FACULTEIT ECONOMIE EN
BEDRIJFSWETENSCHAPPEN



KATHOLIEKE
UNIVERSITEIT
LEUVEN

MOBILE MINDS

The drivers and effects of international researcher mobility

Proefschrift voorgedragen
tot het behalen van de graad
van Doctor in de Toegepaste
Economische Wetenschappen

door

Linda VAN BOUWEL

Nummer 394 2012

COMMITTEE

Prof. Dr. Reinhilde Veugelers (Promotor)	*Katholieke Universiteit Leuven*
Prof. Dr. Dirk Czarnitzki	*Katholieke Universiteit Leuven*
Prof. Dr. Otto Toivanen	*Katholieke Universiteit Leuven*
Prof. Dr. Frank Verboven	*Katholieke Universiteit Leuven*
Prof. Dr. Paula E. Stephan	*Georgia State University*
Dr. Elissavet Lykogianni	*Deloitte*

Daar de proefschriften in de reeks van de Faculteit Economie en Bedrijfswetenschappen het persoonlijk werk zijn van hun auteurs, zijn alleen deze laatsten daarvoor verantwoordelijk.

ACKNOWLEDGEMENTS

Working on a PhD is a serious challenge. An intellectual challenge, to be sure, but as I quickly learned, it is to a great extent a challenge of character and perseverance too. Along the way I also discovered that although a PhD is often thought of as a solitary undertaking, I could never have successfully completed this project without the help of many wonderful people. I would like to take this opportunity to thank them.

First and foremost, I would like to thank my advisor, Reinhilde Veugelers. Thank you for your guidance, for sharing your wisdom and for teaching me valuable research skills, and for always asking critical questions to challenge me to go further. You always asked me, sometimes to my despair, what exactly the question was that I was trying to answer. In so doing, you have taught me a lesson I will never forget: asking questions is easy. Asking the *right* questions is harder.

My gratitude also goes to the members of my doctoral committee, professors Dirk Czarnitzki, Otto Toivanen, Frank Verboven, Paula Stephan and Dr. Elissavet Lykogianni, for their insightful comments and helpful suggestions to improve my work. I owe a special thanks to Dr. Elissavet Lykogianni, for the pleasant and instructive collaboration with her on several research projects. I am also grateful to professor Paula Stephan, for giving me the opportunity to spend a few months at the Andrew Young School of Policy Studies at Georgia State University, an experience which was enriching both intellectually and personally. Also a special thanks to Dirk for giving me the Economist calendar, with the message that I was "the only person he knew who actually thought the jokes in the Economist were funny."

Colleagues are a huge determinant of the atmosphere in a work place, and I am lucky to have had the opportunity to spend almost 5 years with many wonderful people. We shared the highs and lows of the PhD program, complained to one another of our terrible sufferings and cheered for each other when there was something to celebrate. A big thank you to my MSI colleagues Adriaan, Adrian, Annelies W., Annelies G., Antonio, Bart, Benjamin, Cathy, Cecilia, Cindy, Dennis, Dieter, Franz, Fréderic, Hanna, Hannah, Ivanka, Jan V., Jan W., Jesse, Julie, Kevin, Maikel, Méric, Mila, Nazlihan, Peter, Phara, Pieterjan, René, Sam,

Shinya, Shubin, Siegfried, Stijn, Susanne, Sven, Vincent, Ward, Wim and Wytse. My utmost gratitude to Isabelle and Dani for making my life so easy on the administrative front. To my fellow Economics Doctoral Circle members, Annelore, Ine, Laura, Leen, Marjolein, Mathijs, Philippe, Sofie and Vincent, thank you for embarking with me on this wonderful project that has been a very instructive but above all fun experience. I dare say some colleagues have grown to be close friends whom I will cherish for the rest of my life. You guys never fail to put a smile on my face, Ine, Leen, Koen, Sofie and Vincent. Thank you for always defending the silver lining.

When I was pondering the part of my dissertation that would be most read by the general public - the title- I called in the help of my Facebook friends to come up with the perfect 'catchy title' to precede the rather dry 'The drivers and effects of international researcher mobility'. Thanks to all who actively participated in coming up with such gems as 'brains to go', 'scatter brains', and 'doctors without borders'. And of course a big thank you to my genius brother Thomas, who came up with the winning title. Your seemingly effortless creativity amazes me every time. You inspire me, and my admiration for your many talents is boundless. I can't wait to see what you do next.

To my parents, thank you for making me the person I am. I would not be standing here today if it were not for all the valuable lessons you have taught me throughout my life: that hard work and perseverance ultimately pay off, to have faith in myself and my capabilities, to find joy in every step of the journey… the list goes on. My gratitude towards you is endless.

Finally, to the person who stood by my side throughout this journey - who unfortunately was the first to suffer from my grumpy mood when my research wasn't going as expected - but who nevertheless was always present with a listening ear, words of encouragement and comfort, and an occasional kick in the butt when needed (rarely, but still): Kobe, there are no words to express my gratitude and love. I admire your constancy, empathy and your seemingly effortless ability to (appear to) be interested in the utterly boring details of my work. Your patience and kindheartedness are a continuous source of inspiration and comfort to me. I cannot wait to spend the rest of my life with you.

Linda Van Bouwel Leuven, June 2012

CONTENTS

COMMITTEE **3**

ACKNOWLEDGEMENTS **5**

CONTENTS **9**

GENERAL INTRODUCTION **13**

Why economists should care about international researcher mobility **13**

Contributions and research questions **16**

The structure of this thesis **18**

CHAPTER 1

THE THEORETICAL BACKGROUND AND INSTITUTIONAL CONTEXT OF INTERNATIONAL RESEARCHER MOBILITY **21**

1.1 Theoretical background **22**
1.1.1 General theoretical background 22
1.1.2 Theoretical background by career stage 26
1.1.2.1 PhD mobility 26
1.1.2.2 Post-PhD return 29
1.1.2.3 Researcher mobility 34
1.1.3 Conclusion 36

1.2 Institutional context **37**
1.2.1 General institutional context 38
1.2.1.1 General trends for PhD holders 38
1.2.1.2 Country and region characteristics 44
1.2.1.3 Discipline-specific characteristics 50
1.2.2 Career-stage specific institutional context 52
1.2.2.1 PhD mobility 53
1.2.2.2 Post-PhD return 60
1.2.2.3 Researcher mobility 65
1.2.3 Conclusion 69

1.3 Data **71**
1.3.1 The MORE dataset 71
1.3.2 The ProQuest dataset 76

CHAPTER 2

INTERNATIONAL MOBILITY OF EUROPEAN DOCTORAL RESEARCHERS **81**

2.1 INTRODUCTION **82**

2.2 A REVIEW OF THE EVIDENCE ON TERTIARY STUDENT MOBILITY 83

2.3 DATA 84

2.4 RESULTS 87
2.4.1 Characteristics of mobile and non-mobile PhD students 87
2.4.2 Characterizing the research and innovation environment at home 91
2.4.3 Econometric results on the factors driving PhD degree mobility 93
2.4.4 Logit results for PhD degree mobility: at home or abroad 94
2.4.5 Multinomial logit results for the destination of PhD degree mobility: North America versus Europe. 96

2.5 CONCLUSION 98

2.6 APPENDIX 100

CHAPTER 3

AN ELITE BRAIN DRAIN: ARE FOREIGN TOP PHDS MORE LIKELY TO STAY IN THE U.S.? 103

ABSTRACT 103

3.1 INTRODUCTION 104

3.2 CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW 105

3.3 DATA 109

3.4 RESULTS 115
3.4.1 First job 115
3.4.2 Current job 126

3.5 CONCLUSION 131

3.6 APPENDIX 133
A.3.1 List of definitions 133

CHAPTER 4

THE ACADEMIC LABOR MARKET AND FOREIGN STUDENTS' RETURN DECISIONS 137

ABSTRACT 137

4.1 INTRODUCTION 138

4.2 THEORETICAL FRAMEWORK: THE LABOR QUEUE MODEL 141

4.3 DATA 143
4.3.1 Foreign students 143
4.3.2 The academic labor market 144
4.3.3 Top institutions 146

4.3.4 Control variables 147

4.4 RESULTS 149
4.4.1 The model: foreign students' first job decision 149
4.4.2 Basic model 151
4.4.3 Interaction with student quality 152
4.4.4 Return home versus return elsewhere in Europe 155
4.4.5 Long term effects 156

4.5 DISCUSSION AND ROBUSTNESS CHECKS 161

6 CONCLUSION 166

CHAPTER 5

DESTINATIONS OF MOBILE EUROPEAN RESEARCHERS:

EUROPE VERSUS THE UNITED STATES 169

ABSTRACT 169

5.1 INTRODUCTION 170

5.2 A REVIEW OF THE EVIDENCE AND ANALYSES OF INTERNATIONAL RESEARCHER MOBILITY 171
5.2.1 Literature review 171
5.2.2 Hypothesis development 175

5.3 DATA: THE MORE SURVEY 176
5.3.1 The sample 176

5.4 RESULTS 181
5.4.1 Mobility statistics 181
5.4.2 Factors influencing mobility 182
5.4.3 Regression analysis 186

5.5 Conclusion 196

5.6 Appendix 198

CHAPTER 6

THE EFFECTS OF INTERNATIONAL MOBILITY ON RESEARCHERS: INTRA-EU MOBILITY VERSUS MOBILITY TO THE UNITED STATES 199

6.1 INTRODUCTION 200

6.2 LITERATURE REVIEW 201

6.3 DATA 205

6.4 RESULTS 208
6.4.1 Descriptive statistics 208
6.4.2 Logit analysis 210

6.4.3 Propensity score matching 212

6.5 CONCLUSION..... 218

6.6 APPENDIX 220

GENERAL CONCLUSION.....229

1 Summary and contributions 229

2 Limitations and suggestions for further research..... 233

3 Policy implications..... 237

REFERENCES.....241

LIST OF TABLES.....252

LIST OF FIGURES.....254

DOCTORAL DISSERTATIONS FROM THE FACULTY OF BUSINESS AND ECONOMICS 255

GENERAL INTRODUCTION

The first part of this introduction argues why studying researchers has economic relevance, and why economists should pay particular attention to international mobility. The second part discusses the research questions addressed in this thesis, and concludes with an outline of the structure and how the chapters fit together.

WHY ECONOMISTS SHOULD CARE ABOUT INTERNATIONAL RESEARCHER MOBILITY

In the last few decades, most advanced economies have developed into knowledge economies. Innovation and technological change have replaced increases in classic production factors like capital and labor as the prime engine of economic growth (Rosenberg, 1974). The idea that technological change is an essential factor in economic growth goes back to Solow (1957), and led to the formulation of new endogenous growth models where economic growth occurs as a result of knowledge spillovers from intentional research and development (R&D) undertaken by firms (Romer, 1990; Grossman and Helpman, 1994).

Many industrial innovations are based on scientific discoveries[1], which were often not undertaken with the explicit objective of product development or industrial progress. University research is indeed known to 'spill over' into industrial R&D (Jaffe, 1989). In a survey of 76 American firms in 7 industries, Mansfield (1991) found that 11% of all new products could not have been developed – at least not without substantial delay - in the absence of academic research. This is especially true for R&D intensive industries, like pharmaceuticals, instruments and IT. Likewise, Adams (1990) shows that academic knowledge is a major contributor to productivity growth.

Many inputs are needed to produce science that leads to useful innovations, but individual researchers are indispensable. Not only do they make scientific discoveries that are disseminated through publications, but researchers also produce innovations which lead to academic patents (Gurmu et al., 2008). Some scientists commercialize their own research by

[1] Conversely, many scientific discoveries were only possible thanks to technological progress, specifically in instrumentation (Stephan, 1996).

becoming entrepreneurs (Audretsch and Aldridge, 2009). Scientists also have an indirect impact on innovation and entrepreneurship: Zucker and Darby (2006) show that top scientists have an impact on the entry of high-tech firms into a particular region.

Today, more and more countries are starting to convert into knowledge economies. As a consequence, the competition for highly skilled human capital, and in particular for researchers, is bound to intensify in the future. A survey by McKinsey reveals that business executives regard finding talented people as the single most important managerial challenge of the coming years, and they expect intensifying competition for talent, a phenomenon which McKinsey has coined 'the war for talent' (McKinsey, 2007).

It is not surprising then, that policy makers at all levels are increasingly paying attention to the creation of human capital. Europe, for example, has included an explicit objective in its EU2020 strategy to have 40% of 30-34 year olds completing tertiary education by 2020[2]. But policy makers should not only focus on stimulating the creation of human capital through higher education, but also to international mobility of the highly skilled.

The highly skilled are more likely to become internationally mobile than others layers of the population. In some regions, like Central America and parts of Africa, the migration rate of the highly skilled as a proportion of the educated labor force surpasses 50% (Docquier and Marfouk, 2006). Increasing numbers migrate as students to complete higher education abroad: in 2008, 3.3 million students were enrolled outside their country of citizenship, up from 2 million in 2000 (OECD, 2010). Many students regard student mobility as a first step to permanent migration (Tremblay, 2002; Borjas, 2002). This is corroborated by the high stay rates observed for foreign PhD recipients in the U.S.: using tax data, Finn (2010) finds a one-year stay rate of 73% of foreign PhDs who graduated in 2006, and a 10-year stay rate of 60% for foreign PhD recipients from 1997. In its Survey of Earned Doctorates, the National Science Foundation finds similarly high intended stay rates of PhD recipients on temporary visas (National Science Foundation, 2010). Researchers are frequently internationally mobile too: in a survey of academic researchers in the EU27, 56% of European researchers reported international mobility experience of at least 3 months' duration during their career (MORE, 2010).

[2] See http://ec.europa.eu/europe2020 [accessed on January 5th, 2012].

Among mobile students and researchers, the best and brightest tend to cluster in a few places (Maier et al., 2007). Several authors present evidence for this so-called 'elite brain drain'. Nearly half of the world's most cited physicists work in another country, and most tend to concentrate in countries with high R&D spending (Hunter et al., 2009). Using bibliometrics methods, Laudel finds that the most cited researchers in several specialties tend to concentrate in the U.S., with many moving there permanently (Laudel, 2003). Many elite researchers, however, migrate as students or young researchers, indicating that the elite brain drain is more a 'potential elite' than an 'established elite' brain drain (Laudel, 2005).

The United States has benefited enormously from the substantial inflow of foreign students and researchers it has experienced in the last decades. Foreign students and researchers actively contribute to science and innovation in the host country. For a sample of 133 papers published in Science, Black and Stephan (2008) find that over 85% of papers have a graduate student or a postdoc as one of the authors, and almost 40% of graduate students and 60% of postdocs have a name which is neither English nor European, indicating that foreign students play a lead role in university research in the U.S. Foreign graduate students and skilled immigrants significantly increase the number of patent applications and patents awarded to university and non-university institutions in the United States (Chellaraj et al., 2005). Foreign students and postdocs play an important role in staffing university labs and make significant contributions to scientific publications (Black and Stephan, 2008). Hunt and Gauthier-Loiselle (2009) find that skilled immigrants patent at twice the rate of U.S. nationals, which is accounted for by their higher probability to hold science and engineering degrees. Moreover, foreign-born and foreign-educated scientists are represented disproportionately among those making exceptional contributions to U.S. science (Stephan and Levin, 2001).

While the United States has clearly benefited from the migration of students and researchers, the effects on sending countries are less clear. The early brain drain literature focused on the negative effects of lost human capital (see Solimano, 2008 and Ackers, 2005 for an overview). These brain drain models explore market failures in the creation of human capital such as a gap between the private and social marginal products of highly skilled workers, or a public subsidy for higher education to stimulate the consumption of this merit good. These departures from perfectly competitive markets are used to show that highly skilled emigration can have negative consequences for sending countries. In terms of policy conclusions,

scholars have debated the possibilities for taxing highly skilled emigrants to compensate source countries for the foregone social benefits from public investment in higher education – the so-called 'Baghwati tax', first proposed by Jagdish Bhagwati in 1976 (Commander, 2003; Moguérou, 2006).

However, several lines of research suggest that positive effects from highly skilled emigration are possible too. If migrants return to their home country after having improved their human capital or made valuable business connections, the home country can benefit from this so-called 'brain circulation' (Mayr and Peri, 2009; Saxenian, 2002). The possibility of migration can also be a stimulus to acquire more education. If not all the highly educated migrate, then a country might accumulate more human capital than in the absence of migration (Docquier and Rapoport, 2007; Beine et al., 2001; Mountford, 1997). If knowledge is considered a public good, and migrants can produce more or better knowledge in the host country than at home, then a brain drain may also be beneficial for the sending country (Kuhn and McAusland, 2006). Finally, expatriate researchers may continue to channel knowledge to the home country by collaborating with researchers at home. Using patent citation data related to inventions in India, Agrawal et al. (2011) show that emigrated Indian inventors channel valuable information home, as their patents are often cited by the most-cited (and therefore probably most valuable) Indian patents. This is in line with the findings on backward knowledge transfer at the firm level (Corredoira and Rosenkopf, 2010; Oettl and Agrawal, 2008; Agrawal et al., 2006). Similarly, Kerr (2008) uses and ethnic-name database to identify ethnic research communities in the U.S. Using international patent citations, he finds that knowledge diffuses through ethnic networks, and that stronger scientific integration with the U.S. positively impacts manufacturing output in scientists' source countries. Internationally mobile researchers can also channel knowledge home by co-publishing with researchers from the home country. Veugelers (2008) finds a high correlation between patterns of international mobility of scientists and international collaboration patterns.

CONTRIBUTIONS AND RESEARCH QUESTIONS

Although the exact benefits and drawbacks of highly skilled migration are still fiercely debated, both theoretically and empirically, it is clear that student and researcher mobility is a substantial phenomenon that has widespread economic effects. For policy makers who want to promote growth and welfare, from the local to the supranational level, paying attention to

highly skilled mobility has become indispensable. This requires, first and foremost, solid information on the extent and occurrence of international mobility: how many students and researchers become mobile? Where do they go? How long do they stay (away)? Moreover, to formulate coherent policy recommendations, it is crucial to know why the highly skilled become internationally mobile, what factors affect their choice of destination, if they ever return and what factors play a role in this decision, and what the effects of mobility are. However, to date, our knowledge on these matters remains limited.

Studies that collect information on highly skilled mobility can roughly be divided into 'wide data' studies and 'deep data' studies. The former are large scale studies that try to map mobility flows, if not across the globe, then at least in and out of one country or region. The most detailed and comprehensive data collection happens in the United States, for example on the presence of foreign students among PhD recipients and their return intentions by the Survey of Earned Doctorates, or on the short and long term stay rates of foreign PhD students by Finn (2010, 2012). These studies are representative of the entire population, bar a few minor non-response concerns. Efforts on 'wide data' collection have also been made in Europe, through large-scale surveys of researchers such as the Careers of Doctorate Holders (CHD) by the OECD and the Mobility Patterns and Career Paths of European Researchers (MORE) by the European Commission. However, data collection is not yet done directly at the European level, but through national statistical offices, leading to issues of comparability and representativeness. Further advances in wide, comprehensive data collection on highly skilled mobility are needed to complete the mapping of the size and direction of mobility flows.

On the other hand, 'deep data' studies are needed to go beyond the mere mapping of flows of X researchers from location A to location B, to understand who becomes mobile and why, and what elements of the work environment, motivations and other influencing factors affect mobility decisions and outcomes. Studies that address the driving factors of researcher mobility are often smaller in scale, and focus on a particular population in terms of location or discipline because data collection tends to be labor intensive. For example, some studies address the motivations of foreign students to return after completing their studies using structured interviews (Alberts and Hazen, 2005) or web surveys (Wadhwa et al., 2009). Others address the selection of who becomes mobile using bibliometric data (Laudel, 2003; Laudel, 2005) or web data collection (Kahn and MacGarvie, 2008; Gaulé, 2010).

This dissertation explores two new data sources on international researcher mobility: one based on CV data that allows to track researchers' careers over several years, and another based on survey data that offer new insights in researchers' motivations for mobility as well as the effects they perceive from mobility. The central research question throughout the thesis is how various facets of quality interact with mobility outcomes. What impact does the quality of the research environment have on the outward or inward mobility of researchers? And does the ability of the researcher play a role in the selection of who becomes mobile? These are important questions, because not all researchers are equally productive, nor do they all have the same impact. From an economic point of view, the location of a few top researchers may matter more in terms of economic impact than the location of a large number of less productive researchers.

To shed more light on the question of how the quality dimension comes into play in international researcher mobility, this dissertation studies the international mobility patterns of European PhD holders at various points in their careers, with special attention to mobility between Europe and the United States. How does the quality of the home country's science and innovation base affect the decision to obtain a PhD abroad? Are European top PhD students who obtain their degree in the United States less likely to return? Are top PhD students affected by fluctuations in the academic labor market in the same way as their peers? Other aspects of mobility are studied as well: do researchers mobile to different destinations differ in their motivations for mobility? And do the effects of mobility depend on the destination, or on characteristics of the researcher? In what follows, I briefly outline the structure of this dissertation.

THE STRUCTURE OF THIS THESIS

The international researcher mobility events that we observe are the outcome of complex processes involving decisions on the part of the researcher as well as on the part of a host of other actors, including – but not limited to – foreign universities and research institutions, border officials, and governments. It is impossible to include all the factors that directly or indirectly affect mobility events into our analyses, as this would lead to increasingly complicated models of international mobility. In the pursuit of parsimony, the underlying conceptual models often appear to assume that mobility outcomes are due only to decisions

made by researchers. However, it is important to keep in mind that researchers' choice sets are influenced by a multitude of factors outside of their control.

The first chapter is therefore a general introduction to the subsequent chapters, providing the theoretical and institutional foundation upon which the other chapters are built. A first part discusses the relevant theoretical frameworks from which insights can be borrowed to derive hypotheses for international researcher mobility. A second part discusses the institutional context in which researcher mobility takes place, outlining different factors that expand or reduce researcher's choice sets, such as general trends in the market for researchers, admissions policies, visa policies, funding, and higher education and research policies, amongst other things. Finally, it also provides an extensive introduction to the two main datasets which are used throughout the thesis. The following chapters will refer to this introductory chapter to build hypotheses, to define important control variables such as cohorts, regions and disciplines and to discuss the limitations of the research.

Each of the subsequent chapters addresses mobility at various points in PhD holders' careers, from the decision to get a PhD abroad, to the decision to return after the PhD, or to become mobile later as a researcher. The chapters are organized in chronological order, starting with PhD students, moving on to recent PhD graduates, and ending with experienced PhD researchers.

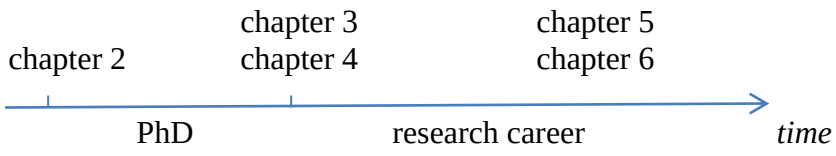


Figure 1: Chronological order of the chapters

Figure 1 illustrates how the chapters follow chronologically. The second chapter addresses mobility decisions of students, who are deciding where to pursue a PhD degree: at home or abroad, and if abroad, within Europe or in North America. The third and fourth chapter are situated at the point in time when researchers have recently received their PhD abroad, and

must decide whether to return or not. The third chapter asks whether top European students who obtain a PhD in the United States are less likely to return compared to their non-top peers, forming a part of the so-called 'elite brain drain'. The fourth chapter, by contrast, takes a demand perspective and studies how the state of the academic labor market in the U.S. influences return decisions of foreign students. Finally, the fifth and sixth chapter study mobility outcomes of 'established' researchers, i.e. researchers who have already obtained their PhD and who become internationally mobile at some time during their research career. In contrast to chapters 3 and 4, which focus mainly on *return* decisions *immediately upon completion of the PhD*, the mobility events studied in chapters 5 and 6 can take place *at any moment in a researcher's career* (after the completion of the PhD). The population under study in these chapters also differs, with chapter 3 and 4 focusing on European researchers who obtain a PhD in the United States, whereas chapters 5 and 6 study European resaerchers who obtain a PhD in Europe. The fifth chapter studies how mobile researchers' characteristics differ depending on the destination of their mobility, whereas the sixth chapter addresses how the effects of mobility differ across destinations.

CHAPTER 1

THE THEORETICAL BACKGROUND AND INSTITUTIONAL CONTEXT OF INTERNATIONAL RESEARCHER MOBILITY

This introductory chapter elaborates the theoretical background, institutional context and the main data sets used as a common platform for all the subsequent chapters of this PhD thesis. International researcher mobility builds on a diverse array of theoretical frameworks including migration theory, economics of education, and job search and matching models. At the same time, mobility outcomes are not only shaped by theoretical forces, but also by a host of exogenous factors, such as visa policies, the availability of funding, the application procedures for graduate entrance, and the modalities of the academic labor market. These exogenous factors shape the institutional context in which mobility takes place, and affect mobility outcomes by influencing individuals' choice sets. In the following chapters, we will often refer to 'mobility choices' or 'decisions' for ease of expression. However, it is important to keep in mind that these 'choices' and 'decisions' are very often shaped by forces beyond the researchers' control, and that the outcomes we observe are not only the result of individual choices but also of processes and limitations that shape researchers' choice sets.

This chapter consists of three sections. The first discusses the various theoretical frameworks which provide relevant insights to approach international researcher mobility issues. The second outlines various facets of the relevant institutional context in which international mobility of PhD students and researchers takes place, and discusses how this context contributes to shaping the mobility outcomes we observe. Finally, the third section presents the two main datasets used for the empirical work in this dissertation.

1.1 THEORETICAL BACKGROUND

This section elaborates the theoretical background of this dissertation. It consists of two main parts: a general theoretical background and a relevant theoretical background by career stage. The general theoretical background discusses the determinants of international migration put forth by different migration theories, and highlights how they can be relevant for PhD students and researchers. The theoretical background by career stage discusses the theoretical frameworks from which insights can be borrowed to study PhD mobility (chapter 2), post-PhD return decisions (chapters 3 and 4) and researcher mobility (chapters 5 and 6).

1.1.1 General theoretical background

International mobility of researchers is a special case of highly skilled mobility, which is in itself a part of general international migration. Therefore a discussion of the theoretical background of international researcher mobility benefits from an outline of the theoretical literature on general migration, with a special focus on highly skilled mobility.

Highly skilled migration can be studied from different perspectives. The **human capital model** approaches international mobility as an investment (Ehrenberg and Smith, 2011). A person incurs certain costs in an early stage to obtain a stream of benefits in the future. If the present value of these benefits exceeds the costs, then the person will decide to move. The present value of the net benefits (the benefits minus the costs) is what determines the mobility decision. This can be represented as

$$\text{present value of net benefits} = \sum_{t=1}^{T} \frac{B_t}{(1+i)^t} - C$$

with B_t the benefits of migration in period t, i the discount rate, C the costs of migration, and T the period over which the benefits can be enjoyed.

