



International mobility of researchers

A review of the literature

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Preface

RAND Europe has been commissioned by the Royal Society to investigate the international mobility of researchers, with a particular focus on the UK. The aim of the work is to better understand the patterns of mobility, drivers of and barriers to mobility, and the benefits and consequences of mobility of researchers, in academia and industry. This work consists of two strands: a review of the existing literature and a survey of researchers currently based in the UK, addressing some of the gaps identified in the existing evidence. This report details the findings of the literature review; the findings of the survey can be found in the related report 'International mobility of researchers: A survey of researchers in the UK'.

The report is likely to be of relevance to policy makers, research funders and managers,

professional bodies, and the research community more widely.

RAND Europe is a not-for-profit policy research organisation which aims to improve policy and decision making through research and analysis. For more information on this report or RAND Europe more widely, please contact Dr Susan Guthrie.

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Executive summary

The aim of this literature review is to develop a better understanding of international researcher mobility patterns and drivers, with a particular focus on mobility to and from the UK, and including researchers in both academia and industry. In the context of the UK's recent decision to leave the EU, it is particularly pertinent to understand how researchers move across borders. We conducted a focused systematic review of the literature, and identified five key evidence-based findings on international researcher mobility:

Finding 1: The UK is an attractive destination for researchers, and foreign researchers play an important role in the research system

Overall, the global population of researchers in the UK, EU and beyond is growing. In the UK, the proportion of researchers and doctoral candidates who are from outside the UK is rising. The UK is an important training ground, attracting a large number of international doctoral candidates and leading the EU in hosting researchers funded by the European Research Council and Marie Skłodowska-Curie Action researchers. Nevertheless, as mobility becomes more common among researchers, the US remains the top research destination.

Finding 2: Researchers' decisions to move are complex and involve a range of personal and professional factors

Researchers make considered choices about their location, and decisions about whether and where to move are shaped by a variety of factors as individuals seek to maximise benefits (professional and personal) and minimise negative effects for themselves and their families.

Overall, researchers move primarily for professional reasons, whether in the short or long term. Key drivers on a professional level are the desire to develop international research networks and collaborations, and to access specific expertise, resources or prestige that allow them to progress their careers. This means that the relative strength of national research systems acts as both a driver and an inhibitor of mobility (depending on the direction of travel).

Differences in entitlements and immigration rules in destination countries can inhibit research mobility, even within the EU, despite the efforts of the EU to develop the ERA. In addition, labour market conditions and the availability of funding can be important barriers for some groups – difficulty obtaining funding is a key barrier to mobility expressed by researchers, particularly those at earlier career stages.

Other wider considerations also play into mobility decisions. Factors related to the culture, language and geographic proximity of destination countries shape patterns of researcher mobility, and children and relationships can act as a barrier to mobility, especially for women.

The relative importance of drivers varies across career stages, geographies and gender. For example, early career researchers prioritise availability of funding, positions and opportunities for career progression while more senior researchers place more value on research autonomy and personal life.

Finding 3: As a popular destination country, the UK benefits from international mobility by gaining access to additional skills and expertise, but there are also benefits for source countries.

It is generally understood that destination countries benefit from having a strong supply of well-qualified workers. However, it is less clear that source countries experience a loss, as might be expected, since mobile researchers tend to retain productive links with their home countries and may also return home, bringing additional skills and expertise. In the case of doctoral students studying in the UK, many return to their home countries to pursue research, bringing skills and training back with them.

Finding 4: International mobility is associated with improvements in researchers' professional development and academic performance, though causality is difficult to establish

Mobility is associated with better international networks, more research outputs, higher-quality outputs and, for most, better career outcomes. However, while these associations are clear, it is more difficult to establish whether these are benefits of mobility, or whether they reflect intrinsic differences in the characteristics of mobile and non-mobile researchers. Only a limited number of studies have tried to establish a causal link, and the results are mixed, with some showing that the positive outcomes are a result of mobility, and others suggesting that they can be explained by differences in the characteristics of the researchers. However, for destination countries such as the UK, as well as their institutions, access to these high-performing researchers – whether this performance is due to their mobility or their intrinsic characteristics – remains a strong benefit.

The nature and extent of these benefits differ across groups. For example, benefits around academic output and, particularly, networks, are more pronounced for senior researchers, whereas junior researchers benefit more in terms of skill and career development. The benefits of international mobility also vary by academic discipline gender, length of stay and country of origin and destination.

Finding 5: Further research is needed to deepen understanding of international mobility and to untangle the different outcomes and drivers of mobility between groups and in different contexts. There is also a particular gap in understanding of industry researchers

One key gap in the evidence is around researchers in industry. Although they make up around half of all EU researchers, evidence on their mobility experiences is limited, with several studies that have attempted to gather evidence on this group noting that the population is less well-defined and harder to reach than academic researchers. There is also fairly limited evidence on the effect of immigration rules on migrant researchers' attitudes to and experiences of mobility (particularly in the UK context). Evidence around the social implications of mobility is limited, with most studies focusing on benefits to the economy, careers or academic output and networks. More work is needed to reflect on the diversity of mobility experiences and drivers and their implications for the benefits (and disadvantages) of mobility. A few studies break down the differences in mobility experiences and the benefits that accrue across stakeholders depending on the length of time spent in a different country, career stages, and other factors such as personal circumstances, age and gender. Available evidence suggests that these factors do lead to important differences in terms of outcomes. Finally, what counts as mobility, how a researcher is defined (particularly in industry) and how their point of origin is determined varies between studies. This lack of comparable definitions of mobility prevents the various sources of evidence from being synthesised to strengthen our understanding. Work is needed to improve the comparability and aggregability of definitions in order to build a more powerful evidence base around the patterns, drivers and outcomes of mobility.

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1. Introduction and background

The aim of this literature review is to develop a better understanding of international researcher mobility patterns, drivers and barriers, with a particular focus on mobility to and from the UK. A further aim is to examine the benefits and consequences of researcher mobility, both in academia and industry. In the context of the UK's recent decision to leave the EU, it is particularly pertinent to understand how and why researchers move across borders.

Previous work by the Royal Society has identified that the UK has a highly mobile researcher population, with almost 70 per cent of active UK researchers in the period 1996–2011 publishing articles in which they were affiliated with non-UK institutions, indicating that they had worked abroad at some point during that period (Royal Society 2016). Attracting talented researchers to the UK from overseas is important to UK science, and 28 per cent of the 194,190 academic staff in UK universities are non-UK nationals.¹ Given the importance of mobility to the UK research system, and that researchers from other countries form an integral part of that system, it would be valuable to better understand the factors that influence mobility, its benefits, and what makes the UK an attractive place to conduct research.

The study of researcher mobility is not new, though the framing and conceptualisation of the issue has changed over time. In fact, the term 'brain drain' was coined by the Royal Society in their 1963 study looking at the emigration of UK scientists to the US and Canada (Royal Society 1963). More recently, the term has been used to describe the flow of high-skilled workers,

including researchers, from the developing world to wealthier countries, with corresponding ethical concerns and implications around the loss of resources (Meyer 2001). However, this conceptualisation neglects many facets of mobility – it does not reflect the mobility of researchers between relatively wealthy countries (e.g. a UK researcher moving to the US) or, indeed, the fact that many researchers move between multiple locations over the course of their career. As a result, the discourse has shifted away from this type of thinking over recent years, towards concepts of 'brain circulation' or 'brain mobility', terms coined to better capture the diversity of mobility pathways (Gaillard & Gaillard 1997; Johnson & Regets 1998). There is a multi-centred, temporary and ongoing movement of researchers and other highly skilled individuals across and between national boundaries.

One facilitator of mobility for researchers in the UK and Europe more widely has been the EU's effort to create a European Research Area (ERA), which is intended to act as an open labour market for researchers, increasing researcher mobility as well as training and career development, and making Europe a more attractive research destination (European Commission 2012). A range of ERA initiatives has aimed to address some of the barriers to mobility by improving access to information, ensuring fair recruitment (Smith 2015), and reducing bureaucratic barriers (European Commission 2012). However, movement to and from the UK is not limited to European countries, and policies exist at the national level in many countries to support and facilitate the movement of researchers. For example, many of the UK

1 2015/16 data from Higher Education Statistics Agency, analysed by the Royal Society.

research councils have funding schemes to support UK researchers to spend extended periods working overseas. It should also be noted that researcher mobility takes place in the wider context of national policies, such as rules around immigration, which may influence mobility behaviours and experiences. A range of policy options has been employed by different countries with the aim of attracting international students and researchers, and a summary of these different options is presented in Table 1.1.

Patterns of mobility also tend to reflect ongoing economic and social factors. For example, the recent economic crisis led to outflows of researchers from southern European countries, facilitated by the ERA allowing them to move to other parts of Europe where opportunities were perhaps more readily available (Weert 2013). Meanwhile, rapid growth in the number of scientists at the global scale – driven by China and other countries – has begun to shift

the balance of scientific activity and leadership away from the wealthiest and most industrialised nations. These trends emphasise the relevance of ongoing discussion around issues of ‘brain drain’ and ‘brain circulation’ and the need for a better understanding of the patterns, drivers and outcomes of the movement of researchers.

These debates have become even more pertinent in light of recent political and popular movements, where aspects of globalisation are being rejected in favour of a focus on national interests. In this context, national policies on migration are subject to change, and the costs and benefits of the movement of people are important political issues. In the UK context, the forthcoming exit from the EU is particularly significant, and it is thus important to understand the role that mobility plays in research in the UK and more widely, to ensure that debate and discussions informing these changes are based on the best available evidence.

Table 1.1. Main policy options to attract inward international mobility of students and researchers

Policy area	Types of instrument	Examples
Funding, financial incentives and working conditions	Fellowships and scholarships for foreign students and researcher; lead researcher positions	Finland (Distinguished Professor Programme); Germany (Graduate School Scholarship Programme); Ireland (International Scholarships)
Degree recognition	Mutual agreements and implicit rules for the recognition of foreign degrees (or credits acquired abroad)	Europe (Bologna process)
Social and cultural support	Relocation assistance and information; grants for spouses and family	Austria (Dual Career Grant); Belgium (Mobility centres)
Visa and immigration policies	Simplified visa process for highly skilled and students	Belgium; Canada (Temporary Resident Program); Netherlands; France
	Post-study work rights for postgraduate students	Australia
	Recognition of overseas qualifications	Germany (Recognition of Qualifications Act 2012); Switzerland
Creating an international environment	Structure of the academic calendar; rules concerning sabbaticals	Germany
	Increased use of teaching in English or a foreign language	Slovenia (National Programme for Higher Education 2011–20)

Source: OECD STI Outlook policy questionnaire 2014 (OECD 2014)

1.1. What is meant by researcher mobility?

The literature refers to a range of types of mobility: between industry and academia, across disciplines, and between institutions within national borders. In the context of this review, we are focused on the mobility of researchers in academia or industry between countries (with a particular focus on the UK). Even within this narrower definition, there is a range of different activities encompassed, from shorter-term exchanges, placements and sabbaticals, to PhD study or postdoctoral research abroad, through to extended periods of employment overseas. Differences in patterns, drivers and experiences between different career stages and lengths of stay might be significant; however, they may also be difficult to untangle. Evidence from Weert (2013), who used three months as a cut-off point in terms of length of stay, found that long-term (> three months) and short-term (< three months) mobility profiles are strongly interrelated. It seems that researchers who are mobile once are more active in terms of future mobility. There are also different directionalities of travel, with motivations, patterns and outcomes differing between departing and returning migrants, and those travelling between different countries and regions.

In addition, there are differences in how country of origin is defined, with approaches used varying from researcher nationality, to country of birth, or where a PhD was completed. The general lack of clear definitions around mobility is also noted by Weert (2013), who suggests that developing a common and widely used set of definitions would be beneficial both to facilitate the monitoring and evaluation of policy efforts, and to allow comparisons across studies.

There can also be challenges in defining what constitutes a researcher. In academia, this is fairly well understood – for example, in the UK, researchers have to declare whether they are ‘research active’ for the purposes of the Research Excellence Framework (REF), and

this is mapped at an institutional level through annual submissions of data to the Higher Education Statistics Agency (HESA). In industry, the situation is less clear cut. Many researchers will not necessarily have a PhD, and equally there may be highly skilled staff (including those with PhDs) in non-research roles. In addition, the lines between research, development, evaluation and implementation are blurred, and equally many senior researchers will move into more management-focused roles taking in both the oversight and direction of research but potentially a range of other responsibilities too. As such, the way a researcher, and indeed mobility, are defined differs from study to study; so far as it is possible, we will reflect this in our analysis and discussion.

1.2. Our approach

This report draws on a scoping review methodology (Levac, Colquhoun & O’Brien 2010) to establish what is known about the international mobility of researchers, in relation to patterns of mobility, drivers of and barriers to mobility, and the benefits and consequences of mobility, with a particular focus on researchers moving to and from the UK. Our approach followed the principles of a systematic review in terms of having clearly defined research questions, systematic and replicable search strategies and explicit inclusion and exclusion criteria. We assessed quality (relevance, study design and interpretation) and used it as a basis for excluding some studies. We also noted methodological concerns in our synthesis. In general, we sought to undertake a narrative synthesis rather than pool numerical results based on our research questions and knowledge of the literature. More details describing the methodology and key sources of evidence can be found in the appendix. In the following chapters we set out our results, describing the evidence around patterns of mobility (Chapter 2), drivers of and barriers to mobility (Chapter 3), and the benefits and consequences of mobility (Chapter 4). Finally, in Chapter 5 we set out our

conclusions and discuss the overarching themes and issues, as well as the limitations of and gaps in the available evidence. The evidence gaps identified informed the development of

a survey of UK researchers, the findings of which are reported in 'International mobility of researchers: A survey of researchers in the UK' (Guthrie et al. 2017).

2. Evidence on international mobility patterns

In this chapter, we review the existing data on patterns of mobility amongst researchers. As there is limited evidence available on researchers in industry, this will primarily focus on academic researchers. We describe trends in the movement of researchers, the overall researcher population in the UK and Europe, and also how these trends differ between different groups. It is important to note throughout that mobility is defined in different ways in the literature and takes many forms, varying in duration, purpose, frequency and other aspects. These differences make aggregation and comparison of data across studies difficult. Nonetheless, we are able to identify some clear patterns and trends.

2.1. Researcher populations are rising

The number of researchers has rapidly increased within Europe and beyond, as indicated by data for the EU and OECD regions (Table 2.1). According to Eurostat data, in 2015 there were 1.8 million full-time equivalent (FTE) researchers in the EU-28, up from 1 million in 1995, with half of them (48 per cent) working in the business enterprise sector, 39 per cent in higher education and 12 per cent in government (Eurostat 2017a). A similar trend can be observed across the OECD, where the number of individuals with doctoral degrees rose by 38 per cent from 2000 to 2009 (Auriol, Misu & Freeman 2013).

