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Veröffentlichungsversion / Published Version
Zeitschriftenartikel / journal article

*Research Evaluation*, 29(3), 2020, 327–351
doi: 10.1093/reseval/rvaa007
Article

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# What effects does international mobility have on scientists' careers? A systematic review

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## Abstract

The internationalization and specialization of science confront scientists with opportunities and sometimes even a need to become internationally mobile during their careers. Against this background, we systematically reviewed empirical studies on the effects that mobility across national borders has on the careers of scientists. Using several search channels, we identified 96 studies – published between 1994 and 2019 – that examine how international mobility influences eight dimensions of scientists' careers. Listed in descending order of the number of identified studies, these dimensions comprise scientists' (1) international networks, (2) scientific productivity, (3) occupational situation, (4) scientific impact, (5) competences and personality, (6) scientific knowledge, (7) access to research infrastructures and funds, and (8) symbolic capital. Existing research provides robust evidence of positive effects of international mobility on the broadening of scientists' networks. Moreover, several solid studies examine the effect of international mobility on scientists' productivity, impact, and occupational situation. Most of them find positive effects, but some also find no or negative effects. Studies on the other career dimensions are not only less frequent, but mostly also less robust. Our review reveals potential to advance research in the field by using less selective samples and more rigorous methodological approaches. Intending to spur further theory-driven empirical research, we develop a model integrating research on the identified career dimensions and derive various questions for future research. We conclude by highlighting policy implications of existing research.

**Key words:** international mobility; scientific migration; scientist; researcher; career; effect

## 1 Introduction

The internationalization and specialization of science confront scientists with opportunities or even a need to become internationally mobile during their careers. From a systemic perspective, scientists' international mobility is considered beneficial because it promotes knowledge production and diffusion between countries (Geuna 2015). From an individual point of view, it is increasingly regarded as a strategy to boost career success in academia (IDEA Consult et al. 2013, 2017). Given the substantial investments of many countries to support scientists' international mobility and the strain it may entail for scientists themselves, it seems appropriate to ask how international mobility actually influences scientists' careers.

In the past decade, in particular, various studies have addressed this question. However, existing knowledge is currently fragmented, not least because the discourses in different disciplines, research communities, and journals are partly detached from each other. We therefore systematically reviewed empirical studies on the effects that international mobility can have on scientists' careers.[1]

In the following, we first develop definitions of the examined group (scientists), treatment (physical international mobility), and outcome (the individual professional career). We then present our criteria for the inclusion and strategy for the identification of relevant studies. Thereafter, we map the research field by showing when and where the identified studies were published, and which types of scientists, mobility, and career dimensions they examine. For each career dimension, we additionally show how institutionalized a respective research subfield is by using network analyses, sketch suitable theoretical approaches, and appraise the existing empirical evidence. We conclude by recapitulating the main findings and by carving out various directions for future research.

## 2 Methodology

### 2.1 Focus of the review and definitions

Our review focuses on scientists, who we define as individuals working in the science system. Scientists can work in the academic and in the corporate sector, and they can be involved in research and teaching. While job profiles tend to overlap in practice, we can conceptually differentiate (1) academic researchers, (2) industrial researchers (sometimes also called corporate researchers), (3) teaching scientists, and (4) scientific consultants (Figure A1 in the Appendix).

Following Netz and Schirmer (2017), we understand international academic mobility as the movement of scientists and information across national borders. As this definition implies, academic mobility can be physical and virtual. While physical mobility describes the relocation of scientists, virtual mobility describes the transmission of information through information and communication technology. Our review focuses on the two major types of physical international mobility: stays abroad and international migration. The former are usually shorter sojourns abroad with intended return and without relocation of the main places of residence and work to another country, whereas international migration involves a longer-term relocation of the main places of residence and work to another country (Figure A2). As most studies do not use any detailed instruments to capture international mobility, we could not classify them using the fine-grained typology presented in Figure A2. Instead, we had to differentiate more highly aggregated and unfortunately also partly overlapping types of international academic mobility: (1) short stays abroad (less than 3 months), (2) long stays abroad (3 months or more), (3) PhD completed abroad, (4) postdoc completed abroad, and (5) current work abroad. Moreover, some studies use (6) no precise definition.

The outcome we examine is scientists' professional career. In lack of an overarching theoretical framework allowing us to study the various possible effects of international mobility on scientists' careers, we adopted an explorative approach instead of classifying studies using a pre-defined typology of scientists' professional career. We first detected different dimensions of scientists' careers in the identified studies, and then grouped these studies into eight research subfields according to their dependent variables.

### 2.2 Criteria for the inclusion of studies

We applied the following criteria to define the corpus of empirical studies to be reviewed: (1) We only included studies examining the effects that *international mobility* may have on the *careers* of *scientists*, thereby using the definitions presented in Section 2.1. We included studies independently of their primary research interest, that is, from strands of literature dealing with career success in academia, academic inbreeding, internationalization of higher education, high-skilled migration, brain drain, social stratification, gender inequalities, programme evaluation, or knowledge transfer. (2) We focused on studies published in English. We are not aware of any major study that we excluded due to this restriction. (3) We only included empirical studies presenting new evidence. We thus excluded studies representing evidence published elsewhere. Additionally, we refer to theoretically valuable studies in the introductory parts of Sections 3.2.1 to 3.2.8. (4) We followed the principle of working with the best available evidence (for details, see Petticrew and Roberts 2006: 185–7): We conducted an inclusive search and did not exclude studies solely on the grounds of study design or methods, as we were interested in both whether and why international mobility influences scientists' careers. We included both quantitative and qualitative studies, using both controlled designs (defined as studies including a non-mobile control group) and uncontrolled designs, with both objectively and subjectively assessed outcome measures. Relatedly, we considered studies published in various publication formats (for details, see Section 2.3). This allowed us to include up-to-date evidence that had so far been published only in research reports or conference papers. It also minimized the risk of overemphasizing studies reporting significant effects, which are more likely to get published in scientific journals (for details on this so-called publication bias, see Waibel et al. 2017). Despite our generally inclusive approach, we gave more weight to multivariate studies, because they can better deal with selection biases and approximate causal effects.

### 2.3 Search and identification process

In line with the PRISMA Statement on systematic reviews and meta-analyses (Moher et al. 2009), we followed a multi-tier strategy to define our corpus of studies (Figure 1). To begin with, we identified potentially relevant studies through a comprehensive search in the Scopus database. We first defined synonyms for the group, treatment, and outcome of interest through an iterative process (for details, see Table A1). We then searched for these expressions in the titles, abstracts, and keywords of journal articles (published and in press), reviews, short surveys, books, book chapters, research reports, and conference papers. We did not restrict the beginning of the search period and considered studies published until September 2019. Through the database search, we found 702 potentially relevant studies. Besides, we added 41 potentially relevant sources which we knew from earlier research. Thereafter, we screened and assessed the accessible studies regarding their eligibility, that is, regarding their fit with the thematic focus, definitions, and inclusion criteria (for details, see Sections 2.1 and 2.2). This procedure yielded 86 studies fulfilling our criteria for inclusion.

In a second step, we checked whether the identified studies referenced further potentially relevant studies (backward references search). Moreover, we checked whether the identified studies were cited by further potentially relevant studies using Google Scholar (forward citation search). Through the references and citation searches, we identified 10 additional studies. Thus, the corpus of reviewed studies eventually comprised 96 studies.

## 3 Results

### 3.1 Mapping the research field

Judging by the publication year of the identified studies, the research field examining effects of international mobility on scientists' careers is rather new and recently very dynamic. The earliest study to fulfil our criteria for inclusion was published in 1994, and 86 of the 96 identified studies (90%) were published since 2008 (Figure 2).

Most studies (83) were published in scientific journals. More than half of the journal articles were published in either

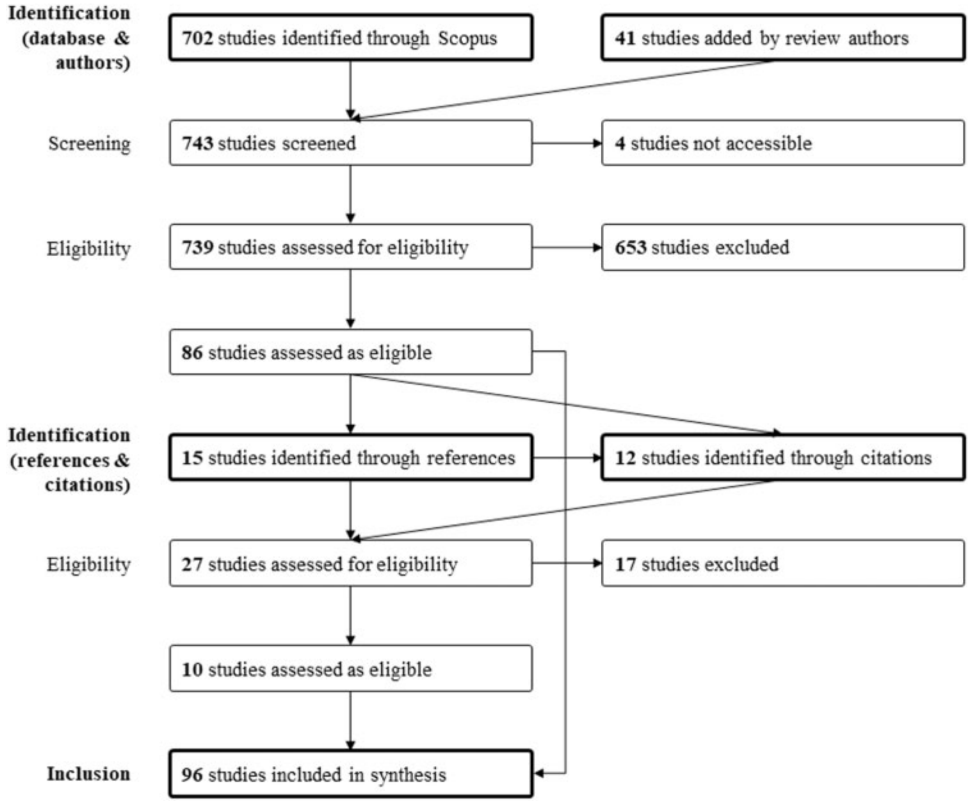


**Figure 1** Visualization of the identification process.

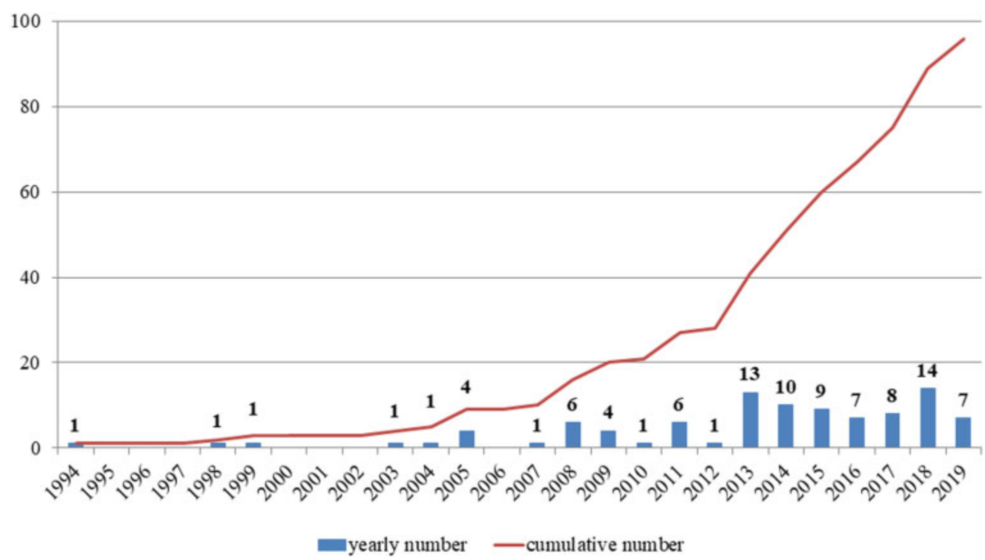


**Figure 2** Number of identified studies by year of publication.

*Scientometrics* (19), *Research Evaluation* (12), or *Research Policy* (11). Further studies were published as book chapters (6), conference papers (5), or research reports (2).