The benefits of migration can be monetary, such as increased earnings, and non-monetary, such as increased utility from being able to work in a better job abroad than at home. Benefits enjoyed in the future are discounted to their present value using the person's discount rate. People who are very forward-looking place more weight on future benefits than present-oriented people, and therefore have a lower discount rate. The costs of migration can be monetary, like the costs of transportation or of obtaining a visa, and non-monetary, like the

psychic costs of being away from one's family and friends or of having to learn a new language and culture.

The present value of net benefits will be higher for people who are less happy with their job or job opportunities at home, since they stand to improve the utility they derive from their job the most from moving to a country with better professional opportunities. Likewise, people who can enjoy the benefits of moving over a longer period of time (higher T) will benefit more from migration than people who can only enjoy them for a few years before retiring or exiting the labor force in some other way (Ehrenberg and Smith, 2011). In the context of students and researchers, the human capital theory predicts that students or researchers are likely to exit countries or regions with fewer job opportunities in research, and that researchers are more likely to move at an early stage in their career, when they stand to benefit from their mobility the longest. Researcher ability can play a role in the migration decision by lowering the cost of migration, for example by making the researcher's work more visible and increasing the likelihood of receiving job offers from abroad, or by increasing the benefits of migration, if higher ability makes a researcher more likely to benefit from an improvement in the work environment.

Because the costs and benefits of moving are manifold, many migration studies use the **push-pull framework** to classify different determinants of mobility. Pull factors are aspects of the receiving country that make it more attractive as a destination, like better opportunities for work and study. Push factors are elements in the home or source country which make people more likely to move abroad, like unfavorable economic, social or political conditions. A typical pull factor is the expected income differential between the source country and the destination. International differentials in real wages drove much of the mass migration in the 19th and 20th century (Hatton and Williamson, 2002). For the highly skilled, labor market conditions such as the quality of work, demand signals, shortages in certain fields such as the computer industry in the United States, and skill-biased technical change which increases demand for highly skilled workers are other possible economic pull factors. Other, non-economic pull factors are, amongst others, immigration policy, taxation, safety concerns, and the political environment (Moguérou, 2006).

Specific pull- and push factors may be of greater concern to researchers than to other migrant groups. Characteristics of the national innovation system of the source country and the destination play a role in researchers' mobility decisions, such as the quality of the research

infrastructure, funding for research, favorable research policies, the reputation of universities and research labs, the relative standing and the salary level of a researcher in a particular country, opportunities for employment and entrepreneurship, and the general perspective for a successful research career (Moguérou, 2006). The relative specialization of a country in particular disciplines forms another pull- and push factor for researchers in those fields (Mahroum, 2002)[3]. Finally, opportunities for research offered by the private sector can also influence the mobility decision. Some PhD recipients prefer to do research in industry, due to salary considerations or a preference for more applied work (Roach and Sauermann, 2010). Countries or regions which offer interesting opportunities and good working conditions for researchers in the private sector may also attract more foreign researchers.

Another consideration in the context of this framework are agglomeration effects. Researchers benefit from working together with other talented researchers, and therefore tend to congregate into a few knowledge-intensive clusters (Moguérou, 2006). In the United Kingdom, foreign academic staff tend to congregate in only a few universities, namely Oxford, Cambridge and Imperial College (Mahroum, 1999). In the United States, the Boston area and the West Coast are two of the biggest knowledge clusters (Moguérou, 2006).

While push-pull models are useful for organizing characteristics of the source country and the destination, other models take into account personal characteristics of the movers as well. One characteristic that influences the probability to move is education. For the highly skilled, the institutional context of the labor market tends to be larger in geographic scope than for the less skilled: a job opening for an academic economist is more likely to be advertised nationally or internationally than a job opening for a factory worker (Ehrenberg and Smith, 2011). For PhD holders, especially in academe, the job market is global, opening up plenty of opportunities for international mobility. Another aspect connected to education level is the **skill premium of the destination country** relative to the source country. Researchers gain from moving from a country with a relatively small premium for their skills (in terms of salary or other benefits) to a country with a relatively higher skill premium. The incentives created by differences in skill premia imply a self-selection of migrants according to skill: in source countries with a relatively low skill premium compared to the destination, the highly skilled have most to gain from migrating, whereas in a source country with a relatively high

[3] Please refer to the next part on the institutional background for more information on specialization patterns among countries.

skill premium, unskilled workers have stronger incentives to migrate (Ehrenberg and Smith, 2011).

In the neo-classical approach to migration, as outlined above, a migrant who successfully increases earnings or some other form of utility by moving has no incentive to return before retirement, so as to enjoy the benefits of having moved over as long a period of time as possible. But migration is a risky investment, and if the migrant does not achieve the expected increase in income or utility, he or she might be better off returning home. In this view, return migration is seen as a failure on the part of the migrant to realize the expected benefits. An altogether different approach is the **new economics of labor migration**, which views migration as a planned project with the aim of achieving a particular goal, such as accumulating a certain amount of savings or obtaining education and experience. Once these goals are fulfilled, the migrant returns home. In this approach, return migration is seen as the successful completion of a project (Cassarino, 2004). Students moving abroad with the goal of obtaining a PhD and perhaps some work experience to advance their research career at home fit well into this approach to migration.

Another characteristic of the new economics of labor migration framework is that the migration decision is made at the level of the family or the household, not at the individual level. Sending someone to work abroad can be a way for a household to diversify its sources of income (Cassarino, 2004). For highly skilled migration, migration decisions at the level of the household fit with the issue of tied movers, where one partner agrees to move without experiencing any gains of migration to join the other partner. As more and more women earn college degrees and advanced degrees and wish to put their skills to productive use in the labor market, their willingness to move for family reasons falls. As a consequence, more college-educated couples prefer to live in large urban areas which offer job opportunities for both spouses. In a recent survey of newly minted PhD economists, Helppie and Murray-Close (2010) find that some economists indeed reject their first-choice job offer in order to accommodate their partner's location preference. However, a sizeable minority also makes the opposite compromise: both partners live in separate locations to work in their preferred location, and commute to see one another.

1.1.2 Theoretical background by career stage

The next part presents the relevant theoretical frameworks by career stage. As outlined in the general introduction, this dissertation studies international researcher mobility at three points in researchers' careers: PhD mobility, the return decision after a PhD abroad, and mobility as an established researcher. For each career stage, different theoretical frameworks contribute insights to studying mobility outcomes of researchers. Each subsection summarizes the main insights from the relevant theoretical frameworks by career stage.

1.1.2.1 PhD mobility

The decision of where to pursue a PhD is preceded by the decision whether or not to pursue a PhD. There are several economic approaches to education, which may also shed light on the related decision of where to apply.

Some PhD applicants may enjoy the occupations and the lifestyle of a student, and are attracted to graduate study to continue working in an academic environment and doing what they like best. For these students, part of the benefits are immediate, which makes graduate study a consumption good (Ehrenberg and Smith, 2011). For undergraduate students in the Netherlands, Sá et al. (2004) find that urban amenities and rent are significant determinants in their choice of study location, which they interpret as evidence for the **consumption perspective** of education. If universities abroad have better facilities or are situated in more enjoyable locations, then students may be willing to pay the costs of moving internationally to enjoy these features.

However, a person going to university for undergraduate or graduate study incurs significant costs, and it is unlikely that the sheer consumption utility of education offsets these costs for the majority of students. Most students expect future benefits from advanced study. In the **human capital perspective**, higher education is treated as an investment. Students bear the costs of tuition, books and foregone earnings in the expectation of higher earnings and better career opportunities afterwards. Education is assumed to directly increase a person's productivity, hence meriting higher pay. As with the human capital perspective on migration, the decision to acquire higher education (or an advanced degree) is the result of comparing the immediate costs with the discounted future benefits (Becker, 1962; Ehrenberg and Smith, 2011):

$$\text{present value of net benefits} = \sum_{t=1}^{T} \frac{B_t}{(1+i)^t} - C$$

Higher education entails direct monetary costs, such as tuition and books, and indirect monetary costs, such as the opportunity cost of foregone earnings during the study period. Costs such as housing and food are generally not included, because these would have been incurred whether the person acquired education or not. There are non-monetary costs to factor in as well, such as the psychic costs of the effort a person has to make to succeed in the courses.

Students with high innate ability for academic study have to make less mental efforts to assimilate the study material than students with lower innate ability, and therefore have lower psychic costs. Conversely, students with high innate ability may also perceive higher benefits, if one thinks of graduate study as multiplying or proportionally increasing the innate ability of the student. Moreover, the increase in productivity could depend on the quality of the university, with better universities conferring higher productivity increases. This would imply that students with high innate ability stand to gain the most from attending a high-quality university.

The benefits of undergraduate study are clear: using U.S. census data, Ehrenberg and Smith (2011) illustrate that the earnings of 21-year old college graduates are almost double that of high school graduates. In the last three decades, the college-high school wage gap has risen remarkably, from about 25% in the mid-70s to 40% in 1998 (Card and Lemieux, 2001). The monetary benefits of graduate study are less pronounced, however: within ten years of receiving their degree, engineering PhDs earn about 1.6 times the salary of those with a bachelor's degree, physics PhDs earn about 1.4 times the comparable bachelor's salary, and PhDs in the life sciences earn less than 1.3 times the average of the benchmark group (Stephan, 2012). These are not particularly high wage increases for an investment of around 7 years in additional education.

Those who undertake graduate study arguably also perceive other, non-monetary benefits. Scientists are motivated by the joy of puzzle-solving, and by the recognition and status that priority in discovery confer within the scientific community (Stephan, 2012; Stephan and Levin, 2001). Barring rare exceptions, graduate study is virtually the only way to enter a career in academic research, and hence to enjoy these benefits which may be of high psychic

value to would-be researchers. These non-monetary benefits probably also differ strongly depending on the specific environment where a graduate student works: the resources available for puzzle solving and the possibilities for recognition are undoubtedly better at a prestigious university with renowned scholars in the field and a large budget devoted to the student's area of interest. This provides one rationale why students bear the arduous selection process and the higher costs of studying at an elite university, as well as why some foreign students might bear the costs of studying abroad at a prestigious university.

Another economic approach to higher education is **the signaling model** (Spence, 1973). This approach sees the educational system as a screening device for employers to select workers with high innate ability. Since employers cannot observe true ability prior to hiring, and perhaps also not for a significant time after hiring, they use certain indicators believed to be correlated with productivity to select workers, such as age, experience, and education. Age and experience are hard for a worker to change, but education can be acquired as a means of signaling ability to potential employers. Workers of high ability are willing to bear the financial and psychic costs of acquiring sufficient higher education to signal their high productivity to employers. Higher education does not increase a worker's productivity; rather, it signals the high innate productivity of a job candidate. People with low innate ability will find acquiring higher education too costly: although the financial costs are probably the same for all students, the psychic costs of studying are higher for low ability workers than for high ability workers. If the benefits of higher education are such that the investment is only worthwhile for high-ability workers with low psychic education costs, then a higher education degree is an effective signal of innate productivity (Ehrenberg and Smith, 2011).

Graduate study is a costly signal to obtain, both monetary, especially in terms of an increasing period of foregone earnings, and psychic, with advanced requirements in the form of a certain amount of original research contributions. Since professors have a substantial responsibility to society in terms of education and research, the selection process for these posts is understandably tough and requires a strong signal of ability in the form of a PhD, preferably from a university with a strong reputation for selecting the best and brightest. Indeed, one can imagine that the 'quality' or the 'strength' of the signal varies with the prestige of the PhD granting institution: a PhD obtained from a highly selective institution with a strong reputation for quality is a better signal of ability, but hence costlier to obtain.

The costs to obtain a PhD from a prestigious university differ among graduate applicants. Innate ability – amongst other factors - is arguably of high importance for success in academic research, as illustrated by the strong differences in research productivity even among those qualified for academic research (Stephan and Levin, 2001). Higher innate ability lowers the psychic costs of obtaining a PhD, and increases the likelihood that the student has what it takes to obtain a degree from a top institution. For foreign students, the costs of obtaining a PhD from a prestigious institution are even higher, since they have to factor in transportation costs as well as psychic costs associated to separation from family and friends and adaptation to a new country and culture. Arguably, only foreign students with high academic ability, for whom the psychic costs of study are low and the expected benefits higher, will be willing to bear the additional cost of moving internationally to obtain a degree or a 'signal' from a prestigious university. Therefore moving internationally to obtain a degree could be seen as an additional signal of innate ability, since the student was willing to bear the added costs of mobility to signal superior ability.

1.1.2.2 Post-PhD return

Chapters 3 and 4 study aspects of the return decision of European PhD recipients in the United States. Several theoretical migration frameworks offer differing views on return migration, as already discussed in the first part. In the first subsection, a few return migration models are discussed in more depth. Return is not always the outcome of a decision on the part of the migrant, but can also arise from a restriction of the migrant's choice set to no longer include any options in the host country. In that sense, the outcome of the job market search can be decisive for the PhD recipient's choice set. From a theoretical point of view, search and matching models can offer insights in how the job market shapes return migration outcomes. Search and matching models are discussed in the second subsection.

1.1.2.2.1 Return migration models

The general discussion of migration frameworks in the first part already touched upon the differing views of the neoclassical approach and the new economics of labor migration on return migration. The neoclassical approach regards migration as a risky investment, and hence return migration as a situation where the investment did not have the expected payoff. Return migration is regarded as the consequence of a 'failed' investment. By contrast, the

new economics of labor migration regards migration as a project where migrants set out to achieve a certain goal, like obtaining labor market experience abroad or accumulating a certain amount of savings, and return home once the goal is reached.

Borjas and Bratsberg (1996) develop a model that incorporates both motives for return migration. The expected wage in the destination country incorporates an element of uncertainty which is only learned upon arrival, leading some migrants, whose destination wages turn out lower than the wage they can receive at home, to return immediately. However, by spending a minimum amount of time working in the destination country, the migrant can improve his options in the home country, which is modeled as a wage premium upon return. Therefore, for some migrants it can be optimal to accept a lower wage in the destination country in exchange for a higher wage later upon return. The last component of migrants' expected wages is the rate of return for internationally transferable skills. In the absence of uncertainty about wages in the destination country, migrants from a source country with a lower rate of return to skills relative to the United States are positively selected, i.e. migrants with higher skills are more likely to migrate to benefit from the higher rate of return to skills in the destination country. By contrast, migrants from countries with a relatively higher rate of return to skills will be negatively selected, i.e. the least skilled workers will migrate to take advantage of the relatively high reward for unskilled labor in the destination country. This initial selection process is intensified by return migration: in the case of relatively higher returns to skills in the destination country, the least skilled among the highly skilled are most likely to find that the wage premium received upon return outweighs the higher returns to skills in the destination country. After return migration takes place, only the most highly skilled among the migrants remain, i.e. only 'the best of the best' migrate permanently. Borjas and Bratsberg (1996) provide indirect evidence of this skill sorting: the outmigration rate of various national origin groups surveyed in the 1980 U.S. census is positively correlated to the earnings inequality in the source country. Using data from the Immigration and Naturalization Service, Bratsberg (1995) provides similar empirical evidence for the 1970-1975 cohort of foreign students who adjusted their visa status in the United States.

This framework could be applied to PhD recipients in the United States as well, although pure wages probably need to be replaced by, or at least complemented with researchers' other rewards, i.e. the joy of puzzle solving and recognition in the scientific community. Assume

that salary levels, possibilities for puzzle solving (i.e. though a lighter teaching load) and opportunities for enhancing recognition in the scientific community are all correlated with the prestige of the employing institution. The spectrum of 'prestige' of research institutions is often said to be wider in the United States than in most European countries, as illustrated by the dominance of the U.S. in the top of most university rankings, while European institutions occupy a majority of spots in the middle of most rankings. For most Europeans, PhD holders with high research ability experience a higher 'prestige' return to their skills in the United States than at home, whereas PhD holders of lower ability experience relatively lower returns, and are more likely to be better off by returning to Europe. If a few years of post-PhD work experience in the United States, be it as a postdoc or an assistant professor, increase PhD holders 'prestige returns' at home (through the so-called 'been to the U.S.' effect), then for a group of PhD holders of moderate ability the optimal migration strategy might be to work in the U.S. for a few years, and then return home to receive a 'prestige premium' in Europe. If this mechanism is at work, this means that European PhD holders are positively selected, and after return migration only the very best remain. The second chapter (partly) tests this hypothesis for a sample of European PhD recipients in economics.

1.1.2.2.2 Search and matching models

The location of a PhD holder is the outcome of a dual process, i.e. choices made by the PhD holder in terms of where to apply, and choices made by employers (and immigration authorities) about which applications to accept. An important process for recent PhD recipients is the outcome of the job market, as the number and location of job offers determine the mobility choice set of the PhD graduate. An often-used theoretical approach of the job market are search or matching models.

The **aggregate matching function** is a modeling tool often used to capture the effects of frictions on equilibrium outcomes. In labor economics, it models the number of jobs formed at a point in time as a function of the number of workers looking for jobs and the number of job vacancies, as well as a few other variables. The basic model is formulated as

$$\text{Matches} = f(\text{Unemployed workers, Vacancies})$$

and assumed to be increasing in both arguments (Petrongolo and Pissarides, 2001). The shape of the matching function f, or the matching rate, is influenced by different variables, some relating to individual choices (such as search intensity) and others unrelated to individual search decisions. One often used variable is mismatch, or the degree to which heterogeneity in the labor market across several dimensions hinders the formation of productive job matches. An example is the extent to which the skills employers demand differ from the skills job seekers have, as in the case of skill-biased technological change which puts relatively unskilled job seekers to a disadvantage. Mismatch can also occur across sectors, where there can be vacancies in one sector whereas job seekers are trained or prefer to work in other sectors (Petrongolo and Pissarides, 2001). In the context of PhD graduates, it could happen, for example, that there is high demand for macro economists while most economics PhD holders on the market specialize in other fields. It takes time for the market signal of a shortage of macro economists to translate into higher enrolments of PhD students in macro specializations, and, in turn, more time for these students to graduate.

Mismatch is also possible in geographic terms, when there are unfilled vacancies in certain areas and unemployed job seekers in others. It takes time and effort for job seekers to find out about employment opportunities in other regions and to move there (Petrongolo and Pissarides, 2001). However, as the market for PhD holders tends to be international, and PhD holders are highly geographically mobile, geographic mismatch seems to be an unlikely source of friction in this market. Indeed, in economics, the labor market does not appear to be characterized by the type of friction that leads to unemployment: in a survey of recent economics PhD graduates in 2001-2002, Siegfried and Stock (2004) find that the unemployment rate is low, at 2.1% of the population of graduates, down from 2.9% in 1996-1997. Rather, labor market friction appears to translate into employment in less desired sectors, such as the private sector. Siegfried and Stock (2004) find that PhD economists working in the private sector report significantly lower job satisfaction, mostly owing to the disconnect between the job and their training. The graduates with the lowest job satisfaction on average spend the greater part of their time on consulting and professional service activities, and relatively little on research, which was apparently not anticipated. Curiously, graduates in the private sector are not more likely to report that they are actively seeking new employment, which suggest that the average higher wage that they earn goes some way toward providing a compensating differential for the less desirable job characteristics (Siegfried and Stock, 2004).

In empirical studies of matching, the density of the labor market is found to influence the matching rate: the more concentrated a labor market is in terms of unemployment and vacancies, the higher the matching rate. Coles and Smith (1996) use employment and census data from 1987 to estimate a matching function for 262 travel-to-work areas in England and Wales. They find that the density of the market influences the matching rate: the larger the geographic area over which a local labor market is dispersed, the lower the matching rate. They also find that wages are higher in larger cities, and interpret this as evidence that the quality of matches is higher in denser markets. For PhD holders, and specifically in economics, the United States could be seen as providing a relatively dense national market: the labor market for new entrants is strongly institutionalized and centralized by the American Economic Association, which probably improves both the matching rate of PhD economists to research jobs and the quality of the matches. By contrast, the European labor market for PhD holders is comparatively fragmented across national labor markets, which could reduce both the rate and the quality of job matching, making Europe a relatively less attractive market for PhD graduates.

Another approach to the labor market is the **theory of job search**. Job candidates' characteristics are summarized in a single 'quality' or 'ability' variable, and firms set minimum hiring standards in terms of quality. Firms make wage offers, dependent on the strictness of the hiring standards. An individual with a particular skill level can only apply for jobs at or below that skill level, and accepts or rejects job offers based on a reservation wage, or the minimum wage for which an applicant is willing to work. If there is imperfect information about individuals skill levels and firms' hiring standards, then there can be frictional unemployment during which candidates have to expend search efforts to find out about vacancies and firms have to make screening efforts to make sure they only hire candidates above their hiring standards (Mortensen, 1970; 1977). The theory of job search can also be applied to the academic labor market, with employing institutions demanding a certain level of research ability, and PhD holders only accepting job offers from institutions of a minimum prestige, or 'reservation prestige'. The higher the applicant's reservation prestige, the lower the probability that he will find an acceptable job. A foreign PhD holder who does not receive a job offer from an institution with a minimum prestige may decide that the costs of staying in the host country outweigh the benefits of working under their reservation prestige, and return home.

1.1.2.3 Researcher mobility

This last section deals with the relevant theoretical frameworks for international mobility decisions of established researchers, i.e. researchers who have obtained their highest degree and are now working as researchers in various stages of their professional career. For researchers in this stage, the **human capital theory** is arguably the most relevant framework to analyze mobility decisions. As discussed in the first part, the human capital framework treats mobility as an investment which yields returns over a certain period of time to offset the costs generally incurred at the beginning of the period. Factors that affect the costs, the benefits or the decision maker's time preference (i.e. the discount factor) influence the mobility decision (Ehrenberg and Smith, 2011).

One implication of the human capital model is that the longer the period over which benefits can be enjoyed, the more likely the net benefit of the investment is to be positive. Young, early-career researchers are therefore more likely to 'invest' in international mobility than older researchers. Indeed, in chapters 3 and 4 most international mobility is observed immediately after completion of the PhD, which corroborates the human capital theory. In chapters 5 and 6 it is not possible to determine the exact timing of the mobility event, which makes it difficult to check this prediction.

In many migration studies, cost is often assumed to increase with distance. Distance proxies for increased travel costs as well as higher psychic costs in terms of adaptation to a new language and culture and of separation from family and friends (Rodriguez Gonzalez et al., 2010; Lee and Tan, 1984; Bessey, 2007, amongst others). Another consistent finding in migration studies is that previous mobility experience tends to lower costs, arguably through a learning effect in terms of procedure, language, adaptation to a new environment, etc. (De Grip et al., 2009; Dreher and Poutvaara, 2006; Parey and Waldinger, 2008).

Another cost element that has received less attention in empirical work is the **transferability of human capital**. If a migrant's human capital is not completely transferable to the destination country, then the benefits from moving are lower than under prefect transferability, and the incentives for migration decrease. Imperfect transferability of human capital can arise from a lack of recognition of foreign qualifications (the infamous 'engineers-become-taxi drivers'), but also from subtler factors such as divergent education systems and

working cultures which make migrants less productive than natives. Mechtenberg and Strausz (2010) model intra-EU labor mobility as dependent on the transferability of human capital. The transferability of human capital is itself endogenous to the level of migration, as higher mobility contributes to internationalization of workplaces and the harmonization of working cultures. They illustrate that Europe may be trapped in a low-migration, low-transferability equilibrium, and argue that this harms Europe's competitiveness to attract talented workers from abroad, who see intra-regional mobility as a form of insurance against adverse shocks in the destination country. By contrast, within the United States the transferability of human capital is high, which is also corroborated by high internal labor migration. In Europe, the Bologna process and the European Research Area can be interpreted as policies with the intention of increasing the transferability of human capital, and therefore decreasing the cost of intra-EU migration.

Another element that influences the cost side of mobility is that some universities, in particular in Europe, are characterized by an **internal labor market**. Internal labor markets are characterized by strong ports of entry at the lowest level, and by wages that are shielded from external wages (Doeringer and Piore, 1971). Careers in institutions with internal labor markets tend to be long, and the most frequent reason of exit at higher ranks is retirement. Haeck and Verboven (2012) provide evidence that a large Belgian university, which shows strong similarities with the French system in terms of hiring and promotion policy, strongly satisfies the conditions for an internal labor market; more so than many of the private companies studied in prior literature (Baker and Holmstrom, 1995). In this university, entry at higher levels is rare; though less so for top researchers. The existence of internal labor markets in universities arguably poses additional obstacles to researcher mobility in and towards Europe, specifically for more senior researchers. European researchers may be reluctant to leave the relative job security provided by an internal labor market, and may encounter difficulties to be hired into a non-entry level rank at a university characterized by an internal labor market. Moreover, the fact that wages are shielded from external wage evolutions makes it difficult for universities to make attractive salary offers to external senior researchers.

Researcher mobility at a later stage in a researcher's career can also be regarded from the **consumption perspective**. Researchers can become mobile to work with prominent colleagues, access particular infrastructure, or simply because they like the environment to

work in. For some researchers, these benefits may be regarded as consumption rather than investment, because immediate utility is derived from them. The consumption perspective may be more appropriate to explain short-term research stays at later stages of a researcher's career.

1.1.3 Conclusion

This section briefly concludes with the main implications of this theory section for the research in this dissertation.

First, from the human capital framework, we retain the approach of research mobility from a cost-benefit perspective, and many hypotheses in the following chapters are formulated with this framework in mind. An important prediction of the human capital framework is that mobility is more likely to take place early in researchers' career, which we check in the third chapter.

Second, from signaling theory we preserve the notion that a PhD from a prestigious institution can be seen as a signal of ability to the labor market. This signal is costly to obtain, but less so for students of high ability. It provides a rationale for why the best students apply to the best universities, and why the most talented students are willing to bear the cost of obtaining education abroad.

Third, from the theory on return migration we retain that there is evidence of skill sorting in return migration of students. This leads us to hypothesize that, given that foreign PhD students to the United States are probably positively selected along the ability spectrum, the best students are also more likely to remain in the United States after graduation, a hypothesis that we test in chapter 3.

Lastly, from the theory on search and matching models, we retain that the density of the labor market influences the matching rate, which leads us to expect that the European academic labor market, which is relatively fragmented, is less attractive for PhD holders because it might produce fewer or lower-quality matches than the American academic labor market, which is relatively uniform and centralized.

