, 2012). Franzoni and colleagues' (2012) survey of 16,504 Western scientists showed that migrants predominantly move for three reasons: (i) to enhance their future career opportunities, (ii) to engage in collaborations with exceptional colleagues in different locations, and (iii) to gain entry into excellent and prestigious foreign institutions specializing in their specific research area.

Institution prestige

A longstanding sociological literature also examines the influence of institution prestige on scientific careers. In the USA, numerous studies have documented how institutional status hierarchies are reproduced through faculty-hiring networks, with the selectivity of the doctoral location highlighted as a critical determinant of future employment prestige (Caplow & McGee, 1958; Crane, 1970; Gross, 1970; Hargens & Hagstrom, 1967). In sociology, for instance, centrality within interdepartmental hiring networks explains 84% of the variance in departmental prestige, implying that institutional hierarchies are perpetuated through processes of closure and status maintenance, with elite institutions almost exclusively hiring candidates at other prestigious institutions (Burris, 2004). Clauset et al. (2015) extensive analysis of placement data on US faculty in computer science, business, and history documents similar processes of status maintenance with elite institutions placing more PhD students in tenure-line positions and with much higher placement rates at top universities.

A small but growing literature also examines the performance gains associated with individual scientists' upward inter-organizational mobility. Traditionally, researchers in this literature have interpreted the link between employment prestige and individual performance as an indication of top universities' ability to attract the highest performing scientists (Long, 1978). However, prestigious institutions may also boost individual scientists' visibility and productivity through better *facilities* (e.g., in-house research funding, lab space, computer hardware, faculty-lines, library holdings, graduate student ability, administrative support, and lower teaching obligations), *motivation* (e.g., monetary and promotion-related incentives for publishing, and individual ambitions to maintain a performance level on par with productive colleagues), and *intellectual stimulation and control* (including collaborations with high-performing colleagues and influence on disciplinary norms and research agendas) (Long, 1978; Allison & Long, 1990). In her foundational work on scientific elites, Zuckerman (1977) highlighted the critical importance of evocative environments (i.e., elite research departments) in fostering outstanding research talent. These environments represent critical transition points that provide promising scientists with excellent instruction, resources, and facilities that enhance their opportunities for doing outstanding science.

Furthermore, prestigious affiliations may cast a "halo effect" (Crane, 1967) that amplifies the recognition and opportunities of scientists beyond what their research merits alone. For instance, field experiments on the effects of blinded peer review find that submissions from prestigious research institutions have higher acceptance rates under single-blind than double-blind review procedures (Ross et al., 2006; Tomkins et al., 2017). Morgan et al. (2018) also show that research ideas that originate from prestigious institutions spread more swiftly throughout the scientific community compared to equivalent ideas emerging from less prestigious locations.

In one of the earliest career studies of upward inter-organizational mobility, Long (1978) determined the association between departmental prestige and productivity in a sample of 147 US biochemists, and found a strong predictive link between departmental prestige and productivity, with past performance exerting a weaker influence on future employment prestige. Building on this foundation, Long and McGinnis (1981) investigated the transition of male biochemists to different organizational contexts, revealing higher productivity and citation levels for scientists moving to research universities compared to those transitioning to teaching universities and jobs in industry. McGinnis et al. (1982) delved into the impact of postdoc affiliations on biochemists' productivity and citation impact after 8–10 years but found inconclusive effects. While these early studies provided foundational insights on the importance of research contexts for scientific careers, they were limited by small sample sizes, a mono-disciplinary focus on biochemistry, and cross-sectional designs that made it difficult to tease apart selection effects (i.e., top universities' ability to attract the highest performing scientists) and departmental prestige effects (e.g., better facilities, intellectual stimulation, or institutional halo effects).

Allison and Long (1990) later addressed some of these limitations through a larger longitudinal study involving 2248 chemists, biologists, physicists, and mathematicians in the USA. Employing panel-based models, they focused on job changes and uncovered a clear association between upward institutional mobility, and increased productivity and citation impact, while downward mobility led to decreased performance.

Fernandez-Zubieta et al. (2013) also focused on job changes and introduced a quasi-experimental approach aimed at mitigating a common selection bias encountered in preceding mobility studies. This bias arises from the correlation between scientists' pre-mobility characteristics and performance trends with their decision to relocate. Employing panel-based CV and bibliometric data and instrumental variable models that used the distance between scientists' origin institutions and their place of birth as instrument, Fernandez-Zubieta and colleagues showed that scientists who moved to better institutions experienced long term, but not short term, increases in research productivity, although no effect was observed for citations. Similarly, Tartari et al. (2020) traced the careers of 348 UK biologists, comparing scientists who moved to richer departments with those who moved to poorer ones. Using CV data, bibliometric data and a matched-pairs design, they found that scientists moving to richer institutions saw higher productivity gains than those moving to poorer ones.

In an attempt to further advance the literature, Ejermo et al. (2020) leveraged unique Swedish administrative register data on 21,821 scientists and a difference-in-differences approach to parcel out the direct effects of cross-institutional mobility on scientific output and impact. While inter-organizational mobility was generally found to boost individual scientists' productivity and impact, researchers that moved from university colleges to universities (here conceptualized as upward institutional mobility) saw declines in their publication outputs and overall influence.

Finally, Way et al. (2019) widely cited career analysis of 2453 tenure-track computer scientists, matching PhDs on the prestige of their origin or destination institutions, suggests that the reputation of scientists' tenure-track employments, not their doctoral location, correlates with future publication output, while both employment prestige and doctoral prestige are linked to future citation impact. In conjunction, Way et al. (2019) findings consolidate Long's (1978) original claim of the performance advantages tied to prestigious institutional locations. However, their design may have been susceptible to collider bias due to a paired matching of scientists from doctoral locations of different prestige with the same destination institution.

As indicated by this overview, most empirical contributions in this area suggest productivity and impact gains from upward institutional mobility. Yet, many are based on small samples and cross-sectional designs that make it difficult to distinguish context effects from endogenous variables (e.g., talent or intrinsic motivation). Furthermore, panel-based and quasi-experimental studies lack a focus on the moderating and mediating effect of institution prestige on within-level changes in performance. While these studies largely confirm that changes in institution prestige shape performance outcomes, they do not specify how the predicted performance gains (or losses) vary depending on the level of change in employment prestige. Furthermore, none of them decompose the indirect effect of institutional prestige on movers' within-level changes in performance. Here, we add to extant literatures on transnational research migration and employment prestige by (i) quantifying the size of the mobility premium for early-career European scientists, (ii) demonstrating the magnitude of the relationship between institutional prestige and migration-related performance gains, and (iii) quantifying the mobility premium once the indirect effect of institutional prestige is decomposed.