The reviewed studies examine different groups of scientists, but primarily researchers who eventually publish their work. The focus on publishing and mostly academically employed scientists surely results from the cognitive interest in the international mobility of highly skilled knowledge producers and diffusers, but arguably also from the features of the most frequently analysed data sources (publication databases and surveys).

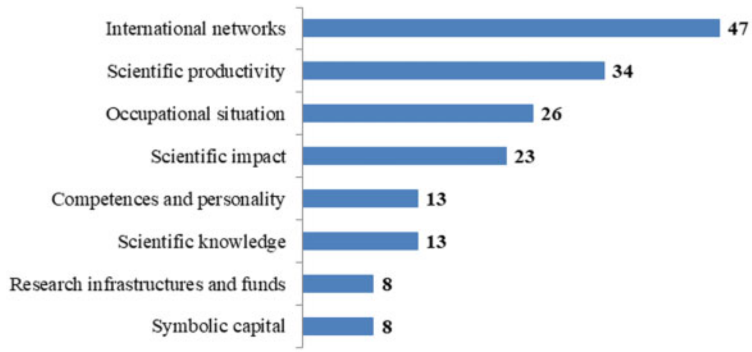


**Figure 3** Number of studies examining effects of international mobility on scientists' careers, by career dimension.

*Notes:* Some studies examine multiple career outcomes and are therefore assigned to several career dimensions.

The type of international mobility examined most frequently is long stays abroad (35), followed by a PhD abroad (16), current work abroad (14), a postdoc abroad (12), and short stays abroad (9). We found many studies (42) that we could not assign to our typology—although we have repeatedly adapted it to better match the existing studies. These studies use continuous variables reflecting the time spent abroad, examine effects of participation in specific scholarship programmes, or bibliometrically operationalize international mobility as changes in the affiliations indicated in authors' publications.

Most studies examine scientists who are employed in European countries, with Germany (23), Spain (21), and the UK (20) being the most frequently examined countries. Surprisingly few studies examine scientists employed in the USA (9). Besides, there is a notable number of studies (15) not specifying the country of employment. These studies primarily comprise bibliometric analyses considering publications of scientists who are employed around the world.

By far the most frequently examined career dimensions are scientists' international networks (47) and their scientific productivity (34), that is, the number of their publications or patents (Figure 3). Several studies investigate whether international mobility influences scientists' occupational situation (26), e.g. their occupational position, wage, or job satisfaction. Slightly less studies examine the scientific impact (23), which is usually operationalized through the number of citations and the rank of the journals in which scientists publish. Some studies look at competences and personality development (13) and the scientific knowledge base (13). Possible effects of international mobility on scientists' access to research infrastructures and funds (8) and the acquisition of symbolic capital (8) have been studied less frequently (for more detailed definitions of the career dimensions, see Sections 3.2.1 to 3.2.8).

The research subfields examining scientists' international networks and scientific productivity stand out not only regarding the number of studies that they comprise; directed citation networks show that studies within these fields also cite each other comparatively frequently (Figure 4). This indicates that these studies have contributed to creating a shared knowledge base and thus to these fields becoming comparatively established.[2] To a much lesser extent, this also applies to studies examining effects of international mobility on the scientific impact. All other research subfields are still less established. Judging by the comparatively large number of studies that are not integrated into the citation network, a high fragmentation is visible particularly regarding research on scientists' occupational situation and their scientific knowledge.

## 3.2 Summary and evaluation of existing evidence

Existing studies mostly suggest that international mobility affects scientists' careers positively. In the research subfields on international networks, scientific productivity, and scientific impact, in particular, notable numbers of studies use inferential statistics and find significantly positive effects of international mobility—in addition to studies reporting insignificantly positive effects and positive effects based on simple frequency distributions (Figure 5).

Some studies also report significantly negative effects of international mobility, namely on the scientific productivity, impact, and occupational situation. Especially regarding the occupational situation, it seems that international mobility has positive effects only under specific circumstances.

The reviewed studies make use of qualitative interviews, surveys, bibliometric databases, and data from curriculum vitae (CV). Relatedly, sample sizes vary from five interviewed academics (Bedenlier 2018) to bibliometric data on almost 50,000 chemists worldwide (Kato and Ando 2013). Multivariate studies examining the effect of international mobility on scientific impact tend to have large sample sizes because they predominantly examine bibliometric data. By contrast, multivariate studies on scientific knowledge, competences and personality, as well as research infrastructures and funds mainly examine smaller samples, which were primarily generated through surveys (Table A2).

Surprisingly many studies (43 out of 96, 45%) use uncontrolled designs. Only 53 out of the 96 identified studies (55%) use controlled designs (Table A2). The use of controlled designs is particularly common within the research subfields on scientific impact (87%), scientific productivity (68%), and the occupational situation (65%). Overall, we could identify rather few studies trying to approximate causal effects of international mobility by both using controlled designs and methods that can deal with unobserved heterogeneity (e.g. Jonkers and Cruz-Castro 2013; Marinelli, Elena-Pérez and Fernández-Zubieta 2013; Dubois, Rochet and Schlenker 2014; Franzoni, Scellato and Stephan 2014; Scellato, Franzoni and Stephan 2015; Baruffaldi, Marino and Visentin 2017; Di Cintio and Grassi 2017; Kato and Ando 2017).

The following subsections carve out the major lines of argument within the identified research subfields.

### *3.2.1 International networks*

Theoretically, international mobility can be an effective strategy to establish contact to scientists working in other countries. It may

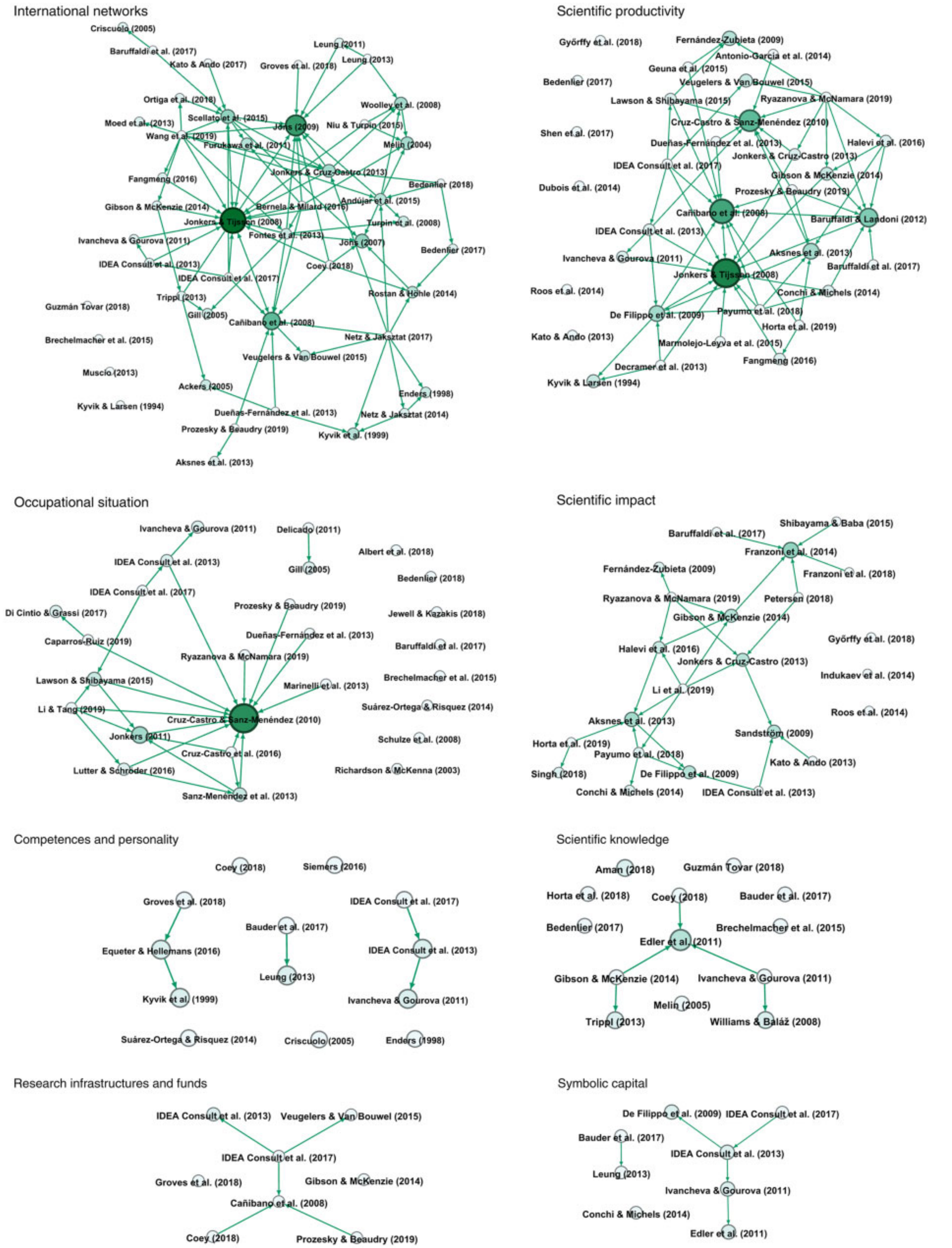


**Figure 4** Directed citation networks of studies examining effects of international mobility on scientists' careers, by career dimension.

*Notes:* The figure graphically illustrates the overall corpus of the reviewed empirical studies (full citations are provided in the References). Some studies appear in multiple citation networks. The networks were produced with Gephi 0.9.2 using the Force Atlas algorithm. An arrow (edge) indicates that a study (node) has cited another one. The larger and darker a node, the more frequently a study has been cited. The citation networks are supposed to indicate how large and established the research subfields are.