1.2 INSTITUTIONAL CONTEXT

The following section elaborates the institutional context in which international mobility of students and researchers in Europe and the United States takes place. The institutional context influences the various outcomes and decisions studied in this dissertation by expanding or restricting researchers' choice sets. A researcher may wish to become mobile to the United States, for example, but cannot do so legally if he cannot obtain the proper work visa. Or a student may wish to study in a particular country, but cannot access the necessary equipment for her particular field of study in that location.

This section consists of two parts. The first part discusses the general institutional context by reviewing, first, the general trends for PhD holders in the U.S. and in Europe, second, the characteristics of countries or regions and third, the discipline specific characteristics that influence student and researcher mobility. The second part elaborates the particular context of researchers in different stages of their career. The first subsection deals with PhD mobility, and is mainly relevant for the second chapter which studies mobility decisions of European PhD students. The second subsection addresses the context of recent PhD graduates who obtained their PhD abroad, and who must decide to stay in their PhD country or to return. This subsection is mainly relevant for the third and fourth chapters, which study return mobility of European researchers who obtain an economics PhD in the U.S. Finally, the third subsection addresses the institutional context for international mobility of researchers at later career stages, i.e. when they have completed their highest degree and are working as established researchers. Although there is a certain amount of overlap with the previous section, the focus in this section is on outward mobility, as opposed to return mobility in the previous section. It is mainly applicable to the last two chapters, which study the mobility of European researchers within Europe and to the United States. At each of these different career stages, the application or job market process, visa policies, funding issues and relevant higher education and research policies are discussed, both in the EU and the U.S. Throughout the text, I emphasize the implications of particular features of the institutional context for the research in this dissertation, and especially for the definitions of variables that are used in most chapters like cohorts, disciplines and regions.

1.2.1 General institutional context

This part discusses a few general traits of the institutional context of higher education and research that affect graduate students and researchers regardless of where they are in their careers. It starts with an overview of general trends for PhD holders in the United States and Europe, followed by a discussion of particular country characteristics and characteristics of scientific disciplines which may have an influence on international mobility.

1.2.1.1 General trends for PhD holders

This section describes the general trends that affect PhD students and PhD holders, focusing on the United States in the first subsection, and on Europe in the second subsection. Relevant policy developments for PhD students and PhD holders are discussed under each relevant subsection of the second part.

1.2.1.1.1 United States

Over the last few decades, the number of PhDs awarded in the United States each year has steadily risen, from a little under 18,000 in 1966 to almost 50,000 in 2009 (National Science Foundation, 2011). One notable trend is the increase in the share of women among PhD recipients: in 2009, women earned 42% of all science and engineering doctorates in the U.S., up from 29% in 1989 (National Science Foundation, 2011). Another significant trend is the substantial increase in the share of temporary citizens earning PhDs in science and engineering, from 27% in 1989 to 37% in 2009. Arguably, the lower relative earnings of scientists relative to other career possibilities for American citizens in business, law and medicine are part of the explanation (Stephan, 2012). Another side of the coin is the increased participation in higher education in many emerging economies, especially in Asia, which has fueled the demand for U.S. graduate education. Much of the growth of the share of foreign PhD recipients has occurred among non-top-ten ranked programs, suggesting a change in the quality of the applicant pool or a change in the preferences of foreign students or elite programs (Black and Stephan, 2007).

The stay rates of foreign PhD recipients in the U.S. have increased in the last two decades as (Moguérou, 2006; Finn, 2010). The proportion of temporary residents who earn science and engineering PhDs and who report plans to stay in the United States has increased from 40%

in 1981 to over 70% in 1999 (Black and Stephan, 2007). For European students, the population studied in this dissertation, stay rates vary strongly according to home country. Around 60% of PhD recipients from the UK plan to stay, compared to lower stay rates for France and Italy, although stay rates have been increasing for these countries also, from 32% in 1994-1997 to 49% in 1998-2001 (Moguérou, 2006).

In recent years, the question has arisen whether the U.S. might be training too many PhDs, creating an excess supply in certain disciplines. Many departments and labs in sciences are structured such that graduate students and postdocs make up the majority of the workforce. This structure is considered an efficient training model, though it is also an inexpensive and flexible way of staffing laboratories. Funding for graduate students and postdocs is often readily available. However, the number of independent researcher positions in academe has not kept up with the strong growth of PhDs and postdocs, leading to a steady decline in the share of PhD recipients taking up tenure track positions upon completion of their degree. The share of PhD recipients going into industry has increased in most science fields, notably from around 45% in 1973 to over 60% in 2006 in engineering, from around 20% to around 40% in physics, and from about 10% to over 20% in biological sciences. An increasing share takes up temporary positions such as post docs, especially in biology and physics. In 2006, less than one quarter of recent PhD recipients held a tenure track position in chemistry or physics, down from one third and 40% in 1973, respectively (Stephan, 2012).

Whether moving to industry is a highly regarded career path is field dependent (Stephan, 2012), but it is an important channel for knowledge transfer to industry (Sumell et al., 2009). Not only can PhDs directly apply their knowledge and skills in industry, they also increase the firm's absorptive capacity (Cohen and Levinthal, 1990). PhDs tend to earn more in industry: in 2002, economics PhDs earned a 38% premium over the mean annual starting salary for those with permanent positions of $82,100. However, economics PhDs in industry tend to be less satisfied with their jobs, as they experience their work as less closely connected to their training and experience (Siegfried and Stock, 2004).

PhD recipients who stay in academe increasingly find themselves writing grant applications to support their research and, in some disciplines, even their own salaries, whereas a few decades ago the university would still guarantee most, if not all, of a researcher's salary (Stephan, 2012). A consequence of this is that an academic researcher's career is affected

more strongly by fluctuations in the availability of funding. Temporary increases in the budgets of funding agencies often stimulate universities to expand their research programs, which ultimately leads to a larger number of applications without a permanent rise in the success rate of grant applications. The doubling of the National Institutes of Health's budget in 1998-2002 did not lead to a higher success rate of grant applications, and the success rate has remained relatively low for young researchers compared to established ones. The stimulus bill of 2009, which has also expanded the NIH budget substantially, albeit temporarily, is also unlikely to create a more stable environment for young researchers to launch an independent academic career (Stephan, 2012).

As some of the chapters focus specifically on economics PhD holders, a few general trends in this discipline during the last two decades are also outlined here. Between 1986 and 1992, the number of PhDs awarded in economics grew thanks to increases in academic R&D budgets (Moguérou, 2006). However, the number of American citizens obtaining an economics PhD decreased following a decline in American economics undergraduates, indicating a stronger inflow of foreign students (Siegfried and Stock, 1999). The stronger inflow of economics PhDs led to a softening of the labor market for econ PhDs between 1987 and 1996, with longer times to degree, more PhDs planning to do a postdoc and fewer PhD recipients with firm post-graduation plans as a result (Siegfried and Stock, 1999).

Between 1992 and 1996, the number of first year PhDs declined by 18%, resulting in a lower supply of new PhDs at the end of the nineties (Siegfried and Stock, 1999). Due to the decline in supply of new PhDs in combination with a smaller contraction in demand for new economics PhDs, the prospects for econ PhDs improved markedly at the end of the nineties, stimulating a strong inflow into economics PhD programs again at the turn of the century. By 2004, however, this increase in the supply of economics PhDs combined with the continuing effects of the economic slowdown following the bursting of the dotcom bubble led to a market with bleaker prospects for economics PhDs (Siegfried and Stock, 2004). As the economy, and by extension universities' budgets, recovered between 2004 and 2008, so did the market for economics PhDs. The current financial and economic crisis, however, has severely hit American universities' budgets, especially public universities which rely on tax revenues.

The general trends in the job market for economics PhDs is most relevant for the third and specifically the fourth chapter, which studies the influence of the job market on the return mobility of European PhD recipients. The practical translation of these trends into cohort dummies is taken up in the relevant chapter.

1.2.1.1.2 Europe

Sketching general trends for PhD holders in Europe is more difficult, because there is no centralized data collection for the continent comparable to the rich data collection done in the United States. Although the OECD compiles yearly statistical overviews on the state of education in the OECD area, these 'Education at a Glance' reports include little information on PhDs. Eurostat, however, centralizes some essential data from national statistics offices. In the EU27, too, the number of PhDs awarded has been on the rise, notably from around 70,000 in 1998 (the earliest date for which counts of graduates at ISCED level 6 are available) to almost 110,000 in 2008 (see figure 1). The majority of PhDs are still earned by men, although the difference with women has been narrowing in the last decade. Data on foreign students earning PhDs in Europe is patchy, with large countries like Germany or strongly international countries like the Netherlands not reporting incoming foreign students at ISCED level 6 to Eurostat, and therefore not reported here.

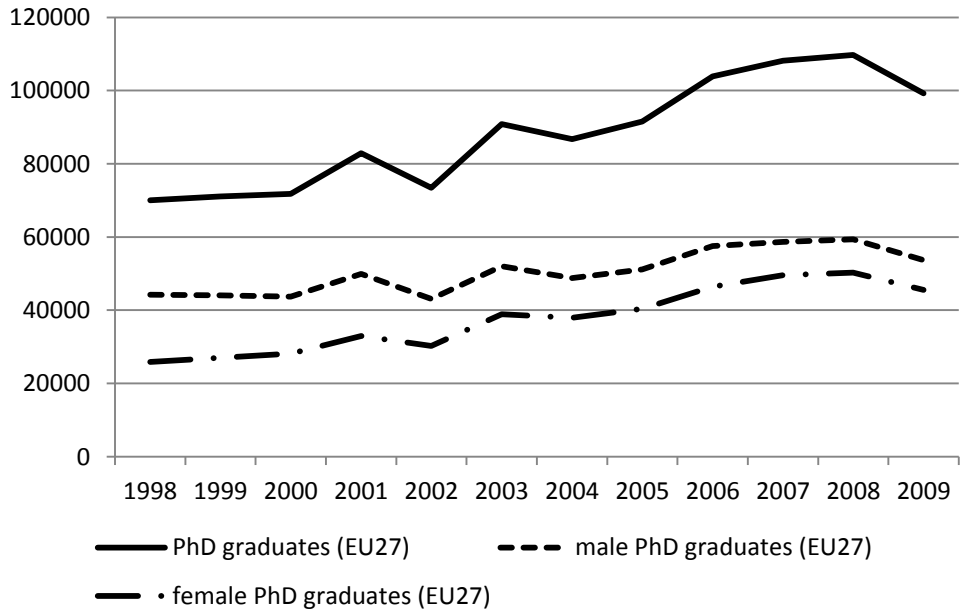


Figure 1.1: PhD graduates in Europe

(source: own calculations based on Eurostat [access: 12 March 2012])

Moguérou (2006) sketches some general trends for PhD recipients in a few major European countries, including some information on the EU as a destination region for foreign students. France witnessed a growth in PhD degrees between 1986 and 1994, followed by a decrease in growth which turned into a decline in 1996 and 1997. In terms of disciplines, the sciences experienced strong growth in the mid-eighties to early nineties followed by a decline, while the social sciences grew more rapidly in the nineties. The share of foreign PhD recipients decreased from one third in the beginning of the nineties to one quarter in 1999. In the UK, the number of PhD graduates grew between 1995 and 2004. Growth was strongest until 2001, followed by a period of slower growth and a decline in some disciplines. The strongest increases were in social sciences, medicine, biology and related fields. Within Europe, the UK is one of the most internationalized countries with 36% of PhDs going to foreign students in 2003-2004. Finally, in Germany there was a steady growth in PhD degrees in the last 30 years, although growth leveled off in the early nineties. Until the end of the nineties, the strongest increases were in natural sciences, mathematics and computer engineering. Germany has a very low degree of internationalization, however, with only 7% of doctoral degrees going to foreign students in 2001. The foreign share is slightly higher in science and engineering disciplines, at 9.3% (Moguérou, 2006).

The origin of foreign Phd students in Europe differs strongly by host country, and is often influenced by historic ties. Asian students are more strongly represented in the UK, while France receives a lot of African students, amounting to 40% of PhDs in 1999. There is also strong variation in intra-EU PhD mobility, which is studied in chapter 2, with a third of foreign students in the UK coming from other European countries, compared to only a fifth in France (Moguérou, 2006).

The demand for PhDs in Europe does not appear to have kept up with the supply in recent years. In Italy, for example, there have been periods when no new permanent positions were allowed to be created, notably in 2002-2004 and again in 2008-2009. In Germany, the total number of professors has been declining, from 23,000 in 1993 to 21,000 in 2004, although the number of students has steadily risen, leading to a spike in the student-professor ratio (Stephan, 2012).

There is little information on stay rates of foreign students in Europe, only some limited information on outward mobility of European PhD recipients in general. In France, a 1999

survey of 1996 PhD graduates found that only 7% had moved abroad, and of those only 21% said their move was permanent (Martinelli, 2001). Studying the U.S. censuses of the last three decades, Tritah (2008) finds that European emigration to the U.S. is relatively small. In the UK and Germany, where outflows are relatively large, the emigration rate does not reach 2%. However, the emigration rate rises as one moves up the educational ladder, and the educational selection has increased over time, resulting in an growing share of U.S. based European researchers over time (Tritah, 2008).

The National Science Board's Science and Engineering Indicators (2010) reports that European students earned far fewer science and engineering doctoral degrees in the U.S. in the period 1987-2007 compared to Asian students: Asian students earned 168,627 degrees in this period, whereas European students earned only 36,073 degrees. The largest European sending countries are Germany, the United Kingdom, Greece, Italy and France. From 1987 until 1993, Greece was the largest sending country, but afterwards the number of students declined. After 1993, Germany took over as the primary sending country, followed by the United Kingdom from 1997 until 2003. Since 2003, Italy is the largest sending country after Germany. Between 1987 and 2007, the number of doctorate recipients in science and engineering from Eastern Europe increased more than 15-fold, from a mere 55 students in 1987 to over 800 in 2007, almost on par with students from Western Europe. Students from Eastern Europe are also relatively more likely to earn a degree in a science and engineering discipline (88%) compared to Western European students (73%). Although the absolute numbers of European PhD recipients in the United States appear high, Moguérou (2006) argues that they should be placed in relation to the stocks of PhD recipients in Europe. In the second half of the period considered by the NSF (1998-2007), Europe produced over 850,000 PhDs. Assuming that about 20,000 PhD degrees were conferred to European students in the United States in the same period (of the 36,000 PhDs awarded to Europeans between 1987 and 2007), and assuming that all of them stay in the United States, this still constitutes only a 2% outflow of European PhDs to the U.S.

Not all European students who obtain a doctoral degree abroad stay; many return home to apply their knowledge and skills in the home country. On average, European doctoral recipients in the United States have lower stay rates than their Asian peers: in 2004-2007, the percentage of European doctorate recipients with plans to stay was 74.5%, compared to 81.8% for East and South Asia, and the remarkably high stay rates of China (90.8%) and

India (88.9%). The stay rate of Europeans has increased over time, from 71.1% in 1996-1999 over 74% in 2000-2003 to its current level. Within Europe, there are marked differences in intended stay rates, ranging from 57.8% for Spain to 75.6% for the United Kingdom in 2004-2007 (National Science Foundation, 2010). Finn (2010) confirms these variations, reporting a one-year stay rate of 68% for doctorate recipients from the United Kingdom compared to a 55% stay rate for Spain and a 54% stay rate for France. It appears that on average, at least half of the European students who obtain a PhD in the United States stay there immediately after graduation.

All in all, the outflows of European PhD graduates appear modest in absolute terms, although there is a concern about the selectivity of outmigration. Even if stay rates are low, if the most talented PhD recipients have a higher tendency to stay in the United States, then Europe may experience significant scientific and economic losses (Moguérou, 2006). Chapters 3 and 4 of this dissertation address this issue, i.e. the selectivity of return migration of a group of European PhD recipients in the United States.

1.2.1.2 Country and region characteristics

This section discusses the characteristics of countries or regions that influence the possibilities and preferences for mobility. A first subsection describes the general standard of living and working conditions, while a second subsection takes up the issue of national or regional specialization in particular disciplines.

1.2.1.2.1 General standard of living

Mobility decisions are very complex and involve a multitude of factors at the level of the researcher, the origin and the destination. This section discusses a few characteristics of countries and regions that can be relevant in influencing or even restricting a researcher's choice set, starting with features of higher education and research, but also discussing general country characteristics that influence mobility decisions.

As the higher education and research sector is the main sector of employment for PhD holders, differences in its characteristics are likely to influence researchers' possibilities and choices for international mobility. Countries and regions differ in the amount of resources they dedicate to higher education and R&D. The OECD (2010) reports the total expenditure

from public and private sources on tertiary educational institutions in 2007 by country. In the EU19[4], the average expenditure as a percentage of GDP is 1.3%. This average masks some differences, ranging from 0.9% of GDP in Italy, Hungary and the Slovak Republic to 1.7% spent in Denmark. By contrast, the United States spends 3.1% on higher education, the highest share in the OECD. Countries also differ in the source of this funding. In Europe, the great majority of funds are from public sources. In the EU19, on average 1.1% of GDP comes from public funding, compared to 0.2% from private sources. In the United States, by contrast, the 3.1% of GDP is divided between 1% from public funds and 2.1% from private sources. In Europe, the United Kingdom has the highest proportion of private funds, 0.6% of GDP compared to a total spending of 1.3% of GDP, followed at some distance by Italy and Portugal, which get around 30% of their total spending on tertiary education from private funds. Israel also has a high share of private sources: 0.8 percentage points of the 1.8% of GDP spent on tertiary funding. Across the OECD, the trend has been for the share of private funds in the spending on tertiary education to increase (OECD, 2010).

Spending on higher education should be put in perspective to the number of students over which the funds must be spread. Spending on public and private higher education institutions in purchasing parity-adjusted euros per student in 2008 was on average €9,300 in Europe, compared to €23,600 in the United States. Within Europe there are, again, marked differences: Scandinavian countries spend on average €14,000 per student, compared to €8,300 in the Mediterranean countries and €5,700 in Central and Eastern Europe. The United Kingdom spends €12,250 per student, putting it among the highest spenders in Europe with the Netherlands, Austria and the Scandinavian countries.

Countries also differ in the amount of resources they devote to research and development (R&D), which ultimately influences the opportunities for careers in research. Eurostat collects data on the gross domestic expenditure on R&D as a percentage of GDP. In 2008, the EU-27 spent 1.92% of GDP on R&D, compared to the 3% target formulated in the Lisbon Agenda and reiterated in the EU2020 strategy. R&D expenditures have grown over time, though not at a terribly fast pace: in 1995, R&D expenditure stood at 1.8% of GDP. The United States, by comparison, devotes 2.79% of GDP to R&D. Within Europe, again, there

[44] The EU countries for which the OECD has data available, i.e. Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Ireland, Luxembourg, the Netherlands, Poland, Portugal, the Slovak Republic, Spain, Sweden, and the United Kingdom. The EU19 average is unweighted.

are stark differences in R&D expenditure. Scandinavia almost reaches the 3% target, with Sweden, Denmark, Finland and Norway spending on average 2.96% of GDP on R&D. Norway, however, is an outlier in this region with only 1.6% of GDP. Without Norway, Scandinavia spends on average 3.42% of GDP on R&D. The Mediterranean countries spend considerably less on R&D, amounting to an average of 1.35%. Eastern European countries spend even less, on average 0.8% of GDP, although there are regional outliers such as Slovenia and the Czech Republic, which spend 1.6% and 1.41% of GDP, respectively; although these amounts are still well below the EU-27 average.

The amount of resources devoted to higher education and research is one aspect that influences researchers' working environments. Another aspect is the institutional organization of higher education and research. In the United States, most basic research is done at universities (Stephan, 2012). In Europe, the picture is more varied. In some countries, a lot of basic research is done at national research institutes outside of universities, like the Max Planck institutes in Germany and the Centre National de la Recherche Scientifique (CNRS) in France. These different working environments can be difficult to adapt to for foreign researchers, not to mention the complications that may arise for non-nationals to gain access to these institutes.

Universities in Europe are also organized according to different models, with implications for researchers' career and promotion opportunities. In Europe, Musselin (2004) distinguishes two main systems. The first is the 'survivor model', of which Germany and Austria are prominent examples. Candidates must survive a long period of strict selections, and tenure is only granted at a relatively old age. The second is the 'protective pyramid model', with France, Italy and Spain – countries with a public system of higher education – as the main examples. In this model, permanent positions are granted relatively early in researchers' careers, after a highly selective competition. Afterwards, researchers progress through an internal system of promotions, though without assurance of ever reaching the top. Other European countries tend to incorporate characteristics of these two systems, and increasingly, of the American 'up or out' system (Haeck, 2012). In the U.S., faculty are initially hired without tenure. They are then traditionally reviewed after three years. If they pass the third year review, their contract is renewed and at the end of the sixth or seventh year they are considered for tenure.

Countries, and sometimes individual universities, also differ in their flexibility of setting salaries or deciding on promotions. Wage autonomy is especially low in Belgium, Germany, Ireland, Italy, Spain and Switzerland, compared to some limited wage autonomy in the Netherlands, Denmark and large wage autonomy in the UK and Sweden (Aghion et al., 2010). Countries with less flexibility in choosing salary offers and promotion paths may have difficulty attracting top researchers from abroad. In any case, in most European countries the tendency to hire foreign professors is rather low, with many universities hiring in-house instead, with the exceptions of Germany and the UK (Aghion et al., 2010). Although the Bologna process and the creation of the European Higher Education Area have made substantial strides in harmonizing higher education, little has been done to coordinate the internal governance of universities (Haeck, 2012), making long-term mobility for university researchers difficult once they are embedded into a particular system. Then again, differences in higher education governance systems can also induce mobility, with researchers moving to countries with the governance systems they consider best.

Apart from the characteristics of the higher education and research system in a potential host country, internationally mobile researchers also take into account various quality-of-life aspects. In private companies, expatriate employees who must work in locations with lower living standards or personal safety guarantees are often compensated with a 'hardship allowance'. Although this is not customary in academe, PhD holders are likely to take similar factors into account in international mobility decisions. Several organizations compile 'quality of life' city rankings, including Mercer and The Economist Intelligence Unit. Mercer, for example, ranks 221 cities worldwide based on 39 indicators grouped into 10 categories, including political, social, economic and socio-cultural environment, health and sanitation, schools and education, public services and transportation, recreation, consumer goods, housing and natural environment. In its 2011 ranking, German and Swiss cities dominate the top 10 with 3 cities each, although Vienna in Austria takes the top spot. In the top 50, 26 cities are European and cover a wide geographic range from Madrid to Helsinki and from Dublin to Berlin. Eastern European cities are less highly ranked, but have evolved positively in the last few years. In North America, Canadian cities rank higher than American ones, with four cities preceding the first American city (Honolulu) that enters in 29th place, followed by San Francisco in 30th place. Only eight American cities make it into the top 50 of most livable cities (Mercer, 2011). In terms of quality of life, Western Europe appears to have an advantage over the U.S. This is also in line with anecdotal evidence of both American and

European researchers with work experience on both sides of the Atlantic, who express that "Europeans work to live, while Americans live to work".

Within the United States, Florida (2002) relates the location of talent, defined as persons with a bachelor's degree or higher, to several factors including a diversity index (measured as the percentage of gay households), a coolness index, which captures cultural and nightlife amenities, the presence of high-tech industry and regional income. He finds that the location of talent is closely associated with diversity, more so than with factors such as climate, cultural and recreational amenities. By contrast, Summell (2006) finds that natural factors such as climate are among the most important in recent PhD recipients' location decisions within the U.S., while reproducible amenities such as air quality and crime matter less. Although the debate on which location characteristics are the most relevant in researchers' location choice remains open, it is clear that characteristics of the location enter into the decision.

Finally, one last important consideration for mobile European researchers is language. Although English has been widely adopted as the *lingua franca* in research, and is increasingly adopted in the advanced stages of higher education, many undergraduate programs in Europe are still taught in the local language. Although this does not necessarily restrict intra-EU mobility of researchers in the short term, it does make long-term integration into a different country difficult without learning the local language. It is often expected that foreign professors acquire sufficient language skills within a certain time frame to be able to teach undergraduate courses. These language requirements can also partially explain why English-speaking countries tend to be popular destinations for foreign students and researchers.

From this section, we conclude that there are several country-specific factors that may influence the attractiveness of regions for mobile researchers. Including them all separately as control variables in our models is not possible due to data constraints. However, many country characteristics appear quite correlated within certain sub-regions in Europe. Therefore all the models in this dissertation include control variables for the region of origin of researchers, which should capture these various factors that may influence researchers' likelihood to become mobile or to return once abroad.

1.2.1.2.2 Country specialization

Some countries tend to specialize in particular fields, while performing less strongly in others. These patterns of specialization influence mobility patterns of students and researchers, by making certain destinations more attractive and effectively modifying the choice sets of researchers in particular fields.

The third European Report on Science and Technology Indicators (European Commission, 2003) compiles an 'activity index' for 15 EU countries. This activity index contains the 10 science and engineering fields in which the share of each country compared to total EU-15 output in that field is highest. The activity index indicates that Scandinavian countries tend to specialize mainly in life sciences, while the UK, the Netherlands and Greece show a stronger specialization in engineering. Belgium, Ireland and Austria have a high share in a few subfields of both life sciences and engineering. In the life sciences, however, the U.S. is clearly the strongest player. Although the EU-15 as a whole produce more basic life science articles, the U.S. receives the highest average number of citations per article, at 12.5 citations compared to 8.5 in Belgium (the next European country in the list), and 7.6 in the UK.

Another approach to characterize the field specialization of countries is the relative specialization index (RSI) (Glänzel, 2000). The RSI is based on the share of a country in total world publications in a given field, relative to the share of a country in total world publications. By compiling an RSI score for 8 major fields of science (clinical medicine, biomedical research, biology, chemistry, physics, mathematics, engineering and earth and space sciences), countries can be characterized into different publication profiles (Glänzel, 2001). Four basic patterns are distinguished in the literature, namely

1. the Western model, with a strong emphasis on clinical medicine and biomedical research, characteristic of developed Western countries;
2. the transition model, with major strengths in chemistry and physics, typical of Eastern European countries;
3. the bio-environmental model, with a strong emphasis on biology and earth and space sciences, characteristic of developing countries and countries with vast natural resources like South Africa and Australia, and;
4. the Japanese model, with accents on engineering and chemistry, typical of many Asian countries.

As this dissertation studies intra-European and EU-U.S. mobility, the first two models are the most relevant to characterize regions in terms of scientific specialization.

Using data from the National Science Foundation's 2010 Science and Engineering Indicators report, we construct relative specialization indexes for the 13 S&E disciplines distinguished by the NSF[5] for the year 2007. The United States has a different specialization profile from the European Union, specializing relatively more in biology and other life sciences as well as in computer sciences. The European Union, by contrast, is relatively stronger in mathematics. Within Europe, there are also clear specialization patterns. Most notably, the Central and Eastern European countries[6] are most strongly specialized in exact sciences, such as chemistry, engineering, mathematics, and physics, and in the social sciences. Scandinavia, by contrast, is most strongly specialized in life sciences such as biology, medical sciences and other life sciences. The Mediterranean countries tend to specialize in earth sciences such as agricultural science and geosciences, as well as mathematics. The other Western European countries tend to have a more balanced profile, although with a tendency to specialize in mathematics and the medical sciences.

