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What do We Know of the Mobility of Research Scientists and of its Impact on Scientific Production

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Abstract

In this chapter we review the literature on the analysis of researcher mobility and productivity highlighting recent changes in the research system - internationalization, inter-sector mobility and collaboration and career diversification which make researcher mobility more relevant for the dynamics of knowledge creation and dissemination. Our review reveals that to date we still know little about the consequences and motivations of increased mobility for individual researchers. We contribute by presenting a typology of researcher mobility, and considering the relevance of multiple mobility events throughout a researcher career. Finally, we review the modeling problems related to analyzing the effect of mobility on academic performance at the individual level, and suggest various solutions.

Keywords: Scientist mobility; academic career; academic labor market; research productivity.

JEL: O31, I23, J24

1. Introduction

The establishment of research networks and the mobility of researchers across different countries, fields, and sectors have become a major policy objective in recent years (OECD, 2008; EC, 2012). Work on mobile inventors' social capital shows that links to the original location are maintained, and that knowledge flows are deeply embedded in labor mobility (Agrawal et al., 2006, 2011; Almeida and Kogut, 1999; Breschi and Lissoni, 2003). Thus, mobility generates positive spillovers among firms (Cooper, 2001; Møen, 2005), sectors (Zucker et al., 1998; Crespi et al., 2007), academic institutions (Azoulay et al., 2012) and countries (Hunt and Gauthier-Loiselle, 2010; Moser et al., 2014). The evidence shows also that university scientists can increase their individual visibility and credibility by moving to a different academic environment, and improving their performance, patterns of collaboration, and career development (Azoulay et al., 2012). Therefore, both the research system and the individual researcher can benefit from mobility.

Recent developments in the research system are demanding a better understanding of the consequences of mobility across locations, sectors, and career stages. First, globalization of the research community and increasing levels of international mobility (Moguerou and Di Pietrogiacomo, 2008; Franzoni et al., 2012; Auriol et al., 2013) and collaboration (Glanzel et al., 2008) are making geographical mobility of researchers more relevant to an adequate flow of knowledge across locations. Second, the importance of improved knowledge transfer between research sectors (Powell et al., 1996; Gassmann et al., 2010; Howells et al., 2012) calls for a stronger emphasis on moves between public and private research. Third, the increased number of foreign PhD students and PhD graduates joining firms, and the greater number of fixed term academic positions and the rapid diversification of academic work roles, are requiring a better understanding of the labor markets for researchers and the career consequences of mobility (Mangematin, 2000; Zellner, 2003; Enders and Weert, 2004; Enders, 2005; Stephan, 2012).

This chapter focuses on the mobility of academic researchers across locations, sectors, and career stages, its social relevance, and its consequences for researcher performance. We propose an approach to the analysis of researcher mobility that considers multiple mobility events throughout a researcher's career (Eurobarometer, 2005). We start by reviewing the relevant literature on researcher mobility to understand its increasing importance, advantages, and disadvantages. We develop a typology of mobility events based on a life-course perspective which allows us to present and select the more relevant mobility events along a researcher's career. We also discuss the modeling difficulties (including selection bias, unobserved heterogeneity, and reverse causality) related to analyzing the effects of researcher mobility, and suggest ways to overcome them.

2. Why are we increasingly interested in researcher mobility?

Researchers have always moved across countries and sectors, and throughout their careers. However, current research systems are characterized by higher levels of internationalization, and increased importance of inter-sector mobility and collaboration, and career diversification (temporariness and changes in work roles), all of which is making researcher mobility more significant to the development of the research system.

Data from the OECD and the United Nations Educational, Scientific and Cultural Organization (UNESCO) Institute for Statistics (hereafter UIS) show a five-fold increase in foreign students worldwide between 1975 and 2012. Since 2000 alone their number has almost doubled (OECD, 2014)[1] while in the US, the number of international students has increased by 32% since 2000-2001 (Institute of International Education, 2012). The trend is similar in the UK where the number of international students in research degree programs in UK higher education institutions increased

[1] Europe hosts about 48% of foreign students (with a large share of intra European mobility), North America 21%, and Asia 18%. Numbers of international students have grown also in Australia, Africa, and Central and South America showing that this is a truly global trend. More than half of all foreign students originate in Asia, with China accounting for 18.6% of international students (OECD, 2014).

threefold between 1994/95 and 2012/13.[2] There is less precise and less comparable information available on the nationalities of research scientists. Moguerou and Di Pietrogiacomo (2008) show that the share of non-national science and technology professionals with non EU-27 citizenship increased from 1.6% to 2.4% in nine European member states between 2000 and 2006. An analysis of the mobility patterns of published authors listed on Scopus between 1996 and 2011 shows that the share of mobile authors differs among countries and regions. In Switzerland, nearly 20% of authors have had a foreign affiliation, while in the rest of Western Europe the share is 12%, in Southern Europe it is 9%, in the US it is 7.4% but in China, Japan and Brazil this share is only 5% (OECD, 2013).[3] The same study shows that the US is the most internationally connected since it is the most important destination for researchers from other parts of the world (confirmed in Franzoni et al., 2012). In the UK, one of the European countries with a high level of internationalization, Higher Education Statistics Agency (HESA) data show that in 2012/13, 28% of research active academic staff were of non-UK nationality.

At the same time, an increasing share of researchers, especially among postdoctoral researchers, is leaving academia due to a lack of available academic positions (Stephan, 2012). For instance, in the US about 37% of doctoral graduates are employed by private sector firms, and the shares are similar for Germany (39%) and the UK (32%).[4] In Japan about 56% of all PhD students for whom destinations are known, after graduating moved to take up positions outside of academia (NISTEP, 2009). Once doctorate holders join a specific sector following the completion of their PhD degree they are primarily mobile within that sector, especially in high intensity research and development

[2] HESA Students, Qualifiers and Staff data tables, https://www.hesa.ac.uk/content/view/1973/239/, Accessed April 17, 2015

[3] While in Switzerland and the US newcomers outnumber returnees, the reverse applies to the rest of Europe and Asia. A 16-country study which surveyed academics about their mobility found similar patterns but a much larger proportion of movers perhaps because it included mobility prior to first publication (Franzoni et al., 2012).

[4] For numbers see: Auriol et al. (2013) for the US, KBWN (2013) for Germany, and Vitae (2010) for the UK. The numbers are comparable to the Netherlands, Belgium, and Denmark (33%-37% of all PhD holders). Employment status was measured 1.5 years after graduation for German PhDs, 3 years after graduation for UK PhDs, and in 2010 for all others regardless of year of graduation. In low intensity R&D countries, e.g. Eastern and Southern Europe, after higher education, government was the most important destination sector (Auriol et al., 2013).

(R&D) countries such as Germany and the US (OECD, 2014).

Within academia, there has been a greater shift towards employment on part-time and fixed-term contracts, particularly through an increase in positions financed by external grants. For example, in the US the number of postdocs in science, engineering, and health tripled between 1990 and 2012 (NAP, 2014), while in colleges the share of contingent (part-time or non-tenured) faculty increased to 75.5% in 2011 (from just 18.5% in 1969 - Roach, 2014). In Germany the share of externally funded positions doubled between 2000 and 2010, with the majority of that increase represented by part-time positions (EFI, 2012). In the UK, fixed-term part-time contracts increased by 19% between 2011 and 2012 alone (Locke, 2014), and a third of positions are now temporary, and a third are part-time. In Japan and Korea more than 50% of academic teaching staff in universities and colleges are employed on part-time contracts (Stephan, 2012; MEXT, 2012). There is also a perceived greater emphasis on activities that are outside the teaching and research roles. Teichler et al. (2013) find that 30% of academic time is spent on other tasks; however, compared to a 1992 survey, they identified only a small shift towards these other activities.