Methods

Dataset

The current paper uses article metadata retrieved from the curated and enriched version of the Web of Science (WoS) database hosted at the Centre for Science and Technology Studies (CWTS), Leiden University. This curated version provides more accurate author disambiguation, more systematic cleaning of reference data, and field-normalized bibliometric indices. The author disambiguation algorithm functions by clustering WoS papers based on names, affiliations, emails, co-authors, grant numbers, subject categories, journals, self-citations, bibliographic coupling, and co-citations, with an estimated precision of 95% and a recall of 90% (Tekles & Bornmann, 2020). The CWTS version of the WoS database also provides an estimated gender (man or woman) for each researcher, based on the author's name and country affiliation. The estimations are based on three different algorithms (Gender API, Gender Guesser, and Genderize.io) (Boekhout et al., 2021).

Given disambiguated and consistent name and affiliation information for each article, we were able to establish career-long publication profiles for individual researchers. We restricted our focus to European researchers (data from 41 countries were initially included) publishing their first article in a WoS-registered journal between 2008 and 2010. The focus on a 2008–2010 cohort gave us enough follow-up years to observe (1) potential mobility and (2) the effect of mobility on scientific performance up to 2 years after the observed mobility event (while maintaining a reasonable citation window in our bibliometric analysis). We deemed it important to trace researchers from the start of their publication careers, as selection effects (due to attrition) may otherwise bias the estimated mobility premiums. To ensure good coverage of each researcher's publication profile, we chose to only include authors who primarily published (determined by the field where the majority of an individual's publications were placed) in disciplines that had reasonable cited reference coverage (> 60%) in WoS. We included all ten disciplines that met this threshold: Biology, Biomedical Research, Chemistry, Clinical Medicine, Earth and Space, Engineering and Technology, Health, Mathematics, Physics, and Psychology. We chose to exclude authors in the Nuclear and Particle Physics subfield of Physics, due to abnormally high mean number of co-authors per paper (139 compared to next nearest subfield Fluids and Plasmas with 18.8). To increase certainty about the country of origin, we only included researchers with a single-country scientific origin (i.e., authors not affiliated to multiple countries in their first paper).

To determine the origin institution of each researcher, we used the institutional affiliation reported in the researcher's first published article. If there were multiple, we selected the institution from these that was most common as an affiliation during the researcher's career. If this was equal, we preferred the institution that was included within the Leiden University Ranking.

We estimated publication profiles for 525,892 researchers globally who started their career between 2008 and 2010 (based on 10,193,946 publications). Of these, 167,014 were European researchers who fulfilled the criteria set out above (women = 78,091, men = 88,923; excluding ~ 7% of author profiles whose gender was not reliably estimated with at least 90% certainty). A flow diagram illustrating the process of identifying our eligible sample can be found in Fig. A1 in the online appendix.

Inferring mobility

We used article metadata to infer the location of authors at the time of publication and assume that changes in affiliation between publication time points represent a physical move. By so doing, we can trace affiliation locations over time to identify those who moved to the USA and those who never moved. To create a sample of eligible movers, we identified 8679 European-origin researchers who had published at least one publication with an institutional affiliation in the USA. All of these cases were of an initial single institutional affiliation to a US institution. Researchers were eligible for inclusion in our treatment condition if their connection to the US institution spanned at least 2 years (i.e., the most recent publication with a US affiliation should be published at least 2 years later than the first) and they did not simultaneously obtain an affiliation to a third country. This increases the likelihood that the researcher had indeed moved, rather than it being a short research visit. Similarly, we only included researchers who moved to the USA 2 or more years into their publication career, had published at least two papers at their home institution, and remained solely at their origin institution until they moved to the USA. This enabled an unbiased comparison of the performance trends between conditions prior to the mobility event. In addition, because the vast majority of PhD students (especially in the natural sciences and health sciences) publish at least one paper with their PhD affiliation (Larivière, 2012; Waaijer et al., 2016), this helps ensure that we are covering researchers who started their academic career in Europe. Moreover, we only included researchers who moved to the USA before 2017. We did so to ensure that we could maintain a reasonable time window for measuring changes in bibliometric outcomes.

To create a control group of eligible stayers who could potentially be matched with eligible movers, we included researchers who never moved to another country or institution (at least until 2 years after their unique matched counterpart had moved). We only included scholars who published at least 4 articles during their career. This was done to increase similarity between the two groups, since authors in the “movers” condition would need to have at least four publications to be included (two at origin, and two at US destination). Finally, the stayers had to be publication active at least 2 years after their matched partner had moved. As a robustness check, we also introduced the additional requirement that stayers had published at least one paper in the year where the paired migrant had his or her first paper registered at a US location.

For all matched researchers, we required that during their career (i.e., the years between the first and last paper observed in the data), there be no publication gaps of 4 years or longer, since we were interested in active researchers (as opposed to individuals who occasionally published papers such as clinicians). The amount of potential included researchers prior to matching was 2368 individuals who moved to the USA, and 87,668 potential matches for them (see Fig. A1).

Matching procedure

Our matching strategy aimed to alleviate differences in pre-treatment characteristics between migrants and non-mobile scientists. We used exact matching to create a quasi-control condition (the stayers) that closely matched the treatment condition (the movers). We paired movers to non-mobile scientists with identical home institutions, research areas, career age, and estimated gender. We obtained a final matched sample of 1989 movers matched to 1989 stayers (see Fig. A1). For a breakdown of matched researchers per country/discipline, see Table A1.

Matching on pre-treatment outcomes is generally discouraged in difference-in-differences analysis due to threats of regression to the mean (Daw & Hatfield, 2018). However, as a robustness check, we ran a complementary analysis using coarsened exact matching (Iacus et al., 2012) including prior performance as a matching criterion. This technique allowed us to alleviate potential differences in pre-treatment performance levels for movers and stayers, thereby reducing selection problems, given that pre-mobility performance may be correlated with being mobile.