The fact that Central and Eastern Europe tend to specialize in different fields compared to Western Europe and specifically the U.S., with its strong emphasis on life sciences and biomedical research, may restrict mobility options for students and researchers from Eastern Europe, or, conversely, force more students from Eastern Europe to become mobile to be able to specialize in the life sciences. This point is, to a certain extent, also valid for other regions, notably for the Mediterranean countries.

1.2.1.3 Discipline-specific characteristics

Not only do countries tend to specialize in particular disciplines, possibilities for and expectations of mobility differ among disciplines as well. One typical example is physics, where successful research often depends on physical access to key infrastructures (Ackers, 2005). These infrastructures often demand huge investments, which is seldom feasible for small countries. However, within Europe and in the context of the transatlantic military alliance, investments are often shared between different countries, such as the facilities of

[5] These are agricultural science, astronomy, biological sciences, chemistry, computer science, engineering, geoscience, mathematics, medical sciences, other life sciences, physics, psychology and social sciences.
[6] Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia.

CERN in Switzerland (European Commission, 2003). Depending on access to these facilities for research places a stronger emphasis on international mobility in these disciplines (Ackers, 2005).

In other fields, a historic advantage and defense-related government spending have created a geographic concentration in the field. In computer sciences, for example, the United States has a clear dominance, producing 32% of all worldwide publications. This is related to its pioneering work on computers in the last decades, its extensive IT industry, as well as to defense-related IT research. Israel takes the lead in computer science in terms of average publication impact, and this can also be linked to extensive defense-related IT research. By comparison, Europe's research base is less defense-oriented, which could explain why it is a relatively weaker player in computer science (European Commission, 2003). These geographic patterns probably partly explain why foreign PhD recipients in computer science in the U.S. have relatively high stay rates.

Indeed, Finn (2010) uses foreign students' social security numbers and tax data to compute actual stay rates of foreign doctorate recipients in the U.S., and finds strong variations in both short-term and long-term stay rates across disciplines. Students in computer sciences, electrical engineering and physical science have relatively high stay rates, 77-78% of the graduates of 2005 were still working in the U.S. one year later. By contrast, students in agricultural science, economics and social sciences have much lower stay rates, ranging from 57% to 44% in the same period. These strong differences are explained to a large extent by differences in country of origin of foreign students in various disciplines: students from countries with the highest stay rates[7] are relatively strongly represented in disciplines with high stay rates, making up almost half of the PhD recipients in computer science, electrical engineering and physical science. By comparison, students from these high-stay rate countries are relatively underrepresented in disciplines like agricultural science (24%), economics (20%) and other social sciences (17%).

Whereas the geographic distribution of necessary equipment, relevant industries and the national background of students offer several explanations for discipline-specific international mobility, certain characteristics of particular disciplines can be another.

[7] These high-stay rate countries are China (92%), Romania (86%), Yugoslavia (88%), the Ukraine (84%) and India (81%) according to Finn (2010).

Chompalov (2006) points out that researchers in the natural sciences have a higher propensity to emigrate than social scientists, because their knowledge is more readily convertible which makes it easier for them to specialize and to find jobs abroad. Jöns (2007) identifies three attributes of scientific fields that influence the possibilities for international mobility in that field. The first is materiality, or the degree to which researchers are dependent on certain objects, spaces or equipment which cannot easily be moved. Examples are archives in historic research, certain field sites in earth sciences or archaeology, or technical equipment like particle accelerators in physics. The second attribute is standardization, or the degree to which research practice in a field relies on uniform terms, criteria, formula, data or methods. Examples are standardized equipment and experiments in biology and chemistry, versus unique equipment developed in engineering or a unique site for archaeology, anthropology or earth sciences. A final attribute is abstraction, or the degree to which heterogeneous information is abstracted into a uniform observation, rule or law. The degree of abstraction is dependent on the stage in the research process. Examples are zoology, which in the discovery of new species relies on the observation of attributes of different organisms, versus mathematical research which tends to be very abstract. Using survey data of foreign researchers who spent some time conducting research in Germany, Jöns (2007) concludes that the more immaterial and standardized the practice in a field is, the easier it is to conduct that research elsewhere. This opens up more opportunities for mobility, as researchers are not bound to one particular place. However, at the same time this takes away some incentives for mobility, as researchers are not forced to become mobile to access certain equipment or information. By contrast, researchers in fields that are more material and specific often have a strong incentive to become internationally mobile to be able to access specific equipment or locations.

1.2.2 Career-stage specific institutional context

This part elaborates the specific institutional context in the three career stages of researchers studied in this dissertation: at the start of the PhD (chapter 2), upon completion of the PhD (chapters 3 and 4), and as a PhD-holding researcher (chapters 5 and 6). Each subsection focuses on the application process or the relevant labor market procedure, visa policies, funding and relevant government policies in the U.S. or the EU.

1.2.2.1 PhD mobility

This subsection deals with the institutional context faced by European students who are considering undertaking a PhD abroad, either in Europe or in the United States. The next four subsections discuss the application process, student visa policies, funding opportunities and relevant government policies.

1.2.2.1.1 Application process

In the United States, the application process for graduate school is quite streamlined, but rather work-intensive. Students require up to a year to complete the process. They start by selecting the schools they want to apply to. Most graduate schools require applicants to take either the GRE or the GMAT. In addition, most graduate schools require students to show proficiency in the English language, evaluated by taking the TOEFL or the IELTS. The application package usually also includes a number of letters of recommendation as well as a personal statement. Some graduate schools structure their admissions into several rounds. The first round admissions deadline is usually around October or November, the second around January, and the third in March or April. Foreign students are usually advised to apply as early as possible, because they need more time to sort out their student visa and funding[8].

Within the European Union, universities are forced to treat intra-EU students the same as local students, and therefore are not allowed to charge them higher tuition fees or award them lower stipends as graduate students. Although Europe has been working to streamline graduate education in the context of the European Higher Education (EHEA), students are still referred to the different national admissions procedures[9]. To date, the process is still not as institutionalized and streamlined as in the United States.

The fact that the U.S. application process is well known, if arduous, may persuade European students who want to pursue a PhD abroad to apply in the U.S., rather than facing different national admissions procedures when applying to different universities in Europe. Moreover, although English is becoming more and more widely adopted in advanced higher education degrees, many courses and administrative requirements still need to be fulfilled in the local

[8] Source: www.gradschools.com [accessed on March 15th, 2012]
[9] Source: http://ec.europa.eu/education/study-in-europe/application_guide_overview_en.html [accessed on March 15th, 2012]

language, which forms an additional barrier for intra-EU mobility. By contrast, there is some evidence that in some fields, graduate school admissions in the U.S. are biased against foreign applicants, although the authors attribute part of this preference to the large amount of applications from foreign students vis-à-vis applications from U.S. citizens. However, the bias in probability of admission is mostly present for East Asian and South Asian students, and is not significant for students from Western Europe (Attiyeh and Attiyeh, 1997).

1.2.2.1.2 Visa policies

European students who wish to enter the United States for graduate study must apply for a visa. There are two broad categories of visas: temporary and permanent. Permanent visas, like green cards, are difficult to apply for on professional grounds, and the majority are granted because the student already has family or a spouse with a permanent visa in the US. There are exceptions, however, like the Chinese Student Protection Act of 1989 which granted permanent visas to Chinese students following the events on Tiananmen Square. The majority of foreign students come on temporary visas, however (Stephan, 2012). For PhD students, there are two common types of visas: F-1 and J-1. The majority of students enter on an F-1 visa. Students can qualify for an F-1 visa with any type of funding, including personal or family funds, and are allowed to work on and off campus, although the latter has a 12-month limit and the work must be directly related to their studies. Students on F-1 visas are allowed to change their immigration status upon completion of their program[10].

To qualify for an F-1 visa, students must be admitted to an educational program approved by the Immigration and Naturalization Service and enroll full-time there, have sufficient funds to self-support during the entire course of study, and maintain a residence abroad with no intention of giving it up. After admission into an INS-approved program, students receive an I-20 form from the institution ("Certificate of Eligibility for Nonimmigrant Student Status"), which they take to the local U.S. consulate to apply for a visa. If a visa is granted after the screening process, then students receive another form, the I-94 ("Arrival-Departure Record"), upon entering the United States (Borjas, 2002).

The other common temporary visa is the J-1 visa. The J-1 visa requires that the student receive a substantive portion of funding from a source other than personal funds, either from

[10] Source: http://www.yale.edu/oiss/immigration/common/vs/index.html [accessed on March 15th, 2012]

the host institution, the home government or another funding agency. J-1 visa holders are allowed to bring dependents which are eligible to apply for permission to work in the United States. Upon completion of their studies, J-1 visa holders are required to return to their home country for at least two years. This requirement can be waived, but only under restrictive and rare circumstances. Departure can be delayed by up to two years for postdoctoral training or up to three years for "occupational or practical training". Another option to avoid the two-year home residence requirement is to work for an international organization like the United Nations or the World Bank, an option that is primarily interesting for economists (Kahn and MacGarvie, 2008).

The number of temporary student visas has risen significantly, from 65,000 in 1971 to 315,000 in 2000 (Borjas, 2002). How many visa applications are rejected, and how the rejection rate has evolved over the past decades, is less clear.

Within the European Union, the free movement of people ensures that European citizens are allowed to study in other member states without having to apply for a visa. Students only need a valid passport, and are sometimes required to register in their host country[11]. With the 2004 and 2007 enlargements of the EU, some restrictions were placed on mobility of workers. Today, only citizens of Bulgaria or Romania need to apply for a work permit in some member states[12]. There appear to be no such restrictions for student mobility. Students coming from outside the European Union must apply for a student visa in their individual host country. The Schengen convention ensures, however, that a visa issued by another Schengen country is automatically valid for all Schengen countries.

The arduous visa application process for the United States, combined with the relative ease of international study within Europe for EU nationals, may make intra-EU mobility more attractive for European graduate students. If a U.S. student visa is denied, this effectively restricts a student's choice set, and makes intra-EU mobility or non-mobility more likely. Student visas are frequently denied on the basis of article 214(B), which requires students to prove they have no intention to immigrate by showing significant ties to their home country. It is possible that students from Eastern Europe, where the disparity in standard of living with the U.S. is the highest, face more difficulty proving non-immigration intentions, which might

[11] Source : http://ec.europa.eu/education/study-in-europe/application_guide_overview_en.html [accessed on March 15th, 2012]

[12] Source: http://ec.europa.eu/social/main.jsp?catId=508&langId=en [accessed on March 15th, 2012]

restrict mobility options to the U.S. more for students from this region of Europe. However, to my knowledge there are no visa rejection statistics by home country to verify this assertion. If there are indeed differences in the probability of visa rejection for different countries of origin, then the control variables for the region of origin of the researchers studied in this dissertation should control for this variation.

1.2.2.1.3 Funding

Besides getting accepted into a graduate school and, if necessary, obtaining a student visa, prospective graduate students also need to ensure they have sufficient funding to cover their tuition and expenses.

For the United States, the National Science Foundation's Survey of Earned Doctorates reports PhD recipients' primary source of support. In 2009, fellowships, grants and research assistantships were the most prevalent forms of support, with over 50% of PhD recipients reporting it as their primary source of support. Teaching assistantships account for another 18%. The rate of self-support has been declining, from about 33% of PhD graduates in 1999 to 20% in 2009. Self-support rates are highest in non-science fields such as education (60%) and the humanities (a little over 20%). Among the science fields, social scientists are most likely to be self-supported, at a little under 30% in 2009. Less than 10% of PhD recipients in life sciences, physical sciences and engineering report private funds as their main source of support (National Science Foundation, 2011). These differences in forms and availability of support for different fields make it important to control for field of study in the second chapter, which studies mobility of PhD students to the United States or within Europe.

For European PhD recipients in economics, the group studied in chapters 3 and 4, 31% reported being supported by a fellowship, and another 8% by a research assistantship in 2006. Around 10% received support from foreign sources, whereas the majority, 47%, reported being supported by teaching assistantships. The latter rate was exceptionally high in 2006, however, with on average around 30% of students reporting teaching assistantships as their main source of support in the preceding 5 years (National Science Foundation, 2011).

Foreign students do not have access to all sources of funding the in United States. In particular, fellowships financed with federal support are typically reserved for U.S. citizens

or permanent residents, including the National Science Foundation's Graduate Research Fellowships and other fellowships tied to NASA, the Department of Defense, etc. This means that foreign students are often precluded from seeking funding from important sources of graduate funding. For example, the National Science Foundation's graduate fellowships are an important source of support for American students: in 2001, around 4% of graduate students were supported by a Graduate Research Fellowship (Freeman et al., 2009). Other funding institutions, such as the Andrew W. Mellon Foundation, also restrict their fellowships to U.S. citizens or permanent residents[13].

By contrast, fellowships from the Social Science Research Council and the Sloan Foundation do not require U.S. citizenship for eligibility. Other sources of support are even reserved exclusively for foreign students, like the Fulbright Visiting Students Program, established in 1946 and sponsored by the Department of State. The Fulbright program gives students from other countries the opportunity to pursue graduate studies in the U.S. In 2008-2009, the program supported 3,193 students, the vast majority of foreign students supported by the U.S. government. Since its inception, it has supported over 125,000 students (Kahn and MacGarvie, 2008).

Most graduate fellowships are highly selective and merit-based, and require that applicants have exceptional academic credentials. The National Science Foundation's Graduate Fellowships, for example, evaluate applications on intellectual merit using indicators such as grade point averages, GRE scores, references, proposed research and previous research experience. The overall award rate of this fellowship was 13.5% over the period 1952-2004 (Freeman et al., 2009). Other graduate fellowships are even more selective: one website[14] that gives prospective students advice on applying for fellowships estimates that the odds of getting one of the most prestigious or lucrative scholarships are between 1 in 250 and 1 in 500. Competitive, merit-based scholarships are therefore routinely mentioned on awardees' CVs.

In Europe, the funding landscape is again more fragmented compared to the United States. Prospective graduate students can apply to a host of national funds, which are generally also available to European students from other member states as well. Since Europe has started

[13] Source: http://www.finaid.org/scholarships/prestigious.phtml [accessed on March 16th, 2012]
[14] Source: http://www.finaid.org/scholarships/lesscompetitivescholarships.phtml [accessed on April 6th, 2012]

the process of converging its education systems, graduate students can also apply to EU-wide fellowships like Erasmus Mundus or the Marie-Curie Research Fellowships. Moreover, improving the portability of grants and fellowships is one of the policy goals within the European Higher Education Area (CHEPS, 2008).

1.2.2.1.4 Higher education policy in the EU

The Bologna declaration of 1999 set in motion a series of reforms intended to harmonize the European higher education system that ultimately led to the creation of the European Higher Education Area in 2010. One of the central points of the Bologna process is facilitating and promoting student mobility. The ERASMUS exchange program, established in 1987, has been very successful in providing undergraduate students the opportunity to study one or two semesters abroad. Over time, however, there has been a shift in focus from credit mobility to degree mobility, which is the type of mobility studied in this dissertation (CHEPS, 2008). Although the Bologna process has introduced reforms to harmonize the structure of higher education into the bachelor-master-doctorate structure across Europe and improved the recognition of foreign degrees both within Europe and beyond, mobile students do not seem to take EHEA membership into account, but rather focus on characteristics of the individual host countries and institutions. This indicates that EHEA is not yet seen as an area providing a uniform level of higher education degrees, according to an eight-person expert panel consulted for an assessment of the Bologna process (CHEPS, 2008). For extra-EU students, the U.S. is still perceived as the most prestigious destination, followed by Europe (CHEPS, 2008).

Higher education is also a central issue in Europe's EU2020 strategy and in its predecessor, the Lisbon strategy. One of the explicit goals in the EU2020 strategy is to increase the number of adults with tertiary education, but also to provide more students with the opportunity to gain additional skills through study abroad[15]. International mobility is central to the modernization of higher education, and is likely to receive continued policy attention in the future.

[15] Source: http://ec.europa.eu/education/higher-education/agenda_en.htm#doc [accessed on March 16th, 2012]

Insofar as the harmonization efforts in the European higher education landscape have been paying off, we might expect to see an increasing trend of intra-EU mobility of PhD students. To capture this, we include cohort variables or time trend variables in our models.

1.2.2.1.5 Higher education policy in the U.S.

In the last decade, there has been an intense debate about foreign student policies in the United States, weighing matters of national security against competitiveness concerns (Haddal, 2008). Given that some of the terrorists who carried out the attacks of 9/11 had entered the United States on a student visa, there was an understandable call for stricter monitoring and regulation on foreign students (Borjas, 2002). Due to the more difficult circumstances for foreign students, after 9/11 the number of foreign graduate students in the U.S. dropped initially. Stay rates of those with PhDs also declined, although part of the decline was related to the recession. By 2007, stay rates of PhD recipients had fully recovered to their previous level (Finn, 2010).

However, many in the United States also realize that foreign students and researchers make significant contributions to science, innovation and economic growth (Black and Stephan, 2007; Stephan and Levin, 2001; Hunt and Gauthier-Loiselle, 2009). In particular, foreign students are more likely to study in science, technology, engineering or mathematics (STEM) than U.S. nationals (National Science Foundation, 2009), and therefore supply a set of skills in high demand that comparatively fewer Americans seem willing to acquire. Consequently, many groups in higher education and in the private sector advocate policy changes that expand the possibilities for foreign students in these fields to stay in the United States. Some employers have promoted a lengthening of the optional practical training period, which allows students to stay up to 12 months after the completion of their degree to acquire practical experience. Another proposal made in Congress was to create a new category of F-1 visa specifically designed for students who pursue higher education in a STEM field, which would suppress the requirement to demonstrate the intent of departing the U.S. upon completion of studies (Haddal, 2008). Such reforms could make pursuing a degree in the U.S. more attractive for students with the intention to migrate permanently.

1.2.2.2 Post-PhD return

This section discusses the institutional context faced by European students who obtain a PhD in the U.S., and upon completion of their degree must decide whether to apply for a job in the United States or to return to Europe. The workings of the job market for new PhDs, visa policies, funding issues and other relevant higher education and research policies are discussed. As the two chapters on post-PhD return focus exclusively on PhDs in economics, the job market subsection also discusses the particular organization of the economics PhD job market. Although there is some overlap between this section and the next, which discusses the institutional context of European researchers who obtain their PhD in Europe and become internationally mobile, there is some value in distinguishing the 'return' perspective from the 'outgoing mobility' perspective.

1.2.2.2.1 The job market for new PhDs

Economics PhD holders who decide to apply for an academic job in the United States enter a strongly institutionalized market. Since 1974, job openings are posted in the American Economic Association's Job Openings for Economists at various points during the year, but mostly from September until December. In 2008, 1,910 academic jobs and 1,004 nonacademic jobs were posted. In November and December, applicants send out applications and letters of reference via mail, e-mail or through a designated web application. Also, since 2005, applicants can send up to two signals to institutions that they are particularly interested in to help with the coordination of candidates and employers. Employers review applications throughout the fall, and in December invite some of the applications for an interview. Initial interviews are carried out during the ASSA meetings, where interviews are typically held in a large ballroom and in hotel rooms. Applicants who pass the initial round of interviews are invited for campus flyouts throughout winter and spring. After these visits, institutions can decide to make an offer. Some offers have long deadlines, and offer the candidate some time to gather other offers for comparison. Especially highly prestigious employers have the capacity to make offers with very long deadlines. Other institutions can make offers with very tight decision deadlines of one or two weeks. Applicants who receive no job offers can signal their continued availability on the AEA's website for the late job market scramble in the spring, or apply in the non-academic job market, or take a temporary academic position as a one-year visiting professor or a postdoc and apply again the following year (Coles et al., 2010).

Since 2005, an ad-hoc committee on the job market within the AEA evaluates the working of the market and makes suggestions for improvement, such as the early market signaling and the late job market scramble, to thicken the market towards the end of the period (Coles et al., 2010).

In Europe, the job market for economics PhDs is not as institutionalized as in the United States. Hiring practices and job requirements differ from country to country and from region to region, as discussed in the first part. In some countries, the hiring decision is not even taken at the level of the university, but rather by a national committee per discipline, as in Italy and France (Stephan, 2012). Moreover, in many European countries universities still tend to hire young researchers in-house, and relatively few foreigners professors are hired (Haeck, 2012). For example, in Spain over 60% of academic researchers receive tenure in the same institution where they obtained their PhD (Cruz-Castro and Sanz-Menéndez, 2009).

One element that hampers the hiring of promising young foreign researchers is that many universities still teach undergraduate classes in the local language, which makes it hard for foreign professors to fulfill their teaching requirements if they do not learn the local language. There are exceptions, however. The United Kingdom and Switzerland are strongly internationalized in terms of staff hiring: in the Times Higher Education Supplement's ranking of universities based on the percentage of international staff, the United Kingdom and Switzerland both have universities that enter the top ten[16] (Ince, 2007). Moreover, across Europe there are a few top universities that are also generally perceived as good destinations for international scholars, such as the University of Toulouse in France, Tilburg University in the Netherlands, and Universidad Pompeu Fabra in Spain. However, as the situation stands, it is not straightforward for returning Europeans to apply outside of their home country, with the exception of a few highly internationalized top institutions. Europe still has substantial scope for opening up national university systems to international hiring.

1.2.2.2.2 Visa policies

European PhD recipients who want to stay in the U.S. and who came on an F-1 visa can either stay for up to 12 months and work under their student visa as a 'training period', or

[16] The London School of Economics in the UK and Ecole Fédérale Polytechnique de Lausanne and ETH Zurich in Switzerland.

adjust their visa status (Haddal, 2008). Students who came on a J-1 visa can even stay for a period up to 24 months. Although postdocs generally stay on J-1 student visas, universities have increasingly applied for H1-B work visas for postdocs as well. The H1-B visa is a nonimmigrant visa that allows U.S. employers hire non-citizens for a limited period of time for jobs that require specialized knowledge and skills, and is the largest visa program for skilled workers, averaging 130,000 workers per year in the 2000s (Gibson and McKenzie, 2011). Universities used to compete with firms for a capped number of H1-B visas, but the 2001 Competitiveness in the Twenty First Century Act has since lifted the cap on H1-B visas for universities, government research labs and certain non-profits. Many foreign faculty and postdocs now take positions at U.S. universities on a H1-B visa (Stephan, 2012).

There is no direct pathway for foreign students to permanent residency, as the criteria for permanent residency place stronger emphasis on having relatives in the U.S. than on specialized skills. Occasionally, a foreign student can win one of the 50,000 green cards given away in the U.S. Government Diversity Lottery Program (Stephan, 2012).

Some foreign researchers who have worked in the U.S. for a long time apply for naturalization, typically after also having been granted permanent residency. In 2003, some 15% of science and engineering doctorates in tenure-track positions in the U.S. had become U.S. citizens through naturalization.

For European citizens returning to work in Europe, the freedom of movement established in the EU and the Schengen convention should ensure that applicants encounter few barriers to apply for jobs in any EU country. The strict visa policy in the United States may drive some European PhDs who did not manage to adjust their visa status to return to Europe, even if they preferred to stay and work in the U.S.

1.2.2.2.3 Funding

A discussion of how research funding influences PhD recipients' international mobility choice sets must include both graduate funding as well as funding for young researchers. European researchers whose PhD research in the U.S. was largely funded by a fellowship or grant, be it from a U.S. institution or from the home country, are likely to have entered the U.S. on a J-1 visa, and are thus subject to a two year return requirement, as discussed in the

previous section. The circumstances under which students can apply for a waiver of this return requirement are very restrictive, including filing for a 'no objection' statement from the country of origin if the funding was received from the home country, a request from an interested government agency if it can argue that the student's departure is detrimental to its interest and that of the public, arguing that there is a threat of persecution in the home country, or that the student's departure will inflict exceptional hardship to a United States citizen. In practice, these waivers are only obtained in rare and exceptional circumstances, and the vast majority of students on J-1 visas indeed leave the country for extended periods of time upon completion of their degree. However, the two-year return requirement need not be fulfilled in one consecutive stretch, allowing students to work part time in the U.S. and part time abroad during summers or semester-long visits (Kahn and MacGarvie, 2008). In the chapters that deal with post-PhD return of European PhD recipients, we are not able to control for the type of visa with which individuals studied in the U.S., but we do include control variables for the type of funding the student received, and from what source: the host university, another U.S. institution, and the home country. Receiving a type of funding that makes the student likely to have entered on a J-1 visa probably also influences the probability of return.

The availability of funding for young researchers also influences European researchers' possibilities to stay in the U.S. In the sciences, newly hired assistant professors usually receive a startup package from the university to establish a lab and a small research team, but after a few years researchers must apply for competitive funding to keep financing their research activities, and increasingly also their own salary. Success as an academic researcher is dependent on being successful at obtaining grants, and independent researchers spend a considerable amount of time writing and following up on grant applications. Past research success often translates into improved chances of obtaining funding in the future, making it especially hard for young researchers, who still need to establish their reputation in the research community, to successfully obtain grants. The decreasing success rate in grant applications makes it more difficult for PhD holders to establish themselves as independent researchers, and consequently young researchers spend an increasing amount of time in temporary positions such as postdocs. This evolution makes careers in the U.S. relatively less attractive, especially in fields where the average time spent as a relatively low-paid postdoc has been increasing strongly, such as the life sciences (Stephan, 2012).

In Europe, universities generally pay a professor's full salary throughout the career, but researchers apply for research funding to finance specific projects with a host of national, regional and EU-wide funding agencies. However, compared to the United States, research success and promotion are less dependent on successfully obtaining competitive funding (Haeck, 2012). One difficulty in Europe remains the fragmentation of the research landscape, including the funding aspect as well. A lot of research funding is still administered through regional or national funding agencies, and it may take some local knowledge to successfully apply to these funding agencies. However, in the EU there are some EU-wide research grants, such as the Marie Curie Fellowships. The Marie Curie grants were first introduced in the 6th Framework Programme which ran from 2002 to 2006[17], and continued in the 7th Framework Programme from 2007 through to 2013. One specific fellowship of interest to our population of European researchers with a U.S. PhD are the Marie Curie Reintegration Grants, which provide a flat-rate contribution of €25,000 per year for a period of 2 to 4 years to help researchers establish themselves in a stable research post in a European country where they have not worked for at least three years, for example after a mobility period abroad. The host institution must provide the researcher with an employment contract for at least the project's duration, and at conditions which are similar or better than that of equivalently qualified researchers in the same institution. Obtaining such funding can be a strong motivator for promising young European researchers to return to Europe.