In the UK, overall increases were less marked. The increase in the number of researchers overall (in all sectors - academia and industry) between 2007 and 2011 (about 1 per cent per

year) was on par with the average global rate of growth during that period, and slightly above that for EU-27 and OECD countries (Elsevier 2013). Of these researchers, 62 per cent (164,000) are in HEIs; their population increased by about 2 per cent per year between 2008 and 2012, whereas the population of researchers working in industry fell by about 1 per cent per year during the same period. As of 2015, according to OECD figures, 1.2 per cent of UK working-age adults have a doctoral or equivalent degree, slightly higher than the OECD average of 1.0 per cent and slightly lower than the US, where it is 1.6 per cent (OECD 2016). Over the period 1995/6 to 2003/4, the number of permanent academic staff in the UK rose by 16 per cent, and between 2005 and 2015 the total number of academic staff rose by 22 per cent (Table 2.1) (Universities UK 2007; HESA 2017a).

In several countries, including the UK, there is a large proportion of researchers from abroad (Table 2.2). The MORE2 survey looked at the number and distribution of researchers from non-EU countries in the EU, and found that there are about 70,000 non-EU researchers working in the EU, making up 6 per cent of all EU researchers. The main source countries for these researchers were China (13 per cent), India (12 per cent) and the US (11 per cent). The non-EU researchers were concentrated in just a few countries, with the UK and Germany hosting more than half of them (Weert 2013).

According to findings from the 2011 GlobSci Survey (Franzoni, Scellato & Stephan 2012), those who had been living in a country different to their present location at age 18, Switzerland had the largest proportion of foreign scientists

Table 2.1. Size of research-relevant populations in the EU, OECD and UK according to various data sources

Population size	Region	Year	Source
1.8m (FTE) researchers (all sectors)	EU-27	2015	Eurostat (2017b)
1.6m (FTE) researchers	EU-27	2010	Eurostat (2017b)
1.3m (FTE) researchers	EU-27	2005	Eurostat (2017b)
0.96m (FTE) researchers	EU-27	1995	Eurostat (Mogu�rou & Paola Di Pietrogiacomo 2008)
213,000 doctoral degree holders	OECD	2009	OECD (Auriol, Misu & Freeman 2013)
154,000 doctoral degree holders	OECD	2000	OECD (Auriol, Misu & Freeman 2013)
290,000 (FTE) researchers	UK	2015	Eurostat (2017b)
260,000 (FTE) researchers	UK	2010	Eurostat (2017b)
250,000 (FTE) researchers	UK	2005	Eurostat (2017b)
201,000 academic staff	UK	2015	HESA (2017a)
165,000 academic staff	UK	2005	HESA (2017a)
140,000 academic staff	UK	2000	HESA (2017b)
59,000 permanent academic staff	UK	2003/4	HESA
51,000 permanent academic staff	UK	1995/6	HESA

Row colours are used to help differentiate data sources.

worldwide (57 per cent). The UK was sixth with 33 per cent (Table 2.2).

In 2006, in the 14 EU Member States² where reliable Eurostat data were available on the Human Resources in Science and Technology Core (HRSTC; people who have completed tertiary education and are employed in science or technology), on average 4 per cent of the HRSTC were non-nationals (2.4 per cent were from the EU and 2 per cent were from non-EU countries). Luxembourg had the highest share of non-nationals (51 per cent, of which 95 per cent are EU nationals), though it should be noted that this is relative to a small national population,

and the UK had the highest share of non-EU country nationals (4.0 per cent). The UK also had the lowest share of EU citizens among its non-nationals (37 per cent), and Luxembourg had the highest (96 per cent), though again the relative size of the population there should be taken into account. The second highest was Belgium (85 per cent). (Mogu rou & Paola Di Pietrogiacomo 2008).

2.1.1. Proportions of non-UK national researchers are rising in the UK

According to the UK's Higher Education Statistics Authority (2017a) among the 198,000 academic staff³ employed in UK HEIs in 2015/16

2 The 14 MS were: Belgium, the Czech Republic, Denmark, Germany, Greece, Spain, France, Cyprus, Luxembourg, the Netherlands, Austria, Finland, Sweden and the UK. There is also data (Table 16) for Norway and Switzerland. They accounted for 26 million of the 35 million HRSTC in the EU-27 (75 per cent).

3 'Academic staff' includes those engaged in teaching and/or research, as well as those with academic administrative appointments (e.g. Vice-Chancellors).

Table 2.2. Proportion of researchers from abroad (EU and national level)

Proportion of researchers from abroad (EU level)	Region	Year	Source
6% of EU researchers were from outside EU	EU	2011–2013	MORE2 Survey
4% of HRSTC personnel were not nationals of the country where they were working	14 EU member states	2006	Eurostat
2% of HRSTC personnel were not EU nationals	14 EU member states	2006	Eurostat
Proportion of researchers from abroad (national level)			
57% of researchers ⁴ were from another country	Switzerland	2011	GlobSci Survey (Franzoni, Scellato & Stephan 2012)
47% of researchers were from another country	Canada	2011	GlobSci Survey
45% of researchers were from another country	Australia	2011	GlobSci Survey
38% of researchers were from another country	US	2011	GlobSci Survey
38% of researchers were from another country	Sweden	2011	GlobSci Survey
33% of researchers were from another country	UK	2011	GlobSci Survey
6% of HRSTC personnel were not nationals of the country	UK	2006	Eurostat
29% of academic staff were non-UK nationals	UK	2015/16	HESA (Universities UK 2007)
19% of academic staff were non-UK nationals	UK	2005/6	HESA (Universities UK 2007)
13% of permanent academic staff were non-UK nationals	UK	2003/4	HESA (Universities UK 2007)
8% of permanent academic staff were non-UK nationals	UK	1995/6	HESA (Universities UK 2007)

Row colours are used to help differentiate data sources.

with known nationality, 140,000 (71 per cent) had UK nationality and 29 per cent were from outside the UK (Table 2.2).⁵ This proportion represents a substantial increase from 2005/6, when 19 per cent of academic staff (of known nationality) had non-UK nationality (Universities UK 2007). This suggests that the UK is an increasingly attractive destination for foreign researchers.

This trend has been consistent further back in time, there was a similar trend for the period 1995/6 to 2003/4: the number of permanent academic staff rose by 16 per cent overall in

this time, and the number of non-UK staff nearly doubled (from about 4,000 to about 7,600) (Universities UK 2007).

However, UK researcher migration trends vary by career stage; according to an analysis of data from 2005/6, the net UK migration trends flip from early to later career stages. Among early career researchers, such as lecturers, there was net inward migration, while among senior lecturers and professors, the opposite was the case (Universities UK 2007).

4 'Researchers' were defined as corresponding authors of research articles published during 2009.

5 Among those with non-UK nationality, 34,000 were from another EU country and 25,000 had a non-EU nationality.

2.2. The UK has a relatively heterogeneous population of foreign researchers

There are considerable differences in terms of the makeup of foreign researcher populations in different countries. The UK is deemed to be fairly diverse on this basis, along with Germany, France and Sweden. According to analysis from the GlobSci Survey, which assessed diversity by looking at what percentage of a country's foreign scientists come from the top four source countries for each country, the UK was fairly diverse with 38 per cent, ranking fourth behind Germany (30 per cent), Sweden (35 per cent) and France (37 per cent). The countries at the other end of the spectrum, with the highest concentrations of researchers from the top four source countries, were Japan (61 per cent) and Switzerland (60 per cent) (Franzoni, Scellato & Stephan 2012).

Findings from an analysis of ERC applicants are broadly similar. Among countries with larger shares of foreign-born ERC applicants, the UK, France, Germany and Sweden were all relatively heterogeneous, with no country being the country of birth for more than 14 per cent of the foreign-born applicants. In the UK, 14 per cent were born in Germany, 9 per cent in Italy, 8 per cent in the US and 5 per cent in Greece. Austria, Switzerland and Ireland (which, respectively, had 47 per cent, 74 per cent and 57 per cent of their applicants being foreign-born in the period 2007–2012) had less heterogeneous populations of foreign researchers. For Austria and Switzerland, Germany was the country of birth for 27 per cent and 42 per cent of researchers, respectively, while in Ireland, 29 per cent of researchers were born in the UK (Mugabushaka, Rieder & Toma 2014).

Among academic staff at UK HEIs, as of 2005/6, the most common country of nationality was

Germany, followed by Ireland, the US, China and Italy (Universities UK 2007).⁶ However, national representation differed for staff of different grades, with Chinese nationals being the most numerous non-UK group among staff graded as researchers, Germans being the most numerous at lecturer grade, and US nationals being most numerous at professor grade (Universities UK 2007).

Non-UK nationals with academic positions at UK HEIs are also more likely to have doctoral degrees than their UK counterparts, and they tend to be younger. As of 2005/6, just over half (53 per cent) of non-UK nationals with UK academic positions had doctoral degrees, compared with 41 per cent of UK nationals. The majority of UK staff (67 per cent) were 40 years and older, while the majority of non-UK staff (64 per cent) were under 40 years old in 2005/6 (Universities UK 2007).

2.3. The UK is a leading international doctoral training destination

Both the EU and UK are important destinations for doctoral training. An analysis of Eurostat data from 21 EU member states showed that, in 2005, 6 per cent of the 487,000 PhD candidates in the EU were citizens of another EU member state, and 14 per cent were citizens of countries outside the EU (Mogu  rou & Paola Di Pietrogiacommo 2008). The non-EU countries supplying the most PhD candidates were China (8 per cent of all PhD candidates from non-EU countries in the EU), followed by Mexico, Morocco, and then the US, which ranked fourth (4 per cent) (Mogu  rou & Paola Di Pietrogiacommo 2008).

According to HESA data, the number of international students in UK research degree programmes tripled between 1994/5 and 2012/13 (Fern  ndez-Zubieta, Geuna & Lawson

6 According to the GlobSci Survey, the main countries supplying foreign researchers to the UK were Germany (15 per cent) and Italy (10 per cent) (Franzoni, Scellato & Stephan 2012).

2015). In 2014, the UK, which had 5 per cent of the total OECD population, hosted 15 per cent of the students studying at master's and doctoral levels in OECD countries (OECD 2016). Also in 2014, 42 per cent of UK doctoral students were from outside the UK; the UK thus ranks fourth among OECD countries on this indicator (behind Luxembourg, Switzerland and New Zealand). In 2011, there were about 20,000 UK PhD graduates, a figure that increased by about 3 per cent per year from 2007 to 2011 and makes the UK the world's fourth largest producer of PhD graduates (behind the US, China and Germany) (Elsevier 2013).

Among EU member states, the UK was the top receiving country for PhD candidates from both within and outside the EU in 2005. It had the highest net gain of intra-EU PhD candidates that year (in absolute and relative terms), with a net gain of 5,300 foreign EU PhD candidates (6 per cent of all PhD candidates in the UK) (Mogu rou & Paola Di Pietrogiacommo 2008).⁷ In the same year, the UK was the member state with the most foreign doctoral candidates of EU origin, 11,500, followed by France with 5,400 and Spain with 3,100 (Mogu rou & Paola Di Pietrogiacommo 2008). The UK was also the leader in relative terms, with its 11,500 candidates of EU origin making up 12.5 per cent of all UK doctoral candidates, followed by Austria (12.5 per cent) and Belgium (12.1 per cent). In 13 of the 21 reporting member states, foreign EU nationals made up less than 5 per cent of the doctoral candidates (Mogu rou & Paola Di Pietrogiacommo 2008).

As the top receiver of candidates from non-EU countries in 2005, the UK received 24,100 candidates, followed by France (23,000) and Spain (11,300), with the three countries together accounting for 85 per cent of the non-EU PhD

candidates across the EU (Mogu rou & Paola Di Pietrogiacommo 2008). The EU received 3,000 PhD candidates from the US in 2005; the majority of them (2,400) chose to study in the UK (Mogu rou & Paola Di Pietrogiacommo 2008). Non-EU doctoral candidates made up 26 per cent of the PhD candidates in the UK in that year, putting the UK behind France, which had 28 per cent (Mogu rou & Paola Di Pietrogiacommo 2008). Consistent with these patterns, MORE2 data showed that PhD candidates from non-EU countries are concentrated in a small number of countries in the EU; close to two thirds of them study in either France or the UK (Weert 2013).

2.3.1. The postdoctoral period is an important time for mobility

The postdoctoral period is also an important time for mobility, though it receives less focus than the doctoral training period in reports, studies and official statistics. According to an analysis of UK researchers (using UK academic scientists' CVs, ISI web of knowledge bibliometrics data, and European patent office data), 57 per cent of researchers in the sample had moved from their PhD institution to take a postdoctoral position elsewhere. Among those who changed institutions, international postdoctoral stays were twice as common as national ones (38 per cent of postdoctoral fellows had an international stay versus 19 per cent with a national stay; the rest remained at the same institution) (Zubieta 2009).

Among researchers who obtained a doctoral degree in the UK in 2004/5 (of which 29 per cent were non-UK nationals⁸), 80 per cent remained in the UK three-and-a-half years later, either working or doing further study, while at least 12 per cent were overseas, according to a survey

7 Other countries with a positive intra-EU net gain were France, Spain, Austria, Sweden, the Czech Republic, Finland and Belgium.

8 There were 15,800 doctoral graduates in 2004/5 in the UK, of which 61 per cent were UK nationals, 13 per cent were from elsewhere in the EU, and 26 per cent were from outside the EU (Vitae 2010).

conducted in 2008.⁹ Graduates from elsewhere in the EU were much more likely than UK nationals to move overseas after graduation; 54 per cent did so, compared with just 7 per cent of UK nationals (Vitae 2010).

2.4. Elite researchers have historically been concentrated in the US

Studies of elite researchers have emphasised the importance of the US as a research destination. Using data on Nobel Prize winners in chemistry, medicine and physics, along with data on highly cited researchers, Weinberg (2009) showed that British science declined slightly in its global position in the 20th century, particularly in physics, but retained a relatively stable, strong position, while there was more of a declining trend in Germany. In contrast, the US saw a very strong increase in its scientific leadership over the same period (Weinberg 2009). This observation was supported by another study of Nobel science prizes in physics. Hunter, Oswald & Charlton (2009) showed that the UK was successful at winning these prizes in 1947–1966 but then its performance declined relative to the US, and from 1967–2006, 10 laureates moved from the UK to the US but none moved in the other direction (Hunter, Oswald, and Charlton 2009).