Performance measures

We assessed scientific performance using five indicators developed by CWTS (Waltman et al., 2012) measured within subjects longitudinally over each career year: (1) sum of publications, (2) mean publication citation score (a standardized measure of citation count where a score of 1 represents the mean number of citations in a given year for a given discipline), (3) mean journal citation score (a standardized measure of journal impact factor where a score of 1 represents the mean impact factor in a given year for a given discipline), (4) sum of publications in high-impact journals operationalized as the number of articles with a journal citation score of double the mean (i.e., "top journals"), and (5) sum of papers among the top 10% most cited within the same subject area and for the same year (i.e., "top-cited papers"). Citation indicators are normalized for publication years and differences in citing patterns across fields based on ~4000 fields (Ruiz-Castillo & Waltman, 2015). Finally, we utilize both full and fractional counting at the author level; we exclude self-citations, and all citation indicators use 3-year citation windows (thus representing the citations accrued within the first 3 years after each paper was published) where the first year is equal to the publication year.

Analytical strategy

We used a staggered difference-in-differences (DiD) analysis (Callaway & Sant'Anna, 2020) to investigate whether the impact of moving to the USA was comparable to a case-control matched counterfactual condition. A typical DiD analysis involves two time periods and two groups: in the first period, no one is treated; in the second period, some units are treated (the treated group); while other units are not (the comparison group). Given parallel performance trends prior to treatment, one can estimate the average treatment effect for the treated subpopulation (ATT). This is done by comparing the average change in outcomes experienced by the treated group to the average change in outcomes experienced by the comparison group.

Our design deviates from the standard DiD setup because researchers can experience the treatment (in our case, moving to the USA), at different points in time. For example, a researcher may move to the USA in the third year of her career, while another may move in the fifth year of her career. Instead, we used a staggered DiD analysis (Callaway & Sant'Anna, 2020) that reduces the bias that can occur in traditional two-way fixed effects models when the timeframe of events occurring is more than a single pre-treatment and a single treatment period (Borusyak & Jaravel, 2021). This works by creating average treatment effects for $group_g$ at $time_t$, where a group is defined by the time period when units are first treated. Aggregating over all these group treatment effects creates a single overall treatment effect parameter with similarities to the ATT in the two periods and two groups setup.

The staggered difference-in-differences (DiD) analysis was run using the DID package in R (Callaway & Sant'Anna, 2020) with doubly-robust estimation (Sant'Anna & Zhao, 2020). To provide a standardized estimate of effect size, we calculated Cohen's *d* using the ATT alongside the pooled standard deviation (Lipsey & Wilson, 2001).

Institutional prestige and within-level changes in movers' performance

We used mixed-effect models, implemented through the lme4 package in R, to demonstrate the marginal effect of mobility given the direction (upwards or downwards) and extent of institutional prestige change. Previous research on the impact of employment prestige has primarily relied on US-specific prestige measures of departments and institutions derived from evaluations of research-doctorate programs and information on faculty-hiring flows (see, e.g., Allison & Long, 1990; Su, 2011; Way et al., 2019). Such measures were not suitable for our analysis, as we needed a standardized measure that covered the prestige of origin institutions in Europe as well as destination institutions in the USA. Hence, change in institution prestige was estimated based on the QS World University Ranking and the Leiden University Ranking.

From QS, we used the comprehensive ranking, which provides a proxy of a university's worldwide reputation, with 40% of the underlying ranking data derived from a global reputation survey. The survey requests academics from around the globe to identify which institutions they see as excelling in their respective fields. From the Leiden Ranking, we relied on the PP-top 10% indicator, which ranks universities based on their proportion of publications among the top 10% most cited globally. Specifically, the PP-top 10% score specifies "the proportion of a university's publications that, compared with other publications in the same field and the same year, belong to the top 10% most frequently cited" (CWTS, 2022a). The indicator is available from the Leiden Ranking website (CWTS, 2022b). Note that it was not possible to calculate this difference for all participants, since not all research institutions are present in these rankings.

For each ranking, we took the raw scores and computed a mean value for the years 2009–2020 (QS ranking), and 2009–2018 (Leiden Ranking). The start date of these ranges was chosen as it was the earliest year of the QS ranking for which we could obtain full results, while the end date was chosen as it was the most recent when the data was collected. Our measure of change in institution status was then the difference between the average ranking score of the destination institution minus the average ranking score of the origin institution. This measure was rescaled by dividing by two standard deviations (Gelman, 2008). We chose to rely on standardized units of underlying performance scores as opposed to raw rankings for two reasons: (i) Rankings are characteristically imprecise, and the performance distances between ranks vary considerably depending on location in the ranking hierarchy. For instance, relative performance differences in the PP-top 10% scores and QS comprehensive ranking scores are much larger among the top 100 most highly ranked institutions than among lower-ranked institutions. (ii) The rescaling of ranking scores allows us to model information from the full distribution in our estimations, rather than relying on crude categorical measures of prestige (e.g., distinguishing between the top 100 most highly ranked universities vs. the rest). The standardized units should be interpreted as a two-standard deviation change in the university ranking hierarchy, from a lower ranking to a higher ranking institution (for instance, a move-up from the 16th percentile to the 84th percentile of the ranking score distribution).

To run these models, we restricted our focus to the treatment group. The main parameter of interest was an interaction between our standardized measure of change in institution status and a categorical variable denoting whether the transatlantic mobility event had occurred or not (observations prior to the mobility event = 0, observations after the mobility event = 1). In the mixed-effects models, we adjusted for career year (to account for any change in performance with increasing career age) and the ranking score of the institution of origin (to account for any baseline differences in performance that can be explained by the ranking of the home affiliation). Because our explanatory variable (ranking change) was nested within the treatment (i.e., the effect of a change in ranking can only apply after the move has occurred), we did not include a main effect of ranking change in these models (Chambers & Hastie, 2017). To adjust for clustering of variance at the individual level, we added a random intercept for each researcher.

To estimate how our measure of change in employment prestige mediated the association between the mobility event and scientific performance, we used the R package mediation. Specifically, we estimated how much of the ATT is lost when the influence of the change in institution ranking (indirect effect) is parceled out (decomposed). Similar to the assessment of marginal effects in the mixed-effect models, we restricted our focus to the treatment group.

Results

The mobility premium

Figure 1 presents the main results of the matched-pairs DiD analysis. Consistent with the parallel trend assumption underlying DiD estimations, the movers and stayers have comparable developments on each performance measure prior to the mobility event. Yet, we observe a slightly lower average publishing rate for migrants than stayers in year − 1, which may reflect disrupted work routines associated with the transnational mobility event.