1.2.2.2.4 Higher education and research policy

As briefly mentioned in the visa subsection, foreign students can stay up to 12 months or 24 month in the United States, depending on the type of student visa, to work as a 'training period'. In the last decade, companies and research organization have progressively pushed for a lengthening of this training period or for the creation of more direct pathways to legal permanent residency, especially in science and engineering fields where foreign students now earn a substantial portion, if not the majority of the degrees. The United States Congress has made proposals in that direction, including the creation of a separate class of F-1 visas for foreign students in STEM fields which do not require the student to prove the intention of return upon completion of studies, and lengthening the optional training period to 24 months (Haddal, 2008).

[17] These grants are therefore only relevant for the four most recent years of the ProQuest sample used in chapters 3 and 4.

Another issue that the United States is trying to tackle is the substantially lower success rate of young researchers in obtaining competitive federal funding. It was hoped that the doubling of the National Institutes' of Health budget in the early 2000s would increase the success rate of proposals, but after a short period of increased approval rates universities and research institutions altered their behavior and applied for more and bigger projects, leaving the success rate even lower than before the doubling (Stephan, 2012). More targeted policies to provide research funding for young researchers are needed to avoid discouraging promising young talents from pursuing an academic research career, and similarly, to prevent talented foreign researchers to leave the U.S. because of deteriorating opportunities to establish an independent research career in the U.S.

In Europe, the past decade has seen substantial efforts to integrate the market for students, but up to now comparatively little has been done to harmonize the internal governance of universities, including the hiring and promotion practices (Haeck, 2012). One of the initiatives undertaken to address this fragmentation is the creation of the European Research Area (ERA) in 2000. The history and evolution of ERA are discussed in more detail in the next section, as it is also relevant for intra-European researcher mobility in general.

1.2.2.3 Researcher mobility

This last section discusses the relevant institutional context for experienced researchers who plan to become internationally mobile, the population under study in chapters 5 and 6. Many elements overlap with the institutional context for newly minted PhDs, however, and will therefore refer to the previous section.

1.2.2.3.1 The job market for experienced researchers

In the United States, the job market for experienced researchers is somewhat less centralized and institutionalized than the market for new PhD graduates. A typical moment when more experienced researchers go back on the job market is in the event tenure is not granted by the researcher's first employer, typically after a period of about 7 years.

In the sciences, the majority of job changes involve a promotion in rank: in a sample of 258 academic scientists who change employers between 1961 and 1975, Allison and Long (1987) find that 60% of assistant professors are promoted to associate professors after a job change,

while 52% of associate professors are promoted to full professor. This suggests that rank promotion may be an important inducement for job mobility in the U.S. (Allison and Long, 1987). The fact that in the United States the promotion path is quite uniform, starting at assistant professor, then promoting to associate professor and finally to full professor, and with similar criteria for promotion – often based strongly on research performance – makes job mobility within the U.S. relatively easy.

By contrast, in the European Union, despite significant efforts in the last decade to standardize higher education, relatively little has been undertaken to harmonize the internal governance of universities, and particularly the hiring and promotion practices, as discussed above. In many European countries, universities remain rigid, hierarchical organizations, with promotions often governed more by seniority than by performance. Moreover, many universities have little to no wage autonomy, making it difficult to hire the best researchers. Perhaps because of this lack of autonomy, universities have tended to hire predominantly their own PhDs, and most professors stay in the same university for their entire career (Haeck, 2012), a practice which hampers intra-EU mobility.

In the context of the Bologna process and the Lisbon objectives, many countries have started to reform their university sectors. Although systems of governance are very diverse, common themes in recent reforms are increased public funding for higher education, a move towards linking performance indicators to the allocation of funding, and encouraging the diversification of funding sources. Increasingly, universities are allowed to own the intellectual property rights of their research results, allowing them more freedom and providing more incentives for them to collaborate with industry in the development of innovations. In most countries, however, universities still have limited freedom to determine staff policy. Only the Netherlands and the UK have a high level of autonomy in human resource management, while in most other countries at least part of the process of recruitment, salaries and promotion is regulated or supervised. Up to now, few countries have undertaken reforms to grant universities more autonomy in terms of personnel management (Veugelers and van der Ploeg, 2009).

1.2.2.3.2 Visa policies

In terms of visa policies, there is a strong overlap with the previous section. Experienced researchers who want to move to the United States will typically apply for a temporary visa such as the H1-B for highly skilled workers. Universities had to compete with firms for a capped number of H1-B visas each year, but since the Competitiveness in the Twenty-First Century Act of 2001, the cap has been lifted for universities, government labs and certain non-profits. Applying for a permanent residency, or a green card, is not straightforward without having family or a spouse who is a citizen or a permanent resident. Once permanent residency is obtained, a small proportion of researchers apply for naturalization as a U.S. citizen.

In Europe, thanks to the freedom of movement established in the EU and in the Schengen convention, there are typically few obstacles in terms of administrative barriers for intra-EU mobility for EU citizens. After the EU enlargement, some EU countries imposed limitations on the inflow of workers from new member states from Eastern Europe, although it is unlikely that these strongly affected the movement of highly skilled workers. These restrictions also have to be phased out over time. At the moment, only a few western European countries still impose work visa restrictions on workers from Romania and Bulgaria.

1.2.2.3.3 Funding

A lack of funding to support international mobility and the lack of portability of existing funding is often seen as a hampering factor for mobility by European researchers (IDEA Consult, 2008). Improving the portability of funding is one of the policy priorities within the EHEA (CHEPS, 2008) and the ERA[18]. Since the 6th Framework Programme, launched in 2002, researchers can also apply for several EU-wide grants under the Marie Curie Actions. Some of these grants are specifically tailored to stimulate international mobility, such the Intra-European Fellowships, the Outgoing International Fellowships and the Incoming International Fellowships. The latter two fellowships also include provisions to assist researchers to return to their home country upon completion of their stay abroad[19].

[18] Source: http://ec.europa.eu/research/era/areas/researchers/researchers_en.htm [accessed on March 18th, 2012]
[19] Source: http://cordis.europa.eu/mariecurie-actions/# [accessed on April 8th, 2012]

1.2.2.3.4 Research policies

In Europe, one of the most significant policy developments for mobile researchers is the creation of the European Research Area. At its start, it was supported by several initiatives, such as the creation of the European Research Council (ERC) and the European Institute of Technology, as well as other initiatives to improve the coordination of research activities and policy initiatives. However, in 2007 the EU recognized that much more work needed to be done to overcome the fragmentation that remained a prevailing characteristic of the European public research base. Therefore, in 2008 the member states committed to the Ljubljana Process, designed to overcome this fragmentation and to build a strong ERA. A first step was the formulation of a shared '2020 vision for ERA', towards which the Member States and the Commission are focusing their programmes and policies. Moreover, Member States and the Commission have also launched partnerships to cooperate on 5 specific areas, including the working conditions and mobility of researchers, joint research programmes, investment in European research infrastructure, transfer of knowledge from science to industry, and international science and technology cooperation[20].

The mobility of researchers is seen as a crucial element in the realization of the European Research Area. One of the ERA initiatives that is most relevant for prospective mobile researchers is the European Partnership for Researchers, which aims to accelerate progress in four key areas, namely in open recruitment and portability of grants, meeting social security and pension needs of mobile researchers, providing attractive employment and working conditions, and improving the training, skills and experience of researchers. Specific initiatives include the setup of a pan-European pension fund for researchers. Another is the creation of Euraxess, best known for providing a portal to the European job market for researchers, as well as providing services to researchers and their families when they relocate within Europe[21].

Although Europe is taking steps to address the fragmentation that has been characteristic of its research market for decades, it will likely be a long way before researchers perceive it as a single market. Until researchers do, the fragmentation of the European research landscape

[20] Source: http://ec.europa.eu/research/era/understanding/what/short_history_en.htm [accessed on March 18th, 2012]
[21] Source: http://ec.europa.eu/research/era/areas/researchers/researchers_en.htm [accessed on March 18th, 2012]

will continue to hamper its attractiveness for internationally mobile researchers (Mechtenberg and Strausz, 2010).

In the United States, most relevant policies are not centered on improving internal mobility of researchers, which is already high, but rather focus on concerns relating to the general attractiveness of scientific careers. This includes addressing concerns on the accessibility of research funding, especially for young researchers to be able to establish themselves as independent researchers, as well as addressing concerns of a possible shortage of PhD holders in STEM fields by adapting immigration laws to broaden possibilities for students to stay upon completion of their studies, as addressed in the above subsections.

1.2.3 Conclusion

This section briefly concludes the main implications of this discussion of the institutional context for the research in this dissertation.

First, the trends for PhD holders discussed in the general section, as well as the discussion of higher education and research policies in the United States and in Europe, make accounting for time trends important in all our models. In chapters three and four, which study European PhD recipients in economics who receive a degree in the United States, trends in the academic labor market for economists at the time of graduation are arguably the most important to account for, and therefore the models in these chapters include a number of cohort dummies defined to capture specific periods of time. In the other chapters, which study mobility outcomes of European researchers in various disciplines, it is more difficult to define a relevant set of cohort dummies, first because the structure of the survey does not allow us to pinpoint the exact moment in time when mobility events take place, and second because different disciplines are subject to different labor market trends. The best approximation we have for the timing of the mobility event is the year of graduation, assuming that most mobility events arguably take place early in the research career, as the human capital model predicts. Therefore in these chapters, we control for graduation cohort groups, and use various definitions of these variables as well as a continuous graduation year variable as robustness checks.

Second, the differences between countries and regions in higher education and research structures, specialization and standard of living arguably affect mobility preferences and

outcomes, and need to be controlled for. Ideally, one would control for the characteristics of all the countries that a researcher considers in her mobility decisions. However, we do not observe researchers' choice sets, only mobility outcomes. Therefore we control, instead, for researchers' country of origin, assuming that the characteristics of the source country have an influence on researchers' propensity to become internationally mobile, as well as their propensity to return if they leave. Due to data constraints in both data sets, some smaller countries are represented by only a few individuals. Therefore countries or origin are grouped together into regions that share similar characteristics: Western European countries, Mediterranean countries, Scandinavian countries, Anglo-Saxon countries (the UK and Ireland) and Eastern and Central Europe.

Third, visa policies and funding are important to control for, as they can effectively restrict the choice set of a researcher planning to become mobile. Unfortunately, neither of our datasets provides any information on the type of visa that a researcher moves with. In chapters 3 and 4, however, we can indirectly control for visa type by including controls for the type and source of funding that a PhD student receives, knowing that some types of external funding are often associated with a J-1 visa for foreign students in the United States, which comes with strict return requirements. In the other chapters, we are not able to control for visa policies or funding opportunities directly, although the survey data that we use do ask respondents to what extent visa restrictions and concerns about research funding played a role in their mobility decision.

As this discussion of the institutional context has made clear, a host of factors stands between a researcher's initial mobility decision and the final mobility outcome. In this dissertation, we attempt to study the former by analyzing the latter, and try to control for the external forces that shape mobility outcomes in the best way possible. However, throughout the thesis we must keep in mind that we cannot control for all the forces that shape mobility outcomes, and that there may be a discrepancy between 'mobility decisions' and 'mobility outcomes'. However, for ease of exposition, throughout the dissertation I will use both terms interchangeably.

1.3 DATA

This last section introduces the two main datasets used throughout this dissertation. The five following research chapters all use one of two main datasets: the second, fifth and sixth chapter use the MORE survey data, whereas chapters three and four use the ProQuest CV data. This section outlines the main features of each dataset, including data collection process and major limitations and drawbacks.

1.3.1 The MORE dataset

The second, fifth and sixth chapter use data from the extra-EU MORE survey (MORE, 2010). The extra-EU MORE survey is part of a group of surveys carried out in the context of a study on mobility patterns and career paths of EU researchers ('MORE'). This study was carried out by IDEA Consult in consortium with NIFU Step, WIFO, Logotech and the University of Manchester for the European Commission in 2009-2010. The aim of the extra-EU MORE survey is to analyze the motives and stay rates of EU researchers who move to the U.S., but the survey extended its aim by also including U.S. researchers moving to the EU, as well as researchers who are internationally mobile without moving between the EU and the U.S. and researchers who are not internationally mobile.

The definition of a researcher and of mobility are pivotal to the MORE survey. A researcher is defined as someone who carries out or supervises research, or who improves or develops new products, processes or services, or supervises these activities. Mobility is defined as a minimum three-month stay in a country different from the country where the highest degree was obtained. In the context of this survey, EU researchers are defined as researchers who obtained their highest degree in an EU-27 country, regardless of country of birth or nationality. The target group are EU researchers who work in the U.S. for a minimum of three months. Additionally, there are three additional target groups: U.S. researchers[22] who work in the EU for a minimum of three months, researchers who have been mobile but who do not belong in the previous two groups, and researchers who have not been internationally mobile.

[22] Equivalent to EU researchers, U.S. researchers are defined as researchers who obtained their highest degree in the U.S., regardless of country of birth or nationality.

The main sampling method of the survey was a web-based search, which identified html-pages or pdf files which match a few keywords that identify an academic CV as well as other characteristics, such as coming from a '.edu' domain name for U.S. web pages. The search program identified names of European countries and variations of the United States. If a combination of these appeared before the words 'publications' or 'journal', this was taken as an indication that the person linked to this CV might have been mobile between the U.S. and the EU. For these persons, the search program identified the e-mail address as the text immediately before and after an '@' sign[23]. The resulting list of e-mail addresses was the primary direct sampling source. Indirect sampling methods were also used, including publishing the survey on LinkedIn and forwarding it to the Euraxess community, the EU Centres of Excellence in the U.S., and the coordinators of the ATLANTIS Programme on EU-U.S. Cooperation in Higher Education and Vocational Training. Respondents were also allowed to forward the survey to others, thus 'snowballing' a number of respondents.

The sampling method allowed to construct a relatively large group of respondents, but the convenience sampling method also has drawbacks. The major drawback is a lack of information on the representativeness of the sample relative to the underlying population. First, the relevant underlying population for the target group of the survey are all EU-educated researchers who move to the U.S. for a minimum of three months. This is a very specific group, and to date there are no data sources that identify this particular population. Second, including the additional target groups of the survey entails comparing the sample with information on the world-wide population of researchers, a group for which, again, hardly any representative data are available. As there is no information about the underlying population, the survey sample cannot be corrected for possible biases that distort its representativeness. The findings drawn from these data therefore cannot be generalized to the whole population, and are valid only for this particular sample. Despite these caveats, given the scarcity of data on EU researchers and particularly on mobility, this sample provides an interesting source of information on a phenomenon that is receiving growing policy and scholarly attention.

[23] Many publicly available academic CVs now list the researcher's e-mail address as a picture or by spelling out 'at', precisely to avoid that the e-mail address is picked up by an automatic search program. There is, however, no way of knowing what percentage of researchers lists their e-mail address in this way, and whether this causes any biases in the type of researcher included in the sample.

The survey itself consists of two parts: the first addresses all mobility groups and asks about researchers' personal and family situation, education and training, current employment as a researchers and experience of mobility. The second part differs for each of the four target groups. The mobile groups receive the same questions, although some are adapted to fit each mobility group's situation (i.e. filling in the name of the destination country). The immobile group receives only the questions which are relevant to them, and the wording of certain questions is sometimes altered (i.e. 'which of these factors were important in your decision to become mobile to…' versus 'which of these factors were important in your decision not to become mobile'.) This part asks respondents about their views on mobility, including personal motivations for mobility, external influencing factors for the decision to become mobile, the effects they experienced from mobility, and how the destination country and source country compare in certain respects.

The survey was initially sent to 93,183 e-mail addresses. Out of these, 22,206 people viewed the email and 5,572 responded (6% of the total invited and 25% of those who viewed the e-mail), of which 4,571 respondents fully completed the questionnaire. An additional 1,393 fully completed surveys were received from non-panel individuals, adding up to a total of 5,964 fully completed questionnaires. After cleaning out responses from respondents who were not working as researchers and which contained illogical or incorrect responses, a total of 5,544 responses remained. This sample was used for the MORE report for the European Commission (MORE, 2010).

From this sample, we additionally select a more homogeneous subsample for the purpose of our research. In particular, we retain only

(i) Researchers who list a PhD as their highest degree, to keep the sample as homogeneous as possible with regard to educational attainment;

(ii) Researchers whose birth country is one of the EU27 countries plus Norway, Switzerland and Turkey. The latter three countries are also part of the European Higher Education and Research Area, and therefore researchers operate within a similar institutional framework in these countries;

(iii) Researchers who become mobile either to the U.S., Canada or within the EU-27 (adding Norway, Switzerland and Turkey). Adding additional destinations outside Europe and the United States complicates our conceptual model of mobility and does not add a great number of additional observations.

This leaves us with a sample of 1,576 European-born PhD researchers. The advantage of restricting our sample to this group is that it is more informative to make comparisons within a relatively homogeneous sample who operate in a relatively similar institutional context, geographically and professionally. The drawbacks of using this subsample are, first, a great loss of observations, and second, that the restriction of the sample does not improve the representativeness of the sample.

This dataset has two major limitations. The first, as mentioned above, is its representativeness of the underlying population. To assess the direction and size of any biases, ideally the MORE sample should be compared to a database of all European-born PhD-holding researchers in the world (or, at least, working in Europe and in North America). No such database exists, however.

To assess the representativeness of the flow of EU-born researchers to the U.S., the sample could be compared to the National Survey of College Graduates (NSCG), as is done in the MORE report. Other data sources such as the Survey of Doctorate Recipients or the National Survey of Recent College Graduates only include foreign researchers if they also receive at least a baccalaureate degree in the United States. The NSCG draws a sample of all college graduates from the decennial U.S. population census, oversampling those who work in a science or engineering (S&E) occupation. The 2003 NSCG is based on the 2000 population census, and includes data from the 2001 Survey of Recent College Graduates to cover more recent degree recipients. The survey calculates weights for each record in the survey data, which should make the NSCG representative of the entire science and engineering community in the U.S. The NSCG allows to compare the MORE sample in terms of disciplines and time window of arrival[24], but does not allow any estimate of the extent to which the MORE sample is biased towards EU-U.S. mobility compared to intra-EU mobility or non-mobility.

[24] The NCSG reports that the recent cohort of adult migrants, who entered the U.S. between 1989 and 2003, represent more than 50% of all adult migrants educated in science and engineering. The MORE survey also finds that more than half of the respondents have obtained their highest degree between 2000 and 2010, and a quarter between 1990 and 2000. The NCSG also reports that migrants from the EU27 are less likely to be employed in business or industry, and more likely to work in higher education, government or other education sectors, a finding also mirrored in the MORE sample. For more details on the comparison of the NCSG and the MORE sample, see MORE (2010).

Another possible candidate for comparison is another survey included in the MORE project, the survey of European academic researchers. This survey should be representative of all researchers working in academic institutions in Europe. The sampling strategy of the survey aimed to be representative within each European country, but strongly differing response rates (with, for example, very low response rates in France) make the survey less reliable as a representation of the academic researcher population as a whole in Europe. More importantly, it does not include European researchers working in the U.S. or Canada and so, again, does not allow us to estimate how the mobility flows within the MORE sample are biased.

A last candidate for comparison is the survey on the Careers of Doctorate Holders (CDH), carried out in several OECD countries in 2006 in cooperation with the OECD, Eurostat and UNESCO Institute of Statistics. In Belgium, the CDH survey was based on the 2000 population census, and sent out to all PhD holders identified in the census. In principle, it should be representative of the population of PhD holders working in Belgium. PhD graduates between 2000 and 2006 had to be identified with graduation records from individual universities, and recent graduates from universities outside Belgium were not included. We compare the researchers in our sample who are currently residing in Belgium to the Belgian sample of the Careers of Doctorate Holders survey. The comparison reveals that the rate of degree mobility (i.e. mobility of PhD students) is twice as large in our sample compared to the CDH, although the probability of being mobile to North America or within Europe is roughly comparable between the two samples. Likewise, our sample picks up four times as much 'career mobility' (i.e. mobility after the highest degree is obtained) as the CDH sample, and this mobility is more likely to be geared towards North America: 52% of career mobility goes toward the U.S. in our sample, versus 12% in the CDH sample. This indicates that the MORE sample is strongly biased towards EU-U.S. mobility, as can be expected from the sampling strategy. The CDH sample, however, only includes PhD holders currently working in Belgium, and does not take into account researchers who moved abroad permanently or who have not yet returned. This biases the mobility rates picked up in CDH downwards, and the true population mobility rates are likely to lie somewhere between the MORE estimate and the CDH estimate.

Another bias in the sampling is towards academic researchers, whereas the initial target population is researchers in all sectors. Because researchers in academe are more likely to maintain an online CV or profile page, the vast majority of the respondents work in the

academic sector, and are thus not representative for the underlying population of researchers across sectors. In the sample we use, only 65 of the 1,576 researchers work in industry, whereas the remaining 96% of researchers work for a university, a public or government research institution or a private, not-for-profit researcher institution like a research foundation. Again, we cannot correct for this bias, but the regressions that use these data include a dummy variable for researchers employed in industry to capture the unobserved heterogeneity between academic and non-academic researchers.

A second major limitation of the MORE data is that the questionnaire was worded differently for different mobility groups. For the three mobile target groups (EU-U.S., U.S.-EU and other mobility), this should not be a major problem, since the wording only changed slightly to include, for example, the name of the destination country in the question. The wording differed more strongly for the non-mobile group of respondents, however. Although the questions were designed to be 'mirror questions' to those for the mobile respondents, the different wording may lead to a different interpretation by mobile and non-mobile respondents. For example, one of the questions in the EU-U.S. mobile group is 'To what extent were the following aspects important as factors motivating you to become mobile to the U.S.?', whereas the mirror questions for the non-mobile group is 'To what extent were the following aspects important as factors dissuading you to become mobile?'. Aspects such as family considerations may be given little weight by the first group if they became mobile *despite* family considerations, even if family considerations received a lot of weight in the overall mobility decision, and vice versa for the non-mobile group. The implication is that the mobility outcome determines the wording of the question, and therefore possibly its interpretation, and therefore the answers to these questions cannot be used to explain the mobility outcome. This places limitations on the research questions that we can answer with these data. Specifically, we cannot use information from these questions to explain who becomes mobile, since the wording of the questions depends on the mobility outcome. However, we can use these questions to study how differences in motivations and external influencing factors affect mobility to different destinations *among mobile researchers*, an issue we take up in chapter 5.

1.3.2 The ProQuest dataset

The dataset used in chapters 3 and 4 is based on the ProQuest dissertation database. This database collects information about PhDs awarded at most major institutions in the United

States, as well as some large institutions in Canada and other countries. The database includes the PhD recipient's name, degree year, institution, the name of the advisor, and the title and abstract of the dissertation. We purchased the dissertation database for degrees awarded in economics from 1950 until 2006 (the dataset was purchased in December 2006).

The ProQuest dissertation dataset was merged with Thomson-Reuters' Social Science Citation Index (SSCI) in September 2008 on the basis of author name. As the coverage of the SSCI is only sufficient as from 1992, only PhDs awarded between 1992 and 2006 were retained[25], which amounts to 18,961 PhD recipients. After the merger, only PhD recipients with at least one publication were retained, totaling 4,761 PhD holders. The reason for selecting only PhD holders with at least one publication is that our population of interest is PhD holders who actively contribute to academic research, either in academia or in institutions such as the Federal Reserve, the World Bank, and the like. Researchers contribute to science, innovation, and by extension the economy, by disclosing the results of their work in journal publications. The productivity of researchers is often linked to how often they publish, and to the quality of their publications. PhD holders who move to the private sector face different incentives and a different institutional context for international mobility, and should, in our view, be treated as a separate group within an appropriate framework[26].

A concern is that we might be excluding a number of economics PhD recipients working in research who have not yet published in a journal covered by the SSCI database. However, at least two years have passed between the graduation date of the youngest cohort in our dataset and the merger with the publications database. Although it is possible that someone working in research to still not have published in an SSCI-covered journal in that timeframe, it appears unlikely, and such a researcher is not likely to build a successful research career as publications are often necessary to apply for academic positions, promotions and research funding.

From these 4,761 researchers, 100% of those with two publications and up were sampled, and 20% of those with just one publication (43% of the total). The stratified sample consists of 3,140 PhD holders. For these researchers, an extensive web search was undertaken to retrieve

[25] Publications up to five years prior of the degree year were allowed, hence the earliest possible publication year is 1987.
[26] This is beyond the scope of this thesis.

either a pdf curriculum vitae or a profile page with sufficient career information. The reason for undersampling those with only one publication is that the probability of finding a curriculum and the quality of information is relatively poor for this group. For only 28% of those with one publication a CV was found, compared to a success rate of over 62% for those with 10 publications or more. Since the web search and coding were all done by a single person, time-efficiency considerations played a part in opting for a stratified sample. The regression models that use these data are weighted to correct for the sampling strategy[27].

From the CVs and profile pages personal information, education and career histories were recorded. Personal information includes gender, age and nationality. If a birth year is mentioned, this is used to derive age, otherwise age was inferred by assuming that the BA degree was obtained at age 22. Nationality is explicitly specified in roughly 30% of the cases; for the remaining 70% we derive nationality from the country where the BA degree was obtained.[28] For education history, the BA institution, optional MA institution and PhD institution are recorded, as well as the graduation years and the field of study for the former two degrees. Finally, for career history, the institutions, entry and exit years and initial position are recorded for all the institutions where a researcher has taken up a permanent position after obtaining the PhD.

The initial intention was to study the return mobility of all foreign PhD recipients in our sample. However, a comparison of our sample to the National Science Foundation's Survey of Earned Doctorates revealed that our sample is not representative of the population of foreign PhD students in economics with respect to their countries of origin. There is a specific bias against Asian PhD holders, presumably because the problem of homonyms is much more present for students of Asian origin than for students from other regions, which leads to problems with matching names to publication data and reliably assigning CV information. Therefore we focus only on the European students in our sample, which has the added benefit that Europe offers a relatively homogenous policy context in higher education and research.[29] The drawbacks of focusing only on European PhD recipients are first, a loss of observations, and second, a probable restriction of the 'quality spectrum' that we observe,

[27] However, descriptive statistics are not corrected for the stratified sampling, and should therefore be interpreted with caution, as the sample is biased towards the higher end of the quality spectrum.
[28] Gaughan (2007) and MacGarvie (2007) provide empirical evidence that the majority of students obtain their BA degree in their country of birth.
[29] We use a broad definition of Europe. Specifically, the countries included in our sample are those of the EU 27 plus Belarus, Croatia, Iceland, Israel, Norway, Russia, Serbia, Switzerland, Turkey and the Ukraine.

given that European PhD students tend to be overrepresented in top tier graduate programs compared to PhD students from other areas of the world (Bound et al., 2009). Given that both chapters that use this dataset focus to some extent on how the quality of the PhD institution influences return mobility, a loss of variation, especially at the lower end of the spectrum, may make it more difficult to find significant results.