Hunter, Oswald & Charlton (2009) also concluded that the world's top physicists have tended to migrate to rich countries – mainly the US and Switzerland – while the UK and other countries have experienced a net loss. Studying a sample of highly cited physicists,¹⁰ they showed that these researchers tended to move to the US during their careers; 30 per cent

of the individuals in the sample were in the US at birth, and this percentage increased for the undergraduate and then PhD degree career stages until 67 per cent of the researchers in the sample were in the US. At the same time, there was a decline in the rest of the world; 70 per cent of the researchers in the sample were outside the US at birth, and this percentage had halved by the time of the study. It should be noted that both these studies, focusing on Nobel prizes, have limitations in terms of their broader generalisability across fields (and particularly to the social sciences and humanities).

Another study, which surveyed a sample of 720 'top researchers',¹¹ concluded that they are concentrated in highly industrialised countries, especially the US (Maier, Kurka & Tripl 2007). Western European countries were found to be the most important sources of the researchers in this group who moved to the US, and London was the top source location for mobile researchers, while movements of these researchers within Western Europe were not so clearly directed (Maier, Kurka & Tripl 2007). More than 50 per cent of the researchers in this group had international mobility experience, being either expatriates (25 per cent) or returnees (27 per cent). The top eight locations to which expatriates had moved were all in the United States; and together, these eight US locations hosted about one fifth of the expatriates. While these studies provide some clear evidence that, at least in the physical sciences, researchers have been concentrated in Western countries (particularly the US), more up-to-date evidence about this group would be valuable to understand whether these patterns are still present today.

9 The remainder of respondents were unemployed, on leave or there was no data. The Destinations of Leavers from Higher Education survey had 2,073 respondents, with a response rate of 45 per cent, and it was broadly representative (although the response rate for graduates overseas may have been lower than for those in the UK) (Vitae 2010).

10 The analysis focused on a sample of 158 of the most-cited physics authors during 1981–1999 and data on their career path and current affiliation; this sample was part of a larger set of 272 authors, for whom further details were not always available.

11 Authors of highly cited journal articles during the period 1981–2002.

2.5. International mobility takes many forms

International mobility takes a range of different forms, with the estimated proportions of researchers who are mobile being highly dependent on the definitions used, and ranging from 15 to 70 per cent for general researcher populations (Table 2.3). International experiences can vary in terms of their duration, purpose, the number and frequency of moves, and when moves occur in a researcher's career, and these differences can have important implications for the researcher and institutions involved. An additional challenge is that different studies take different approaches in terms of the researcher groups analysed as well as in terms of whether movements are considered relative

the country of birth or other reference points such as nationality, country of highest degree or country of first publication. Due to this variation, it is difficult to draw general conclusions about the prevalence of mobility.

The MORE2 Survey indicated that about 15 per cent of EU researchers were mobile at the time of the study (Table 2.3) (Weert 2013). Focusing on mobility that occurred at any point in the researcher's career, the proportion rises to about half (48 per cent). Another 31 per cent of European researchers had not been internationally mobile since completing their PhD, but this percentage varied from less than 15 per cent in Iceland, Luxembourg and Switzerland to nearly two thirds in Poland. According to the earlier MORE Survey, 56 per cent of HEI

Table 2.3. Estimated researcher mobility rates for various types of mobility and researcher groups

Researcher mobility rate	Sample type	Type of mobility	Source (year(s) data collected)
15%	EU HEI researchers	Mobile at time of survey	MORE2 Survey (2011–2013)
48%	EU HEI researchers with PhDs	Mobility for at least three months since PhD	MORE2 Survey (2011–2013)
31%	EU HEI researchers with PhDs	Mobility for at least three months in past 10 years	MORE2 Survey (2011–2013)
56%	EU HEI researchers	Mobility for at least three months since PhD	MORE Survey (2009–2010)
29%	EU HEI researchers	Mobility for at least three months in past three years	MORE Survey (2009–2010)
15–30%	European doctoral holders living in the country of which they are a citizen	Mobility during the past 10 years	Careers of Doctoral Holders survey (2005)
90%	First cohort of ERC Starting grantees (and a control group)	Working in at least two countries during career	Nedeva et al. (2012)
55%	First cohort of ERC Starting grantees (and a control group)	Working in at least three countries during career	Nedeva et al. (2012)
40%	First cohort of ERC Starting grantees (and a control group)	Mobility only within EU	Nedeva et al. (2012)
42%	Academics globally	Any international mobility	CAP survey
72%	Active UK researchers (during 1996–2012)	Had a non-UK affiliation during 1996–2012	Elsevier (2013)

Row colours are used to help differentiate data sources.

researchers were currently or had ever previously been internationally mobile, along with 65 per cent of researchers in research institutes and 41 per cent of industry researchers (IDEA Consult 2010).

According to an analysis of author affiliations on publications from 1996–2012, which included 266,000 active UK researchers,¹² 72 per cent of UK researchers were internationally mobile¹³ during that period (Elsevier, 2013). Overall, 28 per cent of UK researchers were sedentary (of UK origin and with no experience working overseas),¹⁴ making the UK the second least sedentary country (behind Canada, with 27 per cent of its researchers being sedentary); this rate is much higher in China (71 per cent) and Japan (60 per cent), and also higher in the other comparator countries (France, Italy, Germany and the US). Half of UK researchers were considered transitory¹⁴ (the second highest rate among the comparator countries just behind Canada), while 13 per cent migrated out of the UK and 9 per cent migrated in. Overall, the UK had a net outflow of 3 per cent, which was higher than the seven comparator countries.

The GlobSci Survey results indicated that, in 13 of 16 countries, more than half of the respondents had international experience lasting at least six months. Switzerland had the most (78 per cent), followed by India (75 per cent). The country with the smallest share of scientists with international experience was the US (19 per cent). The UK was eighth with 56 per cent (Franzoni, Scellato & Stephan 2012).

Some surveys indicated that short-term mobility is most common. This may reflect its different role in the scientific enterprise, as part of ongoing conduct of research and collaboration, in comparison to longer-term mobility, which is likely to take place in different contexts and for different reasons. Equally, such shorter-term mobility involves less commitment and disruption to one's personal or professional life, which may also be part of the reason that such trips are more commonplace. The MORE survey findings indicated that the most common form of international mobility was research visits, but job migration was also common (Børing et al. 2015). According to the Changing Academic Profession (CAP) survey, which found that 42 per cent of academics globally had experienced international mobility in some form, most common was short-term circulation for study (16 per cent of the whole sample), followed by short-term academic mobility (10 per cent), long-term circulation for work (6 per cent), long-term migration for work (6 per cent),¹⁵ and long-term migration for study (5 per cent) (Rostan & Höhle 2014).

Another survey, which focused on ten European countries including the UK,¹⁶ defined five categories of mobility (Marinelli, Elena-Pérez & Renandez-Zubieta 2013). 'Stayers' have always worked in the country of their PhD, 'returners' have worked abroad but currently work in country of their PhD, 'stable migrants' are in a different country from their PhD country but have held at least two jobs in that other country, 'first-time migrants' moved away from their

12 'UK researchers' were defined as those who had a UK affiliation on at least one paper during the period of analysis, while 'active researchers' were those with at least four publications during 2008–2012, or at least one during the period 2008–2012 and at least 10 during the full analysis period.

13 That is, they were active UK researchers (see definition in previous note) and also published articles under a non-UK affiliation during the period 1996–2012.

14 Mobility patterns were considered 'migratory' if country stays lasted at least two years, 'transitory' if they lasted less than two years, and 'sedentary' if the author maintained only a UK affiliation during the period of analysis.

15 'Circulation' differs from 'migration' in that circulating academics were born in the country where they currently work, whereas migrants were born elsewhere.

16 The SIM-ReC online survey focused on Belgium, France, Germany, Italy, the Netherlands, Poland, Spain, Sweden, Switzerland and the UK. It obtained data from a sample of 2,858 academic researchers who had a tenured position and/or at least five years of postdoctoral experience.

PhD country and now hold their first position elsewhere, and 'repeat migrants' currently work outside their PhD country and have worked in at least one other country. Overall, more than half of the researchers in the sample were stayers (54 per cent), while 21 per cent were returners, 12 per cent were stable migrants and the rest were repeat or first-time migrants. Patterns for the UK sample were similar to those for the overall sample (Marinelli, Elena-Pérez & Renandez-Zubieta 2013).

2.6. A higher proportion of researchers are mobile, and the US remains the top destination

Data from the 2005 Careers of Doctorate Holders survey showed that mobility rates were slightly higher when the results were restricted to individuals who had obtained their PhD between 1990 and 2006, indicating that mobility is more common among more recent graduates than the wider population (Auriol 2010). Findings from several other studies support the idea that mobility is becoming more common. The MORE survey showed that HEI researchers who had been mobile during the past three years were three years younger, on average, than the overall HEI sample (52 per cent were under age 41, compared with 39 per cent of the whole sample) (IDEA Consult 2010). In addition, according to HRSTC data, for the nine Member States that supplied comparable information, the proportion of intra-EU mobile research staff increased from 2.2 to 2.9 per cent between 2000 and 2006, and the proportion of research staff from outside the EU increased from 1.6 to 2.4 per cent (Fernández Zubieta & Guy 2010).

A study that focused on UK postdoctoral researchers, using data from CVs, publications and patents, compared three groups of people: those who completed their PhD prior to 1979 with

those who did so during the 1980s and 1990s. It found that international postdoctoral mobility became more common over time, with 5 out of 17 researchers (29 per cent), 9 out of 26 (35 per cent) and 22 out of 31 (71 per cent), respectively, being internationally mobile as postdoctoral researchers in each cohort (Zubieta 2009).

EU researchers are increasingly moving to the US, with their estimated number increasing steadily year on year from around 9,000 in 2000 to around 15,000 in 2011. According to analysis of the MORE2 Survey, this figure corresponds to there being an estimated 34,000 EU-born researchers working in the US in 2011 (Weert 2013). The US was the leading destination for MORE2 respondents in both PhD and post-PhD career stages, accounting for 18 per cent of moves longer than three months; it was followed by the UK (11 per cent), Germany (11 per cent) and France (8 per cent). The MORE2 data also showed that about 2 per cent of EU citizens who were awarded a PhD degree in 2011 (2,021 individuals) obtained it in the US, and these researchers are increasingly choosing to stay and work in the US (28 per cent did so in 2000, compared with more than 40 per cent in 2005 and 2011).

In terms of UK researchers who move abroad, the US and other majority English-speaking countries are frequent destinations. The GlobSci Survey indicated that 25 per cent of the scientists who had lived in the UK at age 18 were abroad at the time of the survey, meaning the UK ranked fourth on this measure¹⁷ (Franzoni, Scellato & Stephan 2012). Almost half of the UK scientists abroad were in the US (47 per cent); 17 per cent were in Canada and 17 per cent were in Australia (Franzoni, Scellato & Stephan 2012). A bibliometric investigation of mobility using papers dating to 1996–2010, from about 1.4 million authors in five countries (Germany, Italy, the Netherlands, the UK and the US), showed

17 First was India (40 per cent), then Switzerland (33 per cent) and the Netherlands (26 per cent).

that the top six destinations for UK researchers who migrated between 1999 and 2010 were the US (29 per cent went there), Australia (7 per cent), Germany (6 per cent), Canada and France (both 5 per cent) and Italy (3 per cent). The UK was the top destination for people from the US during that period (11 per cent). It was also the second most popular destination (after the US) for researchers from Germany (10 per cent), Italy (13 per cent), and the Netherlands (15 per cent) (Moed, Aisati & Plume 2012).

The CAP survey indicated that relatively few UK academics have worked or studied abroad, and researchers who worked on the survey suggested that UK nationals may build international links through their foreign colleagues working in the UK. Consistent with the findings of the GlobSci Survey, they noted that the links developed mainly involved other English-speaking countries (Bennion & Locke 2010). According to the CAP survey, 85 per cent of UK academic researchers obtained their PhD in the UK (though the proportion was higher – 87 per cent – among more senior staff and lower among more recent graduates – 82 per cent) (Bennion & Locke 2010).

In a bibliometric analysis of the mobility of researchers from Germany, Italy, the Netherlands, the UK and the US, the UK had the highest level of outward migration among the countries assessed, while the US had the lowest (Moed, Aisati & Plume 2012). Among authors who began their career in the UK during the period 1999–2001, 73 per cent were still in the UK 10 years later (during 1999–2010), 15 per cent had moved permanently abroad, and 6 per cent had gone abroad and come back to the UK. In contrast, among US researchers over the same time period, 85 per cent stayed in the US, while 8 per cent had moved abroad and 4 per cent had moved and returned again.

One recent study, relying mainly on bibliometric analyses, compared mobility patterns in Europe and the US, treating European countries as analogues of US states; it found, first of all, that there is less mobility between European countries

than between US states (22 per cent of US researchers have moved between US states, compared to 7 per cent of European researchers who have moved between European countries) (Kamalsky & Plume 2013). Secondly, in both Europe and the US, the most common pattern was to be non-mobile (as opposed to moving across countries/states, or beyond the European/US region). Being non-mobile was much more common in Europe (57 per cent of European researchers were sedentary versus 32 per cent of US researchers), but there was strong variation within Europe. Interestingly, the European countries with more sedentary researchers tended to be those with weaker research systems, while in the US, the opposite effect appeared: the states with more sedentary researchers tended to be those with higher concentrations of large, research-intensive universities (Kamalsky & Plume 2013). However, differences between the US and EU should be noted in interpreting these findings, particularly the larger cultural and language barriers to moving between EU countries. There are also differences in freedom to move between the two contexts (although there is freedom of movement among EU countries, administrative factors can limit movement in practice).

2.7. The UK leads other member states in its net gain of researchers supported by EU programmes

Several studies cover mobile researchers funded by two important EU funding sources: the European Research Council (ERC) and Marie Skłodowska-Curie Action (MCSA). The ERC funds elite researchers across all disciplines within the EU, while MCSA funding is specifically intended to support mobility. Both fall within the wider remit of the EU's framework programmes, which provide funding for research through a range of schemes. The current framework programme, Horizon 2020, has been in place since 2014. Previous framework programmes were named by number, with FP7 running from

2007 to 2013, and FP6 from 2003 to 2006.

Data on participation in ERC and MCSA funding programmes show that the UK frequently hosts recipients of grants from these programmes who are non-UK nationals. The UK was the most popular MCSA destination during FP7, with 5,736 researchers choosing the UK, followed by Germany with 3,388 and France with 2,468. In terms of MCSA researcher flows within the EU, the UK had by far the highest net gain of researchers, with more than 3,600 researchers coming in from elsewhere in the EU (the top three source countries were Italy, Spain and Germany) and only about 600 UK nationals going elsewhere in the EU (the top three destinations were Germany, France and Spain) (Avramov 2015).¹⁸ About one quarter of MCSA researchers (24 per cent) came from outside the EU (mainly China, Israel and Turkey) during FP7 – a significantly larger share than the 17 per cent that participated during FP6 (Avramov 2015). Sweden, Belgium, the Netherlands, Denmark and Germany also had net gains from the MCSA, but these gains were much smaller than that of the UK. In addition to Italy, the countries with the largest net losses were Poland, Spain, Greece, Portugal and Romania.