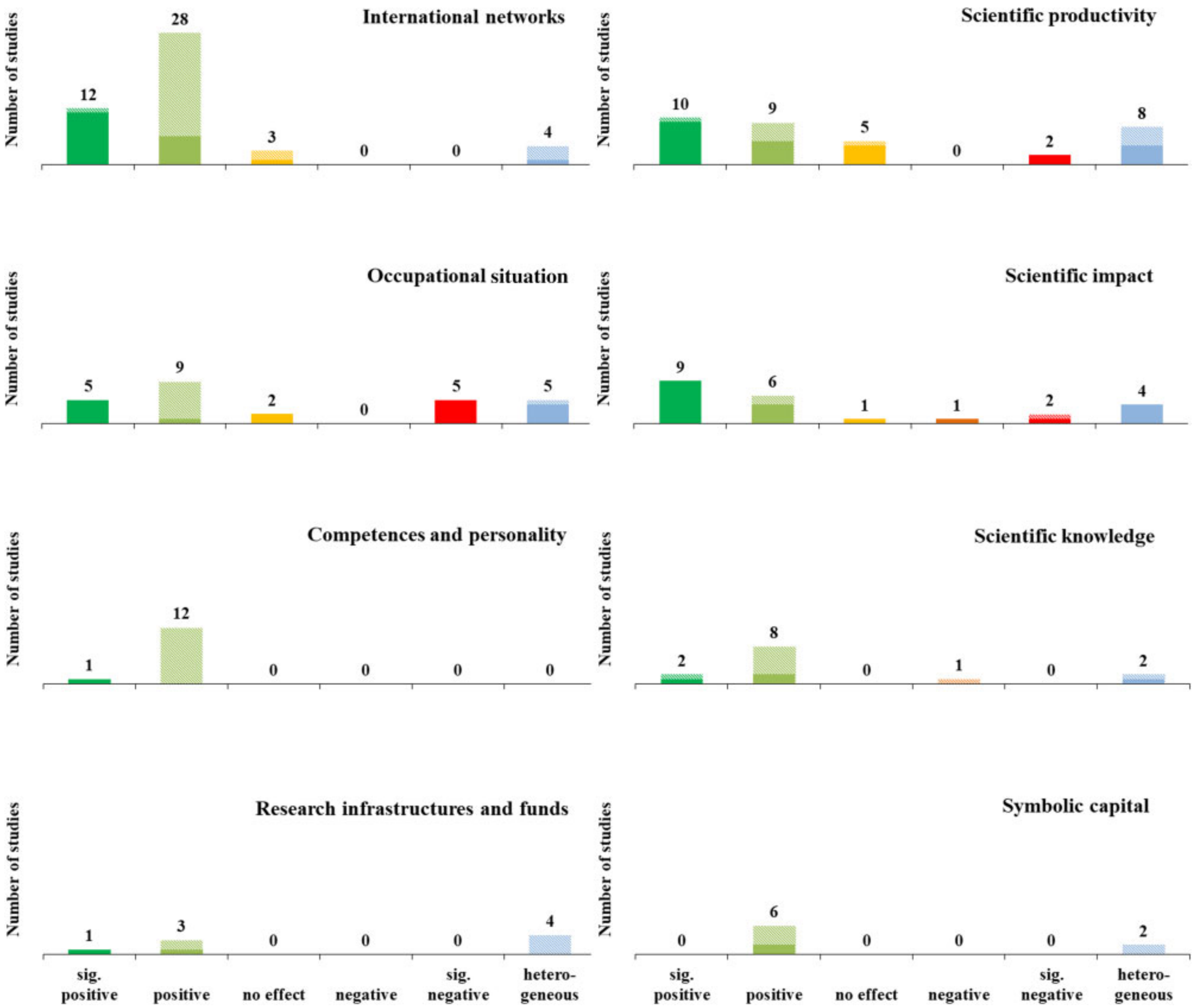


**Figure 5** Results of studies examining effects of international mobility on scientists' careers, by career dimension.

*Notes:* Solid bars indicate studies using controlled designs (i.e. studies including a non-mobile control group), while shaded bars indicate studies using uncontrolled designs. We differentiate studies finding significantly positive/negative effects and those reporting positive/negative effects without performing significance tests. The categories 'positive' and 'negative' also include studies performing significance tests but finding insignificantly positive/negative effects after controlling for confounders. The category 'no effect' comprises studies reporting coefficients that are (virtually) zero and those reporting scientists' self-assessment that international mobility does not have any (meaningful) effect. The category 'heterogeneous' comprises studies finding effects that differ either by dependent variables (e.g. publications versus patents as examples of scientific productivity) or by countries, career stage, or discipline (for details on these studies, see Table A2).

help scientists get in contact with particularly prolific and well-reputed scientists. Moreover, it can increase the size of their networks and grant them indirect access to colleagues of the scientists whom they met abroad (Jonkers and Cruz-Castro 2013). According to Granovetter (1973), such weak network ties can be particularly beneficial because they enable access to non-redundant information, which may, in turn, propel scientists' creativity and productivity.

Largely in line with theory, 40 of the 47 studies on international networks (85%) report positive effects of international mobility (Figure 5). This result is substantiated by both univariate and multivariate studies (Table A2).

Existing studies use different approaches to measure international networks: several studies ask scientists about their contact to scientists (Netz and Jaksztat 2017) or professionals (Veugelers and Van Bouwel 2015) working in other countries. Other studies examine co-authorship networks (e.g. Scellato, Franzoni and Stephan 2015; Fangmeng 2016; Baruffaldi, Marino and Visentin 2017) or the involvement in international research groups and projects (Cañibano, Otamendi and Andújar 2008; Dueñas-Fernández, Iglesias-Fernández and Llorente-Heras 2013). In all cases, there is robust evidence of positive effects of international mobility. However, this positive network effect seems to fade over time: as time to the stay abroad passes, scientists are increasingly less likely to co-publish with their former colleagues abroad (Jonkers and Cruz-Castro 2013). There are also studies not finding any effect on the likelihood of international collaboration (Trippl 2013) and the number of international co-authors (Bernela and Milard 2016). Additionally, some studies highlight the difficulty of maintaining home country linkages whilst abroad and of reintegrating into the domestic network upon return (e.g. Gill 2005; Leung 2013).

Overall, however, the observed effects tend to be positive for short and long stays of scientists in both the hard and soft sciences, who are employed in either Europe, the Americas, Oceania, or Asia.

The majority of studies make use of surveys, but interviews, bibliometric databases, and CV data are also employed. Most studies follow a quantitative approach. About one-third of all studies on international networks employ multivariate methods.

Existing studies strongly rely on subjective measures, which can be considered a general limitation. A stronger focus on objectively observed co-authorship, collaboration, or active and passive social media networks could advance research in the field. Overall, however, the state of research in the research subfield on international networks is reliable already, due to the large number of studies with sound methodological approaches.

### *3.2.2 Scientific productivity*

According to human capital theory, investments in skills raise individual productivity. Correspondingly, international mobility can be considered an investment in scientists' skills, or—following Bozeman, Dietz and Gaughan (2001)—in their scientific and technical human capital (STHC). These skills are, in turn, assumed to increase scientific productivity.

In line with theory, 19 out of 34 studies on scientific productivity (56%) report positive effects of international mobility (Figure 5). Contrary to the theoretical considerations, however, this research subfield is also characterized by several studies finding heterogeneous, no, or negative effects.

There is evidence that international mobility increases the—either absolute or fractional—number of publications (e.g. Cruz-Castro and Sanz-Menéndez 2010; Kato and Ando 2013; Dubois, Rochet and Schlenker 2014). Still, some studies do not find any effect (Cañibano, Otamendi and Andújar 2008; Jonkers and Cruz-Castro 2013; Conchi and Michels 2014; Roos et al. 2014; Baruffaldi, Marino and Visentin 2017). Two studies find significantly negative effects; however, these are limited by a small sample (Győrffy et al. 2018) or a short measurement period (Antonio-García, López-Navarro and Rey-Rocha 2014). The latter study and Halevi, Moed and Bar-Ilan (2016) point to the possibility of short-term decreases in productivity resulting from initial transaction costs in readjusting to the new working environment, which may in the long term be overcompensated by productivity increases unfolding due to better opportunity structures and recognition in the new working environment.

Two studies find positive effects on scientists' patent output (IDEA Consult et al. 2013), particularly among women (Dueñas-Fernández, Iglesias-Fernández and Llorente-Heras 2013). Mobility of European researchers to the USA seems to have a higher impact on patent output than intra-European mobility, even after controlling for observable selection through propensity score matching (Veugelers and Van Bouwel 2015).

The effect of international mobility on scientific productivity seems to depend on the type of mobility and the host contexts in which scientists sojourn. There is some evidence that short stays abroad are more beneficial than long stays (Decramer, Goeminne and Smolders 2013) and that stays at high-ranked institutions (Shen, Liu and Chen 2017) and in larger, research-intensive countries (Gibson and McKenzie 2014) are particularly productive. Moreover, international mobility seems to be most beneficial 2–7 years after completing the PhD (Ryazanova and McNamara 2019) or after scientists have obtained tenure, and not necessarily when an expiring contract forces them to become mobile (Geuna et al. 2015). Several studies find heterogeneous effects across scientific disciplines (Cañibano, Otamendi and Andújar 2008; Decramer, Goeminne and Smolders 2013; Marmolejo-Leyva, Perez-Angon and Russell 2015; Halevi, Moed and Bar-Ilan 2016; Bedenlier 2017; Horta, Jung and Santos 2019), albeit without a clear pattern becoming visible.

Most studies use either surveys or bibliometric data in combination with CV data. Qualitative interviews are conducted rarely in this research subfield. Most studies measure scientific productivity objectively, usually by the number of publications. A few studies measure scientific productivity subjectively, using measures such as self-perceived changes in publication output. The research subfield on scientific productivity comprises the largest number of multivariate studies (Table A2). Although results are not as straightforward as in the case of international networks, the state of research on scientific productivity is also well developed.

Various studies acknowledge the limitations of using cross-sectional data and a need to generate longitudinal and/or internationally comparative data. Relatedly, many studies can only insufficiently tackle bias resulting from the fact that those going abroad are not a random selection from the population of scientists regarding their productivity.

### *3.2.3 Occupational situation*

Through the mechanisms discussed in the other parts of Section 3.2, international mobility may eventually influence scientists' occupational situation. Job matching theory (e.g. Jovanovic 1979) provides a further theoretical explanation, particularly for career-related outcomes of longer stays abroad. From this perspective, international mobility is a means to move towards opportunity structures that better fit scientists' preferences, competences, personality, and research profile (specialty matching), allowing them to work more efficiently and thus to increase their scientific productivity and impact (e.g. Geuna 2015). International mobility could also simply function as a signal (Spence 1973) showing employers the commitment and competences needed for an academic career. Not least, it could be career-enhancing because some funding agencies require scientists to prove international experience to be eligible for financial support.

Fourteen out of 26 studies on scientists' occupational situation (54%) find positive effects of international mobility, but only few find significantly positive effects after controlling for confounders (Figure 5).

Most studies examine the job position: there is some evidence that international mobility reduces time to promotion (Jonkers 2011; Lawson and Shibayama 2015) and time to tenure (Schulze, Warning and Wiermann 2008), but there is also contrasting evidence (Cruz-Castro and Sanz-Menéndez 2010; Sanz-Menéndez, Cruz-Castro and Alva 2013; Ryazanova and McNamara 2019). Studies focusing on the very likelihood of holding a tenured position mostly report no effect (Schulze, Warning and Wiermann 2008; Baruffaldi, Marino and Visentin 2017) or negative effects (Marinelli, Elena-Pérez and Fernández-Zubieta 2013; Cruz-Castro, Jonkers and Sanz-Menéndez 2016). One study finds a slightly positive effect, which seems to be largely mediated by an increased publication output due to mobility (Lutter and Schröder 2016).

Two studies find robust evidence of positive monetary returns of international mobility (Di Cintio and Grassi 2017; Caparros-Ruiz 2019), while others suggest that monetary returns are very small and less substantial than effects on other career dimensions (Dueñas-Fernández, Iglesias-Fernández and Llorente-Heras 2013; IDEA Consult et al. 2013, 2017). Job satisfaction seems to decrease following international mobility among junior academics in Spain (Albert, Davia and Legazpe 2018), but to increase among European PhD candidates (Brechelmacher et al. 2015) and among (multiply) mobile European postdocs (Jewell and Kazakis 2018). Empirical evidence thus only partly supports the theoretical considerations. International mobility seems to positively influence scientists' careers only under specific circumstances.

Existing research has not yet systematically examined effect heterogeneity depending on the type of mobility and country of employment. However, Schulze, Warning and Wiermann (2008) point to differences by disciplines: looking at habilitated scientists, they find that research visits abroad shorten the duration to tenure relatively more in economics than in business administration.