As argued above, researchers with a career in industry are excluded from the sample. Economics PhDs in industry are less likely to post a full CV online, and are thus automatically excluded from the sample. Moreover, in economics, one can argue that a career in industry is very different from a career in academia or government. Economists working in industry are much less likely to be doing 'academic-type' research compared to researchers in other fields. As we want to focus on researchers who are actively contributing to knowledge through publications in scientific journals, we decide to exclude the 17 PhD holders who opt for a career in industry. Most of these were either in private equity or in business consulting. Although PhD holders in science and engineering are known to self-select into academic careers or careers in industry according to their preferences (Roach and Sauermann, 2010), it is not unlikely that some PhD economists who would have preferred an academic career are forced into an industry job because they cannot find a suitable academic job, in which case we no longer include them into our dataset. As this is most likely to happen at the lower end of the quality spectrum, this again reduces the quality variation we observe and creates the possibility of a selection bias, where we observe the effect of quality on the probability to return only for those who reach a minimum quality threshold.

Assuming that research quality has a negative effect on the probability of return, observing only the higher end of the quality spectrum probably biases the estimated effect of quality on the probability of return downwards, by flattening the curve fitted to the binary data by a probit or logit model. To correct for this, ideally our analyses should be preceded by a selection equation that corrects for the probability of being included in our sample. This approach runs into two practical problems, however: first, we cannot observe most PhD holders who fall outside of our sample, and second, we lack certain important variables, such as taste for science and other personal preferences, to predict whether a PhD holder will be included in our sample or not. Therefore our results must be interpreted with caution. However, with due caution, it is reassuring that – given our hypothesis about the effect of

quality on the probability of return – we are probably underestimating the relation between these variables, rather than overestimating it.

After excluding people with incomplete records, we are left with a sample of 375 Europeans who earned a PhD in the U.S. or Canada between 1992 and 2006 and who have built a career in academia or in research departments of other institutions such as the Federal Reserve, the World Bank, the IMF, etc. More descriptive statistics on the dataset are given in the relevant chapters.

CHAPTER 2

INTERNATIONAL MOBILITY OF EUROPEAN DOCTORAL RESEARCHERS

ABSTRACT[30]

Student mobility remains an important component for the completion of a European Higher Education and Research Area. Two issues at the forefront are increasing student mobility within Europe as well as worries about a 'brain drain' of talented graduate students to North America. Unfortunately, there is still relatively little evidence and analysis available to support policy making. In this paper, using a large sample of European researchers, we analyze the decision of students where to pursue their doctoral studies: at home, in another European country or in North America. We find that students from countries with a weaker research and innovation system are more likely to seek their doctoral degree abroad, particularly within Europe. This suggests that graduate student mobility within Europe is driven to some extent by push factors in the home country.

[30] This chapter is joint work with Reinhilde Veugelers and Elissavet Lykogianni. It has benefited from the comments of Dirk Czarnitzki, Otto Toivanen and the participants of the ENID STI Conference (Rome, September 2011) and the TEMPO Conference (Vienna, November 2011).

2.1 INTRODUCTION

Whereas the United States experienced a rapid geographic integration in the second half of the twentieth century (Hoxby, 2002), Europe's higher education market has remained largely segmented into national or regional markets (Musselin, 2004). Students would benefit from a more integrated higher education market in Europe, which would expand their choice sets and arguably lead to better matches between students and programs. Student mobility also increases students' international skills and the transferability of their human capital, increasing their opportunities to work abroad and thereby allowing better employer-employee matches later on, which increase both private and social welfare. Finally, student mobility also contributes to the development of a European identity, and increases students' interest in and knowledge of European affairs (King and Ruiz-Gelices, 2003).

For European policymakers, intra-EU student mobility has gained increasing prominence on the policy agenda in the last few decades. The most visible policy at the European level has no doubt been the creation of the European Higher Education Area, in which students, researchers and teachers can circulate freely. The Bologna process has introduced reforms to make tertiary degrees more comparable and easier to be acknowledged in other member states. But student mobility is also part of the European Research Area objectives and of the goals of the EU2020 strategy and its Innovation Union Flagship (Luukkonen, 2010), and thus closely embedded in research and innovation policy.

Despite growing numbers of mobile students, the general conviction appears to be that Europe still has not reached the optimum amount of student mobility, and that more must be done to remove obstacles to mobility. At the same time, European policy makers remain worried about the large outflow of talented tertiary students to the United States, particularly at the graduate level.

For these reasons it is important to deepen our understanding of the factors that underpin student mobility. In this paper, we study the decisions of a sample of European researchers to pursue their doctoral degree in their home country, in another European country or in North America. In particular, our data allow linking these decisions to students' personal characteristics as well as to features of the research and innovation system in the students' birth country. We find that European students from countries with a weaker research and

innovation system are more likely to seek a doctoral degree abroad, and particularly within Europe.

2.2 A REVIEW OF THE EVIDENCE ON TERTIARY STUDENT MOBILITY

Several sources provide information on the international flows of tertiary students. In its 2010 Education at a Glance report, the OECD reports that 6.7% of all tertiary students in the OECD are international students. In advanced research programs this proportion is even higher, at 18.2%. Student mobility has increased with 70% between 2000 and 2008; the total number of foreign students enrolled outside their country of origin stood at 3.3 million in 2008. The U.S. receives almost 19% of all these foreign students. 11.2% of all international students in the U.S. are from Europe. By contrast, the ten most popular European countries[31] together receive about 35% of all foreign students. Within Europe, the UK and Germany are the most popular destinations for student flows. Switzerland boasts the highest foreign-to-native student ratio (OECD, 2010).

In a study of inward and intra-EU mobility of PhD students, IISER (2007) reports that 5.5% of doctoral candidates are studying in a member state of which they do not hold the nationality, whereas 16.9% come from outside the EU. Asia and Africa are the largest regions of origin of these extra-EU PhD students. For the United States, the Survey of Earned Doctorates collects detailed information on graduating PhD students, including foreign PhD recipients. In its latest Science and Engineering Indicators report, the National Science Foundation (NSF) reports that 33% of all doctoral recipients in science and engineering fields were temporary residents. The proportion is more than half in fields like engineering, mathematics, computer sciences and economics (NSF, 2010). The majority of foreign PhD students studying in the U.S. come from Asia: between 1987 and 2007, 82% of all foreign PhD recipients in the U.S. were from Asia, versus 17% from Europe (NSF, 2010).

A growing literature addresses the factors and motivations that drive student mobility. Many macro-studies that try to explain the size of flows between countries emphasize the importance of 'classic' migration factors such as relative size of host and home country, geographic and cultural distance, colonial and trade ties, relative economic strength and income differentials (Lee and Tan, 1984; Cummings, 1984; Agarwal and Winkler, 1985; McMahon, 1992; Bessey 2007). That classic migration factors play a role in student mobility

[31] United Kingdom, Germany, France, Italy, Spain, Austria, Switzerland, Belgium, the Netherlands and Sweden.

as well is not surprising given that for many students obtaining a degree in a particular country is often a first step for migration into that country (Borjas, 2002; Tremblay, 2001).

However, there are certain driving factors that are more specific to student mobility. Many students go abroad in search of higher-quality education than they could have obtained at home (Van Bouwel and Veugelers, 2011; Alberts and Hazen, 2005; Gordon and Jallade, 1996; Kemp et al., 1998; Aslanbeigui and Montecinos, 1998; Mazzarol and Soutar, 2000; Bourke, 2000; Szelényi, 2006). Getting a foreign degree from a prestigious overseas university is generally perceived as a valuable investment in human capital and future career opportunities. Moreover, students with mobility experience have better intercultural skills (King and Ruiz-Gelices, 2003) and are more likely to be internationally mobile later in their career (Parey and Waldinger, 2008; De Grip et al., 2009). A lack of availability of places in the desired program in the home country is also a push-factor for students to seek education abroad (Naidoo, 2007; Lee and Tan, 1984), especially at the graduate level (Van Bouwel and Veugelers, 2011).

The focus of this chapter is on studying the effect of the science and innovation environment in in the home country on PhD students' propensity to seek higher education abroad. Whereas most studies of student mobility consider either the attractiveness of (or within) the European higher education market (Van Bouwel and Veugelers, 2011; Bessey, 2007; Naidoo, 2007) or of the United States (McMahon, 1992; Agarwal and Winkler, 1985; Cummings, 1984) separately, this study considers both destinations together in one model. This allows us to differentiate the effect of students' personal characteristics and push factors at the home country level for student mobility within Europe or towards North America.

2.3 DATA

To study the international mobility decisions of European graduate students, this paper uses the MORE survey data described in the first chapter. The present paper focuses on the European-born[32] researchers in the MORE survey whose highest educational attainment is a PhD degree. After clearing out all observations with missing values, this subgroup accounts for 1,576 observations. The MORE survey targeted researchers with EU-U.S. mobility

[32] We define Europe as the EU 27 + Norway, Switzerland and Turkey. Although our definition of Europe extends somewhat beyond the borders of the actual European Union, we will use the terms 'EU' and 'Europe' interchangeably throughout the paper.

experience *after* they obtain their highest degree, i.e. mobility from their degree country (regardless of country of birth or nationality) to another country. However, the survey did ask researchers to list their birth country as well as the country where they obtain their highest degree, allowing us to deduct PhD student mobility from the survey responses.

Using the birth country to infer student mobility is likely to overestimate mobility, as some students may already have moved to their destination country as children instead of becoming mobile at a later age. An additional potential source of bias is the fact that the MORE survey specifically targets researchers with EU-U.S. mobility experience, resulting in a sample where EU-U.S. mobile researchers are likely to be overrepresented. The MORE survey defined mobility as occurring *after* the completion of the highest degree, but unless EU-U.S. mobile researchers have similar student mobility profiles as non-EU-U.S. mobile researchers, this sampling bias is likely to also bias the student mobility patterns observed in this sample.

To gauge how much our sample is biased towards mobile researchers, we compare the researchers in our sample who are currently residing in Belgium to the Belgian sample of the Careers of Doctorate Holders survey, which was conducted in 2006 in several European countries in cooperation with the OECD, Eurostat and UNESCO Institute of Statistics. The Belgian part of the survey targeted all PhD holders in Belgium based on census data, and should thus be representative of the population of PhD holders *currently residing* in Belgium. This implies that the survey does not capture Belgian PhD holders who obtained their degree abroad and did not return (yet) to Belgium; it therefore likely underestimates the rate of degree mobility. The comparison reveals that the rate of degree mobility is more than twice as large in the Belgian part of the MORE sample compared to the CDH data: 30.77% of the Belgian respondents were mobile as PhD students according to the MORE survey, compared to only 13.5% according to the CDH survey. The true rate of degree mobility probably lies somewhere in between. Given that the CDH rate of graduate student mobility is also biased, we opt not to weight our data in an attempt to correct for the mobility bias. The results from the MORE dataset should therefore always be interpreted keeping this mobility bias in mind. Among the mobile PhD students, the probability of being mobile to North America or within Europe is roughly comparable between the two samples. Making the (strong) assumption that students mobile within Europe or to the United States have similar return rates (and thus a similar probability of being picked up by the CDH data), the selection of destination country among mobile students appears less biased.

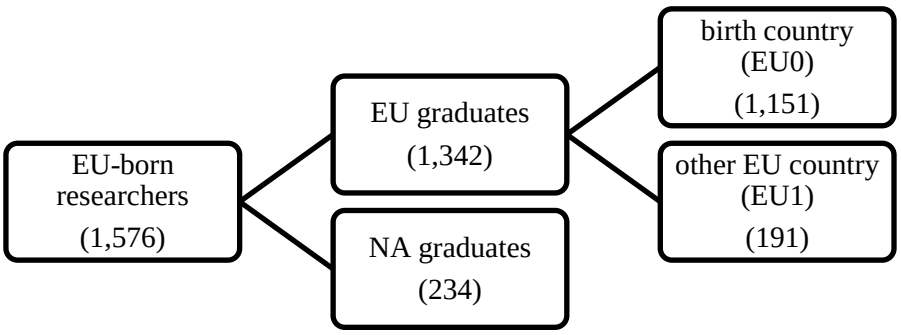
For this group of European-born researchers we study the factors related to their decision to pursue a PhD in the birth country or abroad, either elsewhere in Europe or in North America. We consider the United States and Canada as one region because the two countries are similar in their higher education and research systems, at least from the European perspective.

Among the PhD holders in our sample we distinguish three types of graduates:

a. EU-born researchers who have graduated in their birth country (EU0)
b. EU-born researchers who have graduated in a European country other than their birth country (EU1)
c. EU-born researchers who have graduated in North America (NA)

Figure 2.1 breaks down the sample into these 3 categories. Graduates from a European country (be it their birth country or not) amount to 1,342 researchers or 85.15% of the sample. Of these, 12.12% obtain their PhD degree in another European country than their birth country. The remaining 14.85% of the sample are NA graduates (European-born researchers who have graduated either in the USA or in Canada). All in all, 27% of the researchers in our sample obtained their doctoral degree outside their birth country.

Figure 2.1: Graduation groups



2.4 RESULTS

Which characteristics of student and home countries influence their decision to become mobile for their PhD, and subsequently, their choice of destination? In the first subsection, we briefly present some descriptive statistics for the three mobility groups. We discuss differences between scientific disciplines and along personal characteristics. We also present the most important source and destination regions of doctoral students. In the second subsection, we turn to regression analysis to examine which home country and student characteristics influence the likelihood of a student to pursue doctoral studies abroad, and whether the effects of these characteristics differ for mobility within Europe or to North America.

2.4.1 Characteristics of mobile and non-mobile PhD students

As there is considerable heterogeneity between scientific disciplines in terms of publication behavior (Stephan and Levin, 1992) and mobility behavior (Finn, 2010), we first look at differences in PhD degree mobility across degree field. In some disciplines it is customary to go abroad as a PhD student, while in other fields post-doc mobility is more prevalent. Moreover, in some fields access to certain infrastructure forces prospective researchers to become mobile as PhD students, for example in particle physics where some researchers need access to a particle accelerator to be able to conduct experiments. Finally, countries and regions tend to specialize in certain disciplines. PhD students who want to work in particular field may have to become internationally mobile to be able to work with the best professors and the state of the art techniques.

The survey asked the respondents to indicate the broad field of specialization of their PhD degree. These fields are natural sciences, engineering and technology, medical and health sciences, agricultural sciences, social sciences and humanities.

Table 2.1 reports PhD mobility patterns by degree field. There are strong differences in PhD mobility among the different disciplines. Students of medical and health sciences and agricultural sciences are much more likely to study in their birth country, perhaps because these disciplines are very locally embedded. By contrast, students in social sciences are most likely to go to North America for their PhD degree.

Table 2.1: Distribution over degree fields and degree regions

degree region categories	Natural Sciences		Engineering and Technology		Medical and Health Sciences		Agricultural Sciences		Social Sciences		Humanities		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
EU0	552	76.56	106	75.71	91	88.35	36	80	271	62.3	95	71.97	1151	73.03
EU1	82	11.37	15	10.71	5	4.85	6	13.33	64	14.71	19	14.39	191	12.12
NA	87	12.07	19	13.57	7	6.8	3	6.67	100	22.99	18	13.64	234	14.85
Total	721	100	140	100	103	100	45	100	435	100	132	100	1576	100
%	45.75		8.88		6.53		2.85		27.60		8.38			

Table 2.2 contains personal characteristics by degree region, including gender, age (at the time of the survey), marital status and whether the researcher has children. Personal characteristics influence mobility decisions in various ways. To date, women are more likely than men to prioritize family and children, and therefore not to become mobile for professional reasons. Likewise, having children may be a deterrent for both men and women, as moving abroad with a family entails larger costs than moving as a single, adult person. Younger researchers may be more willing to undertake an international move, since they can benefit from this investment over a longer working life than older researchers. However, as the survey asked respondents about marital status and age at the time of the survey, as opposed to the time of the PhD degree, we cannot use this information to explain PhD mobility since it is likely to have changed in the meantime.

Table 2.2: Personal characteristics by degree region

degree region	mean male	mean age	mean married/cohabiting	mean children
EU0	0.71	44.45	0.81	0.64
EU1	0.67	41.17***,°°°	0.75*,°	0.61°°
NA	0.73	43.9	0.82	0.71**
Total	0.71	43.97	0.8	0.65

Note: * for t-tests done with EU0 as comparison group, ° for t-tests done comparing EU1 and NA

In the sample as a whole, 71% of respondents are male, 80% are married and 65% have children, and the average respondent is almost 44 years old at the time of the survey. The results of t-tests to determine whether the two mobile groups differ significantly from the immobile group are reported. Personal characteristics are rather similar over different degree regions, with the exception of those researchers who obtained their PhD in another EU country (EU1): they are on average 3 years younger, and are consequently less likely to be married. These differences remain significant if we compare only the two mobile groups to one another. Perhaps this indicates that obtaining a PhD in another EU country is a more recent phenomenon. More recent, and thus younger, cohorts are more likely to study elsewhere in Europe than older cohorts, who either stayed at home or went to the U.S. Surprisingly, individuals who obtain their doctoral degree in North America are more likely to have children than researchers who obtained their degree at home, even though the former group is not significantly older than the latter.

Table 2.3 contains the outflows of doctoral students by birth region and from the major birth countries, in absolute numbers and as a percentage of the 425 mobile doctoral students in the sample. The Mediterranean countries in the sample (Portugal, Spain, Italy and Greece) are the largest source region of mobile PhD students, with 36% of mobile students. Western Europe, comprising some of the largest countries in the sample like Germany and France, has the second largest share with 32%. The same pattern is reflected in the ranking of the individual birth countries: the three largest source countries - in absolute numbers - of mobile doctoral students are Italy, Germany and Greece with 62, 54 and 40 mobile students respectively, which totals 37% of all the mobile students in the sample. Since Germany is the largest country in Europe, it is unsurprising that it supplies a large amount of mobile students. Italy and Greece have traditionally sent a large percentage of its student body abroad. Spain, the Netherlands, the United Kingdom and France each have over 20 mobile students in the sample as well.

Table 2.4 summarizes the inflows of foreign students in the different degree regions and major receiving countries in our sample. North America receives the largest inflow, with 55% of the sample choosing it as a destination, of which 53% go to the United States. Western Europe is the second most attractive region, with 19% of students moving there, followed by Anglo-Saxon Europe with 15% of the mobile PhD students. The latter region is mostly

dominated by the United Kingdom, which receives 14% of the mobile students. The other major individual receiving countries are Switzerland, Germany and France, receiving around 4% of mobile students each. Flows of PhD students appear to be more unidirectional than circular: most top sending countries are not among the top receiving countries. Only Germany and France are among the major sender countries as well as receiving countries.

Table 2.3: Outflow of doctoral students by birth region/country

Birth region	frequency	percent
Western Europe	135	0.32
Central and Eastern Europe	78	0.18
Scandinavia	27	0.06
Mediterranean	153	0.36
Anglo-Saxon Europe	32	0.08

Major birth countries	frequency	percent
Italy	62	0.15
Germany	54	0.13
Greece	40	0.09
Spain	39	0.09
Netherlands	23	0.05
United Kingdom	22	0.05
France	21	0.05

Table 2.4: Foreign inflow by degree region/country

Degree region	frequency	percent
North America	234	0.55
Western Europe	79	0.19
Anglo-Saxon Europe	62	0.15
Scandinavia	20	0.05
Mediterranean	26	0.06
Central and Eastern Europe	4	0.01

Major degree countries	frequency	percent
United States of America	225	0.53
United Kingdom	59	0.14
Switzerland	18	0.04
Germany	17	0.04
France	16	0.04

2.4.2 Characterizing the research and innovation environment at home

In our search for factors influencing PhD degree mobility, we are specifically interested in how a researcher's country of origin influences the decision to study abroad, and more particularly how important the quality of the research environment at home is for pushing PhD students abroad. Are students from particular regions in Europe more likely to study abroad than students from other regions? Are students from countries with a weak record in research and innovation more likely to study abroad for lack of opportunities at home? We hypothesize that students from countries with a strong research and innovation record and a high-quality higher education system have less incentive to seek a PhD degree abroad. Students from countries with a weaker research environment have more to gain from studying abroad, and in line with human capital theory, these higher potential benefits from mobility make students from these countries more likely to become internationally mobile.

We use two proxies for measuring the strength of the birth country's research environment[33]. First, we use a measure that captures the research quality of a country by measuring the visibility and quality of a country's publications. Using data from the National Science Foundation's Science and Engineering Indicators 2004, we calculate the relative impact of a country's publications as the share of a country's citations in total world citations in a given year, divided by the share of a country's publications in total world publications in the three preceding years, with a two-year lag. If this measure is above 1, it indicates that a country's publications on average attract more citations than 'the average world publication' and therefore reflects a high quality research system.

A second measure for birth countries' research and innovation strength is a quality indicator for its universities. For this, we construct an indicator based on the Shanghai ranking. The indicator is the weighted sum of the number of universities the birth country has in the top 500 of the Shanghai ranking, with institutions higher up the ranking receiving a larger weight, divided by population to control for country size as suggested by Aghion et al. (2007)[34]. This measure should capture the 'density' of top quality institutions in the birth country, and thus proxy for the availability of opportunities to pursue a PhD at a good institution at home.

[33] Please refer to table A.2.1 in the appendix for an overview of the definitions used in this chapter.
[34] The Shanghai ranking measure is robust to variations in the weighting scheme, to using only institutions in the top 200 instead of the top 500 for the construction of the indicator, as well as to using simple counts of universities per country.

Table 2.5: Science and innovation indicators: descriptive statistics

Panel A: Science and innovation indicators by country

Birth country	Relative impact	Shanghai ranking indicator
Austria	0.93	0.31
Belgium	0.97	0.56
Bulgaria	0.37	0.00
Cyprus	0.51	0.00
Czech Republic	0.52	0.06
Denmark	1.10	0.90
Estonia	0.66	0.00
Finland	1.05	0.55
France	0.96	0.27
Germany	1.03	0.38
Greece	0.55	0.08
Hungary	0.63	0.06
Ireland	0.89	0.23
Italy	0.92	0.16
Latvia	0.43	0.00
Lithuania	0.46	0.00
Netherlands	1.15	0.78
Norway	0.84	0.66
Poland	0.49	0.02
Portugal	0.63	0.02
Romania	0.32	0.00
Slovakia	0.36	0.00
Slovenia	0.58	0.05
Spain	0.79	0.09
Sweden	1.07	1.29
Switzerland	1.37	1.37
Turkey	0.37	0.00
United Kingdom	1.06	0.79

Panel B: Correlation of science and innovation indicators	
Shanghai ranking indicator	0.7472

Table 2.5 summarizes the two science and innovation strength indicators by birth country. The first column contains the relative impact of a country's publications. Countries with a score above 1 on this indicator attract, on average, more citations to their publications than the average world publication. Most northern European countries have a score above 1,

including three Scandinavian countries. At the bottom, Bulgaria, Romania, Slovakia and Turkey's publications only manage to attract about a third of the citations that the average world publication attracts. The Shanghai ranking indicator (column 2) is highest for small countries with a few excellent universities like Switzerland, the Netherlands, Sweden, Denmark and Norway, but also for a larger country with an important number of world-renowned top universities like the United Kingdom.

2.4.3 Econometric results on the factors driving PhD degree mobility

In the econometric analysis we examine how students' and home countries' characteristics are related to the probability of getting a degree abroad in a multivariate setting. We first look at the decision to get a degree abroad versus getting a degree in the birth country. To this end we perform a simple logit regression. Next, we split 'getting a degree abroad' into 'getting a degree elsewhere in Europe (EU1)' and getting a degree in North America (NA)', and use a multinomial logit.

The explanatory variables include a set of personal characteristics, discussed in section 2.4.1, consisting of gender, age at the time the degree was obtained, and field grouped together into 4 major fields, with humanities as the base group. To control for broad trends in student mobility, we group the respondents into four cohort groups depending on how much time has passed since they obtained their degree. These cohort dummies span ten-year periods for the three most recent decades, and 20 years for the respondents who obtained their PhD more than 30 years ago. Replacing the cohort dummies with the time since degree in years (which is tantamount to including a time trend) results in similar findings.

We also include a series of birth country indicators. First, we include 4 birth region dummies for the Mediterranean countries, Scandinavia, Central and Eastern Europe (including many EU-members who joined in 2004 or 2007) and the Anglo-Saxon countries, i.e., the UK and Ireland. The base region consists of the continental Western European countries. Ideally, we would include country dummies for the individual birth countries, but due to the low number of observations for some countries, we are forced to group these country dummies into regions which share similar characteristics. These region dummies capture relative regional strengths in terms of science and innovation, but also other regional factors that may drive PhD mobility flows, such as future job prospects, standard of living, cultural aspects, social security considerations, and so on. Since many of these unobserved factors can play a role in

driving outward PhD mobility, these region dummies are included in all the regressions. Our main focus of attention is the impact of the quality of the research environment at home as driving factor for PhD mobility.

2.4.4 Logit results for PhD degree mobility: at home or abroad

Table 2.6 reports the results for the logit analysis on whether to obtain a PhD degree at home or abroad. In the first logit model we include only the birth region dummies along with the personal characteristics. In the subsequent two specifications we add each of the science and innovation indicators for the birth country in turn.