We find strong and consistent effects of transatlantic migration on research performance. Compared to the matched group of stayers, transatlantic migrants on average see a 38% increase in publication output (average treatment effect on the treated per year [ATT] = 0.68, Cohen's d = 0.30), a 45% increase in citation rates (ATT = 0.61, d = 0.19), a 26% increase in journal impact score (ATT = 0.34, d = 0.25), a 114% increase in number of top-journal publications (ATT = 0.30, d = 0.40), and a 106% increase in number of top-cited papers (ATT = 0.28, d = 0.38), within the first 3 years after the mobility event (see Tables A2-A7). Note here that the large percentage increase observed for top-cited and top-journal publications should be interpreted in view of low average outputs before

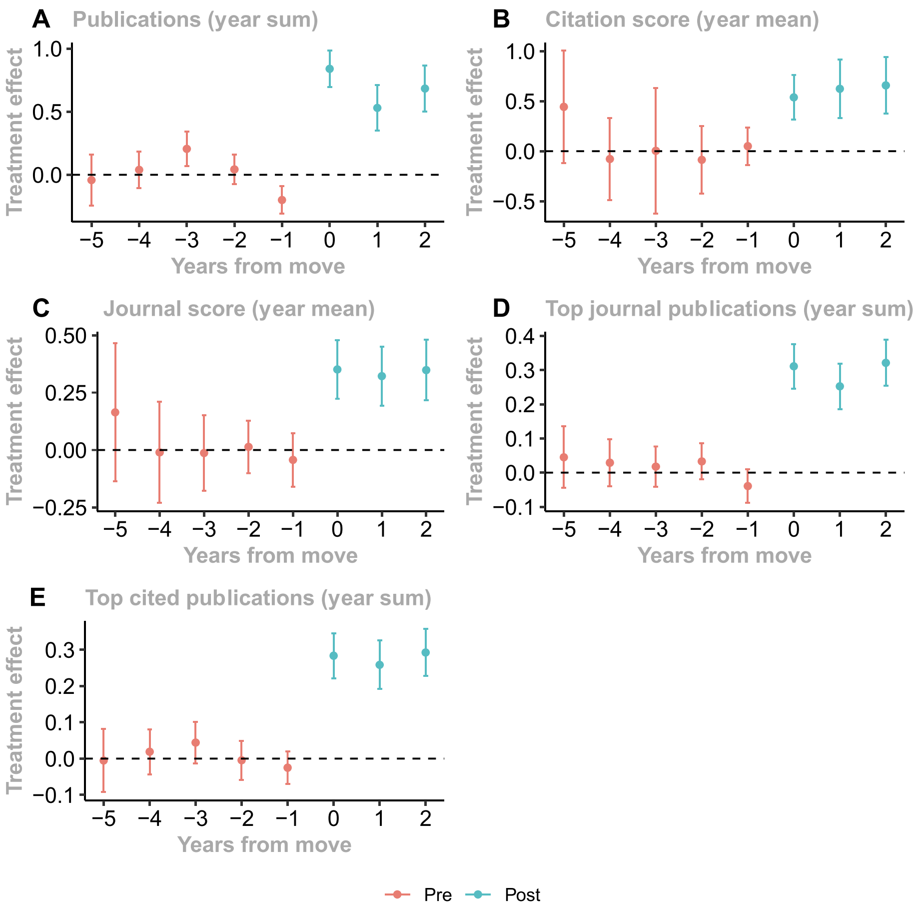

Fig. 1 Estimated difference in the performance of movers and stayers by year and performance outcome, before and after the mobility event. The figure plots the pre- and post-treatment coefficients from the difference-in-differences estimation. Year 0 on the *X*-axis denotes the year of the first publication after the mobility event and covers all publications published within the same year. Positive values on the *Y*-axis indicate a performance advantage in favor of the movers. Model specifications are reported in Tables A2-A7

the move. Complementary analyses based on fractionalized performance measures, which account for variability in collaboration practices across disciplines, yield qualitatively similar results (see Fig. A2).

As shown in Fig. 2, subgroup analyses indicate comparable trends for scientists migrating from different European regions, although the results for publication productivity are inconclusive for Eastern European migrants. We do not stratify our analysis by field due to too low sample sizes to run individual DiDs for each of the ten disciplines.

Robustness checks for the DiD analysis

Our DiD findings concerning the mobility premium are robust to four alternative sampling and model specifications (see Appendix Methods). First, we used coarsened exact

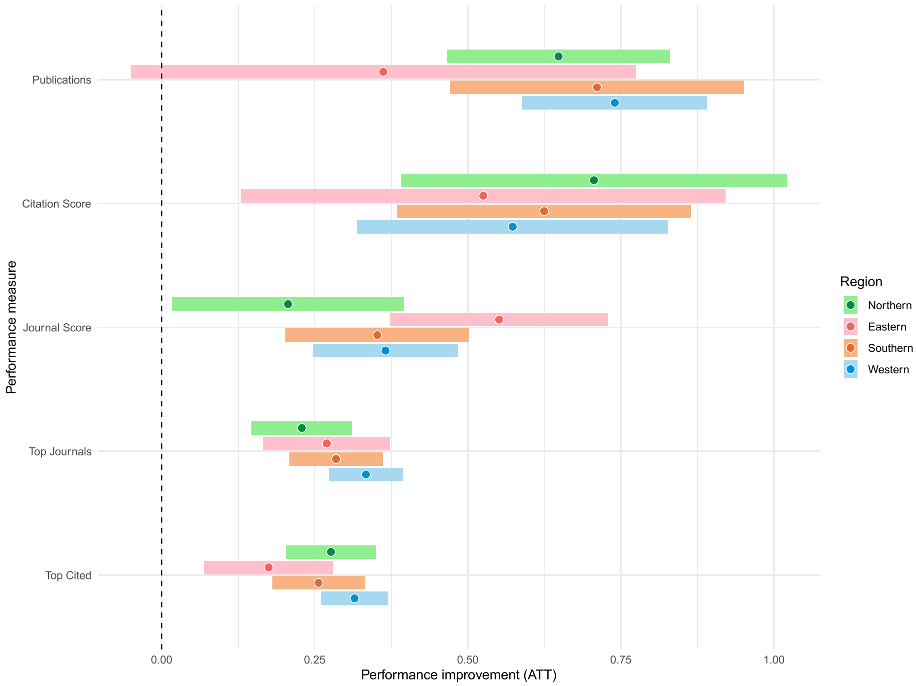

Fig. 2 Average treatment effect for the treated by the home region of the migrating scientist. Nodes indicate average treatment effect for the treated and bars indicate 95% confidence intervals. Countries are placed into the regional categories following the United Nations (2021) geoscheme for Europe, though with Turkey placed in the eastern category

matching to pair migrants and stayers based on pre-treatment performance, since pre-mobility performance trends may correlate with being mobile. As shown in Fig. A3, this matching approach produces qualitatively similar results. Second, we ran an analysis that only included researchers who had origin and destination institutions present in the Leiden Ranking. We did so to reduce variability in the types of institutions that researchers came from. This approach also produced comparable results (Fig. A4). Third, since international movers may differ from stayers on unobservable factors (e.g., intrinsic ambitions and motivations), we also compared migrants' performance to other migrants who had not yet moved (Fig. A5). While this matching strategy reduced the sample size and widened the confidence bands for the estimated treatment effects, the mobility premiums remained salient. Finally, since we infer mobility from publication data, and hence artificially boost the publication output of movers by one publication in the year of the mobility event, we also ran a robustness check restricted to matched pairs in which both migrants and stayers published in the moving year (i.e., year 0) (Fig. A6). Again, this additional restriction did not reduce the observed mobility premium.