Many studies make use of surveys to analyse the link between scientists' international mobility and their occupational situation. This research subfield is characterized by the highest proportion of multivariate studies (Table A2). Most studies use objective—but self-reported—measures, such as holding a tenured position. Overall, results on the impact of international mobility on scientists' occupational situation are comparatively robust.

However, many studies focus on careers until tenure, without considering further career developments. Thus, possible longer-term effects of international mobility on the occupational situation are not yet well examined.

### *3.2.4 Scientific impact*

International mobility may also influence scientists' impact, which the literature tends to capture by the number of citations and the rank of the journals in which scientists publish. Theoretically, an increased impact may result from the larger number of publications that internationally mobile scientists tend to have (see Section 3.2.2). Beyond this productivity effect, it could result from a network effect, as mobile scientists tend to have the opportunity to present their work to more colleagues than scientists working in one place for a long time (Jonkers and Cruz-Castro 2013).

Largely in line with theory, 15 out of 23 studies on scientific impact (65%) report positive effects of international mobility (Figure 5). This finding is corroborated by the large majority of multivariate studies, which stands in contrast to research on the scientific productivity and especially to research on the occupational situation.

There is evidence that international mobility has a positive effect on the number of citations (e.g. Conchi and Michels 2014; Franzoni, Scellato and Stephan 2014, 2018; Petersen 2018). Some studies also suggest that international mobility is associated with more publications in journals with a higher impact factor (Franzoni, Scellato and Stephan 2014; Baruffaldi, Marino and Visentin 2017)—or rather with a lower share of publications in low-impact journals (Shibayama and Baba 2015)—and with a higher individual h-index (Jonkers and Cruz-Castro 2013). One multivariate study finds that Chinese researchers who have spent at least one continuous year abroad experience a decrease in their research impact after return (Li, Ding and Shen 2019). Two descriptive studies find negative effects on the field-weighted citation impact (Payumo, Lan and Arasu 2018) and the likelihood of publishing in high-impact journals (Győrffy et al. 2018).

As with research on scientific productivity, there is evidence that stays in larger, research-intensive countries help scientists generate a higher h-index (Gibson and McKenzie 2014). Moreover, there is suggestive evidence that especially short stays boost the number of citations, while longer stays eventually 'turn into a very normal everyday life abroad' (Conchi and Michels 2014: 32). Some studies compare scientific disciplines (e.g. Halevi, Moed and Bar-Ilan 2016), but without indicating clear disciplinary patterns. One study suggests that researchers in STEM fields benefit more from international mobility than researchers in non-STEM fields (Horta, Jung and Santos 2019).

Many studies use bibliometric databases combined with survey or CV data to analyse the link between international mobility and scientific impact. More than half of the studies on scientific impact employ multivariate methods (Table A2). With the exception of IDEA Consult et al. (2013), all studies use objective outcome measures. Overall, the state of research on the effect of international mobility on scientific impact is comparatively reliable.

Still, the robustness of current results hinges on the coverage of the employed bibliometric databases, which do not capture publications exhaustively in some disciplines. Besides such potential sources of sample selection bias, scientists' selection into international mobility (treatment selection bias) could be addressed more thoroughly. Future research could also examine whether international mobility leads to more citations from authors publishing in high-impact journals and from a wider scope of countries.

### *3.2.5 Competences and personality*

Theoretically, international mobility can improve scientists' foreign language skills and other intercultural competences; by enabling access to knowledge centres abroad, it can also help scientists develop specific technical and methodological skills, which might not be easily acquirable at the current institution (IDEA Consult et al. 2013). A younger line of research—which focuses primarily on university students and only marginally on scientists so far—suggests that international mobility may also positively influence personality development, e.g. by increasing openness and agreeableness and by decreasing neuroticism (Zimmermann and Neyer 2013).

In line with these theoretical considerations, all 13 studies on competences and personality development (100%) find positive effects of international mobility (Figure 5). However, only one of these studies uses multivariate methods (Table A2).

There is descriptive evidence that international mobility increases scientists' foreign language competences (Enders 1998; Kyvik et al. 1999; Ivancheva and Gourova 2011; Leung 2013), technical and methodological skills (IDEA Consult et al. 2013; Bauder, Hannan and Lujan 2017; Coey 2018), as well as problem-solving, organizational, and reflection skills (Siemers 2016). However, interviewed scientists also mention difficulties in using their acquired skills and in working with never-mobile colleagues upon return (Groves, López and Carvalho 2018). Several studies detect personality developments such as increased seriousness and reliability (Leung 2013), open-mindedness (Suárez-Ortega and Risquez 2014), self-confidence (Kyvik et al. 1999), as well as work engagement and well-being (Equeter and Hellemans 2016). Moreover, there is evidence of scientists improving their ability to work in foreign science systems (Enders 1998; Criscuolo 2005; Coey 2018) and in intercultural teams (Siemers 2016).

Existing studies do not systematically examine competences and personality effects contingent on the type of mobility, discipline, or country of employment.

They all employ qualitative interviews or surveys and use subjective and self-reported measures. With the exception of Equeter and Hellemans (2016), who employ regression techniques, the research subfield on competences and personality is characterized by descriptive studies. Empirical evidence is thus not yet as reliable as evidence on the previously discussed career dimensions.

Hence, research on the effects of international mobility on competences and personality could be advanced through studies using better data and more advanced statistical methods. An apparent shortcoming is the frequent lack of control groups of non-mobile scientists. To study personality development, it would also be reasonable to use established psychological constructs and tested instruments.

#### *3.2.6 Scientific knowledge*

According to knowledge recombination theory, knowledge from distant places can be more innovative for scientists than their respective local knowledge (Fleming 2001). Moreover, knowledge is sometimes distance sensitive. The transfer of tacit knowledge, in particular, usually requires individuals to interact personally. Therefore, international mobility can have a brokering function and help scientists access, diversify, create, and transfer knowledge (Williams and Baláž 2008; Franzoni, Scellato and Stephan 2018).

In line with these thoughts, 10 out of 13 studies on scientific knowledge (77%) report positive effects of international mobility (Figure 5).

International mobility seems to broaden scientists' knowledge base (Williams and Baláž 2008; Aman 2018; Coey 2018) and to ease knowledge transfer to colleagues working in both academic and corporate environments (Edler, Fier and Grimpe 2011; Trippl 2013; Gibson and McKenzie 2014; Bauder, Hannan and Lujan 2017). However, two studies caution that knowledge acquired abroad is often not easily applicable after scientists have returned to their home institution (Melin 2005; Brechelmacher et al. 2015).

There is suggestive evidence that research stays abroad of more than a year are more likely to result in knowledge transfer to firms than short-term stays (Edler, Fier and Grimpe 2011). Although some studies examine scientists from different disciplines and countries of employment, no study reports heterogeneous effects in these respects.

Most studies use qualitative interviews or surveys and employ subjective measures derived from self-reported data. Exceptions are Aman (2018), who operationalizes scientists' knowledge base using bibliometric information on references and abstract terms identified through text mining, Horta, Jung and Santos (2018), who measure the multidisciplinarity of knowledge by examining the number of fields in which scientists published, and Gibson and McKenzie (2014), who use the number of conferences and seminars attended abroad as a rough proxy for knowledge transfer. The number of multivariate studies is low in the research subfield on scientific knowledge (Table A2).

In summary, the acquisition of scientific knowledge has not yet been studied comprehensively enough. Ways forward could be further attempts to capture knowledge acquisition and transfer objectively, which would also enable the application of more robust quantitative research designs.

#### *3.2.7 Research infrastructures and funds*

Theoretically, international mobility can not only favour the creation of new knowledge, but—in the first place—also ease access to research infrastructures and funds. This may create the grounds for knowledge production and, thereby, eventually lead to increased scientific productivity and impact. For scientists with a particular thematic or geographic focus and those working in technology-intensive branches, international mobility can also be a necessity rather than a choice (Ackers 2005).

However, empirical evidence on the link between international mobility and access to research infrastructures and funds does not show a clear picture. While four out of eight studies (50 percent) report positive effects, four others report heterogeneous effects (Figure 5).

Some studies suggest a positive connection between international mobility and access to research infrastructures (Coey 2018; Groves, López and Carvalho 2018). While scientists think that they benefit from access to specific research infrastructures whilst abroad, they also mention difficulties in continuing their work upon return due to a lack of similar research equipment at their home institution (Groves, López and Carvalho 2018). Furthermore, there is evidence that international mobility is slightly positively associated with scientists' ability to acquire research funds (Gibson and McKenzie 2014; IDEA Consult et al. 2017; Prozesky and Beaudry 2019). While Cañibano, Otamendi and Andújar (2008) suggest that it eases access particularly to international research grants—albeit not in all disciplines—IDEA Consult et al. (2013) suggest that access is primarily eased to national research funding. For both research infrastructures (Veugelers and Van Bouwel 2015) and research funds (IDEA Consult et al. 2017), the self-assessed effect of international mobility seems to be higher for European scientists mobile to the USA than for European scientists mobile within Europe.

The reviewed studies use surveys or qualitative interviews. They employ objective measures such as the level of funds or subjective measures such as the self-assessed ability to obtain funding. The small number of multivariate studies and their heterogeneous results (Table A2) do not yet permit solid conclusions on how international mobility influences access to research infrastructures and funds.

#### *3.2.8 Symbolic capital*

Several authors consider international mobility a strategy to gain symbolic capital. However, there is no common understanding of this notion in the literature on scientists' international mobility. While some authors (e.g. Bauder, Hannan and Lujan 2017) draw on Bourdieu's (1986) theory of capital, others (e.g. Fernández-Zubieta 2009) refer to the work of Merton (1968) and Long (1978) on how institutional prestige affects scientists' careers. Symbolic capital is often used as an umbrella term capturing various possible mechanisms through which international mobility could influence scientists' career development—including increases in their networks, material resources, and scientific productivity. Personally, we see greater analytical potential in considering these mechanisms separately and in understanding symbolic capital as a signalling effect (Spence 1973), either of having become physically mobile or of having stayed at a prestigious institution or department, which could exert an effect on career development beyond the already substantiated mechanisms.

Although several authors use the notion of symbolic capital, few examine the link between international mobility and symbolic capital empirically. Among the empirical studies, six out of eight studies (75%) report positive effects and the remaining two report heterogeneous effects (Figure 5). Thus, empirical evidence supports the theoretical considerations to a large extent.

There is suggestive evidence that international mobility is associated with greater attractiveness as a collaboration partner in scientific projects (De Filippo, Casado and Gómez 2009; Edler, Fier and Grimpe 2011) and with a higher self-assessed competitiveness in the academic labour market (Bauder, Hannan and Lujan 2017). Some studies examine scientists' self-assessed recognition or reputation in the research community; they either find no clear tendency (IDEA Consult et al. 2013) or slightly positive effects (Leung 2013; IDEA Consult et al. 2017). According to IDEA Consult et al. (2017), European scientists mobile to the USA are more likely to indicate positive effects on their recognition than those mobile within Europe. One study suggests that researchers from less research-intensive countries tend to be more pessimistic about possibilities to increase their recognition in their home country through a stay abroad than researchers from research-intensive countries (Ivancheva and Gourova 2011).

Most reviewed studies use surveys or qualitative interviews. They tend to focus on other career dimensions and examine symbolic capital only marginally. Partly therefore, existing evidence is not very robust. As symbolic capital cannot be easily expressed quantitatively, all existing studies use subjective and self-reported measures. None of the reviewed studies uses multivariate methods.

Thus, we still see great potential to advance research in this research subfield, inter alia by using operationalizations of symbolic capital that are objectively reproducible. To this end, future research could better account for the appraisal of international mobility through gatekeepers who take decisions about scientists' career progression. In this respect, in particular, experimental designs could constitute fruitful ways forward (Gerhards, Hans and Drewski 2018).