The UK has also been the leading host country for ERC grants under Horizon 2020. In the 2016 Starting and Consolidator grant competition results, though British nationality was only the fourth most common grantee nationality with 45 grantees (behind German, French and Italian), the UK was the host institution for the largest number of grants (117) (European Research Council 2016a, 2016b).

2.8. Women are less likely to be internationally mobile than men

Results from the MORE2 Survey, which was based on a representative sample of EU

researchers, indicate that male researchers are one third more likely to be mobile than female researchers (28 per cent of men were mobile versus 21 per cent of women), and this was true for all forms of international mobility, with the gender gap widening for more advanced career stages (Weert 2013). Similarly, the MORE survey indicated that HEI researchers who had been mobile during the past three years were more likely male than in the overall HEI sample (IDEA Consult 2010). The MORE survey results also showed that HEI researchers who had been mobile during the past three years were less likely to be married/cohabitating or have children.

The MORE2 survey indicated that the gender difference was more pronounced for mobility lasting longer than three months (Weert 2013), which is consistent with findings from the CAP survey that long-term academic circulation is less open to women, though short-term academic circulation is not (Rostan & Höhle 2014). The MORE2 survey findings also showed that the gender difference was more pronounced for mobility occurring after PhD completion (Weert 2013).

2.9. There is some evidence that basic researchers and those in the social sciences and humanities are more mobile than others

Only a few studies have looked at differences in mobility based on subject area. These give some initial indication that researchers in biomedical sciences may be less mobile than some other disciplines. In addition, one study showed significant differences in the level of mobility by research type, with basic researchers tending to be more mobile than applied researchers. Some studies indicated that social sciences and humanities researchers may be more mobile

¹⁸ In contrast, Italy had the highest number of researchers supported by MCSAs but the largest net loss of researchers (1,568).

than others, such as the natural sciences and engineering.

The MORE2 Survey found that individuals working in the medical sciences had relatively low rates of mobility, whereas humanities was among the fields with the highest rates of mobility (of short or long duration), along with natural sciences, engineering and technology (Weert 2013). These findings are consistent with data gathered on the first cohort of ERC Starting Grant grantees, which indicated that social sciences and humanities researchers were the most mobile (26 per cent of respondents had either geographic or workplace mobility, or both), while life sciences researchers were the least mobile (only 6 per cent) (Nedeva et al. 2012). The MORE2 survey also showed that mobility lasting longer than three months during the PhD stage was most common in the humanities (25 per cent) and social sciences (22 per cent), compared with around 16 per cent in other fields.

Another study partially confirmed these patterns. On the basis of survey data (two pilot surveys commissioned by JRC-IPTS¹⁹), Moguérou & Paola Di Pietrogiamco (2008) estimated that, in the EU-27, 31 per cent of doctoral candidates

in engineering, 25 per cent in the life sciences, and 25 per cent in the social sciences are from either another EU country or a non-EU country. However, at postdoctoral level, the pattern was slightly different: they estimated that 42 per cent of postdoctoral researchers in the life sciences, 29 per cent in engineering and 22 per cent in the social sciences are from another country (inside or outside the EU).

An analysis of UK researchers, looking at differences between basic and applied research scientists, found that researchers working in basic science were three times more likely than applied researchers to experience an international postdoctoral stay: 48 per cent of basic scientists did, compared with 16 per cent of applied scientists. In contrast, 77 per cent of applied scientists were non-mobile (either nationally or internationally), compared with 31 per cent of basic scientists (Zubieta 2009). This finding was confirmed by another study which highlighted that professional international mobility appears linked to basic or theoretical research rather than applied research, and that international mobility is related to the existence of international scientific communities working in basic research (Rostan & Höhle 2014).

Summary: The UK is an attractive destination for researchers, and foreign researchers play an important role in the research system

- Overall, the population of researchers in the UK, EU and beyond is growing.
- Mobility is becoming more common among researchers.
- In the UK, the proportion of researchers and doctoral candidates who are from outside the UK is rising.
- The UK is an important training ground, attracting a large number of international doctoral candidates.
- The UK also leads the EU in hosting European Research Council and Marie Skłodowska-Curie Action researchers.
- However, the US remains the top research destination.

19 The surveys were Nettoreact and Rescar. Nettoreact focused on life sciences, and had a sample size of 468 academic research groups (26 per cent response rate). Rescar focused on university departments in social sciences and engineering, and 595 research team heads responded (response rate 13 per cent). The data were used as a basis for extrapolation to estimate numbers of postdoctoral fellows.

3. Evidence on drivers and barriers of researcher mobility

The literature reviewed highlighted a range of important drivers and barriers that affected researchers' mobility choices, primarily related to national policy frameworks (extrinsic to research and innovation systems), labour markets and the availability of funding, professional drivers (e.g. access to networks, resources and prestige for career progression), culture, language and geographic proximity, and family and relationships. Importantly, studies also found notable variation in the relative importance of these drivers across career stages, geographies and gender.

3.1. Differences in entitlements and immigration rules in destination countries may influence researcher mobility

National policy in EU countries emerges as a driver of mobility choices in a number of ways, most notably in terms of national social policy (social security, benefits and pension rights), health policy (access to healthcare/health insurance) and immigration policy (visa schemes, work permits and associated costs) (Bennion & Locke 2010; Borchgrevink & Scholz 2013; Weert 2013; Cox 2008; Avramov 2015). A number of policy initiatives aimed at facilitating both mobility within the EU and mobility for researchers from non-EU countries were discussed in the literature, including the establishment of the European Research Area, the adoption of the Scientific Visa Directive and the creation of EURAXESS services, providing information on available funding and job opportunities (Fresco 2015; Avramov 2015). Despite these efforts, differences in health and

social benefit systems and strict immigration rules in EU countries remain important barriers.

Difficulties obtaining visas and work permits were some of the most prominent cited barriers to mobility for non-EU researchers in particular (Weert 2013; Avramov 2015; Cox 2008). For EU researchers, misalignment in benefits between countries and the potential negative effect of mobility on supplementary pension contributions and rights were also noted as potential barriers (Cox 2008). However, these factors were considered less important for doctoral student respondents to the MORE2 survey (Weert 2013).

3.2. Labour market conditions and funding availability are important drivers, but for some groups more than others

According to Rostan & Höhle's (2014) analysis of CAP survey data, patterns of both long- and short-term academic mobility appear to be shaped by economic inequalities at the global level. Indeed, other authors have also emphasised the role of macroeconomic and labour market factors, particularly poor employment opportunities in researchers' countries of origin, as important mobility drivers (Ackers 2008; Van Bouwel, Lykogianni & Veugelers 2011; Avramov 2015). For EU researchers, these included lack of career opportunities, poor employment conditions (including salary), the accessibility and transparency of recruitment processes, and the prevalence of contractual insecurity (Ackers 2008; Van Bouwel, Lykogianni & Veugelers 2011).

In destination countries, salary levels and the availability of positions were important for most in shaping and driving mobility choices (Bennion & Locke 2010; Weert 2013), though research and funding environment were at times considered more critical (Halme et al. 2012). There was also geographic variation in this regard, as maintaining salary levels was important for more US researchers than non-US researchers, likely relating to the higher salary levels found in the US compared to the EU (Halme et al. 2012; Weert 2013). Other studies found that wider factors, such as science investment, and the nature and number of resultant positions available (Guth & Gill 2008), as well as career prospects, research quality and institutional prestige and excellence (Franzoni, Scellato & Stephan 2012), were more important to researchers than salary levels.

3.2.1. Difficulty obtaining funding is a key barrier to international mobility

Along with job security, a number of studies noted that the availability of research funding and scholarships were important drivers of researcher mobility choices (Bennion & Locke 2010; Stephan, Franzoni & Scellato 2013; Weert 2013; IDEA Consult 2010; Cox 2008; Halme et al. 2012), particularly for early career researchers (Weert 2013; IDEA Consult 2010; Cox 2008).

While the availability of funding could be a facilitator of mobility to certain destinations (for example, drawing researchers to Switzerland over the US, but to the US over Australia, France and the UK (Stephan, Franzoni & Scellato 2013)), the converse is also true, with difficulties obtaining funding acting as a barrier to mobility. Of the two, challenges in obtaining funding are raised more often in the literature as a barrier or concern to mobile or potentially mobile researchers (Weert 2013; IDEA Consult 2010; Cox 2008). For example, Weert's (2013) analysis of MORE2 data found that, for EU academics, obtaining funding is the most cited barrier to doctoral and postdoctoral mobility,

noted by 64 per cent of doctoral researchers and 43 per cent of postdoctoral researchers. Mobile non-EU researchers identify funding as the second most important barrier to mobility (after finding a job for their spouse) (Weert 2013). There was also some variation in the importance of these funding concerns by geography and career-stage. Access to funding was more of an issue for researchers moving from the EU to the US than vice versa (IDEA Consult 2010) and was also more concerning for early career researchers who aspire to be mobile (Cox 2008), than for more senior researchers.

While funding availability was clearly a dominant concern expressed by researchers, one study based on 27,000 ERC grant proposals found that greater relative R&D funding in a country did not attract more elite scientists, possibly because this group of elite researchers would find accessing funding less difficult than others (Cuntz 2016). The study reported that elite scientists in Europe (defined here as ERC applicants) were more likely to move between countries with similar expenditure levels, indicating that other factors related to research quality, infrastructure and proximity to home country were more important.

3.3. Researcher mobility is strongly shaped by professional goals and the desire for career advancement

Studies have noted the distinct character of researcher mobility which, as opposed to other kinds of migration, tends to be strategic, self-driven and motivated at least in part by professional goals (Bauder 2015; Cantwell 2011). Some of the most prominent drivers of mobility (both short- and long-term) in the literature related to career and professional concerns, notably intentions to develop international research networks and collaborations (Stephan, Franzoni & Scellato 2013; Franzoni, Scellato & Stephan 2012; Guth and Gill 2008) as well as to progress careers by working with a foreign

institution that offers access to specific expertise, resources or prestige (IDEA Consult 2010; Franzoni, Scellato & Stephan 2012; Weert 2013). Indeed, international mobility is associated with increased international teaching, research collaboration and dissemination (Rostan & Höhle 2014; Bauder 2015; Maier, Kurka & Tripl 2007), and is also thought to offer other professional benefits in terms of cultural and social capital and skills (Bauder 2015). In addition, some authors pointed to an expectation of international mobility in academia (Robertson 2010), where working in a foreign institution for a period of time has become a perceived necessity for career progression, especially in Europe (Cantwell 2011; Ackers 2008; Bauder 2015).

Analyses of MORE survey data indicated that career-related motivations of mobile researchers (e.g. personal research agenda, career progression goals, career opportunities at destination and salary) were more important than personal motivations, and that this tendency was even more pronounced for industry researchers than academic (IDEA Consult 2010). Career progression was also more important to early and mid-career researchers than to more senior researchers (who prioritised research autonomy, personal or family reasons and quality of training and culture) (Weert 2013), and more important for female researchers than male, possibly reflecting a perception of more obstacles in their path (Fernández-Zubieta, Marinelli & Pérez 2013).

3.3.1. The relative strength of national research systems is both a driver and inhibitor of researcher mobility

The quality of the research environment, and its related ability to stimulate researchers to compete at the global level, was a primary

attracting factor for many researchers in the EU (Halme et al. 2012; Universities UK 2007). Important aspects of the research environment in EU countries in this regard included the ambition and talent of colleagues, institutional reputation, and flexibility in the definition of research topics and with teaching and administrative obligations (Halme et al. 2012). Weaker country of origin research systems²⁰ were also found to act as a driver for researchers to move abroad. Van Bouwel, Lykogianni & Veugelers' (2011) MORE analysis reported that, particularly within Europe, students from countries with weaker systems are more likely to pursue doctoral study abroad and those from countries with high research impact (based on analyses of citation and publication data) are less likely to do so (Scandinavians, for example, seem less likely to study abroad, and Central and Eastern Europeans more likely).

Findings from a study of ERC grant proposals also confirmed the presence of an excellence-attracts-excellence mechanism driving the mobility of elite scientists (Cuntz 2016), whereby higher performing national research systems with higher levels of scientific excellence attract more elite scientists.

3.3.2. The desire to build collaborative international research networks is a key driver of mobility

Building international relationships was also a very important factor driving mobility (Franzoni, Scellato & Stephan 2012; Guth & Gill 2008; Stephan, Franzoni & Scellato 2013). International contacts were seen to influence not only when and where mobility might take place, but also to act as motivating factors for researchers to establish their own networks abroad and enhance collaborative working (Guth & Gill 2008; Maier,

20 The authors assessed the strength of national research and innovation environments using three proxies for research quality, strength of the innovation system and university quality, respectively. Research quality was assessed using bibliometric data from National Science Foundation's Science and Engineering Indicators 2004; the assessment of a country's innovation environment was based on its ranking in the European Commission's European Innovation Scoreboard (EIS); and the quality of the country's universities was measured using an indicator constructed based on the Shanghai ranking.

Kurka & Trippel 2007). International researchers' perception of the UK as a particularly valuable setting to enhance their collaborative relationships was emphasised by a study based on GlobSci Survey data, which found that the possibility of network-building draws researchers to Germany and the UK more than to the US (Stephan, Franzoni & Scellato 2013).

Indeed, a bibliometric analysis conducted by Appelt et al. (2015) also found evidence of secondary migration and mobility flows to a given country being partly driven by mobile students who return to continue their careers in their country of origin, demonstrating the potential for established international networks and knowledge to drive further mobility.

3.4. Familiarity with destination language and culture affects mobility choices

Similarly to other migration flows globally, a number of authors have highlighted the importance of factors related to the culture, language and geographic proximity of destination countries for shaping patterns of researcher mobility, both globally and within Europe (Auriol 2010; Cuntz 2016; IDEA Consult 2010; Weert 2013; Rostan & Höhle 2014; Franzoni, Scellato & Stephan 2012). However, important variations were found in the relative importance of these factors among groups and geographies.