In this chapter, we focus on geographical (researchers changing countries), inter-sectoral (researchers changing sectors, especially between the public and private sectors) and career (temporariness and changing work roles) dimensions of mobility, and highlight its consequences for individual researchers and the research system as a whole.

2.1 Geographical dimension: International mobility of researchers and brain circulation

Researchers leaving their home countries traditionally was of concern to national authorities and seen as potentially diminishing their national research and economic potential. However, improved international communications and the return of nationals from abroad have caused the geographical mobility of researchers (brain-drain) to be seen as bringing possible benefits to the origin countries and the mobile researchers (brain-circulation).

Neither geographical mobility nor the possible associated effects are new phenomena. The international travels of early scientists demonstrate the historical relevance of the geographical mobility of researchers, and its costs and benefits. The concept of 'brain-drain' emerged first in the 1960s in a report from the Royal Society of London on the migration of British engineers and scientists to the US (Rhode, 1991). Brain-drain now refers more broadly to the unidirectional migration of skilled workers from less developed to more developed countries or regions. The 'brain drain-gain' debate focuses on the benefits to receiving countries and losses for sending countries or regions. In the 1970s, the 'laissez passer' of the 'dominant' 'cosmopolitan' view defended the compensation and overall efficiency of migration for economic development (Johnson, 1968; Berry and Soligo, 1969; Grubel and Scott, 1977). Some authors (e.g. Patinkin, 1968; Regets, 2001; Nerdrum and Sarpebakken, 2006) were critical of this problem being analyzed in efficiency terms at country level, and claimed that other aspects such as the imperfections related to regional labor markets and individual opportunities for career development, and other levels of analysis should be considered (Gaillard and Gaillard, 1998; Ackers, 2005; Ackers and Oliver, 2007).

While the migration of scientists is normally seen as benefiting the host/receiving country, it can result in the displacement of home-grown researchers. For example, following a high influx of high-skilled immigrants to a firm, native science and engineering workers experience lower wages and longer career transition periods (Pekkala Kerr and Kerr, 2013). In the US, wage decreases, especially for postdocs, have been observed with larger entry of foreign doctoral scientists (Borjas, 2009), although there is no evidence of job displacement beyond postdoctoral positions (Stephan, 2012). Borjas and Doran (2012) studying the case of a large Soviet mathematician influx into the US, found that American academics showed reduced publication performance and increased out-mobility in fields in which Soviet mathematicians specialized. This was perhaps due to the academic institutional environment which was able to support only limited growth.

The increased return of scientists to their countries of origin (Saxenian, 1999), and continued links with diasporas (Agrawal et al., 2011), has brought a new perspective to discussion and analysis of geographical mobility. The 'brain circulation' concept (Mahroum, 1998, 2000; Johnson and Regets, 1998) treats geographical mobility as a two-way process which acknowledges the benefits that leavers and returnees bring to sending countries (Meyer, 2001; Barre et al., 2003; Ackers, 2005; Moguerou, 2006; Meyer and Wattiaux, 2006). For example, collaborations between Indians abroad with their communities back home have been found to increase knowledge flows from the host country to India (Agrawal et al., 2011). Ethnic knowledge flows have been confirmed also in other studies (e.g. Agrawal et al., 2008; Oettl and Agrawal, 2008), with Kerr (2008) showing that a US patent with a Chinese inventor is at least 20% more cited by Chinese patents than the average US patent.

The advancement of international communication techniques (Ding et al., 2010) has made geographical mobility a process that sending countries can benefit from. Also, changes in the patterns and motivations of researcher mobility blur the boundary between migration and mobility (King, 2002), highlighting the importance of focusing on the return of migrants (Boeri et al., 2012). From this perspective, a sojourn abroad is not considered a migration process with clear winners and losers –brain-gain and brain-drain; rather, it is considered a reciprocal process allowing individuals and countries or regions to benefit from current collaborations and future returns – brain circulation. Survey studies of academic researchers confirm that a large share maintain collaborative links with their home countries (Baruffaldi and Landoni, 2012; Scellato et al., 2015), although primarily if the origin country has a large local research base and the individual moved at a career stage, such as for a postdoc or a position, that had allowed the formation of a home country network (Scellato et al., 2015; Gibson and McKenzie, 2012). The increasing share of internationally coauthored papers (Glanzel et al., 2008; BIS, 2013) is further evidence of the importance of

international collaborations for knowledge creation.[5] The chapter by Appelt et al. (Chapter 3 this volume), based on bilateral international scientists flows calculated on publication data for the period 1996-2011, provides support for the brain circulation view of a complex network of international mobile students and scientists with high levels of international cooperation (co-publication).

The greatly improved and cheaper communication channels, and the globalization of the research community and high relevance of international scientific networks, are increasing the return opportunities following geographical mobility. This suggests that geographical mobility could become even more relevant, and that countries and researchers should benefit even more in the future; this would seem to demand a broader conceptualization of geographical researcher mobility.[6]

2.2 Inter-sector dimension: University-to-business mobility and knowledge transfer

The birth of 'Big Science' (Price, 1963), and the necessary collaboration between government, university, and industry, point to the relevance of inter-sector collaborations for research development.[7] At that time, several authors in the sociology of science became interested in inter-sector job mobility. The works of Marcson (1960), Krohn (1961), Kornhauser (1962) and Hagstrom (1965) analyze the 'role strain' problem caused by job transitions between an academic and a business environment, and focus on the problem of adaptation caused by different norms and values in different research sectors. More recently, the focus has shifted to researcher mobility as a mechanism for knowledge transfer between sectors.

[5] The shares of internationally co-authored papers in 1991 to 2005 increased from 13.5% to 27.7%; 12% to 26.8% and 9.8% to 22.4 for the EU-15, US, and Japan respectively (Glanzel et al., 2008).
[6] E.g., virtual mobility as the concept of multiple affiliation and honorary appointments could be considered a new specification of the geographical dimension of mobility.
[7] See Merton (1938) for an analysis of the socio-economic factors in the origins of the institutionalization of science, and the relationship between science and industry.

Research scientists are particularly relevant to the dynamics of knowledge production and dissemination; much scientific knowledge is characterized by embeddedness and tacitness. Location and distance are important for explaining the innovation process, and the significance of knowledge spillovers and mobility allowing access to new knowledge is growing (Audretsch and Feldman, 2004; Agrawal et al., 2006, 2008).[8] Knowledge spillovers tend to be bounded geographically, and researcher mobility can influence this feature. So far, the knowledge spillovers literature has focused on patents (Jaffe, 1989; Henderson et al., 1998), investments, and spin-offs (Bozeman, 2000; Mowery and Shane, 2002) as mechanisms of knowledge transfer. Rather than being "in the air" these spillovers tend to be embodied by researcher mobility (Azoulay et al., 2012). In particular, knowledge spillovers from academia to industry tend to rely on researchers' moves. In addition, and spillovers from academia are stronger when embodied in researchers, which suggests the criticality of researcher mobility for the knowledge dissemination process. Azoulay et al. (2012) analyze inter-regional mobility patterns and their effects on knowledge dissemination for a sample of elite scientists, showing that patent-to-article and patent-to-patent citations in a scientist's origin location decline following a move to another country, while article-to-article citations do not. Importantly, citations from the destination location increase after a move. These results stress the importance of location for knowledge spillovers.