The role of institutional prestige in mobility returns

As shown in Fig. 3, performance returns are, on average, greater for migrants who move upward in the institutional hierarchy compared to migrants moving to equally ranked

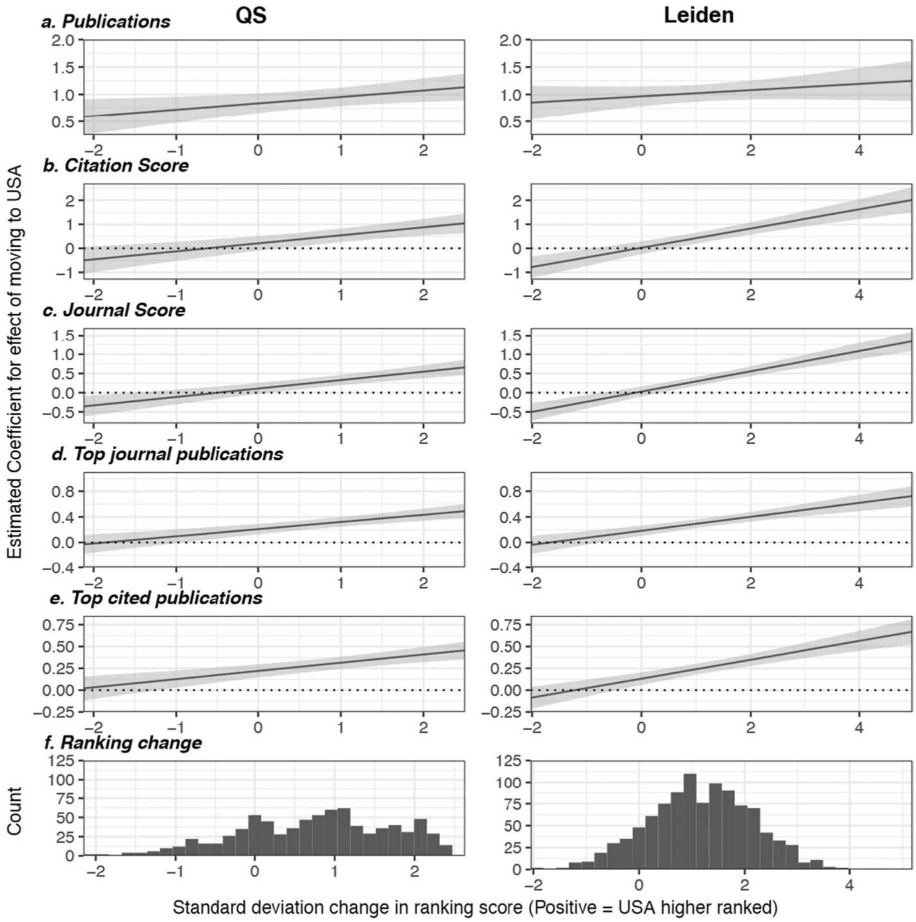

Fig. 3 Marginal effect of transatlantic mobility for different levels of upward (or downward) institutional mobility by performance outcome. Shaded areas around the slopes indicate the 95% confidence intervals. Each unit change on the *X*-axis represents a 1-standard deviation change in institution status. The histograms in **f** display the frequency distribution of movers across various levels of change in institution status. Regression tables underlying these results can be found in Tables A8-A9

or lower-ranked institutions (measured by the Leiden and QS university rankings). For instance, a two-standard deviation move-up in the Leiden and QS rankings is associated with an increase of 0.22 (CI: 0.14–0.29, $\omega_p^2 = 0.006$) and 0.22 (CI: 0.13–0.31, $\omega_p^2 = 0.006$), respectively, in the annual number of top-journal publications (Fig. 3d), and an increase of 0.22 (CI: 0.15–0.29, $\omega_p^2 = 0.007$) and 0.19 (CI: 0.10–0.27, $\omega_p^2 = 0.005$), respectively, in the annual number of top-cited publications (Fig. 3e). We assessed the robustness of the marginal effects analysis by running separate DiD models for movers who saw a substantial increase or drop in institution prestige after their move. Moreover, we ran the marginal effects analysis with an alternative measure of change in institution status. The outcomes of these robustness checks mirror the primary results (see Appendix Methods, Table A10, and Fig. A7).

As indicated in Fig. 3f, most transatlantic migrants move to research institutions of higher prestige than they came from. Our measure of ranking change also mediates the association between transatlantic migration and scientific performance (see Table A11). Ranking change accounts for 96% and 92% (when measured by the Leiden Ranking) of the migrants' gains in citations and journal impact scores respectively, suggesting that moves to equally or lower-ranked institutions do little to increase the uptake of a scientists work (Fig. 3b, c). These indirect effects are smaller but still substantial, when institutional mobility is measured by the QS ranking (38% and 61%, respectively). In contrast, only 6% and 9% of the migrants' gains in publication productivity are mediated through institutional mobility (measured by the Leiden and QS rankings), suggesting that even scientists that move to lower-ranked institutions see increasing publishing rates after the move. A robustness check with an alternative measure of institutional mobility shows comparable results (see Table A12).

Discussion

Every year, thousands of scientists leave their home countries to embark upon careers abroad. Previous research indicates that transnational mobility may benefit careers, but existing studies have been limited by selection problems, since those who relocate abroad are not random subset of the researcher population (Netz et al., 2020). Moreover, while a growing literature uses panel data and quasi-experimental approaches to parcel out the performance gains associated with inter-organizational mobility, the indirect effects of changes in institutional prestige on international migrants' scientific achievements remain uncertain. Previous research also lacks a focus on the moderating and mediating effect of institution prestige on within-level changes in scientists' performance. Addressing these limitations is important, since the performance gains commonly associated with international mobility may largely be driven by migrating scientists' inclination to pursue research opportunities in more prestigious research environments than they came from (Franzoni et al., 2012).