Analysis of MORE survey data showed that while, overall, researchers do not assign great importance to personal and culture-related motives in their decision to move, this varied among sub-groups (particularly across career stages and lifecourse) and was more important for industry researchers than academic and for US to EU mobility than EU to US (IDEA Consult 2010). Similarly, language was more frequently considered to be more important for some groups than others. Language was a difficulty faced when moving to the EU for about 29 per cent of non-EU researchers with experience

of working in the EU but who were currently outside (Weert 2013), and was also a relatively important factor for EU to US mobile researchers (compared to US to EU), since English is widely spoken (IDEA Consult 2010). Rostan & Höhle (2014) report that English attracts researchers to Anglophone countries.

A number of studies emphasised the importance of previous migration history or periods of foreign study as predictors of mobility and mobility patterns (Børing et al. 2015; Mugabushaka, Rieder & Toma 2014; Rostan & Höhle 2014; Veugelers & Van Bouwel 2015). For example, over three quarters of MORE survey respondents who had spent time abroad as an exchange student subsequently experienced mobility in their research careers (Børing et al. 2015), and doctorate holders with experience of mobility in Europe were more likely to move within Europe, rather than move to the US (Veugelers & Van Bouwel 2015). Similarly, a study of ERC grant proposals identified a strong association between 'foreign-born status' and mobility intention overall. However, the UK stood out among countries with a high number of foreign-born researchers, since although the proportion of foreign-born researchers with a mobility intention was higher than the share of native-born researchers, the proportion was relatively low (less than 5 per cent) (Mugabushaka, Rieder & Toma 2014).

In terms of geographic proximity, distance to country of origin was identified as another important determinant of scientists' mobility choices (Cuntz 2016; Franzoni, Scellato & Stephan 2012). For elite scientists, Cuntz (2016) attributed this to high personal costs associated with moving, such as leaving family and friends and logistical difficulties. Franzoni, Scellato & Stephan's (2012) analysis found that cultural/language ties also matter (with the UK as the top source country for Australia). However, these patterns were not without clear exceptions, with China as the US's primary source country and Germany and Italy dominating in the UK.

3.5. Children and relationships can act as a barrier to international mobility, especially for women

One study based on analysis of data from the global CAP survey found that family status, number of children and partner characteristics were non-significant factors in international mobility (Rostan & Höhle 2014). However, a number of other studies found that family and relationship circumstances, for example having caring responsibilities for children and/or a partner, were important determinants (Nedeva et al. 2012; Sang, Al-Dajani & Özbilgin 2013; Ackers 2008; Børing et al. 2015; Cox 2008; Franzoni, Scellato & Stephan 2012) and in some cases acted as inhibitors (Børing et al. 2015; Weert 2013).

Across both university and non-university sectors, single researchers responding to the MORE survey were more likely to have experienced mobility in the last three years than those who were married or cohabiting with a partner (40 per cent versus 30 per cent) (Børing et al. 2015). More explicitly, finding a job for their spouse was cited as a key barrier to moving to the EU by non-EU respondents who had been mobile outside the EU (64 per cent) as well as for those who had worked in the EU but currently lived outside, but to a lesser extent (24 per cent) (Weert 2013). A study of female professors born outside the UK but currently working in UK academia confirmed these findings, with partner's career cited as the second most important factor (after doctoral education and personal reasons) for moving to or staying in the UK (Sang, Al-Dajani & Özbilgin 2013).

Parental or carer responsibilities were also highlighted in a number of papers as a potential barrier to mobility (Ackers 2008; Weert 2013; IDEA Consult 2010; Børing et al. 2015). MORE and MORE2 data showed that researchers without children were more likely to have been mobile in the last three years than those with

them (41 per cent versus 26 per cent) (Børing et al. 2015) and that childcare arrangements and personal/family factors were considerably more important for non-mobile researchers (IDEA Consult 2010; Weert 2013), indicating their potential role as a barrier. When asked to provide explicit reasons for not moving, researchers ranked personal and family reasons as being the most important (Weert 2013). However, another study, based on a survey and interviews with academic researchers in the EU, found that caring responsibilities were a less important inhibitor than personal relationships, and identified a geographic variation in attitudes, with childcare arrangements notably more important for researchers from Nordic countries than for those from other EU or non-EU countries (Cox 2008).

The importance attached to childcare arrangements also varied by gender, and evidence suggested that children affect mobility choices more for female than for male researchers (IDEA Consult 2010; Fernández-Zubieta, Marinelli & Pérez 2013). Indeed Sang, Al-Dajani & Özbilgin's (2013) work on female professors in the UK who were born overseas reports that for this group childcare was rarely supported by partners and assistance was often provided through other channels, such as visiting relatives, friends and childcare professionals. This need to leverage wider personal networks, including mobilising support from family abroad, clearly indicates the potential challenges faced by mobile female researchers with children.

Summary: The decision to move is complex and involves a range of personal and professional factors

- Decisions about whether and where to move are shaped by a variety of factors as researchers seek to maximise benefits (both professional and personal) and minimise negative effects for themselves and their families.
- Differences in entitlements and immigration rules in destination countries can influence researcher mobility, even within the EU, despite the efforts of the EU to develop the ERA.
- Labour market conditions and the availability of funding can be important drivers for some groups – difficulty obtaining funding is a key barrier to mobility expressed by researchers, particularly those at earlier career stages.
- Researcher mobility is strongly shaped by calculations of professional interest, unlike wider migration.
- Some of the most prominent drivers of mobility (both short and long term) in the literature related to career and professional concerns, notably intentions to develop international research networks and collaborations as well as to progress careers by working with foreign institutions that offer access to specific expertise, resources or prestige.
- Correspondingly, the relative strength of research systems acts as both a driver and an inhibitor of mobility (depending on the direction of travel).
- Other wider considerations also affect mobility decisions. Factors related to the culture, language and geographic proximity of destination countries shape patterns of researcher mobility, and children and relationships can act as a barrier to mobility, especially for women.
- The relative importance of drivers varies across career stages, geographies and gender. For example, early career researchers prioritise availability of funding, positions and opportunities for career progression while more senior researchers place more value on research autonomy and personal life.

4. Evidence on consequences and impacts of researcher mobility

International mobility is generally thought of as a positive influence on research and researchers. However, the movement of researchers has also been conceptualised as 'brain drain', with researchers flowing from less affluent countries to a limited number of more wealthy states that can better support research. In this chapter, we explore the evidence for the benefits and disadvantages of mobility. To do so, we need to consider the outcomes of the movement of researchers from a number of perspectives; what may benefit the individual researcher might not necessarily be an advantage at a national level. We identify four main perspectives: that of the individual researcher in question, the institutions at which they are based, the national level, and science as a whole.

4.1. Benefits and consequences for researchers

4.1.1. There is strong evidence that mobile researchers perform better academically than non-mobile researchers

Several studies have looked at measures of academic performance based on publication records across and within research fields. Most find that migrant and/or internationally mobile scientists out-perform domestic scientists (Dubois, Rochet & Schlenker 2014; Franzoni, Scellato & Stephan 2014; Halevi, Moed & Bar-Ilan 2016; Scellato, Franzoni & Stephan 2012; Science Europe & Elsevier 2013). In the specific case of the UK, researchers moving to or from the UK are found to have above average levels of citation impact (weighted for the field

of publication), and returnees (those leaving the UK and then returning) in particular have more than twice the average level of citations to their publications, and this group is also typically highly productive and relatively senior (Elsevier 2013). This observation is reflected in perspectives from the MORE survey, in which both industry and academic researchers suggest that mobility has led to improved outputs, notably in terms of patents for mobile industry researchers and publications for academics. However, it is interesting to note that both network and output effects were rated more highly amongst researchers who had moved from the EU to the US than those who had moved from the US to the EU.

Analysis of the MORE2 survey data by Weert (2013) indicated that although the picture around the impact of mobility on research output was broadly positive, there was some variation across the survey responses. Amongst internationally mobile researchers who are away for more than three months, 60 per cent felt that measures of research output (quality of output, citation impact, patents, number of co-authored publications) had increased, but around 25 per cent felt that the quality and number of co-authored publications had decreased and 15–17 per cent felt their patents and citation impact had decreased. This reflects the more nuanced picture described in the review by Fernández-Zubieta, Geuna & Lawson (2015), who contrast the positive performance effects for mobile UK postdoctoral researchers (Zubieta 2009) with the evidence from Cañibano, Otamendi & Andújar (2008), which suggested that while mobility promoted access to international funding and networks for a cohort of Spanish researchers,

it did not impact on their publication or patent output. Possible reasons for these differences in experience are described by Halevi, Moed & Bar-Ilan (2016), who note that 'On the one hand, mobility can be positive since researchers moving to a new affiliation and/or country might find opportunities to expand their network and further their knowledge and expertise. On the other hand, the period of adjustment and familiarization with a new affiliation and/or country can potentially delay the publication of new studies. In addition, one's affiliation with a new institution might take time to be recognized by the scientific community.' The differences may also reflect different types and experiences of mobility, which are explored in more detail below.

Evidence on the impact of mobility on the academic performance of researchers in terms of their ability to attract funding is more limited. Work by Mugabushaka, Rieder & Toma (2014) indicated that success rates of foreign-born researchers in the ERC competitions did not differ much from those of native-born researchers. Similarly, Weert's (2013) analysis of the MORE2 survey data suggests that the same share of mobile researchers felt that their ability to obtain international research funding had decreased as felt it had increased (39–40 per cent). Locke & Bennion (2010b), in contrast, note that fewer British academics who had studied for their PhD in the UK indicated that more than a quarter of their competitive research funding came from international organisations (18 per cent) in comparison to those who had studied overseas (27 per cent).

4.1.2. One of the most clearly evidenced and widely reported outcomes of mobility is the development of researchers' networks

Several survey-based studies have found that a high proportion of mobile researchers report improved access to networks (Bennion & Locke 2010; Ecorys 2012; IDEA Consult 2010; Economisti Associati, GhK, Fraunhofer ISI 2014; Rostan & Höhle 2014; Weert 2013), and

studies based on bibliometric analyses find that researchers who are internationally mobile or have been mobile in the past are more likely to collaborate internationally (Stephan, Scellato & Franzoni 2014; Scellato, Franzoni & Stephan 2014) and have larger international research networks spanning more countries (Stephan, Scellato & Franzoni 2014). Weert (2013) notes that 'Around three quarters of the mobile researchers who collaborate internationally indicate that these relationships are the result of a mobility experience'. In the UK, a study by Locke and Bennion (2010a) found that non-British academics who had studied for their doctorate abroad were more likely to research and co-author publications with international colleagues. This increased collaboration network is likely linked to the noted improvements in academic publication performance, since it is well established that internationally co-authored papers are more highly cited (Digital Science 2016). Whether this is due to their quality or their wider visibility through networks across several countries is less clear (Lancho Barrantes et al. 2012; Schmoch & Schubert 2008).

4.1.3. Mobile researchers develop new skills and knowledge

As well as the international co-authorship effect, several studies suggest that improved academic performance amongst mobile researchers may stem from the development of new skills and knowledge (Bennion & Locke 2010; Franzoni, Scellato & Stephan 2014; Regets 2007). This could be through access to training and new skill sets (Watson 2010; Economisti Associati, GhK, Fraunhofer ISI 2014; Regets 2007); through exposure to different knowledge and research cultures (Bennion & Locke 2010; Regets 2007); and through the combination of their own knowledge with different perspectives to build new insights (Franzoni, Scellato & Stephan 2014). This is supported by evidence from survey data, where researchers suggest that these skills and knowledge development benefits are one of the useful outcomes of mobility

Box 1. International mobility of postdoctoral researchers

The postdoctoral period is an important time for mobility, though it receives less focus than the doctoral training period in reports, studies and official statistics. Amongst UK researchers, 38 per cent moved following their PhD studies to take a postdoctoral position in another country (Zubieta 2009), and for researchers who obtained a doctoral degree in the UK in 2004/5 (of which 29 per cent were non-UK nationals²¹), 80 per cent remained in the UK three-and-a-half years later, either working or doing further study, while at least 12 per cent were overseas (Vitae 2010). Graduates from elsewhere in the EU are even more likely than UK nationals to move overseas after graduation (Vitae 2010), and there are also indications that international postdoctoral mobility is becoming more common (Auriol 2010; Zubieta 2009).

Availability of research funding is a particularly important barrier to mobility for early career researchers, cited by 43 per cent of postdoctoral researchers in the MORE2 survey (Weert 2013; IDEA Consult 2010; Cox 2008). A key driver of mobility for this group is career progression, and personal circumstances are generally considered to be less of a barrier for this group than for more senior researchers (Weert 2013).

Motivation around career progression is reflected in the outcomes of mobility for early career researchers. Career development effects and skills development are more strongly noted as outputs of mobility for this group, however impacts on the quantity and quality of academic output, as well as the development of networks, are not as strong as those for more senior researchers (Watson 2010; Weert 2013).

(Ecorys 2012; Watson 2010; Weert 2013). For example, evidence from the MORE2 survey suggests that 80 per cent of respondents felt their research skills had increased as a result of mobility (11 per cent unchanged and 9 per cent decreased) (Weert 2013). Watson (2010) noted that mobility led to significant positive impact on the acquisition of skills, particularly for those in industry. However, Melin & Janson (2006) note that some returning researchers experience challenges incorporating the knowledge they have acquired abroad.

4.1.4. Mobile researchers may also benefit from access to equipment and infrastructure

Access to research equipment and infrastructure has also been noted as a benefit of international mobility (Fresco 2015; Economisti Associati, GhK, Fraunhofer ISI 2014), with researchers moving to other countries to enable the use of particular pieces of equipment or to allow

access to better-quality research infrastructure for their field. This is likely to be the case more frequently, though not exclusively, for researchers moving to a country with greater research resources. Conversely, one study notes that moving between countries can be detrimental in this regard when good-quality or specialised research equipment is available at the point of origin which cannot be moved along with the researcher (Nedeva et al. 2012), but the researcher needs or wants to move locations for other reasons. One can imagine this might be the case for returnees, moving back to their home country for social and personal reasons.

4.1.5. International mobility can have a positive impact on academic researchers' careers, but this depends on the nature of the mobility and the researchers' characteristics

Overall, the general impression is that international mobility has a positive impact

21 There were 15,800 doctoral graduates in 2004/5 in the UK, of which 61 per cent were UK nationals, 13 per cent were from elsewhere in the EU, and 26 per cent were from outside the EU.

on academic researchers' careers. Specific evidence that mobility has a positive career impact is available in a number of studies (Dubois, Rochet & Schlenker 2014; Watson 2010; Economisti Associati, GhK, Fraunhofer ISI 2014; Veugelers & Van Bouwel 2015). Exceptions include returning researchers who were observed to have difficulties returning to their home country, resulting in delayed promotion (Fernández-Zubieta, Geuna & Lawson 2015), or evidence suggesting some types of migration (particularly permanent moves overseas, or multiple movements across several countries as compared to one post overseas then returning to their home country) had negative impacts on the ability of researchers to achieve a permanent post (Marinelli, Elena-Pérez & Renandez-Zubieta 2013).