However, little attention has been paid to the inter-sector mobility of researchers, and very few papers look at the mobility of academics to industry, with most focusing on academic entrepreneurship (e.g. Audretsch and Stephan, 1999; Stuart and Ding, 2006; Toole and Czarnitzki, 2010). A study by Zucker et al. (2002) considers the mobility of academic stars to industry, on a full or part-time basis, and finds that academics are valuable to firms, and that their moves depend largely on mobility costs and the availability of other outside options. Crespi et al. (2007) look at

[8] There is a rich literature on the importance of hiring for knowledge acquisition and firm performance (Almeida and Kogut, 1999; Rosenkopf and Almeida, 2003; Møen, 2005; Agrawal et al., 2006; Palomeras and Melero, 2010; Singh and Agrawal, 2011; Ejsing et al., 2013; Herstad et al., 2015).

sector mobility of academic inventors in the European context and find that academics with more valuable inventions are more likely to move to industry. Works by Herrera et al. (2010), Ejsing et al. (2013) and Herstad et al. (2015) show that scientists that move to private firms from universities or research institutes have a positive effect on both the inputs to and outputs of firms' innovation processes. These studies show that researcher mobility is a relevant mechanism of knowledge and technology transfer, and sheds light on some of the factors that affect the probability of a move from public research to industry. These authors indicate that researchers' inter-sectoral mobility is crucial for the knowledge dissemination process, and might also be important for explaining the process of dissemination via other mechanisms than patenting and licensing.

Similar to the case of geographical mobility, inter-sectoral mobility has been considered so far as a single (one-time, one-way) event. The increasing frequency and importance of inter-sectoral mobility for the dynamics of knowledge production and dissemination requires analysis that considers multiple mobility events.

2.3 Career dimension: Temporariness and work role changes

The linear career progress from PhD graduate to professor is no longer straightforward due to the existence of more part-time and short-term contracts (Blaxter et al., 1998; Stephan and Ma, 2005; Stephan, 2012). Alternative work arrangements and postdoctoral appointments and other types of temporary employment contracts have become common in universities. These developments raise questions about their effect on researchers' career development. The "extension of the educational career ladder" (Zumeta, 1985) is a source of temporariness and uncertainty (Stephan, 2012; Cruz-Castro and Sanz-Menendez, 2005; Smith-Doerr, 2006) which can create problems for the future recruitment of researchers (Enders, 2005; Enders and Weert, 2004; Stephan, 2012). More fragmented career paths and a reduced focus on scientific research result in a lack of autonomy and fewer opportunities for specialization (Stephan, 2012; Smith-Doerr, 2006). For example, Gaughan and Robin (2004), Jonkers (2011), and Cruz-Castro and Sanz-Menendez (2011) in studies for

France, Argentina, and Spain respectively, show that postdoctoral positions delay promotion to a tenured/permanent position. This fragmentation and job insecurity could be driving promising scientists out of academia (Stephan, 2012), and could be negatively affecting scientific knowledge production and advancement generally.

The increase in temporary positions could also be an indication of a changing academic market that is requiring more flexibility in relation to a research career (Enders, 2005). Temporary positions might then be positive for performance and career development by enlarging networks and encouraging interdisciplinarity (Rhoten and Parker, 2004; Zubieta, 2009; Su, 2011). For example, postdoctoral stays have been shown to improve academic performance (Su, 2011) and the scientific impact of academic research (McGuinnis et al., 1982). These positive effects are evident in the context of the quality of the institutions hosting postdocs (McGuinnis et al., 1982; Long, 1978). Temporary positions in the early career stage could also be positive from a job market perspective by allowing better career matches (Jovanovic, 1979; Parsons, 1991).[9] From a labor market perspective, temporary positions might reduce the cost of science. Also, temporary positions are wider spread among foreign researchers (Lan, 2012; Stephan, 2012), indicating that labor costs may be a factor (Stephan, 2012). Therefore, it is important to determine whether temporary positions are a mechanism to attract talent and to improve research capacity (as discussed in Chapter 4 by Lawson et al.), or if they work to create poorer employment conditions which in the long-term, could diminish national research potential (Freeman, 2006).

Researchers are being required also to take on increasingly diverse work roles (Blaxter et al., 1998; Kim and Cha, 2000; Enders, 2005), raising concerns about the consequences. Encouragement and

[9] In the context of job matching, young researchers lack experience making the return on their investment in information greater, and their probability of job mobility higher compared to older researchers who are more likely to have found their optimal match. Young researchers are required to experience more job changes in the search for an optimal match (Jovanovic, 1979; Parsons, 1991). However, in the market structure approach (Ryan, 2001), labor market structure causes high mobility (turnover) among the young. The job rewards offered to young people are smaller, and it takes longer to achieve high wages. This encourages job mobility which frequently has a negative effect.

reinforcement of knowledge transfer activities and applied research might be working to diminish other traditional academic roles, and to crowd out basic research and the public dissemination of science (Blumenthal et al., 1996; Heller and Eisenberg, 1998). Increased teaching workloads can also reduce research activity and decrease promotion opportunities (Stephan, 2012). Similarly, faculty time allocated to service and administration activities reduces the opportunities for research, and thus, award of tenure and promotion (Porter, 2007). These negative effects on careers risk researchers being pushed to take up temporary employment or move out of research. However, these new work roles could also generate new projects and ideas for research, and open new career opportunities for researchers. For example, Lee (2000) and Coate et al. (2001) point to the importance of the bottom-up generation of ideas through teaching, consulting, and knowledge transfer activities.

Figure 1.1 summarizes the main advantages and disadvantages of researcher mobility along the three dimensions discussed in this section. Geographical mobility can lead to a brain-drain for the sending countries, and to displacement of researchers in the receiving countries. However, a significant strand in the academic and policy literature acknowledges the benefits from brain circulation, and the positive returns to sending countries and institutions. The literature on the inter-sectoral mobility of researchers focuses on their role as facilitators of the knowledge transfer process while also acknowledging that loss of talent through mobility out of academia can be damaging to scientific research. In the context of career development, researcher mobility and higher availability of positions could introduce flexibility into the labor market, and reduce the costs of research. These features also allow individual researchers to find better matches and new research directions, providing opportunities to adjust their working lives to suit their preferences, which potentially could improve the performance of the research sector. However, a declining academic job market with more fixed term positions and the incompatibilities among the multiple academic work roles could result in job insecurity, loss of promising researchers, and inability to

pursue groundbreaking research with potentially detrimental effects on science generally.

Figure 1.1 Main advantages and disadvantages of researchers' mobility

	GEOGRAPHICAL	INTER-SECTORAL	CAREER
(-)	Brain Drain / Displacement	Loss of Talent	Job Insecurity / Loss of Talent
(+)	Brain Circulation / Productivity Increase	Knowledge Transfer	Labor Market Flexibility

3. Mobility from a life course perspective

Although geographical, inter-sectoral, and career mobility are not new phenomena, changes in the research system - internationalization, increasing inter-sector collaboration, and diversification of career and work roles - make researcher mobility more relevant to the dynamics of knowledge creation and dissemination. New approaches to the analysis of mobility show that in order to be able properly to account for and assess these changes it is crucial to adopt a life course perspective to the consideration of mobility since we can expect a relationship between sequential mobility experiences. For example, inferior employment prospects, and increased job mobility (e.g. increase in postdoctoral positions) among young researchers, is reducing their job-prospects and performance as senior researchers (Stephan and Ma, 2005). Also, Parey and Waldinger (2011) among others suggest that there is a strong relationship between mobile researchers and previous mobility events. Therefore, it seems that there are career and mobility path dependencies. This broader approach tends to both increase the scope of analysis and reinforce the advantages of increased researcher mobility across its dimensions - geographical, inter-sectoral, and career.