## 4 Conclusions

### 4.1 Main findings

We systematically reviewed 96 studies that empirically examine the effects that international mobility may have on scientists' careers. We found that these studies mostly focus on longer-term stays abroad. They mainly examine publishing research scientists who are employed at academic institutions in Europe. Most reviewed studies were published in scientific journals and during the past decade. This shows that the analysed research field is young and recently very dynamic.

The research subfields on the eight identified career dimensions are in diverse states of development: The subfields examining effects of international mobility on scientists' international networks (47 studies) and scientific productivity (34) stand out regarding the number of existing studies and the extent to which these studies cite each other. Studies on scientific impact (23) also constitute a comparatively well-integrated, yet much smaller research subfield. Although similar in numbers (26), studies on scientists' occupational situation form a relatively fragmented research subfield. The research subfields on scientists' competences and personality (13), scientific knowledge (13), access to research infrastructures and funds (8), and symbolic capital (8) are least established so far.

Comparatively robust evidence shows that international mobility—rather independently of its type—helps scientists manifold their ties to co-authors and project collaborators abroad. Scientists tend to continue working with colleagues they have met in different places, which grants them access to larger scientific networks. However, this generally positive effect seems to vanish over time unless scientists continue to be internationally mobile. Some studies highlight the difficulty of maintaining home country linkages whilst abroad and of reconnecting to the domestic network upon return.

Fewer, but similarly robust studies find that international mobility can increase scientists' productivity, that is, the number of their publications and patents. Effects seem to vary across scientific disciplines, but without a clear pattern becoming visible yet. Productivity increases seem to manifest primarily if scientists move towards higher-rank institutions. Unlike with international networks, there are also studies suggesting that international mobility can negatively influence scientific productivity, especially immediately after the move, when scientists first need to readjust to their new working environments.

A similar share, but a smaller absolute number of studies than in the case of scientific productivity suggests that international mobility positively affects the occupational situation. However, only a few studies confirm this result after controlling for confounders. Broadly in line with job matching theory, there is evidence that international mobility is an effective strategy to quickly move to higher-status and better-paid positions. This effect seems to be at least partially mediated by the publication output increasing due to mobility. Simultaneously, however, internationally mobile scientists seem to be less likely to obtain a permanent position in the short to medium term. Finally, there is initial evidence that international mobility can—while sometimes stressful to prepare and execute—eventually lead to higher job satisfaction.

As with international networks and scientific productivity, comparatively many studies—mostly using bibliometric data—find significantly positive effects of international mobility on the scientific impact. Scientists with experience abroad tend to achieve a higher impact because they publish in higher-ranked journals and are cited more frequently. However, this positive effect can decline over time and it vanishes among scientists who stay abroad permanently.

A smaller and largely descriptive body of studies suggests that international mobility helps scientists improve their language, technical, and methodological skills, orientation in foreign science systems, and ability to work in diverse teams. Some studies also suggest that international mobility comes along with increased work engagement, well-being, and personality maturation. However, compared to the previously discussed research subfields, existing evidence is less robust overall.

A similarly small and descriptive body of studies suggests that (particularly longer) stays abroad help scientists acquire new scientific knowledge and contribute to knowledge and technology transfer. In this respect, however, there are also accounts of scientists reporting difficulties in applying the knowledge acquired abroad upon return.

A few studies suggest that international mobility eases access to research infrastructures and funds. Concerning research infrastructures, the advantage mainly takes effect during the time abroad. Internationally experienced scientists are more likely to receive funding both whilst abroad and upon return, suggesting that many funding agencies consider international mobility an experience signalling fitness for an academic career.

First studies examining symbolic capital corroborate this view. They mostly suggest that international mobility has positive effects. However, the signalling value of international mobility seems to hinge on various factors, such as the host institution attended and the later country of employment. There is suggestive evidence that international mobility has a lower symbolic value for scientists working in less research-intensive countries.

In summary, most empirical studies come to the conclusion that international mobility positively influences scientists' careers. However, it can require additional effort and introduce instability into scientists' careers, meaning that scientists need to carefully consider the objectives, circumstances, and risks of their international mobility before going abroad.

## 4.2 Directions for future research

Besides the many substantive results, our review has also revealed several limitations and follow-up questions, which highlight ways forward for research.

### *4.2.1 Transparency and standardization*

To begin with, the research field would benefit from more transparency. We found various studies not (precisely) defining the examined target group, treatment, or outcome. Moreover, information on sampling strategies, data collection and processing, and representativeness was sometimes incomplete or missing. This complicated the assessment of the state of research.

Furthermore, the degree of standardization in the research field is still rather low. Attempts have been made to put forth, for instance, definitions and typologies of scientists and typical career stages in academia (e.g. IDEA Consult et al. 2013, and Figure A1) as well as mobility (e.g. Rostan and Höhle 2014; Fernández-Zubieta, Geuna and Lawson 2015; Robinson-Garcia et al. 2019; and Figure A2), but these have not yet led to a common understanding and use of the relevant concepts. Rather, the state of research is currently characterized by the parallel use of various tailor-made operationalizations. This current lack of standardization hampers comparisons and generalizations across studies, and particularly systematic meta-analyses. Future research would thus benefit from further attempts to develop and/or disseminate definitions of scientists, international mobility, and typical career stages in academia that are meaningful and operationalizable in as many countries as possible.

### *4.2.2 Data and methods*

Research would also benefit from better data. We found surprisingly many studies examining only internationally mobile scientists. We therefore recommend a more frequent use of controlled designs. Defining control groups without running the risk of introducing sample selection bias is certainly difficult when studying hypermobile target groups such as scientists. Therefore, further attempts to minimize selection bias through sophisticated sampling strategies are required. Moreover, further attempts to increase the coverage and thus external validity of bibliometric databases and survey samples are needed. The latter concern has, in part, already been addressed through large-scale data collection exercises such as the MORE studies, Careers of Doctorate Holders (CDH), The Changing Academic Profession (CAP), and GlobSci, which provide reference points for further data collection in the field.

For the advancement of research, it is important that future large-scale data collection initiatives will simultaneously include accurate measures of international mobility, the discussed career outcomes, and further possible mediating mechanisms (see Sections 4.2.3 and 4.2.4 for suggestions of constructs to consider in further research). This is an important precondition for analysing not only whether, but also why international mobility may causally influence scientists' careers.

Many reviewed studies rely exclusively on subjective self-assessments. Where reasonable, it would thus be helpful to additionally examine objective observations of the same outcomes. Moreover, further samples enabling comparisons across countries,[3] within groups of scientists (e.g. by their gender, social background, discipline, or employment sector), and by the type of international mobility are needed to thoroughly analyse heterogeneity in the effects of international mobility (for details, see Section 4.2.4).

The combination of different data sources is often considered a solution to the sketched data limitations (e.g. Cañibano, Otamendi and Andújar 2008; Sandström 2009; Moed and Halevi 2014). Combined data from bibliometric databases, publicly available CVs, and possibly also large-scale surveys of scientists would provide not only various objectively observed indicators of scientists' network embeddedness, productivity, and impact, but also of their socio-demographic characteristics, personality, motivation, self-assessed competences, and private and professional life courses. Importantly, this approach would capitalize on the strengths of bibliometric research in providing objective measures of productivity and impact, while at the same time overcoming the limitation that purely bibliometric studies can only imprecisely operationalize international mobility based on changes of the affiliations indicated in authors' publications. However, producing multi-source datasets is not only labour-intensive, but in some countries also impeded by data protection regulations. The coming years will show whether scholars can conform to these regulations by obtaining informed consents directly from the examined scientists, which is possible in surveys, and where legal amendments by policymakers will be needed.

Finally, several authors have stressed that advancing research on causal career effects of international mobility will require panel data, which are currently scarce. Once more comprehensive panel data will become available, the research field can also be advanced methodologically by more frequent applications of sophisticated techniques for longitudinal data analysis. This would ease not only the separation of selection and causal effects but also the examination of how career effects of international mobility develop over scientists' life courses. However, our review suggests that even using the existing datasets, there are still ample opportunities to apply methods enabling a better approximation of causal effects of international mobility. This would also be supported by more nuanced specifications of the theoretical models underpinning the empirical analyses.

### *4.2.3 Integration of research on different career dimensions*

Sections 3.2.1 to 3.2.8 have shown that the examined career dimensions are interrelated. While implicit in vague concepts such as STHC, this idea is currently only rarely substantiated explicitly in order to describe interrelations between several dimensions. Taken together, however, the recapitulated studies suggest that the ways in which international mobility may influence scientists' careers are more complex than usually assumed—or at least than usually specified in empirical models. Major theoretically plausible paths that we derived from the literature and own reasoning are summarized in our model of career effects of international academic mobility (Figure 6).

To give an example, the model suggests that international mobility may help scientists broaden their international networks, which could grant them access to new knowledge that eventually flows into publications increasing their scientific impact; in turn, this

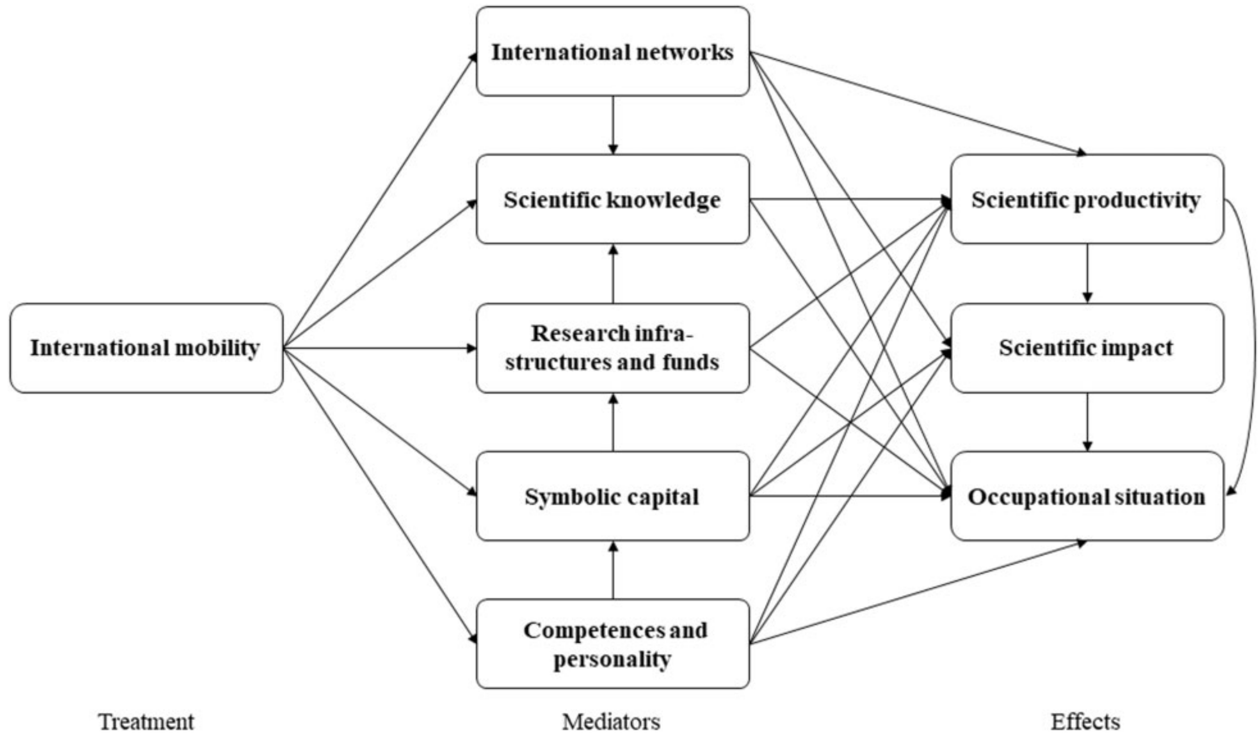


**Figure 6** A model of career effects of international academic mobility.

could improve their occupational situation. International mobility could also simply help scientists acquire symbolic capital; the mere fact of having been abroad could function as a signal improving their occupational situation. As a counterexample, international mobility could also negatively affect career progression: For instance, prolonged stays abroad could result in detachment from the former network, without necessarily leading to the establishment of a network at the new workplace. Cut off from career-relevant insider knowledge, scientists could in this case face difficulty in reaching attractive occupational positions.