Table 2.6: Logit for degree country: degree at home (EU0) or abroad (EU1 or NA)

VARIABLES	(1) PhD abroad	(2) PhD abroad	(3) PhD abroad
1 if male	0.0435	0.0785	0.0481
	(0.131)	(0.134)	(0.132)
Age at degree	-0.0304**	-0.0352***	-0.0306**
	(0.0133)	(0.0133)	(0.0133)
Cohort 10-19	0.115	0.107	0.113
	(0.132)	(0.135)	(0.132)
Cohort 20-29	-0.364*	-0.401**	-0.363*
	(0.199)	(0.202)	(0.199)
Cohort 30-49	-0.366	-0.367	-0.368
	(0.227)	(0.230)	(0.228)
Exact Sciences	-0.375*	-0.505**	-0.385*
	(0.220)	(0.224)	(0.220)
Life Sciences	-0.977***	-1.014***	-0.982***
	(0.311)	(0.315)	(0.311)
Social Sciences	0.364	0.268	0.357
	(0.223)	(0.227)	(0.224)
Mediterranean	-0.116	-0.892***	-0.180
	(0.142)	(0.189)	(0.183)
Anglo-Saxon Europe	-0.247	-0.224	-0.204
	(0.232)	(0.234)	(0.246)
Scandinavia	-0.460*	-0.421*	-0.387
	(0.242)	(0.245)	(0.277)
Central and Eastern Europe	0.478***	-1.535***	0.397*
	(0.181)	(0.364)	(0.233)
Relative impact home country publications		-3.541***	
		(0.555)	
Shanghai ranking indicator			-0.177
			(0.324)
Constant	0.148	4.032***	0.244
	(0.502)	(0.790)	(0.531)
Observations	1,576	1,576	1,576

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Across different specifications we observe that students who obtained their degree 20 to 29 years ago are less likely to have studied abroad, although the coefficient is only significantly different from zero at the 10% level. This is in line with the observations that international PhD degree mobility is on the rise over time. Replacing the cohort dummies by a time trend variable results in a similar finding: PhD holders who have graduated in more recent years, are more likely to have studied abroad. Students in the life sciences are significantly less likely to study abroad, as we already observed in the descriptive section. One possible explanation is that life sciences may include a large group of medical doctors, for which mobility is more common as a postdoc than as a PhD student. In line with the descriptive statistics, there is no significant gender dimension in outward PhD mobility. The older a researcher was when she obtained her degree, the less likely she is to have studied abroad. This can have two interpretations: either that researchers who pursue a degree in the home country take longer to complete their degree on average, assuming that they start at the same age as researchers who complete their degree abroad, or that researchers who pursue a PhD at home start the program at a later age, on average, than researchers who go abroad, assuming that both groups take the same average time to complete the degree. The latter interpretation is compatible with the human capital view of higher education, which predicts that younger people are more likely to make human capital investments because they have a longer life span left over which to enjoy the benefits of the investment. Assuming that pursuing a PhD abroad is an investment with a higher upfront cost than pursuing a PhD at home, then it could be the case that for older students the discounted net benefits for a PhD abroad are negative while the discounted net benefits of a PhD at home are positive, even if the benefits of a PhD abroad are higher than the benefits of a PhD at home.

When the birth region dummies are included on their own (column 1), Scandinavians appear less likely to go abroad – arguably because they can obtain high quality education in their home country. The opposite can be argued for the positive and significant coefficient for Central and Eastern Europe: a lack of sufficiently high quality education at home may drive these students to seek higher education abroad. To test this more explicitly, we include the quality of the birth country's research. The results confirm that students from countries that score well on the relative impact indicator are also less likely to seek higher education abroad (column 2). Also, once the quality of the home country's research is accounted for, the dummy for Central and Eastern Europe becomes negative and significant, i.e. students from these countries are less likely to seek higher education abroad, once their science and

innovation quality has been accounted for. The result for the Shanghai ranking indicator is similar, although the coefficient is not significantly different from zero (column 3). This is arguably because the Shanghai indicator is more skewed towards excellence and fails to capture heterogeneity in the tail.

2.4.5 Multinomial logit results for the destination of PhD degree mobility: North America versus Europe

In Table 2.7, we split 'getting a degree abroad' into 'getting a degree elsewhere in Europe (EU1)' and getting a degree in North America (NA)', and thus use a multinomial logit instead of a simple logit model with three outcomes: a PhD degree in the birth country (the base outcome), a PhD degree in another European country (EU1) and a PhD degree in North America (NA).

The age at time of degree is negative in all regressions, but in most models only significantly different from zero in the intra-EU equations. This suggests that either time to degree is shorter for students who are mobile within the EU, or that students who pursue a degree at a later age are less likely to be EU-mobile.

We now observe more distinct patterns in the cohort dummies: all cohorts save for the most recent one are less likely to study elsewhere in Europe. This indicates that the most recent cohort (the base group) is more likely to study elsewhere in Europe compared to older cohorts, which suggests that the attractiveness of the European Research Area for PhD degree mobility is increasing. Conversely, the cohort that graduated between 10 and 20 years ago is more likely to have studied in North America; this probably reflects the rapid rise of foreign students in the United States in the 1990s and perhaps also the dip in foreign student admissions immediately after 9/11 for the following cohort. The events of 9/11 and the subsequent tightening of visa policies for foreign students could offer an alternative explanation for the rise of intra-EU PhD mobility in the youngest cohort, with students who might have preferred to pursue a PhD in the United States but did not get a suitable position or a student visa applying in Europe instead. These results are confirmed when the cohort dummies are replaced by the time since degree (in years): the longer ago the researcher graduated, the lower the likelihood of having obtained a degree elsewhere in Europe. Researchers who graduated more recently are significantly more likely to have obtained their

degree in another European country (see appendix table A.2.2). Students in the social sciences are more likely to go to North America, whereas students in the life sciences are less likely to study abroad, no matter the destination.

Table 2.7: Multinomial logit for degree country (base outcome: degree at home)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Intra-EU	NA	Intra-EU	NA	Intra-EU	NA
1 if male	-0.0512	0.128	-0.00227	0.151	-0.0187	0.114
	(0.175)	(0.169)	(0.178)	(0.170)	(0.176)	(0.169)
Age at degree	-0.0371**	-0.0251	-0.0439**	-0.0285*	-0.0376**	-0.0245
	(0.0187)	(0.0166)	(0.0185)	(0.0166)	(0.0185)	(0.0168)
Cohort 10-19	-0.346*	0.490***	-0.358*	0.477***	-0.355*	0.500***
	(0.186)	(0.166)	(0.189)	(0.167)	(0.186)	(0.166)
Cohort 20-29	-0.644**	-0.103	-0.699**	-0.133	-0.637**	-0.106
	(0.283)	(0.252)	(0.287)	(0.253)	(0.284)	(0.253)
Cohort 30-49	-0.686**	-0.0837	-0.680**	-0.0918	-0.691**	-0.0758
	(0.333)	(0.282)	(0.335)	(0.283)	(0.333)	(0.282)
Exact Sciences	-0.503*	-0.260	-0.668**	-0.361	-0.555*	-0.223
	(0.288)	(0.289)	(0.294)	(0.291)	(0.289)	(0.291)
Life Sciences	-1.005**	-0.961**	-1.041**	-0.994**	-1.032**	-0.940**
	(0.411)	(0.423)	(0.416)	(0.425)	(0.412)	(0.424)
Social Sciences	0.0120	0.649**	-0.111	0.570**	-0.0270	0.683**
	(0.296)	(0.289)	(0.302)	(0.291)	(0.297)	(0.290)
Mediterranean	-0.0561	-0.173	-1.066***	-0.744***	-0.536**	0.0290
	(0.193)	(0.179)	(0.260)	(0.236)	(0.258)	(0.232)
Anglo-Saxon Europe	-0.651*	-0.0291	-0.611	-0.0178	-0.272	-0.146
	(0.381)	(0.272)	(0.383)	(0.273)	(0.410)	(0.284)
Scandinavia	-0.479	-0.457	-0.415	-0.431	0.106	-0.682**
	(0.351)	(0.303)	(0.354)	(0.304)	(0.413)	(0.343)
Central and Eastern Europe	0.633***	0.329	-1.955***	-1.168**	0.0113	0.581**
	(0.233)	(0.231)	(0.483)	(0.459)	(0.324)	(0.295)
Relative impact home country publications			-4.537***	-2.644***		
			(0.735)	(0.699)		
Shanghai ranking indicator					-1.471***	0.524
					(0.567)	(0.372)
Constant	-0.0214	-1.014	4.950***	1.903*	0.672	-1.323*
	(0.689)	(0.636)	(1.056)	(0.992)	(0.727)	(0.679)
Observations	1,576	1,576	1,576	1,576	1,576	1,576

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

In all models, the academic birth country quality indicators have larger negative coefficients for studying in Europe than for studying in North America. The Shanghai ranking indicator is negative and significant for intra-EU mobility, but remains non-significant for mobility to North America. Wald tests confirm that the coefficients are significantly different for the relative impact indicator (at the 5% level) and the Shanghai ranking indicator (at the 1% level). This suggests that degree mobility within Europe is more attractive for students from countries with a weaker academic environment than mobility to North America. These results also suggest that graduate student mobility in Europe is driven to a larger extent by push

factors, i.e. by lack of opportunities in the home country, than mobility to North America, although more analyses with different data sources are needed to confirm this assertion.

2.5 CONCLUSION

Student mobility remains an important item on European policy makers' agendas, which contains both issues of increasing student mobility within Europe as well as worries about a 'brain drain' of talented graduate students to North America. Therefore it is important to deepen our understanding of the factors that underpin student mobility flows. In this paper, we address the decision of a sample of European researchers to pursue the doctoral degree at home, in another European country or in North America, using data from the MORE survey, which targets EU-U.S. mobile researchers.

The data suggest that intra-EU PhD mobility is on the rise in recent years, suggesting that the efforts to harmonize Europe's higher education and research systems may be starting to produce their intended benefits. The recent rise in intra-EU PhD mobility could also be attributed to the tightened conditions in the last decade for foreign students to pursue a PhD in the United States, however.

We find that European students from countries with a weaker research and innovation system are more likely to seek their doctoral degree abroad, particularly within Europe. Graduate student mobility within Europe appears more driven by push factors in the home country, i.e. a lack of opportunities for researchers. This observation provides a hopeful signal that the European Higher Education and Research Area could indeed be an effective tool for catching-up strategies of economically weaker regions in Europe by stimulating the mobility of PhD students from catching-up countries to other EU countries, all the while keeping scientific talent within Europe instead of losing it to the brain drain of talented researchers to North America.

A serious limitation to this analysis is that the MORE survey is not representative for the underlying population of European-born PhD holders. Since the survey explicitly targeted researchers with (post-PhD) EU-U.S. mobility experience, the sample is biased towards researchers who become internationally mobile, in particular to the U.S. Since no comprehensive database on European-born PhD students is available as of yet, it is not

possible to weigh our sample to correct for these biases. All results must therefore be interpreted with caution.

To fully evaluate the effectiveness of stimulating student mobility for catching-up, we need to look beyond the outward mobility of PhD students to assess their post-PhD degree mobility: are these students returning to their home country? If not, do they contribute to science and innovation in the home country by staying connected through collaborations or research visits? In the near future, more comprehensive data collection on PhD recipients around the world and further analysis is needed to deepen our understanding of these issues.

2.6 APPENDIX

Table A.2.1: Variables and definitions

variable	Definition	source
PhD mobility	If the PhD is obtained in a country different from the birth country. Values: • EU0: PhD obtained in the birth country (in Europe) • EU1: PhD obtained in another European country • NA: PhD obtained in North America	MORE
Degree field	The scientific discipline in which the PhD was obtained. Values: • Natural sciences • Engineering and technology • Medical and health sciences • Agricultural sciences • Social sciences • humanities	MORE
Gender	Male or female.	MORE
Age	Is deducted from the year of birth, at the time of the survey.	MORE
Marital status	Marital status at the time of the survey. Values: • Married or cohabiting • Single/widowed/divorced	MORE
Cohort	Based on the number of years passed since the highest degree was obtained, grouped together in 10-year cohorts for the most recent 3 decades, and into a 20-year cohort for researchers who obtained their PhD more than 30 years ago (due to the low number of observations).	MORE
Birth region	Region in which the researcher was born. Values: • Western Europe (base region): Austria, Belgium, France, Germany, the Netherlands, Luxembourg, Switzerland • Scandinavia: Denmark, Norway, Sweden, Finland • Central and Eastern Europe: Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, Turkey • Mediterranean: Portugal, Spain, Italy, Greece • Anglo-Saxon Europe: the United Kingdom, Ireland	MORE
Degree region	Region in which the PhD degree was obtained. Values: • North America: the United States, Canada • Western Europe (base region): Austria, Belgium, France, Germany, the Netherlands, Luxembourg, Switzerland • Scandinavia: Denmark, Norway, Sweden, Finland • Central and Eastern Europe: Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, Turkey • Mediterranean: Portugal, Spain, Italy, Greece • Anglo-Saxon Europe: the United Kingdom, Ireland	MORE

Relative impact of home country publications	Measures whether a country's research attracts on average more or less citations than the average world publication, giving an indication of the visibility and quality of a country's research. Measured as the share of a country's citations in total world citations in 2003, over the share of a country's publications in total world publications in 1999, 2000 and 2001.	National Science Foundation's Science and Engineering Indicators 2004
Shanghai Ranking Indicator	Measures the 'density' of top universities in a country. Constructed as the weighted sum of the universities a country has in the top 500 of the Shanghai ranking, with higher ranked universities receiving a larger weight, divided by the country's population to control for size. Variations used for robustness checks: • Indicator constructed with the top 200 of the Shanghai ranking instead of the top 500. • Simple counts of universities in the top 500/top 200	www.arwu.org for the Shanghai ranking, Aghion et al. (2007) for the construction of the indicator

Table A.2.2: Multinomial logit model with time since degree instead of cohort dummies

VARIABLES	(1) Intra-EU	(2) NA	(3) Intra-EU	(4) NA	(5) Intra-EU	(6) NA	(7) Intra-EU	(8) NA
1 if male	-0.0440	0.155	0.00155	0.180	-0.0116	0.142	-0.00436	0.145
	(0.175)	(0.169)	(0.178)	(0.170)	(0.176)	(0.169)	(0.178)	(0.171)
Age at degree	-0.0392**	-0.0220	-0.0455**	-0.0259	-0.0396**	-0.0214	-0.0459**	-0.0268
	(0.0187)	(0.0164)	(0.0186)	(0.0163)	(0.0186)	(0.0165)	(0.0186)	(0.0165)
Years since graduation	-0.0290***	-0.00383	-0.0294***	-0.00433	-0.0289***	-0.00370	-0.0295***	-0.00438
	(0.00924)	(0.00758)	(0.00936)	(0.00763)	(0.00923)	(0.00759)	(0.00937)	(0.00770)
Exact Sciences	-0.500*	-0.274	-0.658**	-0.372	-0.554*	-0.243	-0.654**	-0.332
	(0.288)	(0.287)	(0.294)	(0.289)	(0.289)	(0.288)	(0.294)	(0.292)
Life Sciences	-1.009**	-0.943**	-1.046**	-0.978**	-1.040**	-0.927**	-1.040**	-0.928**
	(0.411)	(0.421)	(0.416)	(0.423)	(0.412)	(0.422)	(0.417)	(0.425)
Social Sciences	0.0199	0.624**	-0.0979	0.549*	-0.0213	0.650**	-0.0926	0.587**
	(0.295)	(0.287)	(0.301)	(0.289)	(0.297)	(0.288)	(0.301)	(0.291)
Mediterranean	-0.0659	-0.169	-1.066***	-0.745***	-0.540**	0.0135	-1.013***	-0.445*
	(0.193)	(0.178)	(0.260)	(0.235)	(0.257)	(0.231)	(0.279)	(0.252)
Anglo-Saxon Europe	-0.623	-0.0634	-0.591	-0.0529	-0.254	-0.170	-0.695*	-0.586**
	(0.381)	(0.271)	(0.383)	(0.272)	(0.409)	(0.283)	(0.416)	(0.293)
Scandinavia	-0.471	-0.471	-0.413	-0.449	0.113	-0.673**	-0.584	-1.479***
	(0.351)	(0.301)	(0.354)	(0.302)	(0.413)	(0.341)	(0.454)	(0.392)
Central and Eastern Europe	0.633***	0.311	-1.935***	-1.190***	0.0181	0.538*	-2.027***	-1.456***
	(0.234)	(0.231)	(0.482)	(0.456)	(0.324)	(0.294)	(0.485)	(0.459)
Relative impact home country publications			-4.501***	-2.655***			-5.025***	-4.878***
			(0.734)	(0.693)			(0.863)	(0.837)
Shanghai ranking indicator					-1.457**	0.471	0.431	2.219***
					(0.566)	(0.370)	(0.643)	(0.485)
Constant	0.148	-0.899	5.062***	2.036**	0.829	-1.175*	5.406***	3.280***
	(0.700)	(0.636)	(1.060)	(0.988)	(0.737)	(0.678)	(1.084)	(1.023)
Observations	1,576	1,576	1,576	1,576	1,576	1,576	1,576	1,576

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

CHAPTER 3

AN ELITE BRAIN DRAIN: ARE FOREIGN TOP PHDS MORE LIKELY TO STAY IN THE U.S.?

ABSTRACT[35]

Many world regions, including Europe, have the perception that their best students and researchers leave to study and work in the United States. This phenomenon has been coined 'the elite brain drain'. With a sample of European students who obtain a PhD in economics in the U.S., we study whether the most promising among them are indeed less likely to return. We find that PhD recipients from top institutions, or with a highly cited advisor, or a pre-PhD publication or a higher impact factor on their first publication are more likely to stay in the U.S. or Canada, but only at a top institution. This suggests that the quality of the working environment is of crucial importance to top researchers, and that the attraction of the U.S. consists at least in some part in its many top economics departments. In short: the best students go to the best institutions for their first job, and the majority of these are located in the United States. The location choice made for the first job strongly predicts the location of the current job. Once a top researcher has made the decision to stay, particularly at a top institution, later return is not very likely. This suggest that from the European perspective, there is indeed an 'elite brain drain', with two facets: some of the most talented students stay in the U.S., attracted by its top institutions, and those who stay initially, once embedded in the North American research system, are not very likely to return.

[35] This chapter is joint work with Reinhilde Veugelers. It has benefited from the comments of Henry Sauermann, Paula Stephan, Dirk Czarnitzki, Otto Toivanen, Frank Verboven and Stijn Kelchtermans, as well as the participants of the EARIE Conference (Istanbul, September 2010) and the seminar series of the College of Management at Georgia Institution of Technology (April 2011).

3.1 INTRODUCTION

As more and more countries convert into knowledge-based economies, the competition for scientific talent has become fiercer. The United States has traditionally been very successful at attracting foreign students and researchers. In 2008, the U.S. hosted 18.7% of all foreign students in the OECD, making it the single largest destination country. Moreover, there are indications that the U.S. not only attracts a large number of students and researchers, but specifically the best and brightest among them, a phenomenon that has been coined 'the elite brain drain' (Hunter et al., 2009; Maier et al., 2007; Laudel, 2003; Laudel, 2005). Furthermore, with high stay rates upon graduation, these foreign talents contribute substantially to the buildup of the U.S. science and innovation system. When surveyed by the National Science Foundation on their intentions to return home upon graduation, a large majority of foreign PhD recipients in the U.S., on average around 70%, indicate that they intend to stay in the U.S. (National Science Foundation, 2010). This high stay rate is confirmed by the actual stay rates computed by Finn (2010). Less is known about the quality level of the staying PhDs, however.

Naturally, from the perspective of many sending countries, there is a fear of a substantial loss of human capital to the U.S. Whether this is indeed the case, depends to a large extent on whether the best foreign students who received their PhD in the U.S. stay connected to their home country and eventually return. More information is needed about the return rates at later stages of foreign PhD recipients' research career, and which types of students are more or less likely to return.

In this paper, we study whether it is the case that 'top' foreign PhD recipients are less likely to return home upon graduation, or later during their research career. Using a unique dataset with information on the careers of 375 European students who obtain a PhD in economics in the United States, we study whether PhD holders with certain quality characteristics, such as having a PhD from a top institution, working with a highly cited advisor or obtaining an ISI publication prior to finishing the PhD are more likely to stay in the U.S. for their first job and later jobs. We find that the labor market allocation process, where good students are more likely to obtain a job at a top institution, plays a crucial role: we observe that the best PhD recipients are most likely to work in the U.S. *at a top institution* for their first job, but are also willing to return to Europe if they can work at a top European institution. Top PhD holders

therefore do not seem necessarily more likely to stay in the U.S. for their first job unless they can work at a top institution. The prestige of the employing institution appears to play a more important role than its location, suggesting that the many top institutions in economics are among the most important attractive factors of the U.S. for PhD holders in this field. The initial location decision does matter, however, for later jobs: Europeans who initially stayed in the U.S., be it at a top institution or not, are more likely to still be working in the U.S. for their current job. However, those who initially stay to work at a top institution are even less likely to return compared to those who stay at a non-top institution, suggesting that there is indeed an 'elite brain drain' from Europe to the United States.

3.2 CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

Several authors document and analyze the stay rates of foreign PhD students in the U.S. The U.S benefits from the presence of foreign PhD students and researchers (Chellaraj et al., 2005; Stephan and Levin, 2001), but has also become increasingly dependent on the inflow of foreign students and postdocs to fuel the expansion of research in certain fields (Black and Stephan, 2007), notably in the life sciences (Stephan, 2010). Therefore there is a lot of interest to know how many foreign students intend to stay, and what factors affect these stay rates. The National Science Foundation, in its Survey of Earned Doctorates, asks PhD recipients with temporary visas whether they have firm plans after their PhD, and whether they intend to stay in the U.S. In the period 2003-2009, 70.9% indicated an intention to stay. This stay rate varies strongly by country of origin: students from East and South Asia have a stay rate of 76.9%, compared to a stay rate of 68% for Europe and 54.6% for North and South America (NSF, 2011). Finn (2010) computes the stay rates of foreign PhD recipients using tax records, and finds a similar stay rate as the NSF: the one-year stay rate of PhD recipients from 2006 was 73%. There is also substantial variation by nationality: 94% of Chinese students are still in the U.S. one year after graduation, compared to 61% of European students. Stay rates also vary strongly by discipline, with 78% of physicists and computer engineers staying in the first year after their PhD, but only 57% of agricultural scientists and 45% of economists.

Besides variation in stay rates across disciplines and nationalities, an important consideration is whether those who stay are among the most talented, or vice versa. Borjas and Bratsberg (1996) develop a model where the skill selection of migrants is based on the relative rewards

to skills in the source country versus the destination country, and the initial skill sorting is intensified by return migration. If the skill premium is higher in the destination country relative to the source country, then migrants with higher skills are more likely to migrate to benefit from the higher rate of return to skills in the destination country, and vice versa. Moreover, if migrants earn a wage premium upon return for the experience they have acquired abroad, then for the least skilled among the highly skilled the return wage premium may outweigh the skill premium earned in the destination country, making it optimal to spend a minimum amount of time working in the destination country, and then return to the home country to earn the return premium. Therefore the initial selection process is intensified by return migration, as only the most skilled among the highly skilled migrants remain. As argued in the first chapter, this model can be applied to PhD recipients, if monetary returns are complemented with such immaterial returns as access to resources for puzzle solving and recognition in the scientific community.

Several empirical studies address the relationship between foreign students' ability and their probability to return. Gaulé (2010) studies the return patterns of foreign chemistry faculty in the U.S. and finds that the 20% most productive professors are significantly less likely to return. Similarly, Black and Stephan (2007) find that PhD recipients from top 10 programs in their field are more likely to indicate an intention to stay for their first job. Kahn and MacGarvie (2008) estimate the effect of return on foreign students' scientific productivity. Their prior is one of a negative selection of returnees: PhD recipients with less research talent may have a harder time obtaining a job in the U.S. and may be more likely to return – and subsequently publish less not because they returned, but because they were less talented in the first place. To account for this unobserved heterogeneity, Kahn and MacGarvie instrument the return decision with grant and visa information, and match foreign PhD recipients with a particular grant tied to a J-1 visa - which forces students to return for at least two years upon completion of their program irrespective of their quality – to similar students without such grants. They find that return is indeed associated with a negative impact on scientific productivity, but only if students return to poorer countries. All these studies suggest that the most talented researchers are more likely to stay in the U.S.

Why would better students be more likely to stay in the United States? Generally, professional considerations are found to be the major motive why students stay, while personal and societal considerations encourage them to return home (Alberts and Hazen,

2005; MORE, 2010). These findings provide a first indication why students who stay may be better than students who return, as they are on average more motivated by professional considerations relative to personal ones.

It is no surprise that professional considerations motivate foreign PhD recipients to stay in the United States. The United States is perceived to have a better overall working environment for researchers in terms of salaries, funding opportunities, teaching load, access to talented students, researchers and research infrastructure and the like (MORE, 2010). This high quality environment is particularly present at the top institutions in the United States, where the most prominent researchers tend to cluster. Although Europe also hosts a few prominent universities and research institutions, the large majority of top institutions are located in the United States, as illustrated by the dominance of U.S. institutions at the top of university rankings. If the best PhD graduates have stronger preferences with regard to the quality of their working environment, then they should be more motivated to stay, despite the costs of immigration status adjustment, job search, and the psychic costs of continued separation from family and friends at home. This holds particularly if they can secure a place at one of the top institutions.

Not all PhD recipients have access to these top institutions, however. In previous U.S. studies, the prestige of the PhD granting institution is found to have a strong and persistent effect on the prestige of first and later jobs (Allison and Long, 1987, Burris, 2004; Smeets et al., 2006). We therefore expect that European PhD holders with a PhD from a prestigious U.S. institution are more likely to receive an offer from a top U.S. academic institution compared to Europeans who graduate from less prestigious U.S. universities. The choice set of top students is likely to differ from that of non-top students, with a higher probability that for the former group it contains attractive options such as staying at a top U.S. university. In other words, PhD holders who can send a 'favorable signal' to the market about their ability, in the form of a degree from a top institution, are more likely to have a choice in their location decision, whereas PhD holders without such a signal may be more likely to be 'forced' to return if they receive no offer from a U.S. institution at all. PhD programs from prestigious institutions tend to be large, though, and within prestigious universities there may still be considerable heterogeneity in the quality of PhD recipients (Smeets et al., 2006). Other quality signals, such as having a good advisor or a publication in a good journal, may prove more important for PhD holders' job market outcome.

The theoretical approach of return at a later stage in the career is less clear cut. The neoclassical approach regards migration as a risky investment, and hence return migration as a situation where the investment did not have the expected payoff. This might be the situation of a European PhD recipient who does not get tenure, and is forced to return to the job market. By contrast, the new economics of labor migration regards migration as a project where migrants set out to achieve a certain goal, like obtaining labor market experience abroad or accumulating a certain amount of savings, and return home once the goal is reached. If a few years of post-PhD work experience in the United States, be it as a postdoc or an assistant professor, increase PhD holders' returns at home, then for a group of PhD holders of moderate ability the optimal mobility strategy might be to work in the U.S. for a few years, and then return home to receive a 'prestige premium' in Europe. By contrast, the longer the time spent working in the U.S., the more a researcher might become embedded in the U.S. research environment, using databases, techniques or equipment only available in the U.S. or specializing in U.S.-focused research topics. This increased 'embeddedness' might increase the costs of later return mobility, implying a lower likelihood of return the longer a researcher stays in the U.S.