3.1 A typology of research mobility

Mobility can be defined as a change, and types of mobility defined according to what is changed. First, it is important to differentiate between educational mobility and job-to-job mobility. The former refers to mobility among students ending with completion of a PhD; the latter refers to changing employers and includes the postdoc period. Student mobility has been quite well studied due to the better availability of data (Moguerou and Di Pietrogiacomo, 2008) but little work exists on researchers' job-to-job mobility. Changes of employers can be analyzed in terms of occupational mobility (changes to occupational status) and sector mobility (changes in the sector of employment). All these mobility dimensions can be qualified by a change in geographic location (geographical mobility), by prestige (social mobility) of the sending and receiving institutions, and by subject focus (disciplinary mobility). The main types of mobility reviewed in this chapter,[10] and their defining changes are listed below:

- Educational mobility: change across levels of formal education;
- Job-to-Job mobility: change of employer;
- Occupational mobility: change of occupational status, e.g. job profile and content;
- Sectoral mobility: change in the sector of employment;
- Geographical mobility: change of location;
- Social mobility: change in social position;
- Disciplinary mobility: change of disciplinary focus.

[10] Employment mobility which considers transitions between unemployment, employment, and inactivity, or changes to the proportions of full-time vs. part-time employment, is generally the focus of labor economics. Employment mobility is usually measured through changes in the International Labour Organization (ILO) survey categories. However, ILO surveys, due to the small number of observations, are not appropriate to measure researcher mobility (Moguerou and Di Pietrogiacomo, 2008).

Educational mobility

Educational mobility refers to changes in levels of formal education. Although education levels are important criteria for selecting the population for an analysis of other types of mobility (e.g. high skilled population), it is used primarily as an indicator of the future supply of researchers. A more refined proxy for the educational mobility of researchers is the international mobility of PhD candidates, and analyses of specific mobility programs for students (e.g. Erasmus and Marie Curie programs). Analyses of these programs indicate that there is a relationship between mobile researchers and previous mobility events (e.g. Ackers, 2004, 2005). For instance, van der Sande et al. (2005) and Hansen (2003) show that more than 60% of Marie Curie scholarship holders had previously lived in another country.

The mobility and migration literature does not consider mobility during the early stages of education even though this "provides the 'seeds' for future international skilled labour" (Balaz and Williams, 2004: 235). Mobility during education is instead used primarily to explain future mobility, for example, taking up a postdoctoral or job position in another country or institution (Ackers, 2004). Ackers (2005: 108) suggests also that it might be "more 'efficient' to address some of the issues around undergraduate mobility retrospectively" since a large share of mobile undergraduates will not progress to become researchers. Sretenova (2003) proposes a focus on post-doctoral or more senior scientists, that is, on job-to-job mobility, in order to study the mobility of research scientists.

Job-to-job mobility

Job-to-job mobility refers to a move from one employer to another. Research scientists tend to move more to improve their opportunities for research, and less to achieve greater economic rewards. For example, research scientists use job mobility to access the best scientific equipment

and scientific teams (Martin-Rovet, 2003), and to improve their career prospects either at home or abroad (Ackers, 2005). In particular, a job move to another country is frequently linked to academic career progression and performance (e.g. Ackers, 2005). In addition, other characteristics of the national academic labor market, for example a transparent and meritocratic recruitment system with a clear promotion system linked to "objective" evaluation procedures that reward excellence, have been shown to drive job mobility among research scientists (Ackers, 2005; Sockanathan, 2004; Fernandez-Zubieta and van Bavel, 2011). Although in the US, researcher mobility is associated with scientific merit and is encourage by universities, many European countries are characterized by academic inbreeding and a reluctance among academics to move (Stephan, 2012). For example, over 59% of the university professors in Spain were awarded chairs by their PhD awarding institution (Cruz-Castro and Sanz-Menendez, 2011). The importance of social ties in achieving promotion is very high, and further reduces the probability of mobility (Pezzoni et al., 2012; Zinovyeva and Bagues, 2015).

Occupational mobility

Occupational mobility refers to changes in individual occupational status. Occupational mobility is usually measured by changes in International Standard Classification of Occupations (ISCO) categories. However, this criterion cannot be applied to researchers since most job changes would not result in a change in ISCO category. Thus, we need to consider other substantial changes in job profiles and job content in order to analyze researchers' occupational mobility. Career progression is a driver of occupational mobility. Changes within the academic career, for example, promotion from Assistant Professor to Associate and then Full Professor, are usually associated with positive changes in the job profile and job content, and provide access to additional resources. Therefore, job changes that result in a promotion could be considered a proxy for occupational mobility. A considerable number of studies have focused on the determinants of academic promotion, showing

the importance of a higher rank to enable full access to resources and institutional advantages (e.g. Long et al., 1993). In addition, gender discrimination in academia has been shown to operate through promotion (Ginther and Hayeks, 2003; McDowell et al., 2006; Ginther and Kahn, 2004). Occupational mobility can be used also to assess other types of mobility. For example, Oswald and Ralsmark (2008) show that 75% of Associate Professors in the top-10 economic departments in US universities did their first degree outside the US, that is, engaged in a type of educational mobility.

Occupational mobility also captures the transition from research active to research inactive academics. In a typical academic career researcher time is split among research, teaching, and administration/service. However, not all scientists are involved in doing administration or teaching activities, and not all teachers engage in research. While all PhD holders have conducted some research at the start of their careers, some might have decided or been pushed to abandon research and focus on teaching, administration, or (technical) support tasks (see Chapter 11 by Geuna and Shibayama, for a study of occupational mobility in Japan).

Sectoral mobility

Sectoral mobility refers to job changes that involve a move to a new position (research related or not) in a company or a public research organization, or return mobility from non-academic sectors into academia. In particular, mobility from academia to business is considered among the most important occupational changes for a research scientist. Different sectors have different evaluation and recognition systems, and mobility between them could have different effects on a research career. Since Kornhauser's (1962) work, more recent studies have examined the different drivers and effects of a move from academia to industry (Zucker et al., 2002; Crespi et al., 2007; Herrera et al., 2010; Herstad et al., 2015), to a public research center (Ponomariov and Boardman, 2010), to government, and to other not-for-profit organizations (Su and Bozeman, 2009). For example,

Hottenrott and Lawson (2014) show that scientific researchers in research intensive university departments are equally or more likely to move to industry than to remain in academia; however, a focus on contract research is more closely associated with a move to a public or government research center or a small firm.[11] In terms of the individual level effects of a move out of academia, Toole and Czarnitzki (2010) find that US academics who left academia to start their own firms, experienced a decline in research performance.