Watson (2010) in particular noted that the impacts of international mobility on career development were robust, with 63 per cent of FP6 Marie Curie fellows noting a significant impact on career progression. However, another study looking at Marie Curie fellowships found that the career development advantages of the fellows over a control group were small, suggesting that this may be partly due to the length of time that career advantages take to emerge, and also partly due to the control group being able to access mobility through alternative routes (Economisti Associati, GhK, Fraunhofer ISI 2014). Other studies based on surveys of researchers' perspectives or reviews of existing data support the positive perceptions of the impact of mobility on academic careers (Bauder 2015; Børing et al. 2015; Fresco 2015; IDEA Consult 2010). For example, the MORE2 survey found that the overall effect on career progression of mobility was perceived as positive (scores over 4 out of 5) for mobile academic researchers (Weert 2013). However, the overall picture was more nuanced: according to 55 per cent of researchers, career progression had increased as a result of mobility, but a significant group (31 per cent) describe a decrease in career progression and more researchers felt that their job options in academia had decreased (33 per cent increase versus 48 per cent decrease), as

had their job options outside academia (27 per cent increase versus 47 per cent decrease) and progression in remuneration (17 per cent increase versus 43 per cent decrease). Around 45 per cent of researchers felt their recognition in the research community had increased (compared to around 40 per cent decreased). Views regarding the impact on career progression were particularly positive for researchers moving from the EU to the US (Kim & Locke 2010). It is suggested that this may reflect the differing motivation of different groups: EU researchers moving to the US are mainly driven by professional considerations, whereas moving from the US to the EU appears to be driven more by personal motives. However, while Veugelers & Van Bouwel (2015) noted similar findings, with EU researchers moving to the US reporting stronger positive effects on their academic output and career development than those mobile within the EU, they identified through modelling approaches that this 'US premium' can be almost entirely explained by differences in the characteristics of mobile researchers who move to the US compared to those who move within the EU.

Network effects were seen as more important than output effects in terms of the overall impact on career progression by both academic and industry researchers. More generally, evidence around the impact on researchers in industry, their careers, productivity and access to networks is more limited, coming primarily from the MORE survey. Little empirical analysis has been conducted on this group. Based on the MORE survey, industry researchers note network effects from mobility are most significant, and also note a small but significant impact on output (numbers) of patents. There is no notable impact on publication output (in terms of quantity or citation levels).

4.1.6. International mobility can have negative personal and social consequences

Even for academic researchers, where the career benefits of mobility are fairly well established, there are possible trade-offs on a

personal level. These can include the loss of social ties (Heining, Jerger & Lingens 2007) and the challenges associated with mobility for those with a partner and children (Nedeva et al. 2012), as noted in the previous chapter. This is also reflected in the comment from Watson (2010) that the impact of the MCSAs could be improved by better customisation and allowing more flexibility to accommodate the requirements of different family situations – for example, it is noted that few fellows had children under 18, and thus more could be done to aid researchers with dependent children. However, it should also be noted that in some cases mobility is driven by personal and social factors rather than professional drivers (Weert 2013).

4.1.7. The extent and importance of the benefits and disadvantages will vary depending on the career stage of researchers, the length of their stay overseas and personal circumstances

As described above, for many researchers there are challenges in moving country at later career stages due to family considerations (Nedeva et al. 2012). Female researchers tend to report more positive effects: in the MORE2 survey of EU HEIs, women were more positive overall about the benefits of mobility, most notably with respect to network effects such as ‘recognition’ in the research community, international and national contacts/networks (Weert 2013).

Timing is also important: the point in a researcher’s career at which they move countries can affect the extent to which some of the benefits described are realised. For example, two studies note that collaborative links with the country of origin are better maintained for researchers who move at a slightly later career stage (after PhD for example), when they have had chance to develop a network of research contacts in their home country (Scellato, Franzoni & Stephan 2014; Gibson & McKenzie 2010). Rostan & Höhle (2014) also note that those who move at an early stage (e.g. for study) are less internationally collaborative than those who move later in their

career, explaining ‘It is likely that moving to another country, when having deeper intellectual and personal roots in the country of origin and having successfully started one’s career there, increases academics’ ability to be very internationally active, while moving at an early stage of life does not offer the same potential. In fact, it seems that the timing of migration affects the ability to be internationally active.’

Watson (2010) reports that amongst the statistically significant impacts of international mobility, quantity and quality of publication output and inter-sectoral mobility were most strongly observed for more experienced researchers. Conversely, skills development, transnational mobility and job option impacts were stronger for early stage researchers (with less than four years’ active research experience). Weert (2013) notes similar effects, with output and network effects most significant for more senior researchers, and career development effects more important for junior researchers.

The destination and origin countries of researchers will also affect their experiences of mobility. As noted above, motivations for and corresponding benefits from researcher mobility differ depending on the direction of travel between the EU and US (Kim & Locke 2010), and there are also interplays between the direction of travel and researcher characteristics (Marinelli, Elena-Pérez & Renandez-Zubieta 2013). Scellato, Franzoni & Stephan (2014) and Stephan, Scellato & Franzoni (2014) note that the size of a migrant’s network is correlated with the relative strength of the science base of their country of origin. Equally, non-EU researchers are particularly positive about their mobility experiences in the EU compared to those who are mobile within the EU (Weert 2013). Also, highly mobile researchers tend to report more positive effects from their experiences of mobility, with considerably higher impacts on career progression for HEI researchers where they have been mobile both within and outside the EU (rather than just within the EU) (Weert 2013).

Nedeva et al. (2012) also indicate that research discipline may have an impact on experiences of mobility: for example, in some topics (experimental physics is given as an example) it may be difficult or impossible to move necessary research equipment between locations.

Length of mobility may also affect outcomes. Weert (2013) used three months as a cut-off point in terms of length of stay and found that long-term (> three months) and short-term (< three months) mobility profiles are strongly interrelated. Correspondingly, it is hard to distinguish differences in outcomes between these different terms of mobility in this data set. Watson (2010) noted that the duration of a Marie Curie fellowship has a small but statistically significant impact on a range of outcomes including improvements in quality of research outputs, skills development and career progression.

4.1.8. Benefits are associated with mobility, but causality is hard to show, and they should be considered in the wider context

Some studies refer to an 'expectation' that academic researchers should be internationally mobile (Robertson 2010). It is suggested that a stint overseas (typically in the US, or increasingly for some EU countries, in the UK) is an important part of a researcher's CV, and a requirement for progression in academia (Kim & Locke 2010). This therefore raises a question about the extent to which the benefits around career progression, for example, are related to the benefits of mobility or rather stem from the underpinning culture in academia. It's also not clear what the characteristics of mobile researchers are in comparison to others – it may be that higher-achieving researchers are better able to access positions at overseas institutions and, as such, mobility is a marker rather than a driver of academic excellence and consequentially career, network and output benefits. A study focusing on elite researchers, for example, found that the world's top research scientists are typically highly mobile, migrating disproportionately to

the richest countries, but that amongst that group of elite researchers, mobile researchers were no more productive than those that stay in one country (Hunter, Oswald & Charlton 2009). Also, Veugelers & Van Bouwel (2015) noted that differences in outputs and career outcomes between EU researchers moving to the US and those mobile within the EU could be explained by differences in the characteristics of the two groups. Evidence from Franzoni, Scellato & Stephan (2014), however, indicates that migrant scientists out-perform domestic scientists even after controlling for selection effects, suggesting that migration may be a cause of superior performance at least in terms of certain measures of academic output.

It is important to consider the wider context in which mobility can and does occur. As discussed previously, short-term contracts for postdoctoral researchers and more widely in academia facilitate the mobility of researchers, both between and within countries (Cox 2008). However, there are negative impacts related to lack of job security and the social implications of working on short-term contracts over many years (Fernández-Zubieta, Geuna & Lawson 2015). This may not be solely a direct outcome of mobility, and as such is to some extent outside the scope of this study. However, it is important to note the connection between mobility and these wider contextual factors around short-term contracts, which may affect the ability of individuals to pursue research careers and/or their job satisfaction and security and family life. It is worth reflecting on the appropriate balance between an academic research environment that allows researchers to move between countries and one that requires them to move, with the underpinning impetus from insecure working conditions and limited opportunities for progression into permanent posts (Cox 2008; Fernández-Zubieta, Geuna & Lawson 2015; Weert 2013).

Box 2: International mobility of elite scientists

Studies of elite researchers have emphasised the importance of the US as a research destination. Using data on Nobel Prize winners, two studies showed an increase in the proportion of this group based in the US over recent decades, with some declines in the UK (and Germany) relatively, as elite researchers move to the US over the course of their careers (Weinberg 2009; Hunter, Oswald & Charlton 2009), as did another based on bibliometric data (Maier, Kurka & Tripl 2007). However, the UK is also a popular destination for elite scientists, particularly ERC grantees (Maier, Kurka & Tripl 2007; Mugabushaka, Rieder & Toma 2014).

Specific evidence on barriers and drivers for this group is more sparse, though one study found that ERC applicants were more likely to move between countries with similar expenditure levels, indicating that factors related to research quality, infrastructure, and proximity to home country were important, and that funding was less of a consideration for this group than it is for other researchers (Cuntz 2016). In line with findings from studies of more general populations of researchers, Nedeva et al. (2012) note that family and relationship circumstances, for example having caring responsibilities for children and/or a partner, are important determinants of mobility, and that field may also have an impact on experiences of mobility: for example, in some topics (experimental physics is given as an example), it may be difficult or impossible to move necessary research equipment between countries. Findings from a study of ERC grant proposals also confirmed the presence of an excellence-attracts-excellence mechanism driving the mobility of elite scientists (Cuntz 2016).

Evidence suggests that more senior scientists may better maintain collaborative links with their country of origin and may be better able to benefit from networking benefits as well as gains in terms of academic performance (Scellato, Franzoni & Stephan 2012; Gibson & MacKenzie 2010; Watson 2010). However, mobility does not seem to influence success rates in funding applications amongst this group, at least in terms of ERC competitions (Mugabushaka, Rieder & Toma 2014).

4.2. Benefits and consequences for institutions

4.2.1. The skills and knowledge of mobile researchers can bring reputational and performance benefits for institutions

It is clear that some of the individual benefits that are thought to stem from international mobility around improved publication, patent and funding performance as described above will also produce benefits for the institutions and/or companies at which those researchers are based. One study noted that the international mobility of academic staff makes a contribution to some international university rankings, with one of the major rankings weighting the 'percentage of international staff' at 5 per cent (Teichler 2015). One study investigated the best 'mix' of researchers for publication performance in the life sciences, finding that teams which are

all domestic or mostly non-domestic in origin are at a disadvantage compared to teams that feature a greater mix of domestic and non-domestic researchers (Barjak & Robinson 2008). The authors reflect on the likely skill mix this implies, suggesting that the diversity of the team will bring a better mix of 'skills, experience and cognitive frameworks', enhancing productivity, although they also note that there will be costs associated with the necessary efforts to bridge conceptual and normative gaps around research. Possible language and cultural barriers between native and immigrant researchers are also reported elsewhere as a challenge for host countries and institutions (Regets 2007).

4.2.2. Mobility also offers financial benefits for institutions

Regets (2007) notes that one benefit that might be significant for institutions in countries such as the UK, which typically see large numbers

of international students at the graduate level, could be higher levels of enrolment in graduate programs, which not only may offer financial benefits for the institution, but also might enable institutions to keep smaller programmes running and help maintain and build quality in larger programmes. Regets also notes that at a broader level, access to a global talent pool may better enable institutions to hire good-quality researchers with a good fit to the desired research skills and knowledge and, in particular, to access rare or unique skill sets. Migration may also allow institutions to access research skills at lower cost, as noted in the review by Fernández-Zubieta, Guena & Lawson (2015), though the wider literature on high-skilled migration gives a more mixed picture (Borjas 2005; Grossmann & Stadelmann 2013; Ruhs & Vargas-Silva 2015) (note that a detailed review of this literature is outside the scope of this review).

4.3. Benefits and consequences for countries

4.3.1. The concept of 'brain gain' is over-simplistic

Discussion of the mobility of researchers across countries has evolved from the concepts of 'brain drain' and 'brain gain' to 'brain circulation', reflecting the fact that mobility is often not unidirectional – many researchers spend a period abroad and then come back – and that researchers often maintain connections with their country of origin, facilitating networking and collaboration (Appelt et al. 2015). As noted by Franzoni, Scellato & Stephan (2014), 'brain migration is not a zero-sum gain', in that the benefits that accrue to one country are not necessarily at the expense of another, with the potential for benefits (and indeed disadvantages) on both sides. In the UK, as a host country in most cases, much of the discourse has been around 'brain gain', that is the benefits of being able to access global research talent. However, the story is not necessarily so straightforward,

as many UK researchers spend some time abroad, and equally, several studies indicate that there are both advantages and disadvantages of mobility for both host and origin countries, as outlined below.

4.3.2. Internationalisation may affect working conditions

As noted above, migration of scientists can potentially have effects on wage levels which are beneficial at the institutional level, but may not necessarily be of benefit at the national level (Fernández-Zubieta, Geuna & Lawson 2015). However, in a survey of Marie Curie researchers, internationalisation of research was noted as a potential benefit of mobility, in part through its potential to improve/standardise working conditions across a broader research market. This is perhaps reflecting the fact that the impact of mobility and the internationalisation of research will depend to a large extent on the country context in question.

4.3.3. There are potential benefits (and challenges) for both host and source countries economically and in terms of skills development

Regets (2007) classifies potential benefits and disadvantages of mobility according to status as either host or sending country, noting both positive and negative potential outcomes on both sides. Potential positives for host countries noted by Regets include increases in R&D and economic activity through the increased availability of highly skilled workers and export opportunities for technology. However, the study suggests possible negatives such as a decreased incentive for natives to seek higher skills, and the potential for technology to be transferred to competitors (and potentially even to hostile countries). Although mobility offers opportunities to access wider skill sets, there is also the risk that the skill sets and/or research interests of incoming researchers do not correspond to local research needs and priorities.

Alongside this, Regets (2007) also points to challenges for sending countries, particularly the loss in productive capacity ('brain drain'), and possible reductions in public funding for higher education. There are correspondingly some positives such as increased incentive for natives to seek higher skills, possibilities to export technology and other products and services, returning researchers with increased human capital, and remittances and/or other support for diaspora networks. Scelleto, Franzoni & Stephan (2014) note that, on average, just over 40 per cent of foreign-born researchers report ongoing research collaborations with researchers in their countries of origin.