Based on a matched-pairs DiD analysis, we show a substantial mover's advantage for European scientists who cross the Atlantic. This mover's advantage manifests in larger increases in publication outputs, citation rates, journal impact scores, and numbers of top-cited and top-journal papers for transatlantic migrants compared to a counterfactual control sample of non-mobile scientists. Overall, these findings are consistent with ideas from the innovation literature suggesting that mobility may boost performance through knowledge recombination and improved employer-employee matches (Franzoni et al., 2014; Hoisl, 2007; Fernandez-Zubieta et al., 2013). Moreover, they align with the few previous studies that, like ours, attempt to alleviate the common selection bias encountered in mobility studies, where pre-mobility characteristics and performance trends are correlated with being mobile (Dubois et al., 2014; Franzoni et al. 2015; Petersen, 2018). Our study thus reiterates the need for sophisticated estimation techniques and attention to mediating factors in studies of researcher mobility (Netz et al., 2020).

Despite evidence suggesting changing power relations in global science (Heinze et al., 2019; Nielsen & Andersen, 2021), our findings bolster the image of the USA as a highly desirable destination for migrating European scientists. While researcher mobility to and from the USA generally appears to be on the decline (Gomez et al. 2020), those that do relocate from Europe to the USA, on average, see performance gains. These estimated gains are salient for scientists from Northern and Western Europe, where possibilities to reach US partners through existing mobility and collaboration linkages are high, as well as for scientists from Southern and Eastern Europe, where such possibilities (on average) may be more restricted (Chinchilla-Rodríguez et al., 2018). In a policy perspective, these findings speak to the effectiveness of the US science system (or its research institutions) in identifying and fostering international research talents from across the European continent. In the future, researchers should examine how many of these transatlantic migrants end up returning to their origin countries and how their careers and performance are affected by return mobility. According to Gaulé's (2011) study on return migration among US PhDs in chemistry, a mere 9% of foreign faculty members returned to their home country throughout their careers. Interestingly, the study also found that the most successful scientists were the least inclined to return, although they were more likely to relocate within the US academic job market. The US system's attractiveness to scientific migrants (in terms of wealth, wages, and opportunities) likely restricts the generalizability of our findings beyond this specific destination context. Indeed, national and pan-European funding schemes (e.g., the Marie Curie fellowships) may provide favorable support options for European migrants that cross the Atlantic, which are not available to scientists in less research intensive science regions. In the future, studies could employ a methodology similar to ours to estimate how individual mobility gains vary depending on the R&D capacities of sending and receiving countries and the policies they have in place to promote and support international mobility (Jacob & Meek, 2013).

Importantly, the observed mobility premium depended on the extent of the rise in institutional ranking, with move-ups in the hierarchy inducing additional performance gains. While those relocating to less prestigious institutions also saw productivity gains from mobility, benefits in citation and journal impact were substantially less evident. Indeed, changes in institutional prestige mediated up to 96% and 92% of migrants' gains in citation and journal impact, but only around 9% of the observed increases in publication productivity.

In conjunction, these findings extend prior research by factoring in the "visibility advantage" tied to prestigious institutional locations: while moving abroad is associated with higher levels of visibility and productivity—as much research suggests—the observed visibility boost is primarily driven by migrating scientists' tendency to enter more prestigious employments than they came from (Fig. 3f). These findings align with empirical insights from surveys of scientific migrants, which highlight entry into excellent and prestigious foreign research environments as an important pull-factor in migration (Ivancheva & Gourova, 2011; Schiller & Diez, 2012). Whether this tendency and the associated visibility advantage are specific to European migrants destined for the USA, or whether they apply to a broader population of international movers, remains an open question.

Similarly, it is unclear to what extent the observed visibility advantage is due to the greater facilities, intellectual stimulation, or work motivations that top ranking institutions provide, or to institution-related "halo effects" that bias the uptake of science. However, recent research suggests that the greater availability of funded graduate and postdoctoral labor at prestigious institutions may be a decisive factor (Zhang et al., 2022).

Another plausible explanation might be that prestigious institutions are better capable of identifying and recruiting scientists based on their future potential (Long, 1978; Merton, 1968). Yet, our findings are robust to alternative model specifications, where migrants are compared to other migrants who are yet to move. Hence, the visibility boost may not be explained by top universities' recruitment abilities alone. Sociological factors related to the characteristics of the receiving environments and the social connections they provide likely also play a role, and understanding which of these characteristics matter the most is a promising avenue for future research.

This study has a number of limitations. First, bibliometric metadata provides a rich and comprehensive picture of scholarly mobility, but it is not without drawbacks. The disambiguation algorithm may in rare cases merge multiple authors into a single profile, or split distinct authors into multiple profiles (Nielsen & Andersen, 2021). While such errors can add noise to the data, they are unlikely to systematically bias our conclusions, and we have imposed specific constraints on the algorithmic ouput to improve its precision. Second, despite our matched design, unobserved differences between the movers and stayers may bias our estimations of the returns to migration. For instance, migrants and non-mobile scientists may differ in their intrinsic level of work-related ambitions and motivations, which could introduce a selection problem if these ambitions and motivations were correlated with long-term performance. Yet, we observe comparable performance levels for migrants and non-mobile scientists in the years prior to the mobility event, and as mentioned above, results are comparable when migrants are compared to other migrants who are yet to move (see Fig. A5). Third, our main analysis was only designed to estimate performance gains within the first years after the mobility event. However, descriptive results also hint at longer-term (up to 5-year post move) performance gains (see Fig. A8). Finally, while scientific productivity and impact correlate with important career-related factors such as funding, salary levels, and promotions, they are in themselves quite narrow indicators of how transnational migration may influence careers. Future research might build on our methodology to get closer to the direct effect of international mobility on changes in other career-related factors such as collaboration networks, occupational situations, research novelty, and access to research facilities and support.

In conclusion, our study suggests a substantial "mover's advantage" where researchers benefit from an immediate increase in scientific performance after moving from Europe to the USA. Our results also highlight the importance of institution prestige as a mediator of this effect, thereby reaffirming the cumulative advantages tied to prestigious institutional and geographic locations.

Supplementary information The online version contains supplementary material available at https://doi.org/10.1007/s10734-023-01089-7.