Figure 6 reflects our impression that the examined dimensions have a different weight in the literature on scientific careers: the occupational situation is usually considered an ultimate outcome. For scientists, however, scientific productivity and impact may assume a similarly relevant role even independently of the occupational situation. The remaining five identified career dimensions can rather be considered important mediators of career development.

We are aware of possible bidirectional causalities that we have not specified. For instance, acquiring funds from prestigious sources could also increase symbolic capital, and a high occupational position may raise the scientific productivity and impact by increasing visibility and access to human resources. However, such effects are arguably more likely to manifest in the longer term. Also, we preferred a model in the form of a directed acyclic graph (DAG), which is at least theoretically testable through causal inference. Clearly, this complex model is difficult to test on the whole. We still hope that it promotes further theoretical reasoning and empirical specifications testing not only if, but also why international mobility causally influences scientists' careers.

*4.2.4 Further research questions*

There are questions for further research going beyond those implicit in Figure 6 and those already sketched for the individual career dimensions in Section 3.2.

First, various studies suggest to better examine heterogeneous career effects of international academic mobility. This comprises analyses of how effects vary depending on scientists' socio-demographic characteristics (Jewell and Kazakis 2018), discipline (Halevi, Moed and Bar-Ilan 2016), and opportunity structures at their employing institutions (Equeter and Hellemans 2016). Moreover, further analyses of how career effects of international mobility vary depending on scientists' country of employment are needed. Factors explaining the observed cross-country variations could be the scarcity value of mobility experience (Payumo, Lan and Arasu 2018), the institutional logics governing career trajectories in different academic systems (Geuna 2015), and the overall scientific capacity and centrality or periphery of countries in the science system (Ivancheva and Gourova 2011; Gibson and McKenzie 2014). Furthermore, many authors recommend further analyses differentiating by types of international mobility, that is, by the motivation for mobility, its duration, and frequency (Siemers 2016), the host country (Horta, Jung and Santos 2018), and its timing in scientists' careers (Marinelli, Elena-Pérez and Fernández-Zubieta 2013). Effects may not only vary by career stages (Jonkers and Cruz-Castro 2013; Rostan and Höhle 2014), but also increase or decrease in magnitude throughout scientists' careers (Cruz-Castro and Sanz-Menéndez 2010). It is also relevant to examine whether, for instance, repeated short-term stays yield different effects than a single long-term stay (Criscuolo 2005). Although challenging to analyse in practice, we also suggest examining whether virtual international mobility can nowadays substitute specific forms of physical international mobility. Combining the previous thoughts would be promising as well: does the potential to replace physical by virtual mobility change as scientists' careers unfold? Is a basic physical experience abroad needed at the beginning of the career to capitalize on virtual international mobility during the later career?

Second, future research could study further dependent variables. For instance, it could better examine how international mobility influences the development of scientists' cognitive career (Laudel and Gläser 2008), that is, their research trail in terms of scientific content. Does international mobility increase or decrease scientists' autonomy in developing and implementing their own research agendas? By connecting to the literature on academic entrepreneurship (Krabel, Siegel and Slavtchev 2012), it could also be studied whether the knowledge, skills, and networks developed abroad actually help scientists start their own businesses, and how this may influence their careers. This would also direct more attention to possible effects of international mobility on scientific careers outside academia, which are so far understudied due to the data-driven focus on publishing scientists.

Third, some authors suggest to analyse how specific national mobility policies (e.g. Fernández-Zubieta, Geuna and Lawson 2015) or mobility programmes (e.g. Győrffy et al. 2018) affect scientists' careers, as this may help further explain why effects of international mobility on scientists' careers sometimes differ across countries. It also matters how scientists' personal characteristics moderate the effects of policy measures (Fontes, Videira and Calapez 2013).

### 4.3 Policy implications

The fact that most studies suggest that international mobility benefits scientists' careers can justify the costly funding schemes that many governments have set up to promote cross-border academic mobility. This holds especially as positive effects were found not only for career dimensions primarily benefitting mobile scientists, e.g. the occupational situation, but also concerning dimensions such as scientific productivity and knowledge transfer, which may benefit society at large.

The review has also revealed that international mobility—although often associated with more rapid promotions to higher-status positions—may come along with career instability. Restrictions in social security claims, a gradual detachment from the domestic scientific network, and a partial incompatibility of knowledge acquired abroad in the home country are examples of risks that international mobility can introduce into scientists' careers. If scientists' international mobility continues to be considered beneficial for society, a task for policymakers will be to further reduce career instability linked to moving across borders. Easing the transferability of social security claims and introducing more comprehensive tenure track programmes could further increase the predictability of scientists' careers under conditions of international mobility, and thus favour career decisions leading to symbiotic job matches instead of dead ends.

Finally, the review has highlighted a need to further invest resources in the generation of high-quality data enabling meaningful and robust analyses of the effects of international academic mobility. High up on authors' wish lists are longitudinal and internationally comparative data collected through designs that permit generalizable assertions, not only for scientists on the whole, but also depending on the discussed variety of scientists' personal and professional characteristics. Generating such data will hardly be possible without a clear commitment of policymakers. Such commitment should not only comprise the provision of funds over longer periods of time, but also the removal of dubiety regarding how to perform innovative analyses—e.g. using combinations of bibliometric, CV, and survey data—within the realms of current data protection laws. Anyhow, we expect the research field examining how international mobility influences scientists' careers to remain highly vivid.

## Notes

1. For a first policy-oriented overview of the literature on the international mobility of researchers in the UK setting, see Guthrie et al. (2017).
2. In some research subfields, early studies are identifiable that have apparently contributed to starting specific lines of inquiry (e.g. Jonkers and Tijssen 2008, in the research subfields on international networks and scientific productivity and Cruz-Castro and Sanz-Menéndez 2010, in the research subfield on the occupational situation).
3. Ideally, information on scientists' countries of prior and current employment and on the country of their stay abroad would be needed.

## Acknowledgements

We thank Luisa Klee, Jalaluddin Schekeb, Hendrik Schirmer, Julia Stadermann, and especially Torben Rauhut for their valuable support in searching and analysing the reviewed literature. We appreciate that we could use data from the DZHW Competence Centre for Bibliometrics [01PQ17001].

## Funding

This work was supported by the German Federal Ministry of Education and Research [01PQ16002].

*Conflict of interest statement*. None declared.

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## Appendix

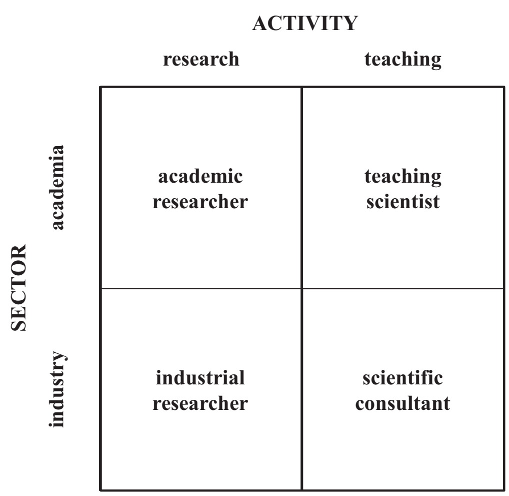


**Figure A1** Types of scientists.

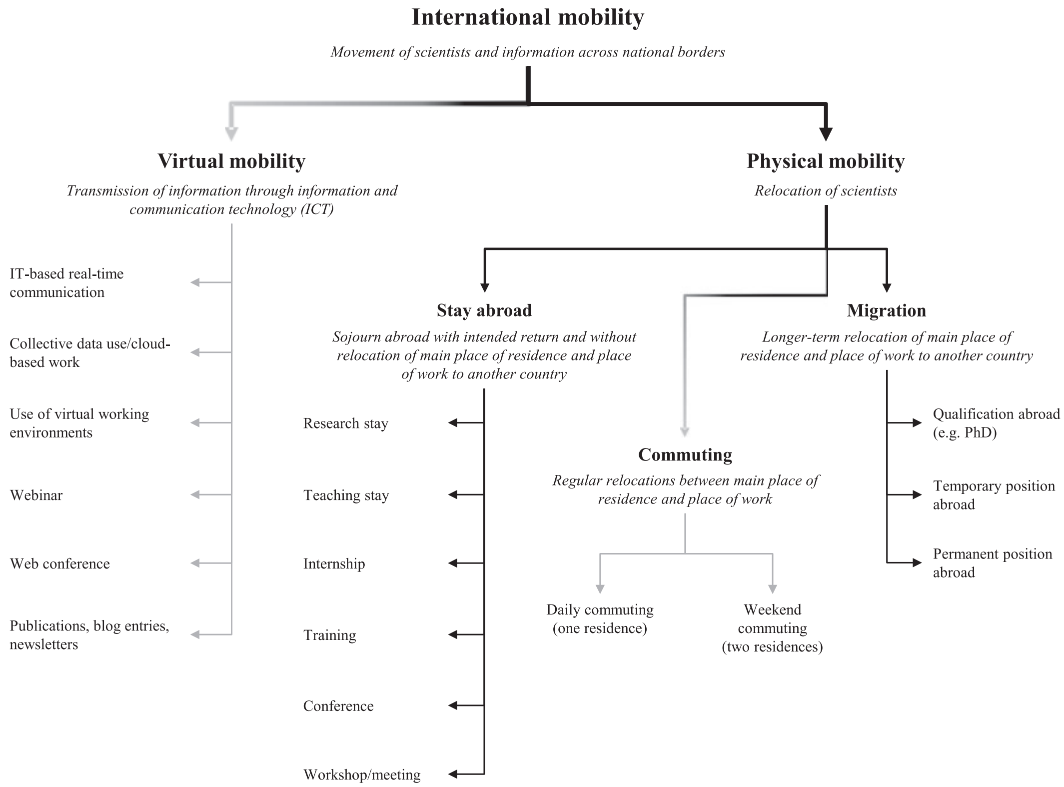


**Figure A2** Types of international academic mobility.

*Source:* Translated from Netz and Schirmer (2017: 7).

**Table A1** Search strings for database search.

| Group of interest | Treatment | Research focus |
|---|---|---|
| Academic | Academic inbreeding | Brain circulation |
| Researcher | Academic migration | Brain drain |
| Scientific workforce | Academic mobility | Brain gain |
| Scientist | Diaspora | Career |
| | Foreign-born scientist | Effect |
| | Geographic mobility | Impact |
| | International migration | |
| | International mobility | |
| | Migrant scientist | |
| | Mobile academic | |
| | Mobile researcher | |
| | Mobile scientist | |
| | PhD abroad | |
| | Postdoc abroad | |
| | Research stay | |
| | Researcher migration | |
| | Researcher mobility | |
| | Researchers' mobility | |
| | Scientific migration | |
| | Scientific mobility | |
| | Scientist mobility | |
| | Stay abroad | |

*Notes:* We searched the Scopus database using 528 combinations of synonyms for our group of interest, treatment, and research focus. Structure of the search query: (TITLE-ABS-KEY('synonym for group of interest' 'synonym for treatment' 'synonym for research focus') OR TITLE-ABS-KEY('synonym for group of interest' 'synonym for treatment' 'synonym for research focus') OR . . .). The full search query is available upon request.