However, this simple stratification does not capture all the nuances in terms of the differences in experience depending on country context. For example, the extent to which academic researchers maintain links with their home countries will depend on the extent to which their country of origin has a large local research base, as well as their career stage, as noted previously (Scellato, Franzoni & Stephan 2014; Gibson & McKenzie 2010). Similarly, experiences and motivations differ depending on the direction of mobility between the EU and US, despite largely well-supported and established research systems on both sides of the mobility pathway (Kim & Locke 2010).

4.4. Benefits and consequences for science

4.4.1. Internationalisation of research can bring benefits in terms of knowledge and skills development

A number of the benefits described in the sections above, involving increases in networking and collaboration and increased/improved academic output, are potentially beneficial for science and research as a whole. However, this depends on the extent to which mobility can be established as causal – perhaps the best researchers are also the most mobile,

meaning we would expect them to have a better publication performance regardless of their movement between institutions.

However, one consequence of mobility for research as a whole where causality is clearer is the increased internationalisation of research. Although collaboration and increased connectivity through the Internet have also contributed, the movement of researchers across international borders must also play an important role in the growth of internationalisation in research. This issue is explored in several studies, and noted as a positive outcome of mobility by Watson (2010), and Regets (2007), with Regets referring in particular to international flows of knowledge supporting research and business, greater employment opportunities and opportunities for the formation of international research or technology clusters, and Watson noting the potential to improve working conditions and the employment position of researchers. Borchgrevink & Scholz (2013) see international mobility as being key to meeting some of the grand societal challenges in Europe. Locke & Bennion (2010b) note the different perspectives that incoming researchers bring to British research, with a higher proportion of non-British academics who had studied for their doctorate abroad stating that their primary research had an international scope or orientation (90 per cent), compared with British academics – even those who had studied for their doctorates abroad (67 per cent).

In contrast, Robertson (2010) raises concerns about the standardisation that may result from the increasing globalisation of research. While other studies reference the benefits of drawing on a diversity of research cultures and conceptual viewpoints through mobility, Robertson notes that as mobility increases, this diversity, both in terms of practice and linguistically, could be eroded.

Summary:

As a destination country, the UK derives benefits from mobility through access to additional skills and expertise; there are also benefits for source countries

- In line with the idea of 'brain drain', it is generally understood that destination countries benefit from having a strong supply of well-qualified workers. However, it is less clear that source countries experience a loss, as might be expected, as mobile researchers tend to retain productive links with their home countries and may also return home, bringing back additional skills and expertise.
- In the case of the UK, many foreign doctoral candidates return to their home countries to pursue research, taking skills and training back to their home countries.

Mobility is associated with improvements in researchers' professional development and academic performance, though causality is difficult to establish

- Mobility is associated with better international networks, more research outputs, higher-quality outputs and, for most, better career outcomes.
- The extent to which these benefits can be causally linked to mobility, however, is less clear. Only a limited number of studies have tried to address this issue, controlling for other researcher characteristics, and the results are mixed.
- However, for host countries such as the UK, and their institutions, access to these high-performing researchers – whether this performance is due to their mobility or their intrinsic characteristics – is a benefit of mobility.
- The nature and extent of the benefits differ between different groups. For example, benefits around academic output and, particularly, networks, are more pronounced for senior researchers, whereas junior researchers benefit more in terms of skills and career development.
- Field, gender, length of stay and country of origin/destination, are also noted as potentially affecting researchers' experiences of mobility.

5. Conclusions

International mobility is a broad concept, hard to define and hence hard to study. The evidence gathered for this review makes it clear that mobility comes in many forms, and from a policy-making perspective it is important to recognise this variability. Mobility can occur between different countries, at different career stages and for different lengths of time, and it can bring varied impacts and outcomes for individuals, institutions and research systems.

As Fahey & Kenway (2010) put it, ‘Some researchers are mobile some of the time, whilst for others, travel has become a routine part of their life.... Neither is the mobile researcher positioned as being either settled or on the move. Such either/or categorisations are seen as inadequate, for they fail to see that understandings of ‘home and away’ have become increasingly complex and that many researchers are at home in motion....’.

Making comparisons between studies is challenging because each defines mobility in different ways, taking a different scope in terms of duration of mobility and taking different starting points (comparing location of work to nationality, country of birth, country of education, or country in which a researcher’s PhD was completed). However, despite these challenges, we are able to identify some key findings about the patterns and drivers of mobility, the barriers to mobility, and its benefits and consequences:

- The UK is an attractive destination for researchers, and foreign researchers play an important role in our research system.
- The decision to move is complex and researchers consider a range of personal and professional factors.
- As a destination country, the UK derives

benefits from mobility through access to additional skills and expertise, alongside which there are also benefits for source countries.

- Mobility is associated with improvements in researchers’ professional development and academic performance, though causality is difficult to establish.

In addition to these key findings, there are a number of emerging themes and issues, as well as key gaps in the evidence, based on the literature reviewed. These are explored below.

5.1. Discussion and emerging issues

One key emerging theme from this analysis is the diversity of types of international mobility and motivations for mobility and correspondingly the diversity in the range of outcomes depending on the nature and intentions of mobility and the personal characteristics of the researchers in question (Weert 2013; Scellato, Franzoni & Stephan 2014; Gibson & McKenzie 2010; Rostan & Höhle 2014; IDEA Consult 2010; Fernández-Zubieta, Marinelli & Pérez 2013; Van Bouwel, Lykogianni & Veugelers 2011; Cox 2008; Watson 2010; Kim & Locke 2010; Marinelli, Elena-Pérez & Renandez-Zubieta 2013; Nedeva et al. 2012; Avramov 2015). It is difficult to provide an overall summary of drivers of mobility or outcomes, because these will vary significantly from case to case, reflecting differences in context, experience and preferences as well as wider socioeconomic factors.

It is also worth reflecting that the picture regarding mobility differs significantly between countries. Though many countries, including the

UK and other western nations, see the conduct of science and research as an international, increasingly mobile and collaborative endeavour, this is by no means the case the world over. Even within the EU, the majority of mobility is limited to just a few host countries, notably the UK and Germany (although there is a 'long tail' of countries seeing lower levels of mobility), and many countries fall outside of the available EU- and OECD-focused datasets (Mogu rou & Paola Di Pietrogiacommo 2008; Weert 2013; Moed, Aisati & Plume 2012). The concept of research as being conducted by a wide mix of varied nationalities as experienced in the UK and other stronger research countries (e.g. the US, Germany and other Western European countries) is an experience specific to those stronger research areas.

The prevalence of international mobility in stronger research systems links into the concept of the 'expectation of mobility' – the idea that to have a successful research career, international mobility is a prerequisite (Robertson 2010; Cantwell 2011; Ackers 2008; Bauder 2015). This is an interesting concept that has implications in many ways. For example, it has been noted elsewhere that women are less likely to move internationally, and that they face greater personal barriers to mobility (Nedeva et al. 2012; Sang, Al-Dajani &  zbilgin 2013; Ackers 2008; B ring et al. 2015; Cox 2008; Franzoni, Scellato & Stephan 2012; IDEA Consult 2010; Weert 2013). If mobility is a 'prerequisite' for academic success, this means that women are likely to be systematically disadvantaged. Equally, this higher barrier to mobility perhaps helps to explain why women tend to experience greater benefits from mobility (Weert 2013) – to overcome these barriers, the offer has to be more attractive and more likely to be beneficial.

Motivations for mobility, though potentially diverse, can be considered to fall into two broad underlying categories. Some researchers move in order to access better facilities, work with high-quality collaborators, or generally to benefit their career (Bauder 2015; Cantwell

2011). These professional motivations are often likely to apply to those coming to the UK to do research, but may also include some UK researchers going to other countries (e.g. the US). The second category involves personal motivations. Researchers sometimes move to another country because of personal or family ties – often, though not exclusively, returning to their home country following a period overseas (Auriol 2010; Cuntz 2016; IDEA Consult 2010; Weert 2013; Rostan & H hle 2014; Franzoni, Scellato & Stephan 2012). In this second category, we might not necessarily expect to see significant professional benefits from migration – indeed career prospects may be worsened after the move, reflecting the fact that professional motivations were not the primary concern. This dichotomy goes some way to explaining the split in findings regarding outcomes of mobility for researchers seen in several studies, notably the MORE2 survey analysis (Weert 2013). This interplay of personal and professional motivations in different contexts is explored more in the survey analysis (Guthrie et al. 2017).

Professional versus personal motivation is not the only stratification that impacts on mobility outcomes. Also interesting is the observation that mobility has different effects (and drivers) at different career stages (Scellato, Franzoni & Stephan 2014; Gibson & McKenzie 2010; Watson 2010; Weert 2013). Early career researchers move to develop their skills and advance their careers (Weert 2013; Scellato, Franzoni & Stephan 2014; Gibson & McKenzie 2010), while senior researchers are more likely to benefit from mobility through increased academic output and developing networks, building on their established reputation in their home country, as well as their developed knowledge and skills (Scellato, Franzoni & Stephan 2014; Gibson & McKenzie 2010).

Short-term contracts are reported as a facilitator of mobility, but equally mobility, and the corresponding supply of high-quality researchers, also facilitates institutions offering short-term positions in the knowledge that new

researchers will be available to fill any vacancies, since the UK is an attractive destination (Cox 2008; Fernández-Zubieta, Geuna & Lawson 2015; Weert 2013). This is again beneficial to institutions, and potentially to the UK research enterprise, as a more flexible labour force is available, but may carry costs in terms of the quality of life for researchers, and potentially through the loss of high-quality individuals from research to careers that offer more job security and stability (Cox 2008; Fernández-Zubieta, Geuna & Lawson 2015; Weert 2013).

Finally, it is important to note that the evidence on the effects of mobility often struggles to move from correlation to causality. It is hard to show that the claimed benefits in terms of career prospects or publication record are a result of mobility rather than simply a result of the differences in characteristics of researchers who choose to be mobile compared to those who choose not to be (Hunter, Oswald & Charlton 2009; Veugelers & Van Bouwel 2015; Franzoni, Scellato & Stephan 2014). This also ties into the idea of mobility as a 'prerequisite' – if it is considered that mobility is required for a researcher to progress, it is unsurprising that researchers who move then see an increase in their prestige and career prospects. Some benefits may therefore stem from mobility as a concept rather than the actual mobility itself.

5.2. Gaps in the evidence base

One critical gap relates to researchers in industry. This group tends to be less well-defined and more difficult to reach through surveys; as a result, although statistics indicate that half of European researchers work in private organisations (Eurostat 2017a), academic researchers are the focus of the majority of mobility studies.

Other authors have noted that data on the international mobility of higher education students are much more readily available, comprehensive and comparable than data on

the international mobility of researchers (Rostan & Höhle 2014; Fernández Zubieta & Guy 2010). This observation is consistent with our findings that statistics on mobility are not widely and systematically collected, and that differences in reporting pose further challenges. These include differences in how researchers are defined, which time periods are covered, which activities are deemed to constitute mobility and whether one uses nationality, country of birth, country of highest degree or another reference point in determining where researchers are 'from'. Despite this, there is generally more evidence available on patterns of mobility and flows of mobile researchers than on drivers and consequences of mobility. The latter are more difficult to assess, and consequently the evidence is sparser, though a few large-scale surveys are available that start to address that gap (IDEA Consult 2010; Weert 2013; Franzoni, Scellato & Stephan 2012).

Considering drivers and barriers, one notable gap in the evidence is around the effect of immigration rules on migrant researchers' attitudes to and experiences of mobility. In particular, very little evidence is available on this topic in relation to UK immigration rules, which may be of interest in the current context.

There is also a lack of evidence around the social implications of mobility, both at a personal level and in terms of research outcomes. Most studies focus on benefits to the economy, careers or academic output and networks. The advantages of mobility have chiefly been assessed in terms of publications, which does not present a full account of the benefits to society that research provides. On a personal level there are many studies that look at the consequences of mobility at the individual researcher level, but amongst them there is less reflection on mobility as a social dynamic, and little attention on the mobility of families rather than individuals and the wider implications this has, spanning impacts on careers of partners to social and family relations and connections.

More work is needed to reflect on the diversity of mobility experiences and drivers and their implications for the benefits (and disadvantages) of mobility. A few studies break down the differences in mobility experiences and the benefits that accrue across stakeholders depending on the length of time spent in a different country, career stages and other factors such as personal circumstances, age and gender (Scellato, Franzoni & Stephan 2014; Gibson & McKenzie 2010; Watson 2010; Weert 2013; Kim & Locke 2010; Marinelli, Elena-Pérez & Renandez-Zubieta 2013; Stephan, Scellato & Franzoni 2014). The evidence that is available suggests that these factors do lead to important differences in terms of outcomes. Further work would be beneficial to understand how and when mobility can lead to benefits. There is also some, but again limited, reflection on the role of the motivations for mobility and the implications this has for the ultimate outcomes of the movement of researchers (Kim & Locke 2010; Weert 2013). This encompasses different personal and professional motivations, but also the contrast between researchers who move because they

want to experience other research contexts, and those that feel they need to be mobile in order to progress in their careers.

Finally, the lack of comparable definitions of mobility prevents the various sources of evidence from being synthesised to strengthen our understanding of mobility. Work is needed to improve the comparability and aggregability of definitions in order to build a more powerful evidence base around the patterns and drivers of mobility.

To address some of these gaps, as part of this project we have conducted a survey of researchers currently based in the UK, in higher education institutions, public sector research establishments and research institutes. The survey aims to capture information not just on mobility patterns, but also on the drivers and barriers of mobility, the role that family plays, and the outcomes of mobility. The findings of this survey are reported in 'International mobility of researchers: A survey of researchers in the UK' (Guthrie et al. 2017).

Appendix: Methods and key sources

Our review drew on a scoping review methodology (Levac, Colquhoun & O'Brien 2010) to establish what is known about the international mobility of researchers, in relation to patterns of mobility, drivers of and barriers to mobility, and the benefits and consequences of mobility, with a particular focus on researchers moving to and from the UK. Our approach followed the principles of a systematic review in terms of having clearly defined research questions, systematic and replicable search strategies and explicit inclusion and exclusion criteria. We assessed quality (relevance, study design and interpretation) and used it as a basis for excluding some studies. We also noted methodological concerns in our synthesis. In general, we sought to undertake a narrative synthesis rather than pool numerical results based on our research questions and knowledge of the literature.

Search strategy

An initial trial of search terms was conducted by two researchers to refine search terms and scope based on the quantity of relevant literature identified. Additional checks were conducted to confirm the comprehensiveness of our search criteria through a review of the publication sections of the following websites:

- The Royal Society (Royal Society 2017)

- Elsevier (Elsevier 2017)
- European Commission, DG Research and Innovation (European Commission 2017)
- European Research Council (ERC) (European Research Council 2017)
- Joint Research Centre (JRC) Science Hub.