However, mobility back to academia, and experience in other sectors have been understudied. Previous industry experience and inter-sectoral affiliations might provide substantial benefits for researchers and universities since they are conducive to network creation, and may allow those scientists to bridge between sectors. Indeed, Dietz and Bozeman (2005) find a positive effect of industry experience on patent outcomes, implying that the researchers involved have a stronger footing in commercially driven research which may also benefit university research. Lin and Bozeman (2006) show that previous industry experience also has a positive impact on the productivity of academics affiliated to research centers if the institutional conditions are appropriate. Ponomariov and Boardman (2010) extend these benefits to include academics affiliated to new collaborative research centers, and show that this affiliation enhances scientific production, and cross-discipline and cross-sector collaborations. Fernandez-Zubieta et al., Chapter 5 in this volume, show that the publications performance of researchers previously employed in the private sector, following a short period of adjustment, is equal to that of researchers with experience only in academia. Previous industry experience and inter-sectoral affiliations could provide benefits to researchers and universities by enabling more wide-ranging networks and bridging between sectors. These findings indicate that research scientists are able to adjust to new sectoral demands. Although we observe different values within sectors, De Graaf and Van Der Wal (2008) in a study of 60

[11] De Graaf and Van Der Wal (2008) suggest that small businesses are more similar to small government organizations than to large business.

switchers between the public and private sectors in the Netherlands, found that the values espoused by public to private and private to public switchers were similar.

Geographical mobility

Geographical mobility refers to a move from one location to another, involving different countries or different regions. Analyses of geographical mobility in the migration literature focuses mainly on the direction and volume of labor flows. The availability of data on international flows is higher at the student and tertiary education levels (Moguerou and Di Pietrogiacomo, 2008). Thus, levels of international mobility of research students and highly skilled workers with tertiary education are among the most frequent indicators of the geographical mobility of researchers (Guellec and Cervantes, 2002).[12]

In recent years, based on the construction of ad hoc databases, a few papers have analyzed the international mobility of researchers and its impact on their performance, careers, and networks. In a study of mobile scientists in 16 countries, Franzoni et al. (2014) find that foreign academics and those that spent extended periods abroad achieve publications with a higher impact.[13] Positive performance effects for international stays are found also in relation to postdoctoral stays of UK scientists (Zubieta, 2009). However, Cañibano et al. (2008) for a sample of Spanish researchers, show that international mobility results in better access to international funding and networks but does not improve publication or patenting performance. Lawson and Shibayama, Chapter 10 in this volume, also provide mixed evidence. They find that Japanese bioscience professors who experienced international stays are promoted sooner but only if they were already employed on

[12] The population of Human Resources for Science and Technology (HRST) includes people who completed tertiary level education in a science and technology (S&T) field of study or those employed in an S&T occupation which usually requires tertiary level qualifications. The data sources to measure these populations, such as labor force surveys, international education statistics, and census data, do not usually allow a clear breakdown.
[13] See also Franzoni et al. Chapter 3 in this volume.

permanent contracts. On the other side, international mobility can result in the loss of social ties (Heining et al., 2007), and difficulties related to incorporating the knowledge acquired abroad (Melin, 2005) which may explain the difficulties of re-entry and delayed promotion observed in Cruz-Castro and Sanz-Menendez (2011) and Jonkers (2011) for Spain and Argentina respectively.

Differences might also exist in the population that emigrates, and between the sending and receiving countries. For example, Borjas and Doran (2012) and Gaulé and Piacentini (2013) find higher performance among Russian and Chinese emigrants to the US compared to the native population, while Hunter et al. (2009) find no differences in the performance of UK emigrants to the US and domestic US scientists. In the latter case, it might be that the US does not attract the best talent since the UK can compete on equal terms for talented researchers. Weinberg (2009) using data on Nobel laureates in chemistry, medicine, and physics, shows a positive trend in US leadership in science and capacity to attract the best researchers, compared to a declining trend in Germany and a slightly declining pattern in UK science and Levin and Stephan (1999) find that highly productive scientists are disproportionately drawn from the foreign born and foreign educated in the US.

Motivations for researchers to move to a different country are important for understanding researchers' behavior. The available evidence highlights that research related reasons such as working on interesting research topics, quality of the receiving institution, and career prospects, dominate (Ivancheva and Gourova, 2011; De Grip et al., 2009). Franzoni et al., Chapter 3 in this volume, based on a sample of more than 45,000 researchers working in 16 countries, confirm that career prospects and research quality are the main drivers of researcher emigration while salary plays a minimal role. They report also that personal or family reasons are the most important factor explaining the return home. Using a sample of about 1,000 European-born researchers with a European PhD, Veugelers and van Bouwel, Chapter 9 this volume, find that career motivations are more strongly related to EU-US mobility compared to intra EU mobility, and that PhDs with

previous experience of mobility in Europe are more likely to move within Europe compared to moving to the US.

Social mobility

Social mobility refers to changes in social status. Science is a social system in which resources tend to accumulate in a few individuals and a few institutions (Merton, 1968). Social systems are structured in ways that limit movements across social strata which means that individuals and groups move down or, less often, up the socioeconomic scale in terms of property, income, or status. Thus, a researcher who joins a high quality department could be considered to be upwardly mobile whereas a researcher who joins a lower quality department could be considered downwardly mobile. Since movements up and down are associated with different access to resources and peers, social mobility aspects are relevant to an analysis of researcher mobility and its effects. Allison and Long (1990) address the departmental affiliation effects on research productivity for a sample of 179 job changes, and find that researchers who move upwards show increased publication and citation rates, while those who move downwards experience a productivity decrease. Fernandez-Zubieta et al., Chapter 5 in this volume, confirm the importance of qualifying mobility according to the quality of the sending and receiving departments, and show that mobility downwards into a lower quality department can decrease the mobile researcher's academic performance. Similarly, Kahn and MacGarvie (2014) show that researchers obliged by visa restrictions to leave the US and return to a low income country, publish less than a matched researcher who is able to remain in the US. Thus, social mobility is observed across country boundaries.

Disciplinary Mobility

Career progression demands on mobility are sometimes discipline driven (Mahroum, 1998), and it is necessary therefore, to check the drivers and consequences of mobility across disciplines. Disciplinary mobility refers to a move from one discipline to another, or a move among subfields within a discipline. It applies mostly to a research scientist who joins a department with a different disciplinary focus, or joins an interdisciplinary research center (Aboelela et al., 2007). Disciplinary mobility can be used to study the emergence of a new discipline (Basu and Dobler, 2012; Lawson and Soos, 2014); this type of mobility occurs among researchers searching for new promising areas that could lead to significant new findings (Gieryn, 1978). However, Borjas and Doran (2012) shows that disciplinary mobility can also be caused by supply shocks; American mathematicians moved away from fields that received larger numbers of Soviet immigrants. Disciplinary mobility is often accompanied by other types of mobility. For example, Garvey and Tomita (1972) found that research scientists moved to a new field primarily because of the conclusion of a project, or a change of institution.

3.2 Researcher mobility in a life course perspective

As the Section 3.1 shows, mobility types are not mutually exclusive. For example, a researcher's job change may require relocation in a different country, and this combines job-to-job and geographical mobility. One of the challenges involved in analyzing mobility from a life course perspective which accounts for diverse mobility events through a researcher’s career, is to select the changes that are the most relevant, and apply the other dimensions of mobility. This implies that we need to establish a basic researcher trajectory and select the most relevant changes that occur.