**Table A2** Multivariate studies examining effects of international mobility on scientists' careers, by career dimension

| Authors | Types of mobility | Country of current employment | Country of stay | Sample | Outcome measure | Method | Effect |
|---|---|---|---|---|---|---|---|
| **International networks** | | | | | | | |
| Baruffaldi, Marino and Visentin (2017) | Long stays abroad (Advanced Postdoc Mobility Fellowship) | CH | Worldwide | Bibliometric, CV, and application data, 950 cases (controlled design) | Number of new research collaborations (obj. observation) | Regression discontinuity design | Significantly positive |
| Cañibano, Otamendi and Andújar (2008) | Short stays abroad (< 1 month vs. 1+ months), no separation between national and international mobility | ES/worldwide | Worldwide | CV data, 266 cases | Involvement in international research projects (obj. observation) | OLS regression, probit model, structural equation model | Significantly positive |
| Dueñas-Fernández, Iglesias-Fernández and Llorente-Heras (2013) | Other (1+ months) | ES | Worldwide | Survey data (no info on survey method and sample size; controlled design) | Collaboration with international research groups (obj. self-report) | Factor analysis, logistic regression | Significantly positive |
| Fangmeng (2016) | PhD abroad, other (duration of stay abroad) | CN | AU, CA, CN, HK, NZ, SG, US, UK | Bibliometric, CV, and survey data (CAWI), 451 cases | Likelihood of international collaboration (obj. observation) | Logistic regression | Heterogeneous: significantly negative (PhD abroad) and significantly positive (duration of stay abroad) |
| Fontes, Videira and Calapez (2013) | Long stays abroad (1+ years), PhD abroad, currently working abroad | PT | Worldwide/PT | Survey data (CAWI), 353 cases (controlled design) | (At least) one foreign organization in scientists' core networks (subj. self-report) | Logistic regression | Significantly positive |
| Gibson and McKenzie (2014) | Other (returnees, current migrants, never-migrants) | NZ, PG, TO/ worldwide | Worldwide | Survey data (no info on survey method), 800 cases (controlled design) | Number of international co-authors (obj. self-report) | OLS and median regression | Significantly positive (for returnees) |
| Jonkers and Cruz-Castro (2013) | Long stays abroad (1+ years) | AR | Worldwide | Survey data (CAPI), 124 cases (controlled design) | Number of international co-publications (obj. self-report) | Negative binomial panel regression | Significantly positive |
| Kato and Ando (2017) | Other (affiliation) | Worldwide | Worldwide | Bibliometric data, 20,160 cases (controlled design) | Amount of bilateral co-authorships (macro level, obj. observation) | Negative binomial regression, Poisson regression, instrumental variable regression | Significantly positive |

(continued)

**Table A2** Continued

| Authors | Types of mobility | Country of current employment | Country of stay | Sample | Outcome measure | Method | Effect |
|---|---|---|---|---|---|---|---|
| Muscio (2013) | Long stays abroad (3+ months) | IT | Worldwide | Survey data (CAWI), 197 cases (controlled design) | Engagement of universities in distant collaborations (obj. self-report) | Negative binomial regression, ordered probit regression | Significantly positive |
| Netz and Jaksztat (2017) | Other (non-touristic stay abroad during PhD or postdoc) | DE | Worldwide | Survey data (CAWI), 3,850 cases (controlled design) | Strength of embeddedness in personal international networks (subj. self-report) | Structural equation model | Significantly positive |
| Rostan and Höhle (2014) | Long stays abroad (<2 years vs. 2+ years) | 19 countries worldwide | Worldwide | Survey data (P&P + CAWI), 25,938 cases (controlled design) | Collaboration with international colleagues in research efforts | Logistic regression | Significantly positive |
| Scellato, Franzoni and Stephan (2015) | Other (affiliation) | 16 countries worldwide | Worldwide | Survey data (CAWI), 15,109 cases (controlled design) | Collaboration with individuals outside the current country of work or study (obj. self-report) | Ordered probit model, instrumental variable regression | Significantly positive |
| Trippl (2013) | Other (expatriates, returnees, non-movers) | Worldwide | Worldwide | Survey data (CAWI), 720 cases (controlled design) | Engagement in international academic collaboration (obj. self-report) | Logistic regression | No significant effect |
| Veugelers and Van Bouwel (2015) | Long stays abroad (3+ months) | European countries, USA | European countries, USA | Survey data (CAWI), 998 cases | Access to an international network of professionals (subj. self-report) | Probit regression, propensity score matching | Heterogeneous: more positive effect of mobility to U.S. than of mobility within EU (mostly explained by selection) |
| Wang et al. (2019) | Long stays abroad (no further info) | SG | Worldwide, SG | Bibliometric, CV, and survey data (CAWI), 378 cases | Number of collaborators in the current country/from previous countries (obj. observation) | Fixed effects model, random effects model | No significant (positive) effect |
| **Scientific productivity** | | | | | | | |
| Aksnes et al. (2013) | Long stays abroad (6+ months) | NO | Worldwide | Bibliometric data, 11,465 cases (additional study on 324 scientists who have worked abroad; controlled design) | Number of publications (obj. observation) | OLS regression, analysis of frequency distributions | No significant (positive) effect |
| Antonio-García, López-Navarro and Rey-Rocha (2014) | Other (academic stays abroad, predoctoral or postdoctoral) | ES | Worldwide | Survey data (CAWI), 175 cases (controlled design) | Number of papers in journals (obj. self-report) | One-way between-subject analysis of variance | Significantly negative |

(continued)

**Table A2** Continued

| Authors | Types of mobility | Country of current employment | Country of stay | Sample | Outcome measure | Method | Effect |
|---|---|---|---|---|---|---|---|
| Baruffaldi and Landoni (2012) | Currently working abroad | IT, PT | IT, PT | Survey data (no info on survey method), 497 cases | Number of papers (obj. self-report) | Probit regression, negative binomial regression | Significantly positive effect of home country linkages |
| Baruffaldi, Marino and Visentin (2017) | Long stays abroad (Advanced Postdoc Mobility Fellowship) | CH | Worldwide | Bibliometric, CV, and application data, 950 cases (controlled design) | Number of publications (obj. observation) | Regression discontinuity design | No significant effect |
| Cañibano, Otamendi and Andújar (2008) | Short stays abroad (< 1 month vs. 1+ months), no separation between national and international mobility | ES/worldwide | Worldwide | CV data, 266 cases | Number of different kinds of publications (obj. observation) | OLS regression, probit model, structural equation model | Heterogeneous: no significant effect, except for molecular biologists (significantly negative) |
| Conchi and Michels (2014) | Long stays abroad (6+ months) | AT, DE, FR, UK | Worldwide | Bibliometric and survey data (CAWI), 1,531 cases (controlled design) | Number of publications (obj. observation) | Negative binomial regression, network analysis | No significant effect |
| Cruz-Castro and Sanz-Menéndez (2010) | Long stays abroad (3+ months), postdoc abroad | ES | Worldwide | Survey data (CAWI), 1,538 cases (controlled design) | Number of publications until tenure (obj. self-report) | OLS regression, negative binomial regression, logistic regression | Significantly positive |
| Decramer, Goeminne and Smolders (2013) | Other (number of times abroad, number of days abroad) | BE | Worldwide | Bibliometric data, 169 cases | Number of different kinds of publications (obj. observation) | OLS regression | Heterogeneous effect for different types of publications; duration matters |
| Dubois, Rochet and Schlenker (2014) | Other (affiliation), currently working abroad | Worldwide | Worldwide | Bibliometric data, 32,574 cases (controlled design) | Fractional number of publications (obj. observation) | OLS regression, instrumental variable regression | Significantly positive |
| Dueñas-Fernández, Iglesias-Fernández and Llorente-Heras (2013) | Other (1+ months) | ES | Worldwide | Survey data (no info on survey method and sample size; controlled design) | Publication of books, papers, or patents (obj. self-report) | Factor analysis, logistic regression | Significantly positive |
| Fangmeng (2016) | Other (stayers, returnees, emigrants) | CN | AU, CA, CN, HK, NZ, SG, US, UK | Bibliometric, CV, and survey data (CAWI), 451 cases | Number of publications (obj. observation) | Logistic regression | No significant (positive) effect after controlling for occupational position |
| Gibson and McKenzie (2014) | Other (returnees, current migrants, never-migrants) | NZ, PG, TO/worldwide | Worldwide | Survey data (no info on survey method), 800 cases (controlled design) | Number of publications (obj. observation) | OLS and median regression | Significantly positive (for current migrants) |

(continued)

**Table A2** Continued

| Authors | Types of mobility | Country of current employment | Country of stay | Sample | Outcome measure | Method | Effect |
|---|---|---|---|---|---|---|---|
| Horta, Jung and Santos (2019) | Other (number of country changes) | HK, MO | Worldwide | Bibliometric and survey data (CAWI), 487 cases (controlled design) | Number of articles published in the last 3 years (obj. observation) | Negative binomial regression | Heterogeneous: significantly positive in STEM fields |
| Jonkers and Cruz-Castro (2013) | Long stays abroad (1+ years) | AR | Worldwide | Bibliometric and survey data (CAPI), 124 cases (controlled design) | Number of publications (obj. observation) | Random effects negative binomial panel model | No significant effect |
| Kato and Ando (2013) | Other (affiliation) | Worldwide | Worldwide | Bibliometric data, 49,599 cases (controlled design) | Number of publications (obj. observation) | Logistic regression | Significantly positive |
| Lawson and Shibayama (2015) | Long stays abroad (up to 3 years) | JP | Worldwide | CV and survey data (P&P), 370 cases (controlled design) | Number of publications (obj. observation) | Cox proportional hazard model, propensity score matching | No significant (positive) effect |
| Ryazanova and McNamara (2019) | Other (affiliation) | BE, CH, DE, ES, FI, FR, IL, IT, NL, UK | Worldwide | Bibliometric and CV data, 376 cases (controlled design) | Number of publications (obj. observation) | Multinomial logistic regression | Heterogeneous (timing): negative directly after PhD, positive 2-7 years after PhD |
| Shen, Liu and Chen (2017) | Long stays abroad (1-2 years) | CN | 7 EU countries | Survey data (CAWI), 1,091 cases in EU sample and 150 interviews | Number of international publications before and after graduation (obj. self-report) | Poisson regression | Heterogeneous: significantly positive effect increasing with ranking of host university |
| Veugelers and Van Bouwel (2015) | Long stays abroad (3+ months) | European countries, USA | European countries, USA | Survey data (CAWI), 998 cases | Publication and patent output (subj. self-report) | Probit regression, propensity score matching | Heterogeneous: more positive effect of mobility to U.S. than of mobility within EU (mostly explained by selection) |
| **Occupational situation** | | | | | | | |
| Albert, Davia and Legazpe (2018) | Long stays abroad (3+ months) | ES | Worldwide | Survey data (CAWI + CATI), 1,432 cases and interviews (controlled design) | Job satisfaction (subj. self-report) | Logistic regression | Heterogeneous effects for different career stages |
| Baruffaldi, Marino and Visentin (2017) | Long stays abroad (Advanced Postdoc Mobility Fellowship) | CH | Worldwide | Bibliometric, CV, and application data, 950 cases (controlled design) | Likelihood of obtaining a professorship (obj. observation) | Regression discontinuity design | No significant effect |
| Caparros-Ruiz (2019) | Postdoc abroad | ES | Worldwide | Survey data (no info on survey method), 3,585 cases (controlled design) | Income (obj. self-report) | OLS regression with Heckman correction, probit model | Significantly positive |