Acknowledgements We thank Erin Leahey, Rodrigo Costas, Sune Lehmann, Emil Bargmann Madsen, and Kristian Karlson for helpful comments on the manuscript. We also received valuable feedback from audiences at the Department of Sociology, University of Copenhagen, and the Centre for Science Studies, Aarhus University.

Funding Open access funding provided by Royal Library, Copenhagen University Library

Data and code availability The custom code required to reproduce the results is available at the Open Science Framework: https://doi.org/10.17605/OSF.IO/Z6QNH. Anonymized data for the matched sample is available at the same address.

Declarations

Conflict of interest The authors declare no competing interests.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

References

Abramo, G., D'Angelo, A. C., & Murgia, G. (2017). The relationship among research productivity, research collaboration, and their determinants. *Journal of Informetrics, 11*, 1016–1030.

Ackers, L. (2008). Internalisation, mobility and metrics: A new form of indirect discrimination? *Minerva, 46*, 411–435.

Aksnes, D. W., Rørstad, Kristoffer, Piro, Fredrik, N., & Sivertsen, G. (2013). Are mobile researchers more productive and cited than non-mobile researchers? A large-scale study of norwegian scientists. *Research Evaluation, 22*(4), 215–223.

Allison, P. D., & Long, J. S. (1990). Departmental effects on scientific productivity. *American Sociological Review, 55*(4), 469–478.

Appelt, S., van Beuzekom, B., Galindo-Rueda, F., & de Pinho, R. (2015). Which factors influence the international mobility of research scientissts?. In Aldo Geuna (eds.), *Global Mobility of Research Scientists* (pp.177–213).

Azoulay, P., Ganguli, I., & Zivin, J. G. (2017). The mobility of elite life scientists: Professional and personal determinants. *Research Policy, 46*(3), 573–590.

Boekhout, H., van der Weijden, I., & Waltman, L. (2021). Gender differences in scientific careers: A large-scale bibliometric analysis. *arXiv preprint arXiv:2106.12624*.

Borusyak, K., Jaravel, X., & Spiess, J. (2021). Revisiting event study designs: Robust and efficient estimation. *arXiv preprint arXiv:2108.12419*.

Burris, V. (2004). The academic caste system: Prestige hierarchies in PhD exchange networks. *American Sociological Review, 69*(2), 239–264.

Callaway, B., & Sant'Anna, P. H. C. (2020). Difference-in-differences with multiple time periods. *Journal of Econometrics, 225*(2), 1–31.

Cañibano, C., Otamendi, J., & Andújar, I. (2008). Measuring and assessing researcher mobility from CV analysis: The case of the Ramón y Cajal programme in Spain. *Research Evaluation, 17*(1), 17–31.

Caplow, T., & McGee, R. J. (1958). *The Academic Marketplace*. Basic Books.

Chambers, J. M., & Hastie, T. J. (2017). *Statistical models in S.* Routledge.

Chinchilla-Rodríguez, Z., Miao, L., Murray, D., Robinson-García, N., Costas, R., & Sugimoto, C. R. (2018). A global comparison of scientific mobility and collaboration according to national scientific capacities. *Frontiers in Research Metrics and Analytics, 3*, 1–14.

Clauset, A., Arbesman, S., & Larremore, D. B. (2015). Systematic inequalities and hierarchy in faculty hiring networks. *Science Advances, 1*(1), e1400005.

Crane, D. (1967). The gatekeepers of Science: Some factors affecting the selection of articles for scientific journals. *American Sociological Review, 2*(4), 195–201.

Crane, D. (1970). The academic marketplace revisited: A study of faculty mobility using the Cartter ratings. *American Journal of Sociology, 75*(6), 953–964.

Cruz-Castro, L., & Sanz-Menéndez, L. (2010). Mobility versus job stability: Assessing tenure and productivity outcomes. *Research Policy, 39*(1), 27–38.

CWTS (Centre for Science and Technology Studies, Leiden University) (2022a). *Leiden Ranking*. https://www.leidenranking.com/ranking. Accessed 3 Jan 2021.

CWTS (Centre for Science and Technology Studies, Leiden University) (2022b). *Indicators.*https://www.leidenranking.com/information/indicators. *Accessed 3 Jan 2021.*

Daw, J. R., & Hatfield, L. A. (2018). Matching and regression to the mean in difference-in-differences analysis. *Health Services Research, 53*(6), 4138–4156.

Dubois, P., Rochet, J.-C., & Schlenker, J.-M. (2014). Productivity and mobility in academic research: Evidence from mathematicians. *Scientometrics, 98*, 1669–1701.

Ejermo, O., Fassio, C., & Källström, J. (2020). Does mobility across universities raise scientific Productivity? *Oxford Bulletin of Economics and Statistics, 82*, 603–624.

Fernandez-Zubieta, A., Geuna, A., & Lawson, C. (2013). Researchers' mobility and its impact on scientific productivity. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2244760

Fernandez-Zubieta, Ana, Geuna, A., & Lawson, C. (2013). Researchers' mobility and its impact on Scientific Productivity. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2244760