Figure 1.2 Researcher mobility in a life course perspective

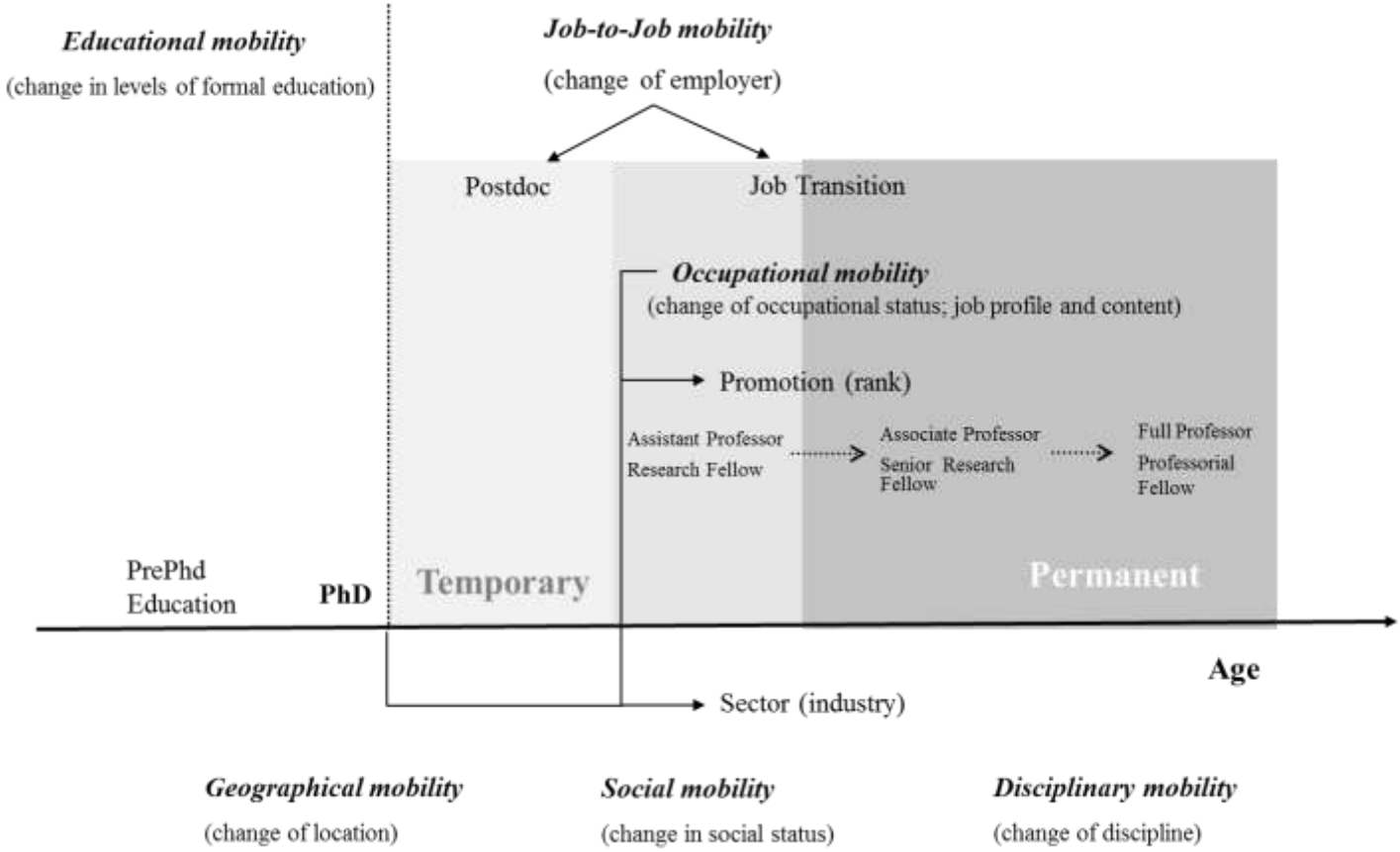


Figure 1.2 depicts the trajectory and most relevant mobility events in a researcher's career that we discussed above. For a researcher, successful completion of doctoral studies is generally the starting point of a researcher career and allows educational and job mobility dimensions to be clearly differentiated.[14] After award of the PhD degree, many research scientists take up postdoctoral positions, some then move on to a tenure-track/tenured or permanent position, others leave academia. The difference between a post-PhD, non-tenure-track (fixed term with no prospect of permanent employment), tenure-track (fixed-term with prospect of permanent employment), and tenured position (permanent) helps to establish a clear difference within job-to-job mobility: 'postdocs' and 'job transition'. The distinction between tenured (and tenure-track) and non-tenure-

[14] A researcher can also have pre-PhD working experience. These events can be controlled for by including variables that indicate if a researcher was employed before PhD completion. This is especially relevant if the researcher has pre-PhD work experience in industry since the job content is different.

track (or permanent and non-permanent) job changes is supported for several reasons. Tenured positions have a clear institutional ascription, job profile, and access to resources. Furthermore, the increasing number and concatenation of postdoctoral and temporary research positions reinforces the need to treat job mobility among tenured and non-tenured academic staff differently since many temporary positions lead to involuntary job mobility. Job-to-job mobility of tenured/permanent academics is (mostly) the result of an individual choice, not a necessity. In the case of comparisons among international samples, institutional differences may hinder the proper identification of comparable permanent positions. For this type of analysis it is better to consider only associate and full professors as permanent/tenured positions, in line with evidence presented in Chapter 4 in this volume by Lawson et al..

4. The challenges related to analyzing researcher mobility within a life course perspective

Changing job positions, and collaborating with other researchers and sectors is part of an academic career. Researcher mobility is affected by different national S&T policies and human resources management and labor markets promote different research trajectories (Gaughan and Robin, 2004). Mobility can become a system requirement, thereby creating more mobility (Mahroum, 2000).

An individual level analysis of research mobility from a life course perspective allows simultaneous characterization of different mobility events and checking of their effect on academic performance, taking account of national and field specific characteristics. Analyzing mobility from a life course perspective can also help to clarify the direction of causality between researcher performance and mobility (see Figure 1.3). For example, the effect of job mobility on a senior researcher's academic performance might be determined by earlier mobility experience and academic performance as a

young researcher. Thus, the relationship between researcher mobility and productivity could go in both directions.

There is theoretical support for and empirical evidence pointing in both directions. Some studies show that mobility improves academic performance. For example, Franzoni et al. (2014) find that geographically mobile researchers show superior academic performance compared to non-mobile ones even taking account of positive selection mechanisms in migration processes. Cañibano et al. (2008) find no evidence of a positive effect of mobility on academic performance but do not focus on job-to-job mobility[15] or the quality of performance. Dietz and Bozeman (2005) consider the effect of researcher's time spent in industry on performance and find a positive effect of years spent outside academia on patent productivity.

However, these results could be biased by migrants' self-selection. The economic literature on the assimilation of immigrants suggests that there are positive self-selection effects such as immigrants being more talented, more entrepreneurial, and less risk averse (Chiswick, 1978; Borjas, 1985; LaLonde and Topel, 1992). Ganguli, Chapter 6 in this volume, based on a large sample of Russian scientists, shows that after the collapse of the Soviet Union migration was characterized by positive selection, and, as economic theory suggests this positive selection increased with migration costs and the wage premium. Higher productivity is also likely to affect inter-sector mobility. There is evidence that individual performance increases the likelihood of moving from academia to industry. For example, "star scientists" are more likely to have part-time appointments or affiliations with industry (Zucker et al., 2002), or to leave academia to start their own companies (Toole and Czarnitzki, 2010).