The modified search terms were applied to Google and Google Scholar databases²² (IP in Virginia, USA) between 3 November and 16 December 2016. Searches of eligible studies' reference lists were also conducted. The search terms used are presented in Table A.1.

A review of relevant databases was also conducted to locate potentially useful datasets. This covered Eurostat, the Organisation for Economic Cooperation and Development (OECD), the UK Office for National Statistics (ONS), and the UK Higher Education Statistics Authority (HESA).

Inclusion and exclusion criteria

Any type of study published in English from 2006 onwards (i.e. in the last 10 years) that examined the international mobility of researchers to or from the UK was eligible for inclusion. We did not exclude literature based on methodology, though commentaries and other opinion pieces which were not based on cited evidence were not included. Studies that only examined pre-

²² Based on our experience from previous studies, repeating searches in other databases such as Web of Science or specialist subject area databases does not yield significant additional useful results. Our experience is that for most topics, Google Scholar's coverage is fairly extensive and duplication of searches across multiple databases is not an efficient use of resources. This is supported by other research, e.g. Gehanno, Rollin & Darmoni (2013).

Table A.1. Search terms

“Brain gain” OR “Brain drain” OR “Brain circulation”

(Migrant OR Migrate OR Migration OR Migrants OR Immigrant OR Immigrate OR Immigration OR Immigrants OR Emigrant OR Emigrate OR Emigration OR Emigrants OR Mobility OR Brexit OR “EU national” OR foreign) AND (Research OR Researcher OR Researchers OR Science OR Scientist OR Scientists OR Scientific OR Academic OR Academics OR Academia OR Engineer OR Engineers OR Engineering OR R&D OR “R and D” OR Postdoc OR Post-doc OR Postdocs OR Post-docs OR Postdoctoral OR Post-doctoral OR “Post doc” OR “Post docs” OR “Post doctoral”)

“academic mobility” AND (research OR science)

“research staff” AND (mobility OR international)

doctoral student mobility were excluded, as were those that concerned non-geographic (e.g. cross-disciplinary) mobility. Studies that did not address the UK setting (whether from a regional or national perspective) were also not included. Table A.2 summarises the inclusion and exclusion criteria used.

Quality criteria were developed and piloted for five studies by all reviewers and any discrepancies discussed and the criteria refined before the full review of all studies took place.

Quality of the studies was assessed on the basis of the following criteria:

1. Topic relevance:
 - Does the study directly address the patterns, drivers and consequences of the mobility of researchers to and/or from the UK?
2. Quality of study design and conduct:
 - Is the study well designed to meet the research aims/questions?

Table A.2. Inclusion and exclusion criteria

	Inclusion	Exclusion
Types of mobility	Geographical mobility of researchers (national or international)	Non-geographic forms of researcher mobility, e.g. across disciplines or between academia and industry
Types of researcher	Provides evidence on researchers operating at a doctoral level and upwards, in academia or industry	Sole focus on undergraduates or other pre-doctoral researchers
Nature of evidence	<ul style="list-style-type: none"> • Provides evidence on mobility (patterns, drivers and/or benefits/disadvantages) • Policy documents relating to current policy only • Policy reviews/evaluations relating to current and past policy 	<ul style="list-style-type: none"> • Does not provide any evidence on patterns, drivers and/or benefits/disadvantages of researcher mobility • Policy documents, except reviews/evaluations, which relate to past policies
Language	English	Any language other than English
Country setting	Literature relating to the UK, or to the UK among a group of other countries (e.g. studies of EU or OECD countries, or at the global level)	Sole focus on a country, group of countries or a region of which the UK is not part
Document type	Any type of publication the assertions of which are based on cited evidence	Commentaries, editorials or opinion pieces with no underpinning evidence cited
Date of publication	2006 onwards (last 10 years)	Before 2006

- Is the sampling approach appropriate and well justified?
- Is the data collection approach appropriate and well justified?

3. Quality of analysis and interpretation:

- Are data appropriately analysed and findings adequately corroborated?
- Does the interpretation of the findings adequately reflect the assumptions made, limitations of the method, and any issues around generalisability of the findings?

For each of the three criteria, studies were rated as 'Green: Addressed the criteria clearly and fully', 'Amber: Addressed the criteria partially', or 'Red: Did not address the criteria'. Studies rated 'red' under at least one area were excluded from the main analysis. Remarks about study quality were also noted during the data extraction and taken into account in the synthesis.

Study selection

Records identified by the searches were assessed for inclusion by scanning titles and abstracts against the inclusion and exclusion criteria. Reference details of potentially relevant studies were recorded in a Microsoft Excel spreadsheet template.

At this stage studies were deliberately retained if there was any uncertainty as to their relevance. This was done by two reviewers against the stated inclusion and exclusion criteria, and uncertainties were resolved through discussion with the wider study team. Full-text screening of potentially eligible studies was undertaken as part of the data extraction stage, and additional studies were excluded against the same inclusion and exclusion criteria at this stage, based on the more detailed information available through full-text review. In addition, a 'snowballing' approach was used, where the reference lists of relevant studies were reviewed for further potentially relevant studies

for inclusion, which were then screened in the same way.

Data extraction and synthesis

Data from studies identified as eligible were extracted into the Microsoft Excel template and included records were managed in Zotero (version 4.0.29.10). Guided by our research questions, data were extracted on study type and methods, evidence on patterns of mobility, evidence of drivers of mobility (barriers and facilitators), evidence on the effects and consequences of mobility (benefits and disadvantages), relevant schemes and policy initiatives, and other notable findings. The data extraction template was piloted on a small number of studies and refined. Data extraction was undertaken by three researchers.

We synthesised the evidence available in relation to each of our research questions and identified additional themes arising from the literature that we considered potentially important in the context of understanding the evidence landscape on the international mobility of researchers.

Overview of the evidence base

Our searches identified a range of articles, reports, commentaries and data sources. A total of 219 sources were initially selected on the basis of title and abstract review. Following data extraction and quality assessment, 65 were selected for inclusion in the review. Taken together, these sources presented a range of different types of evidence on international mobility – ranging from survey data and analysis of official statistics to discussion and evaluation of policy initiatives, interview data and analysis of participation in mobility-related research programmes.

About half of the studies were journal articles, reflecting the fact that there is strong interest in researchers' mobility among both policy makers and researchers themselves. A further quarter were grey literature (i.e. policy reports),

and the rest were working papers, conference outputs and policy briefs. In terms of the data sources they provided, one third had survey data, half included reviews of existing literature or syntheses of data from other sources (including official statistics), and one sixth used bibliometrics and/or patent analysis. The remainder were based on interviews, focus groups, case studies, analysis of official statistics and CV analysis. Some studies relied on multiple data sources.

While the majority of studies did not clearly state which career stages they covered, five covered European Research Council (ERC) or Marie Skłodowska-Curie Action (MCSA) programme participants, and 11 focused on doctoral and/or postdoctoral researchers. Some 43 studies focused on academia, while just four covered industry explicitly and many others did not specify which sector they focused on. In terms of geographical focus, 28 focused on Europe, 11 had a global or OECD focus, nine focused on a group of countries that included the UK, five focused on the UK specifically, and others had a mixed or unspecified geographical focus.

In addition to specific studies, we also identified 10 datasets relevant for analysis. These were primarily identified through the literature reviewed. Of these, four were European-level datasets, two were UK datasets, two were from the OECD, and two were bibliometric datasets, focusing on the UK and EU respectively, but with international benchmarks.

While there are limitations in the data available in terms of its comparability and comprehensiveness, the range of sources that exist presents a diverse set of approaches and perspectives on the concept and measurement of international mobility. The following subsections provide an overview of the content of some of the key sources of evidence around researcher mobility and a brief summary of the methods

used to provide a sense of the kind of research that has been conducted in this area, and in particular, the differences and limitations of the key data sources that underpin the evidence.

Studies and data on European programmes: FP7/MCSAs/ERC

Programme evaluations and other studies on applications to and participation in European research programmes – including the Seventh Framework Programme (FP7), the Marie Skłodowska-Curie Actions (MCSAs)²³ and the European Research Council (ERC) – provide a source of information on mobility into and within Europe. Within FP7, the European Commission's research and innovation funding programme for the period 2007–2013, the FP7-PEOPLE programme aimed to improve researchers' mobility and networking across Europe. The MCSAs, which were part of FP7-PEOPLE (and continue to be supported under Horizon 2020, the successor to FP7), provide individual fellowships and other funding to support researchers' career development and training, including through international mobility. The ERC awards grants to independent researchers doing research in science, humanities or engineering, on the basis of the 'scientific excellence' of their work. It is open to researchers of any nationality who will do their research at an EU or associated country institution (European Research Council 2017).

Studies selected for inclusion in this review analysed participation in these programmes. Fresco (2015) evaluated the FP7 programme overall, while Avramov (2015) did an evaluation focusing on the FP7-PEOPLE programme. Nedeva et al. (2012) and Mugabushaka, Rieder & Toma (2014) looked at and gathered data related to the ERC programme. Nedeva et al. (2012) focused on the first cohort of ERC Starting grantees (who applied in 2007), and conducted a survey in 2010/11 of both the

23 Known as the Marie Curie Actions prior to 2014.

grantees and a matched control group. The survey explored mobility, demographics and other characteristics. Mugabushaka, Rieder & Toma (2014) aimed to identify national research systems in Europe in which mobile researchers play an important role, operationalising a definition of 'foreign born' to characterise mobility. Publicly available data on ERC awards provide another source of information on mobility related to this programme (European Research Council 2011, 2016a, 2016b).

Eurostat and OECD statistics

Eurostat and the OECD provide some useful baseline statistics around mobility covering their respective geographical remits. Eurostat data include statistics on human resources in science and technology (HRST) as well as doctorate students in science and technology fields, broken down by country. Breakdowns are also available by gender in both cases, and by sector for the HRST data. The OECD holds data on international student mobility including at the doctoral level, as well as information on the number of foreign-born doctoral holders by country, proportions of highly educated individuals in native and immigrant populations, and international bilateral flows of researchers by authorship on journal articles. It also holds information on the international mobility of scientific authors and expected citation impact by mobility profile for each country. Most of the bibliometric-based data is for 2013.

The GlobSci Survey

Respondents to the GlobSci Survey were corresponding authors of research articles published during 2009 in the fields of biology, chemistry, materials, and earth and environmental sciences, and who worked in one of 16 countries: Australia, Belgium, Brazil, Canada, Denmark, France, Germany, India, Italy, Japan, the Netherlands, Spain, Sweden, Switzerland, the UK or the US (Franzoni, Scellato & Stephan 2012). The survey,

conducted in 2011, had a sample size of 17,182 and a response rate of 36 per cent. Mobility was investigated based on country of residence at age 18, which was used as a proxy for the researchers' country of origin. Information gathered through the survey included respondents' research interests, education, career and international mobility history, factors that influenced researchers' mobility decisions, and the perceived impact of their international experience.

The MORE and MORE2 Surveys

MORE (data gathered 2009–2010 and results published by IDEA Consult (2010)) and MORE2 (data gathered 2011–2013 and results published by Weert (2013)) were large-scale projects to gather data on researchers' careers and mobility in Europe. Both consisted of multiple surveys, and details of the data gathered are given in Table A.3.

For both projects, the surveys collected information on respondents' career and mobility history, and about factors that motivated or acted as barriers to international mobility. Mobility was defined based on location of doctoral study (or study for highest degree), with a minimum stay of three months required. The respondents represented a range of different fields and career stages.

Studies on 'elite' researchers

At least one group of authors has explored the mobility choices and patterns of highly successful researchers, generally defining research 'success' as having strong publication and citation records. They used the ISI Highly Cited database, which had identified the ~250 most cited individuals in each of 21 different subject areas on the basis of publications and citations from the period 1981–2002 (Maier, Kurka & Trippi 2007; Trippi 2013). Overall, the database included 5,570 individuals with varying levels of biographical information for each; 5,472 provided information on their current country of

Table A.3. Summary of data gathered in the MORE and MORE2 projects

Survey		Respondent type	Respondents' current countries	Sample size	Representative at country level?
Higher Education Institute (HEI) Survey	MORE	<ul style="list-style-type: none"> • Researchers currently working in EU HEIs 	EU-27	4,538	Yes (except France)
	MORE2	<ul style="list-style-type: none"> • Researchers currently working in EU HEIs 	EU-27 + 6 associated and candidate countries.	10,547	Yes
Extra-EU Survey	MORE	<ul style="list-style-type: none"> • Researchers who have been mobile between the EU and US • Non-mobile researchers • Researchers in other regions 	Mainly EU-27 and US, plus other countries	5,544	No
	MORE2	<ul style="list-style-type: none"> • EU researchers currently working outside EU • Non-EU researchers who have worked in EU • Non-EU researchers who have been internationally mobile outside EU • Non-EU researchers who have not been mobile 	EU-27 plus Iceland, Liechtenstein, Norway and Switzerland	4,090	No
Industry Survey	MORE	<ul style="list-style-type: none"> • Researchers working in the private sector 	EU-27	3,061	No
Research Institute Survey	MORE	<ul style="list-style-type: none"> • Researchers working in the non-university public research institute sector 	EU-27	5,050	No

Source: IDEA Consult (2010) and Weert (2013)

residence while 2,278 provided information on their country of birth. In one article (Trippel 2013), this data was supplemented with information from a survey, to which 2,841 scientists were invited (all those who were listed in the database and provided a valid email address) and 720 responded (response rate 25 per cent). The survey, conducted in 2008, covered respondents' career and mobility histories, research areas and basic demographic information. Frequencies of research visits and other international activities were also included. (In addition, the studies described above focused on ERC grantees can be considered to be focused on elite researchers.)

The Changing Academic Profession (CAP) Survey

The CAP Survey was part of an international project that involved at least 18 countries around the world, including the UK (Locke & Bennion 2010a). It aimed to gather and compare evidence on how academia was changing across the higher education systems studied, and on the causes and effects of those changes. The survey was administered at a national level in 2007 and 2008 to obtain representative samples from each country. Overall, the survey received 21,130 responses (Rostan & Höhle 2014). It was not focused on mobility specifically, but covered questions related to mobility (based on location

of doctoral study) in sections on respondents' career and professional situation, general work situation and activities, and personal and professional background. Internationalisation was a key theme.

The UK survey was conducted in 2007, and targeted all academics (full- and part-time academics who do teaching or research, senior academic managers, and healthcare professionals with research and teaching roles). According to UK national statistics, the target population consisted of 169,995 individuals, and 1,667 responses were received, which were weighted by gender, grade, institution type and subject area (Locke & Bennion 2010a).

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