Franzoni, C., Scellato, G., & Stephan, P. (2012). Foreign-born scientists: Mobility patterns for 16 countries. *Nature Biotechnology, 30*(12), 1250–1253.
Franzoni, C., Scellato, G., & Stephan, P. (2014). The mover's advantage: The superior performance of migrant scientists. *Economic Letters, 122*(1), 89–93.
Franzoni, C., Scellato, G., & Stephan, P. (2015). International mobility of research scientists: Lessons from GlobSci. In Global mobility of research scientists (pp. 35-65). Academic Press.
Gaule, P. (2011). *Return migration: Evidence from academic scientists*. Mimeo.
Gelman, A. (2008). Scaling regression inputs by dividing by two standard deviations. *Statistics in medicine, 27*(15), 2865–2873.
Gibson, J., & McKenzie, D. (2014). Scientific mobility and knowledge networks in high emigration countries: Evidence from the Pacific. *Research Policy, 43*(9), 1486–1495.
Gomez, C. J., Herman, A. C., & Parigi, P. (2020). Moving more, but closer: Mapping the growing regionalization of global scientific mobility using ORCID. *Journal of Informetrics, 14*, 101044.
Gross, G. R. (1970). The organization set: A study of sociology departments. *The American Sociologists, 5*(1), 25–29.
Hargens, L. L., & Hagstrom, W. O. (1967). Sponsored and contest mobility of American academic scientists. Sociology of education, 24–38.
Hargens, L. L., & Hagstrom, W. O. (1982). Scientific consensus and academic status attainment patterns. *Sociology of Education, 55*(4), 183–196.
Heinze, T., Jappe, A., & Pithan, D. (2019). From north american hegemony to global competition for scientific leadership? Insights from the Nobel population. *PLoS One, 14*, 1–14.
Hoisl, K. (2007). Tracing mobile inventors—the causality between inventor mobility and inventor productivity. *Research Policy, 36*(5), 619–636.
Iacus, S. M., King, G., & Porro, G. (2012). Causal inference without balance checking: Coarsened exact matching. *Political Analysis, 20*(1), 1–24.
Ivancheva, L., & Gourova, E. (2011). Challenges for career and mobility of researchers in Europe. *Science and Public Policy, 38*(3), 185–198.
Jacob, M., & Meek, V. L. (2013). Scientific mobility and international research networks: Trends and policy tools for promoting research excellence and capacity building. *Studies in Higher Education, 38*(3), 331–344.
Larivière, V. (2012). On the shoulders of students? The contribution of PhD students to the advancement of knowledge. *Scientometrics, 90*(2), 463–481.
Leahey, E. (2007). Not by productivity alone: How visibility and specialization contribute to academic earnings. *American Sociological Review, 72*(4), 533–561.
Lipsey, M. W., & Wilson, D. B. (2001). *Practical meta-analysis*. SAGE Publications.
Lissoni, F., Mairesse, J., Montobbio, F., & Pezzoni, M. (2011). Scientific productivity and academic promotion: A study on french and italian physicists. *Industrial and Corporate Change, 20*(1), 253–294.
Long, J. S., & McGinnis, R. (1981). Organizational context and scientific productivity. *American Sociological Review, 46*(4), 422–442.
Long, J. S. (1978). Productivity and academic position in the Scientific Career. *American Sociological Review, 43*(6), 889.
McGinnis, R., Allison, P. D., & Long, J. S. (1982). Postdoctoral training in bioscience: Allocation and outcomes. *Social Forces, 60*(3), 701–722.
Merton, R. K. (1968). The Matthew effect in science: The reward and communication systems of science are considered. *Science, 159*(3810), 56–63.
Merton, R. K. (1988). The Matthew effect in science, II: Cumulative advantage and the symbolism of intellectual property. *Isis, 79*(4), 606–623.
Morgan, A. C., Economou, D. J., Way, S. F., & Clauset, A. (2018). Prestige drives epistemic inequality in the diffusion of scientific ideas. *EPJ Data Science, 7*(1), 40.
Netz, N., Hampel, S., & Aman, V. (2020). What effects does international mobility have on scientists' careers? A systematic review. *Research Evaluation, 29*(3), 327–351.
Nielsen, M. W., & Andersen, J. P. (2021). Global citation inequality is on the rise. *Proceedings of the National Academy of Sciences, 118*(7), 1–10.
Petersen, A. M. (2018). Multiscale impact of researcher mobility. *Journal of The Royal Society Interface, 15*(146), 20180580.
Ross, J. S., Gross, C. P., Desai, M. M., Hong, Yuling, Grant, A. O., Daniels, S. R., Hachinski, V. C., Gibbons, R. J., Gardner, T. J., & Krumholz, H. M. (2006). Effect of blinded peer review on abstract acceptance. *JAMA, 295*(14), 1675–1680.
Ruiz-Castillo, J., & Waltman, L. (2015). Field-normalized citation impact indicators using algorithmically constructed classification systems of science. *Journal of Informetrics, 9*(1), 102–117.

Sant'Anna, Pedro, H. C., & Zhao, J. (2020). Doubly robust difference-in-differences estimators. *Journal of Econometrics, 219*(1), 101–122.
Schiermeier, Q. (2011). Career choices: The mobility imperative. *Nature, 470*(7335), 563–564.
Schiller, D., & Diez, J. R. (2012). The impact of academic mobility on the creation of localized intangible assets. *Regional Studies, 46*(10), 1319–1332.
Su, Xuhong. (2011). Postdoctoral training, departmental prestige and scientists' research productivity. *The Journal of Technology Transfer, 36*, 275–291.
Sugimoto, C. R., Robinson-García, N., Yegros-Yegros, M. D. S., Rodrigo, A. C., & Larivière, V. (2017). Scientists have most impact when they're free to move. *Nature, 550*(7674), 29–31.
Tartari, V., Di Lorenzo, F., & Campbell, B. A. (2020). Another roof, another proof": The impact of mobility on individual productivity in science. *The Journal of Technology Transfer, 45*(1), 276–303.
Tekles, A., & Bornmann, L. (2020). Author name disambiguation of bibliometric data: A comparison of several unsupervised approaches. *Quantitative Science Studies, 1*(4), 1510–1528.
Tomkins, A., Zhang, M., & Heavlin, W. D. (2017). Reviewer bias in single-versus double-blind peer review. *Proceedings of the National Academy of Sciences, 114*(48), 12708–12713.
UN (2021). United Nations geoscheme for Europe. https://unstats.un.org/unsd/methodology/m49/overview/. Accessed 18 Jan 2022.
van Leeuwen, Thed, N., & Moed, H. F. (2012). Funding decisions, peer review, and scientific excellence in physical sciences, chemistry, and geosciences. *Research Evaluation, 21*(3), 189–198.
Waaijer, C. J. F., Sonneveld, Hans, Buitendijk, S. E., van Bochove, C. A., & van der Weijden, Inge, C. M. (2016). The role of gender in the employment, career perception and research performance of recent PhD graduates from Dutch universities. *Plos one, 11*(10), e0164784.
Wagner, C. S., & Jonkers, K. (2017). Open countries have strong science. *Nature, 550*(7674), 32–33.
Waltman, L., Clara, C. M., Kosten, J., Noyons, Ed, C. M., Tijssen, Robert, J. W., van Eck, N., van Leeuwen, J., Thed, N., van Raan, A. F. J., Visser, M. S., & Wouters, P. (2012). Data collection, indicators, and interpretation. *Journal of the American Society for Information Science and Technology*, *63*(12), 2419–2432. The Leiden Ranking 2011/2012.
Way, S. F., Morgan, A. C., Larremore, D. B., & Clauset, A. (2019). Productivity, prominence, and the effects of academic environment. *Proceedings of the National Academy of Sciences, 116*(22), 10729–10733.
Zhang, S., Wapman, K., Hunter, Larremore, D. B., & Clauset, A. (2022). Labor advantages drive the greater productivity of faculty at elite universities. *Science Advances, 8*, 46.
Zuckerman, H. (1977). *Scientific elite: Nobel laureates in the United States*. Transaction Publishers.

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.