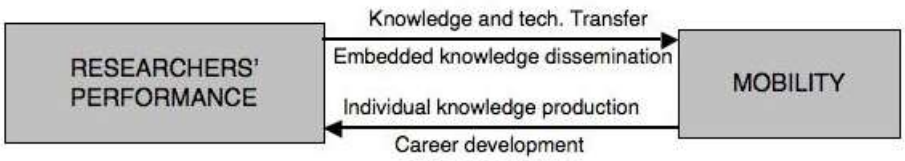
Due to this bi-directional relationship of mobility performance, some, such as Hoisl (2007), analyze both simultaneously and find that a move increases productivity but that increased productivity

[15] Cañibano et al. (2008) analyse "stays" - differentiating between short (less than a month) and long (more than 1 month) stays, and pre and post-doc periods, and the number of countries and centres in which the researcher has worked.

decreases the probability of moving. This appears to support the productivity enhancing mechanism predicted by job matching theory. Evidence in the academic environment is less frequent but Fernandez-Zubieta et al. (2015b) suggest that a productivity enhancing effect is not confirmed if the analysis is limited to domestic moves.

In light of the evidence on the different effects for different mobility types, the bidirectional relationship of mobility and productivity, and the dynamic nature of these variables, an econometric analysis should address potential biases when estimating causal links (e.g. omitted variables, reverse causality, measurement error, sample selection) and find ways to overcome them. A few of the chapters in this volume take this approach. For example, the chapter by Fernandez-Zubieta et al. (Chapter 5), shows that job experiences per se do not increase academic performance, and that job mobility to a better department has a positive weakly significant impact, while downward mobility reduces academic performance. In addition, job mobility is always associated with a short-term decrease in performance. The relationship between mobility and research productivity not only changes across different types of mobility but also across diverse career moves. Lawson et al. (Chapter 4 in this volume) indicate that work experience in the US labor market provides a performance premium, and that postdoctoral experience in a top-quality US institution adds a quality premium, both effects that are geographically transferable.

Figure 1.3 Researchers performance and mobility relationship



4.1 Problem of biases when estimating causal effects

Econometric research and methods have to deal with the recurrent problem of biases (Heckman, 1979) when estimating causal effects (e.g. omitted variables, reverse causality, measurement error, sample selection). To measure mobility and its impact on productivity the model needs to include information on researcher's characteristics and the job, and the match between the two in order to address selection into mobility (Osberg et al., 1986). Biographical information, such as researcher's age, gender, and household structure, are as important as information on prior mobility events, research ability, and researcher's expectations about mobility outcomes. Job characteristics models should include details on teaching hours, capital availability, and job satisfaction. The model should also include some measures for the structure of the academic market. These data are difficult to obtain, and thus selection bias is difficult to resolve. From a life course perspective, there are additional problems related to personal and job characteristics which may change over time and affect selection into mobility and its effect on productivity. First, personal characteristics change over time. As already mentioned, younger researchers are more likely to move because they are less likely to have found their optimal conditions or optimal match. However, mismatch which is likely in the case of early job changes, does not increase productivity and might result in decreased productivity.[16] Thus, job mobility should have a stronger positive effect on the productivity of older researchers since information on researchers' performance and characteristics increases with career progression. Also, researchers' family situations change over time as do job characteristics and the motivations for job mobility. Teaching commitments and capital availability could change every academic year which can affect the researcher's productivity and her willingness to move. Similarly, the structure of the academic labor market is subject to change. In the UK, the research assessment exercise resulted in changing measures for the assessment of research quality and this

[16] See fn. 10.

has affected the requirements of the academic profession and the competition between universities for the best staff.

Thus, when estimating the effect of mobility on productivity, standard regression estimates are biased since unobserved personal attributes are correlated with both the variable of interest and the independent variable. Mobile researchers might appear more productive than the comparison group but this effect might be caused by the variable of interest (mobility) or by other variables (e.g. ability, greater motivation) in the mobile group, for which data are not available and thus are not controlled for. If we assume that only the most promising and productive researchers are offered positions and are able to move, this introduces two elements which need to be solved: 1) reverse causality - the probability of moving depends on past productivity (the variable of interest is not exogenous), and 2) omitted variables - the ability to do research (and be productive) influences both the probability of being offered a position, and research productivity. Then the challenge is to isolate the effect of the omitted variable and to resolve the reverse causality problem.

In an ideal setting social scientists want to study the effect of mobility in an experiment that randomly assigns researchers into a mobile or an immobile group, thereby exploiting an exogenous source of variation in the explanatory variable to analyze the effect of mobility on productivity. A natural experiment sets an exogenous and abrupt change in the group under scrutiny. For example, a university department that is unexpectedly closed forcing all researchers to move, assuming that the closure was not caused by their productivity. Then the possible causal link of productivity on mobility can be controlled for by using this external shock as an instrument, or by defining an unaffected control group. Moser et al., (2014) use the dismissal of Jewish scientists from Nazi Germany as a natural experiment to address the endogeneity problem in an analysis of mobility to the US. Similarly, Borjas and Doran (2012) use the collapse of the Soviet Union as an external shock to measure mobility and productivity. Alternatively, when treatment effectively is random, the regression discontinuity (RD) design (Imbens and Lemieux, 2008) can be used. This assumes

that the value of a treatment predictor is on either side of a fixed threshold. This design can be applied to situations where an administrative body sets transparent rules for treatment and defines a cut-off point due to resource restrictions. The RD design was implemented originally by Thistlewaite and Campbell (1960) who analyzed the impact of scholarships based on observed test scores, on future outcomes, and compared the group that just passed with the group that just failed. In the case of mobility, the RD design is particularly useful to assess PhD student/postdoc mobility if places are determined by a placement test/assessment (such as in the case of the European Commission Marie Skłodowska-Curie grants) or participation in research visit programs when these are determined by a stringent set of criteria (e.g. the Fulbright Program). In the case of job-to-job mobility the RD design is difficult to implement since assignment to treatment is not based on program participation or observable selection criteria.

Thus, natural experiments and quasi-randomized assignment represent rare events that allow for advanced econometric exercises but are of little policy relevance to investigate the importance of job-to-job mobility. If the interest is in analyzing common patterns of mobility in science we need to develop econometric models that address intrinsic problems of heterogeneity, endogeneity, and selectivity differently. Since mobility cannot be randomized, the most common solution in econometric analysis is to control for confounding factors, for example, gender, age, and past productivity. However, standard models do not adjust for confounding if the treatment - in our case mobility - is time-variant (Robins, 1999). Thus, controlling, for instance, for past values of productivity which affect later mobility but which may be affected also by earlier mobility, can lead to biased estimates because we control for the pathway that is hypothesized to lead to higher productivity. A second solution would be to use fixed-effects estimators which remove individual unobservable time-invariant differences between mobile and immobile researchers. However, they do not adjust for unobserved time-varying confounding, and thus might still result in a spurious correlation between mobility and publications (Robins, 1999).