(continued)

**Table A2** Continued

| Authors | Types of mobility | Country of current employment | Country of stay | Sample | Outcome measure | Method | Effect |
|---|---|---|---|---|---|---|---|
| Cruz-Castro and Sanz-Menéndez (2010) | Long stays abroad (3+ months), postdoc abroad | ES | Worldwide | Survey data (CAWI), 1,538 cases (controlled design) | Tenure within 3 years after obtaining PhD (obj. self-report) | OLS regression, negative binomial regression, logistic regression | Significantly negative |
| Cruz-Castro, Jonkers and Sanz-Menéndez (2016) | Long stays abroad (3+ months) | ES | Worldwide | Survey data (P&P + CAWI), 12,625 cases (controlled design) | Likelihood of holding a permanent position (obj. self-report) | Logistic regression | Significantly negative |
| Di Cintio and Grassi (2017) | Other (1+ months) | IT/worldwide | Worldwide | Survey data (CATI), 10,066 cases (controlled design) | Hourly wage (obj. self-report) | OLS regression, instrumental variable regression | Significantly positive |
| Dueñas-Fernández, Iglesias-Fernández and Llorente-Heras (2013) | Other (1+ months) | ES | Worldwide | Survey data (no info on survey method and sample size; controlled design) | Higher occupational category, higher income (obj. self-report) | Factor analysis, logistic regression | Significantly positive (in the academic sector, esp. for women) |
| Jewell and Kazakis (2018) | PhD abroad, currently working abroad, other (stay abroad after PhD of undetermined length) | European countries | Worldwide | Survey data (CAWI + CATI), 3,189 cases (controlled design) | Various indicators of job satisfaction (subj. self-report) | Multinomial treatment model | Heterogeneous: significantly positive mainly for current migrants |
| Jonkers (2011) | Long stays abroad (1+ years) | AR | Worldwide | CV and survey data (CAPI), 124 cases + 9 interviews (controlled design) | Time to promotion (obj. observation) | Cox proportional and Weibull hazard model | No significant (positive) effect after controlling for productivity indicators |
| Lawson and Shibayama (2015) | Long stays abroad (up to 3 years) | JP | Worldwide | CV and survey data (P&P), 370 cases (controlled design) | Time to promotion (obj. observation) | Cox proportional hazard model, propensity score matching | Significantly positive |
| Li and Tang (2019) | PhD abroad, postdoc abroad, short stays abroad | CN | Worldwide | CV and application data, 1,447 cases (controlled design) | Time from PhD to Chang Jiang Scholars title (obj. observation) | Poisson regression | Heterogeneous: only PhD abroad combined with other overseas experiences has a positive effect |

(continued)

**Table A2** Continued

| Authors | Types of mobility | Country of current employment | Country of stay | Sample | Outcome measure | Method | Effect |
|---|---|---|---|---|---|---|---|
| Lutter and Schröder (2016) | PhD abroad, other (number of months abroad) | DE | Worldwide | Bibliometric and CV data, 1,260 cases (controlled design) | Attainment of a tenured position (obj. observation) | Cox proportional hazard model | Significantly positive (mostly mediated by higher publication output) |
| Marinelli, Elena-Pérez and Fernández-Zubieta (2013) | Other (stayers, returners, stable migrants, first-time migrants, repeat migrants) | 10 European countries | Worldwide | Survey data (two stage stratified cluster sampling, CAWI), 2,858 cases (controlled design) | Likelihood of holding a permanent position (obj. self-report) | Logistic regression with fixed effects | Significantly negative for current migrants |
| Ryazanova and McNamara (2019) | Other (number of moves) | BE, CH, DE, ES, FI, FR, IL, IT, NL, UK | Worldwide | Bibliometric and CV data, 376 cases (controlled design) | Time to tenure and time to full professorship (obj. observation) | Multinomial logistic regression | Significantly negative |
| Sanz-Menéndez et al. (2013) | Postdoc abroad (<6 months vs. 6+ months) | ES | Worldwide | Survey data (P&P), 2,588 cases (controlled design) | Time to tenure (associate professorship) | Weibull, Gompertz, log-logistic, exponential, and Cox proportional hazard model | Significantly negative |
| Schulze, Warning and Wiermann (2008) | Long stays abroad (1+ years) | AT, CH, DE | Worldwide | Survey data (CAWI), 934 cases (controlled design) | (1) Likelihood of getting tenure and (2) time to tenure (obj. self-report) | Probit model, Cox proportional hazard model | Heterogeneous: (1) no significant (positive) effect; (2) significantly positive |
| **Scientific impact** | | | | | | | |
| Aksnes et al. (2013) | Long stays abroad (6+ months) | NO | Worldwide | Bibliometric data, 11,465 cases (additional study on 324 scientists who have worked abroad; controlled design) | Number of citations (obj. observation) | OLS regression, analysis of frequency distributions | No significant (positive) effect |
| Baruffaldi, Marino and Visentin (2017) | Long stays abroad (Advanced Postdoc Mobility Fellowship) | CH | Worldwide | Bibliometric, CV, and application data, 950 cases (controlled design) | Average impact factor (obj. observation) | Regression discontinuity design | Significantly positive |
| Conchi and Michels (2014) | Long stays abroad (6+ months) | AT, DE, FR, UK | Worldwide | Bibliometric and survey data (CAWI), 1,531 cases (controlled design) | Citation rate (obj. observation) | Negative binomial regression, network analysis | Significantly positive |
| Franzoni, Scellato and Stephan (2014) | Currently working abroad | 16 countries worldwide | 16 countries worldwide | Bibliometric and survey data (CAWI), 14,299 cases (controlled design) | Impact factor of a randomly selected focal article (obj. observation) | OLS regression and GMM estimates with instrumental variable | Significantly positive |

(continued)

**Table A2** Continued

| Authors | Types of mobility | Country of current employment | Country of stay | Sample | Outcome measure | Method | Effect |
|---|---|---|---|---|---|---|---|
| Franzoni, Scellato and Stephan (2018) | Currently working abroad | 16 countries worldwide | 16 countries worldwide | Bibliometric and survey data (CAWI), 4,336 cases (controlled design) | Impact factor, total number of citations (obj. observation) | Poisson regression | Significantly positive (for mobile scientists in international teams) |
| Gibson and McKenzie (2014) | Other (returnees, current migrants, never-migrants) | NZ, PG, TO/ worldwide | Worldwide | Survey data (no info on survey method), 800 cases (controlled design) | Number of citations and h-index (obj. observation) | OLS and median regression | Significantly positive (for current migrants) |
| Horta, Jung and Santos (2019) | Other (number of country changes) | HK, MO | Worldwide | Bibliometric and survey data (CAWI), 487 cases (controlled design) | Number of citations (obj. observation) | Negative binomial regression | Heterogeneous: significantly positive in STEM fields |
| Jonkers and Cruz-Castro (2013) | Long stays abroad (1+ years) | AR | Worldwide | Bibliometric and survey data (CAPI), 124 cases (controlled design) | (1) Citation rate and (2) number of articles in journals with high-impact factor (obj. observation) | Random effects negative binomial panel model | Heterogeneous: (1) no significant (positive) effect; (2) significantly positive |
| Li, Ding and Shen (2019) | Long stays abroad (1+ years) | CN | Worldwide | Bibliometric and CV data, 214 cases | Average journal impact factor of international publications (obj. observation) | Logistic regression, Cox proportional hazard model | Significantly negative (relationship between research impact abroad and research impact after returning to China) |
| Petersen (2018) | Other (affiliation) | Worldwide | Worldwide | Bibliometric data, 26,170 cases (controlled design) | Normalized average citation impact (obj. observation) | Propensity score matching | Significantly positive |
| Ryazanova and McNamara (2019) | Other (affiliation) | BE, CH, DE, ES, FI, FR, IL, IT, NL, UK | Worldwide | Bibliometric and CV data, 376 cases (controlled design) | Number of citations (obj. observation) | Multinomial logistic regression | No significant effect |
| Shibayama and Baba (2015) | Long stays abroad (<6 months vs. 6+ months) | JP | Worldwide | Bibliometric, CV, and survey data (P&P), 377 cases; 30 interviews (controlled design) | Number of citations, impact factor (obj. observation) | OLS regression | Significantly positive |
| **Competences and personality** | | | | | | | |
| Equeter and Hellemans (2016) | Short stays abroad (<1 month vs. 1+ months) | BE | Worldwide | Survey data (CAWI), 515 cases (controlled design) | Work engagement and general well-being (subj. self-report) | OLS regression | Significantly positive |
| **Scientific knowledge** | | | | | | | |
| Edler, Fier and Grimpe (2011) | Short stays abroad (1-3 months), long stays abroad (4-12 months, 12+ months) | DE | Worldwide | Survey data (CAWI), 1,509 cases | Engagement in knowledge and technology transfer to firms in the home or host country (subj. self-report) | Probit regression | Significantly positive (for long stays abroad) |

(continued)

**Table A2** Continued

| Authors | Types of mobility | Country of current employment | Country of stay | Sample | Outcome measure | Method | Effect |
|---|---|---|---|---|---|---|---|
| Gibson and McKenzie (2014) | Other (returnees, current migrants, never-migrants) | NZ, PG, TO/worldwide | Worldwide | Survey data (no info on survey method), 800 cases (controlled design) | Number of attended (international) conferences and seminars (obj. self-report) | OLS and median regression | Significantly positive (for returnees) |
| Horta, Jung and Santos (2018) | Other (number of country changes) | HK, MO | Worldwide | Bibliometric and survey data (CAWI), 487 cases (controlled design) | Multidisciplinarity: number of fields in which scientists published (obj. observation) | Negative binomial regression | Heterogeneous: significantly positive in STEM fields |
| **Research infrastructures and funds** | | | | | | | |
| Cañibano, Otamendi and Andújar (2008) | Short stays abroad (< 1 month vs. 1+ months), no separation between national and international mobility | ES/worldwide | Worldwide | CV data, 266 cases | International and national research grants (obj. observation) | OLS regression, probit model, structural equation model | Heterogeneous effects for different disciplines |
| Gibson and McKenzie (2014) | Other (returnees, current migrants, never-migrants) | NZ, PG, TO/worldwide | Worldwide | Survey data (no info on survey method), 800 cases (controlled design) | Having current funding from other countries; level of funding (objective self-report) | OLS and median regression | Significantly positive (for current migrants) |
| Veugelers and Van Bouwel (2015) | Long stays abroad (3+ months) | European countries, USA | European countries, USA | Survey data (CAWI), 998 cases | Access to research infrastructures (subjective self-report) | Probit regression, propensity score matching | Heterogeneous: more positive effect of mobility to U.S. than of mobility within EU (mostly explained by selection) |

*Notes*: ‘Controlled design’ indicates studies with a non-mobile control group.

CATI, computer-assisted telephone interview; CAPI, computer-assisted personal interview; CAWI, computer-assisted web interview; P&P, paper & pencil.

We differentiated studies based on ‘objective observations’ (information theoretically objectively reproducible by any person, e.g. number of publications listed in a bibliometric database), ‘objective self-reports’ (information obtained directly from scientists on theoretically objectively measurable criteria, e.g. number of publications), and ‘subjective self-reports’ (individual assessments of potential effects of international mobility, e.g. scientists’ opinion on how mobility influences publication output).