We need to discuss other research designs able to deal with reverse causality and selection processes such as instrumental variables (cf. Wooldridge, 2010) and treatment effects (cf. Wooldridge, 2006). Instrumental variables are variables that affect the regressor causing the bias but do not affect the variable under scrutiny. When analyzing the effect of mobility on productivity, instrumental variables for mobility are those variables that affect mobility but not productivity. However, finding plausible instruments is very difficult, especially in the case of mobility and productivity, where one researcher's instrument might be another researcher's hypothesized cause of publication. Addressing the causality between inventor mobility and productivity, Hoisl (2007) proposes a simultaneous relationship and considers "city size" as an instrument for mobility in the productivity equation, and "external sources of knowledge" as an instrument for productivity in the mobility equation. Toole and Czarnitzki (2010) use lagged regional variables as an instrument in their productivity equations for joining or founding a firm. While these instruments might explain mobility opportunities to business firms without effecting productivity, they are less convincing in the academic context. Researchers in larger or more dynamic cities may have both more employment opportunities and proximity to more peers which may also affect their productivity. A positive effect of mobility on publications may simply be a spurious relation caused by access to larger networks. However, instruments beyond regional indicators are difficult to identify and measure.

We propose six instruments for voluntary mobility of permanent academic staff. We consider these instruments feasible although likely to involve extensive data compilation.

(1) Dahl and Sorenson (2010) show for a sample of Danish scientists and engineers, and Gibson and McKenzie (2011) for a sample of migrants from three Pacific countries, both of which are highly skilled, value proximity to family and friends, and are willing to forgo a part of their incomes to live closer to home. Franzoni et al. (2012) confirm that family ties are an important motivation for research active scientists to return to their home countries. Therefore, we propose the distance to

one's place of birth, and the distance to the city of undergraduate education as the first set of instruments. Researchers that live further away from home are more likely to move since the social costs associated with a move are lower. Distance from home should not affect productivity although this cannot be ruled out since close family may provide help with childcare which in turn, could affect productivity.

(2) Our second instrument is the number of available job openings. Job openings directly affect the opportunities for receiving job offers and accepting an offer. Detailed information on available positions in a given year, field, and ranking could act as instruments for mobility and should not affect productivity unless they represent an overall increase in capital availability for universities.

(3) Third, we suggest using the foreign language proficiency of researchers. Language proficiency is assumed to be correlated to the researcher's interest in other cultures and could indicate a higher propensity to be mobile without affecting productivity. Gibson and McKenzie (2011) confirm that highly able students who study a foreign language are more likely to emigrate.

(4) Previous papers have used migration during childhood (Franzoni et al., 2012), or participation in international exchange programs during undergraduate studies (Parey and Waldinger, 2011) as instruments for later migration. Franzoni et al. (2012) concede that their instrument is valid only if early migration happens irrespective of investment in education and parents' wealth. However, Gibson and McKenzie (2011) show that when controlling for education and parents' characteristics, migration during childhood has no effect on later migration.

(5) Gibson and McKenzie (2011) find weak evidence that a spouse with a foreign nationality will reduce the propensity to return to the home country. Family characteristics such as spouse's background (in terms of distance to home, or profession), or children's age might explain mobility. Researchers' with school age children are expected to move less. While young children can have a

performance hampering effect for female researchers, children of school age do not affect performance significantly (Stack, 2004) and could present a possible instrument.

(6) Finally, to control for individual time varying characteristics that might affect mobility it is possible to compute a performance mismatch instrument based on the idea that rising star scientists might have incentives to leave departments that are in a relative productivity decline. A scientist with increasing productivity located in a department that experiencing an overall decrease in performance will not only have a higher incentive to move out but also will have more opportunities.

In Fernandez-Zubieta et al. (2015b), we present the results of the estimates using instruments one and six.

In the absence of natural experiments and instruments we can address the problem of reverse causality by modeling the likelihood of being treated. Thus, we can account for selection into mobility based on pre-mobility observable characteristics. Amongst the important selection criteria that should be considered when matching academics are age, experience, contract type, past productivity, prior mobility events, family related factors, and reputation factors. The sample should be split into a treated group and an untreated control group. Treatment effect methods assume that each individual has potentially two outcomes dependent on treatment. Thus, by assuming that the treatment and control groups are alike we can estimate the causal effect. Selection on observables is achieved through propensity score matching (PSM) (Rosenbaum and Rubin, 1983). PSM allows the propensity for each individual to be mobile to be modeled and creation of a control group based on propensity scores.[17] If treatment, confounding variables and outcome variables vary over time, estimates based on PSM may be biased (Robins, 1999). Robins and colleagues (e.g. Robins, 1999; Robins et al., 2000; Hernan et al., 2001) propose inverse probability of treatment weights (IPTW) to

[17] Other matching techniques are Mahalanobis matching or coarsened exact matching (CEM) (Blackwell et al., 2009).

deal with this problem. IPTW allows the estimation of average treatment effects even if confounding variables predict publications and mobility, and are themselves predicted by past-mobility. Thus, they allow us to consider past publication and past mobility events for estimating selection into mobility. The problem of matching based on observables is that the likelihood of being mobile also depends on unobservable characteristics. Thus matching can reduce endogeneity concerns but not eliminate them (Heckman and Navarro-Lozano, 2004).

5. Conclusion

Academic mobility is not a new phenomenon. Since universities began to flourish in Medieval Europe academics have moved across institutions acquiring new knowledge and social connections and bringing and diffusing their knowledge to new colleagues and students. In recent years, scientists' mobility has increased significantly and has been associated with major changes in research systems. In this chapter we have identified and discussed mobility along three main dimensions: internationalization, increasing inter-sector collaboration, and diversification of career and work roles. The literature on mobility of researcher scientists is scarce due to lack of reliable data to trace scientists along their careers. However, we have highlighted some overall trends and discussed some individual and social advantages and disadvantages of researcher mobility.

The literature review suggests that in order to properly analyze the effect of mobility in the current evolving research system it is necessary to consider multiple mobility events and short and long-term return opportunities (not just to consider mobility as a one-time, one-way process). A life course perspective should be adopted in order properly to assess the positive or negative effects of increased researcher mobility.

We have highlighted that the analysis of mobility requires identification and selection of the most relevant mobility events in a researcher's career. We have presented a typology of mobility that

differs between educational, job-to-job, occupational, sectoral, geographical, social, and disciplinary mobility, and a researcher's career trajectory, which allowed us to select job-to-job mobility as the main mobility type in a researcher's career, and to consider the other mobility types across it. We emphasized the need for clear differentiation of job changes among researchers in permanent positions versus non-tenured, non-permanent positions when analyzing the impact of mobility on productivity. The analysis of job positions at the individual level allows analysis of the relationship between different types of mobility, academic markets, and researcher careers.

We reviewed the different research designs able to deal with biases such as unobserved heterogeneity, endogeneity, reverse causality, in order to study the causal links between mobility and researchers' productivity. We considered the advantages and disadvantages of these methods - natural experiments, quasi-randomized assignment, instrumental variables, and treatment effects - and discussed some possible instruments.

There are several reasons for adopting a life course perspective (sequentialist approach) to study mobility and to overcome some of its limitations. Firstly, changes in the research system require an analysis of mobility that does not consider mobility as a one-time, one-way event. Secondly, there might be a relationship between diverse mobility experiences. For example, deterioration of young researchers' employment prospects and increased young researcher job-mobility (precarité) (e.g. increased number of postdoctoral positions) which might decrease job-prospects and performance for a senior researcher (mobility path dependence). Thirdly, the prospect of increased availability of longitudinal datasets encourages the analysis of mobility in a life course perspective and addresses biases when analyzing causal links. Finally, the strong policy interest in mobility requires tools able to properly evaluate the outcomes of these policies.

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