Most empirical studies of foreign students' return rates address immediate return upon completion of the PhD. Tracking researchers afterwards is more difficult. Finn (2010) computes long-term stay rates using tax records linked to social security numbers of foreign students. He finds that stay rates only decrease slightly as time passes, and that the majority of students who return do so immediately after their PhD. Of those foreign students who received their PhD in 1997, 69% were still in the U.S. 2 years after graduation, whereas 10 years later, this stay rate has only decreased to slightly under 66%. Although Finn points out that there is a certain amount of 'churning', with some students who initially left returning to the U.S. and some who initially stayed leaving, the initial stay-or-return choice appears to be quite persistent into the future. This finding is corroborated by Gaulé (2010), who studies the return rates of foreign chemistry faculty in the U.S. He finds that only 9% of foreigners who held at least one faculty position in the U.S. eventually return during their professional career, indicating that once foreign PhD holders become embedded in U.S. academe, they are not very likely to return.

On the basis of the theoretical and empirical literature discussed above, we develop 4 hypotheses we want to test about the employment and location patterns of European

researchers who obtain a PhD in the United States. First, graduates with a PhD from a top university are more likely to remain in the U.S. compared to their peers with PhDs from lower ranked universities, because they are more likely to have a choice set that includes offers at U.S. institutions. Second, as there may still be considerable heterogeneity among graduates from top institutions, we expect that 'quality signals' at the individual level, such as the reputation of the advisor or the quality of the first publication, may be stronger signals to the labor market about a PhD holder's ability than having a PhD from a top institution. Third, top PhD holders may not want to stay anywhere in the U.S., but may only be more likely to remain in the U.S. insofar as they can work at a top institution. Top institutions provide the best environment to conduct research in terms of access to resources, talented colleagues and students, and opportunities for recognition in the scientific community. If researchers attach more importance to the prestige of their working environment than to its geographic location, then top researchers may not be more likely to stay in the U.S. per se, but employment at a top institution may be a crucial condition to stay in the U.S. Likewise, top PhDs may also be more likely to return to Europe if they can work at top institution there, although the U.S. to date remains dominant at the very top of most rankings. To our knowledge, no empirical study on the selection of returning PhD recipients has taken into account the quality of the exact institution where researchers take their first job and later jobs. Finally, assuming that researchers become increasingly embedded in their research environment, we hypothesize that location choices are persistent: return occurs mostly immediately after the PhD, and researchers who initially stay are unlikely to return later in their professional career. However, in line with the new economics of labor migration, we also expect some researchers to return after obtaining a few years of working experience in the U.S.

3.3 DATA

This chapter uses the ProQuest dataset, with information on the careers of 375 European researchers with a PhD in economics from the U.S. or Canada[36]. Although the analysis of researchers in a single discipline does not allow us to generalize our results to the entire population of academic researchers, it eliminates heterogeneity due to discipline specific characteristics such as different academic labor market characteristics or metrics for assessing research quality.

[36] Please refer to the third section of the first chapter for a detailed description of the data collection and sampling methodology.

As we want to make a distinction between graduates from 'top' and 'non top' universities, and jobs at 'top' and 'non top' institutions, we need to define what universities are considered 'top'. We compile a list of 'top institutions' using three rankings of economics departments: Tom Coupé's ranking based on the productivity of the 20 most prolific scholars in a department (Coupé, 2003), the National Research Council's 2010 regression-based ranking of economics PhD programs, and the 2010 REPEC ranking of economics departments. We define an institution as top if it features in the top 50 of all three rankings, which results in a list of 32 top institutions. Alternatively, we define a more narrow subgroup of 'supertop' institutions, which are included in the top 15 of all three rankings; this list contains 11 institutions. For Europe, which compared to the U.S. has fewer top institutions, we define a somewhat broader set of top institutions: an institution is considered as top if it is included in the top 100 of the REPEC ranking and the Coupé ranking (the NRC does not rank foreign universities). To summarize, we define 3 tiers of universities, which we call supertop (top 15 of 3 rankings, 11 institutions), midtop (top 50 of 3 rankings, 21 institutions) and subtop (top 100 of 3 rankings, 23 institutions)[37]. The first two are included in the definition of top institutions for the U.S., the latter two are included in the definition of top institutions for Europe[38].

The prestige of a job candidate's doctoral institution may not be the only relevant signal of her ability. Top institutions often have large doctoral programs, and there may still be considerable heterogeneity among PhD recipients from those institutions. Therefore we also look at a set of other measures that may signal a young researcher's ability on the job market: having a highly cited advisor, having an advisor that co-authors on a publication at least once during the researcher's career, whether the PhD holder has any ISI publications before graduation, and the impact factor of the first publication. A PhD recipient's advisor may play an important role in a PhD holder's job search by introducing the doctoral student to the right networks and through a 'second-hand reputation effect'. However, highly reputed advisors may have a large number of PhD students, and devote relatively little time and effort to each. Therefore we also use an alternative advisor indicator, whether the advisor ever co-authored a publication with the student. We interpret co-authoring (during the PhD, or after) as a signal

[37] The list of subtop, midtop and supertop institutions does not vary over time, as few sources provide historical rankings. However, the composition of the top of most rankings is quite stable over time (Burris, 2004).
[38] A list of definitions can be found in appendix A, as well as an overview of the universities included in each tier.

of strong involvement of the advisor with the student's research. Co-authoring with the advisor may also help a student to obtain a publication before graduating, which may be a strong signal of research ability to the academic labor market[39]. Similarly, having a publication in a good journal before graduation is an important asset for job candidates as the importance of research performance for hiring decisions and promotions increases. A caveat for this last measure is that only 55 researchers in the sample obtain their first publication before their PhD, so for those whose first publication is published afterwards the quality of the journal may be influenced by the prestige of the first job.

Finally, in the econometric models we control for a number of factors that may also affect European students' probability to return. First, we include a measure of the quality of the research environment in a student's home country. This indicator is computed as the weighted sum of economics departments in the top 10% of the REPEC ranking divided by the home country's population to account for size. The resulting measure captures the 'density' of high quality economics departments where a researcher might consider working in the home country. The indicator is normalized so that the U.S. has a score of 1. Arguably, researchers from countries with a higher density of high quality economics departments have more suitable employment opportunities at home and are therefore more likely to return. A drawback of this measure is that it is computed at one point in time, using the 2010 REPEC ranking. As REPEC does not provide historical rankings, it is not possible to compute a measure for each year considered in our sample. Although quality at the top is known to be very persistent, there may be considerable change in the lower parts of the ranking over the years. Second, we control for a researcher's gender and age at the time he or she starts the first job, to control for possible heterogeneity along these personal characteristics. Gender and age may also be correlated with important variables such as marital status or children, which we are unable to control for directly (see infra). Third, three dummy variables indicate whether a researcher received a fellowship or a grant, and from what source: the PhD granting institution (host institution), another U.S. institution such as, for example, the Sloan foundation (other U.S. institution) or the home country. Certain types of funding may be tied to a contractual obligation to return to the home country, or students who were financed by the home country may simply feel an obligation to return and contribute to their home country's economy. Grant selection may also entail a quality selection, if the best students are

[39] Most job market papers are traditionally single authored. However, we can assume that an advisor only wants to actively co-author with the best students, so co-authoring could still be a signal of quality.

selected for a scholarship. In this case, the grant variable may correlate with the student quality characteristics included in the analysis. Fourth, we control for the region of origin within Europe. We divide the home countries in our sample into 6 regions, i.e. Western Europe (the base region), Central Europe (including the countries that joined the EU in 2004 and 2007), Eastern Europe, Scandinavia, the Mediterranean countries and the Anglo-Saxon countries (Ireland and the UK). We include separate dummies for Turkey and Israel as well. These home region dummies should capture differences in academic culture, standards of living, and other geographic factors that influence researchers' location preference.

Finally, cohort dummies are included to capture any time-varying trends that influence European PhDs' stay rates, such as the state of the labor market, or political events or policy changes that affect PhD recipients. A few key trends for the economics labor market were outlined in the first chapter. In particular, the first half of the nineties was characterized by a loose labor market with more PhDs forced to take a post-doc instead of a tenure-track position, and fewer PhD recipients with firm plans upon graduation. Due to these bleak labor market conditions, enrolments in PhD programs declined markedly between 1992-1996. Due to the decreased inflow of PhDs and strong economic growth in the United States, employment conditions improved markedly in the second half of the nineties. Then the terrorist attacks of 9/11 happened in 2001, leading to a political and policy climate that arguably made staying in the United States more difficult or less attractive for European students. In light of these evolutions on the labor market for economists, we define 3 5-year cohort dummies for the cohorts 1992-1996, 1997-2001 and 2001-2006. The most recent cohort is the control group.

Ideally, we would also want to control for family characteristics, like whether the researcher is married or has children, which may affect the location decision as well. However, very few researchers indicate their marital status and/or children on their CV, and those who do all indicate that they are married and/or have children. We could assume that all researchers who do not mention marital status and children on their CV are single and childless. Using these definitions and including these two variables into the analyses does not change our main findings, and neither were they significant themselves. As the quality of these variables is questionable, we omit them from further analyses.

Table 3.1: Summary statistics of the explanatory variables

Variable	type	mean
Top PhD institution	0/1	0.66
Supertop PhD institution	0/1	0.48
Highly cited advisor	0/1	0.29
Co-authoring advisor	0/1	0.25
Pre-PhD publication	0/1	0.15
Impact factor first publication	continuous	0.97
Age at first job	continuous	29.44
Female	0/1	0.20
Top economics departments pc	continuous	0.29
Funding source: host	0/1	0.40
Funding source: other US institution	0/1	0.21
Funding source: home	0/1	0.22
Eastern Europe	0/1	0.06
Central Europe	0/1	0.07
Mediterranean	0/1	0.06
Scandinavia	0/1	0.06
Anglo-Saxon countries	0/1	0.04
Turkey	0/1	0.14
Israel	0/1	0.06
Cohort 1992-1996	0/1	0.29
Cohort 1997-2001	0/1	0.50
Cohort 2002-2006	0/1	0.21

Table 3.1 presents summary statistics for all explanatory variables. A sizable part of our sample obtains a PhD at a top institution in the U.S. or Canada (66%), the majority of which obtain their PhD at one of the 11 'supertop' institutions (48%). This is partly due to the skew in our sample towards researchers with at least one or more publications[40]. However, it also illustrates that top economics departments tend to have large PhD programs, and that Europeans tend to be overrepresented at top departments compared to foreign students from other continents (Bound et al, 2009). The other quality indicators are more 'exclusive': 29% have a highly cited advisor, 25% have an advisor that co-authors with them at least once in their career and 15% have at least one ISI publication before they graduate. The average impact factor of the first publication is 0.97, although there is substantial variation ranging from 0.05 to 4.41. The average researcher is 29 and a half years old when she takes up her first job after graduation, and 80% of PhD holders are male. Many receive fellowships or

[40] The descriptive statistics are not corrected for our stratified sampling, the regression analyses are.

grants from various sources: 40% are financially supported by their host institution, 21% by another U.S. institution and 22% by the home country. Italians are the most numerous in the sample, with 77 PhD holders, followed by Turkey with 53 and Germany with 37.

Table 3.2: First job location by home region and home country

Home region	Stay (%)	Home (%)	Third (%)	Total
Mediterranean countries	61.36	24.24	14.40	133
Western Europe	71.08	13.25	15.67	83
Turkey	73.58	22.64	3.78	53
Central Europe	84.62	7.69	7.69	25
Israel	82.61	8.70	8.69	23
Eastern Europe	90.48	4.76	4.76	21
Scandinavian countries	61.90	28.57	9.53	21
Anglo-Saxon Europe	75.00	25.00	0.00	16
Total	70.40	18.67	10.93	375

Home country	Stay (%)	Home (%)	Third (%)	Total
Italy	63.64	18.18	18.18	77
Turkey	73.58	22.64	3.78	53
Germany	72.97	16.22	10.81	37
Spain	52.94	41.18	5.88	34
Israel	82.61	8.70	8.69	23
France	68.42	15.79	15.79	19
Russia	86.67	6.67	6.66	15
Greece	73.33	13.33	13.34	15
UK	71.43	28.57	0.00	14
Denmark	80.00	10.00	10.00	10
Belgium	55.56	11.11	33.33	9
Hungary	62.50	12.50	25.00	8
Austria	71.43	14.29	14.28	7
Switzerland	85.71	0.00	14.29	7

Table 3.2 contains the number of researchers in our sample by home region (and the major home countries), and by location of their first job. Of the 375 Europeans in our sample, 264 stay in the U.S. for their first job (70.4%). The remaining 111 return to Europe (29.6%), of which 70 to their home country and 41 to another European country[41]. The latter group fans out over several countries: the UK is the most popular destination with 14 researchers, but

[41] A very small number of researchers leave the U.S. to go to third countries outside of Europe, notably 4 researchers to Australia, one to China and one to Mexico, but these are excluded from the sample.

Spain (6), Belgium (5), France (5), Germany (3), the Netherlands (3), Israel (2), Denmark (1), Ireland (1) and Turkey (1) receive non-native European PhD holders as well. There are substantial differences in location patterns between nationalities: for example, 83% of Israeli PhD holders stay in the U.S. or Canada, compared to only 53% of Spanish PhDs. However, as many nationalities are only represented by a few individuals, it is not possible to make any meaningful comparisons with this sample. Other sources, such as Finn (2010) and Black and Stephan (2007) are better suited to do this.

For foreign PhD recipients, the workings of the academic job market imply that return may not always be the result of the preferences of the student alone. Some students may receive job offers from various institutions, in the U.S. and at home, and choose their location according to their preferences. Other students, however, may not receive a job offer from what they perceive to be a suitable institution in the U.S. and are thus 'forced' to return home[42]. Unfortunately, in our data we do not observe the job offers PhD holders receive, nor do we observe the reasons why certain PhD holders return. We only observe the final outcome of a complex matching process in the academic labor market. Nevertheless, we can analyze the employment and mobility patterns of European students with a PhD from the U.S. to see if they support the existence of a quality selection in return mobility. We are particularly interested in how the quality of the PhD and the quality of the employing institution matter for PhD recipients' location immediately after the PhD and for the current job.

3.4 RESULTS

In the first subsection, we analyze the stay rates for the first job, linking them to our various indicators of PhD holders' ability and analyzing how the quality selection process that takes place in the academic labor market interacts with location decisions. In the second subsection, we address how initial location decisions affect researchers' current location.

3.4.1 First job

Is it the case that better researchers are more likely to stay? Before analyzing this question econometrically, we first present some descriptive statistics. Table 3.3 compares the stay

[42] It is also possible that a foreign student receives an offer from a U.S. institution but cannot get the appropriate work visa to stay in the U.S., and thus be forced to return because of immigration regulations.

rates and return rates of researchers with our various quality indicators. T-tests are done to check whether the stay rate of top students was significantly different from that of their peers. Those with a top or supertop PhD or with a highly cited advisor are not significantly more likely to stay for their first job. Having a co-authoring advisor is related to a significantly higher stay rate. However, co-authoring with one's advisor may be endogenous to staying: the probability of co-authoring after the PhD is probably higher for researchers who remain in the same country or area. If we only take into account advisors who co-authored on publications obtained before the PhD was completed, the difference becomes much less significant. This may also be due to the low number of observations: only 26 researchers co-author with their advisor on a publication that appears before they obtain their PhD[43]. Only 55 researchers obtain an ISI publication prior to their PhD, but those who do are significantly more likely to stay.

Table 3.3: Quality indicators by stay/return for the first job

First job	Return	Stay	Obs.
all	111	264	375
%	*29.6*	*70.4*	*100*
Top PhD	71	174	245
%	*28.98*	*71.02*	*100*
Supertop PhD	51	127	178
%	*28.65*	*71.35*	*100*
Highly cited advisor	28	81	109
%	*25.69*	*74.31*	*100*
Co-authoring advisor	19	77	96
%	*19.79*	*80.21***	*100*
Pre-PhD publications	8	47	55
%	*14.55*	*85.45****	*100*
Pre-PhD co-authoring advisor	2	24	26
%	*7.69*	*92.31**	*100*
Impact factor	0.85	1.06**	375

Table 3.4 presents the results of a series of logit regressions, with the a dummy that is one if the PhD recipients stays in the U.S. or Canada for the first job. The various quality indicators are included in the model successively, and the last model includes all quality indicators together to check whether significant coefficients in the individual models remain significant

[43] As the number of observations for pre-PhD co-authoring advisor is so small, we do not include it in the regression analyses, although it yields similar results as the other quality indicators below.

when the other quality characteristics are accounted for. Specifically, we are interested to check whether individual-level indicators are more significant than institutional-level indicators. The models confirm that a pre-PhD publication is associated with a higher probability to stay for the first job (column 5), even when all ability indicators are controlled for together (column 7)[44]. None of the other ability indicators are significant when other factors are controlled for. Having obtained a PhD in a top institution does not significantly affect the probability of return.

The funding source for the PhD plays a significant role in European PhD holders' return rates: researchers financed by the host institution are significantly more likely to stay for the first job. This may reflect a student quality effect[45] or a stronger link to the U.S. Researchers financed by the home country are significantly more likely to return, which may reflect the grant conditionality. Researchers from Eastern European countries are significantly more likely to stay in the U.S., perhaps indicating that these researchers have fewer job opportunities at home and are less inclined to move to another country within Europe. Finally, the earlier cohorts in our sample are less likely to stay for their first job, corroborating the observations of increasing stay rates by other authors[46] (Finn, 2010; Black and Stephan, 2007).

All in all, the evidence for the hypothesis that more talented European PhD students are more likely to stay in the U.S. is not overwhelming. Only a pre-PhD publication is significantly associated with an increased probability to stay for the first job. Admittedly, all of the used indicators are only imperfect proxies for researcher's ability.

[44] However, having a pre-PhD publication may not necessarily be an indication of quality: the impact factor of pre-PhD publications is significantly lower than the impact factor of the other publications in our sample, and interacting the pre-PhD publication dummy with the impact factor of the first publication makes this variable insignificant. Moreover, a pre-PhD publication is negatively correlated with the other quality indicators (see table A.3.2 in the appendix).

[45] However, dropping the funding variables from the regressions does not improve the significance of the quality indicators.

[46] Including a continuous degree year variable results in similar findings.

Table 3.4: Logit models for the probability to stay (first job)

VARIABLES	(1) Stay	(2) Stay	(3) Stay	(4) Stay	(5) Stay	(6) Stay	(7) Stay
PhD in a top institution	0.0825						0.0767
	(0.374)						(0.413)
PhD in supertop institution		-0.0149					-0.167
		(0.315)					(0.356)
Highly cited advisor			0.0617				-0.0629
			(0.249)				(0.260)
Co-authoring advisor				0.330			0.266
				(0.317)			(0.295)
Pre-PhD publication(s)					1.206**		1.450***
					(0.468)		(0.423)
Impact factor of first publication						0.316	0.427*
						(0.217)	(0.238)
Age at first job	-0.0543	-0.0571	-0.0561	-0.0549	-0.0763	-0.0417	-0.0630
	(0.0498)	(0.0492)	(0.0488)	(0.0485)	(0.0500)	(0.0488)	(0.0523)
Female	-0.203	-0.216	-0.208	-0.225	-0.224	-0.170	-0.209
	(0.204)	(0.208)	(0.205)	(0.193)	(0.221)	(0.205)	(0.215)
Top economics departments p/c relative to US	-0.229	-0.220	-0.217	-0.227	-0.422	-0.291	-0.579
	(0.494)	(0.492)	(0.501)	(0.477)	(0.521)	(0.501)	(0.515)
Funding source: host institution	0.608**	0.614**	0.609**	0.627**	0.716*	0.608*	0.767**
	(0.300)	(0.300)	(0.308)	(0.299)	(0.368)	(0.314)	(0.369)
Funding source: other US institution	0.486	0.501	0.494	0.490	0.526	0.474	0.495
	(0.398)	(0.392)	(0.413)	(0.402)	(0.409)	(0.404)	(0.409)
Funding source: home country	-1.418**	-1.408**	-1.408**	-1.412***	-1.495***	-1.430***	-1.543***
	(0.574)	(0.561)	(0.555)	(0.547)	(0.571)	(0.549)	(0.572)
Eastern Europe - non EU	0.694**	0.685**	0.707**	0.684**	0.742**	0.703**	0.770**
	(0.322)	(0.307)	(0.347)	(0.314)	(0.318)	(0.302)	(0.337)
Central Europe - EU	0.828	0.811	0.833	0.798	0.765	0.823	0.721
	(0.727)	(0.724)	(0.746)	(0.721)	(0.690)	(0.747)	(0.740)
Mediterranean countries	0.0792	0.0889	0.0933	0.0764	0.0560	0.0161	-0.0697
	(0.320)	(0.322)	(0.335)	(0.320)	(0.344)	(0.326)	(0.347)
Scandinavian countries	0.430	0.448	0.448	0.414	0.413	0.477	0.448
	(0.630)	(0.633)	(0.631)	(0.641)	(0.687)	(0.630)	(0.691)
Anglosaxon countries	0.615	0.606	0.628	0.522	0.577	0.711*	0.596
	(0.397)	(0.400)	(0.407)	(0.350)	(0.432)	(0.414)	(0.423)
Turkey	0.370	0.343	0.372	0.339	0.346	0.424	0.390
	(0.315)	(0.328)	(0.333)	(0.289)	(0.313)	(0.285)	(0.336)
Israel	0.291	0.291	0.304	0.291	0.314	0.229	0.226
	(0.360)	(0.361)	(0.357)	(0.343)	(0.380)	(0.355)	(0.346)
Cohort 1992-1996	-1.542***	-1.540***	-1.542***	-1.482***	-1.419***	-1.521***	-1.312***
	(0.311)	(0.321)	(0.314)	(0.312)	(0.307)	(0.285)	(0.267)
Cohort 1997-2001	-0.883***	-0.882***	-0.888***	-0.862***	-0.758***	-0.927***	-0.758***
	(0.222)	(0.229)	(0.226)	(0.220)	(0.218)	(0.205)	(0.215)
Constant	3.319**	3.451**	3.394**	3.294**	3.857***	2.753*	3.098*
	(1.501)	(1.449)	(1.426)	(1.404)	(1.413)	(1.423)	(1.589)
Observations	375	375	375	375	375	375	375

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 3.5: Logit models for the probability of a top first job

VARIABLES	(1) Top first job	(2) Top first job	(3) Top first job	(4) Top first job	(5) Top first job	(6) Top first job	(7) Top first job
PhD in a top institution	1.913***						1.213***
	(0.326)						(0.397)
PhD in supertop institution		1.670***					0.945***
		(0.234)					(0.272)
Highly cited advisor			0.596**				-0.0350
			(0.275)				(0.274)
Co-authoring advisor				-0.183			0.191
				(0.340)			(0.405)
Pre-PhD publication(s)					0.627		0.491
					(0.565)		(0.551)
Impact factor of first publication						0.586***	0.592***
						(0.108)	(0.126)
Age at first job	-0.119*	-0.134*	-0.152**	-0.173***	-0.181***	-0.138**	-0.0980
	(0.0664)	(0.0685)	(0.0641)	(0.0654)	(0.0598)	(0.0619)	(0.0654)
Female	-0.824**	-0.726**	-0.957***	-0.976***	-0.975***	-0.938***	-0.698**
	(0.338)	(0.296)	(0.293)	(0.307)	(0.297)	(0.303)	(0.308)
Top economics departments p/c relative to US	-0.0759	-0.119	-0.0413	-0.0658	-0.183	-0.219	-0.304
	(0.568)	(0.622)	(0.540)	(0.531)	(0.560)	(0.536)	(0.621)
Funding source: host institution	0.548**	0.470*	0.638**	0.673**	0.706**	0.680**	0.486
	(0.262)	(0.264)	(0.260)	(0.273)	(0.288)	(0.319)	(0.307)
Funding source: other US institution	0.292	0.323	0.461	0.576*	0.548*	0.531*	0.180
	(0.343)	(0.363)	(0.363)	(0.331)	(0.324)	(0.307)	(0.348)
Funding source: home country	-0.150	-0.137	0.0423	0.00887	0.00246	-0.0407	-0.218
	(0.311)	(0.346)	(0.306)	(0.294)	(0.302)	(0.312)	(0.367)
Eastern Europe - non EU	-0.565	-0.768	-0.583	-0.669	-0.635	-0.678	-0.494
	(0.499)	(0.491)	(0.439)	(0.441)	(0.435)	(0.455)	(0.479)
Central Europe - EU	0.491	0.309	0.235	0.116	0.0440	0.0954	0.464
	(0.777)	(0.710)	(0.714)	(0.742)	(0.770)	(0.706)	(0.730)
Mediterranean countries	-0.460	-0.370	-0.241	-0.262	-0.314	-0.481	-0.676
	(0.464)	(0.402)	(0.409)	(0.422)	(0.418)	(0.446)	(0.432)
Scandinavian countries	0.174	0.196	0.546	0.547	0.487	0.620	0.199
	(0.614)	(0.618)	(0.617)	(0.607)	(0.635)	(0.624)	(0.639)
Anglosaxon countries	0.296	0.514	0.377	0.231	0.110	0.359	0.543
	(0.343)	(0.416)	(0.398)	(0.406)	(0.391)	(0.434)	(0.361)
Turkey	-0.798	-0.845*	-0.936**	-1.118**	-1.182**	-1.035**	-0.702
	(0.502)	(0.452)	(0.424)	(0.474)	(0.475)	(0.494)	(0.465)
Israel	-0.121	-0.195	0.0368	-0.0857	-0.0297	-0.236	-0.237
	(0.376)	(0.439)	(0.384)	(0.387)	(0.391)	(0.386)	(0.389)
Cohort 1992-1996	0.533*	0.426	0.469*	0.428	0.628**	0.533*	0.730*
	(0.289)	(0.279)	(0.255)	(0.264)	(0.284)	(0.277)	(0.402)
Cohort 1997-2001	1.211***	1.093***	1.107***	1.124***	1.286***	1.068***	1.271***
	(0.371)	(0.371)	(0.342)	(0.339)	(0.401)	(0.337)	(0.439)
Constant	0.465	1.450	2.537	3.395	3.420*	1.851	-0.820
	(2.064)	(2.144)	(2.044)	(2.121)	(1.984)	(2.007)	(2.154)
Observations	375	375	375	375	375	375	375

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

In this stay/return analysis, we have so far disregarded at which specific institution a researcher works. However, a top PhD holder may attach more importance to the prestige and the quality of the specific institution where she works than to its geographic location. The hypothesis that top PhD holders are more likely to stay in the U.S. is based partly on the fact that the U.S. is home to the majority of the top institutions in economics, which form an attractive environment for talented researchers to work in. However, top institutions are very selective in their recruitment procedures, and will typically only recruit the best PhDs with a PhD from a top institution (Allison and Long, 1987; Burris, 2004; Smeets et al., 2006). Table 3.5 reports a series of logit regressions with as dependent variable a dummy variable that is one if the researcher's first job is at a supertop or midtop institution, regardless of location. The results show that our indicators measuring whether a PhD has been obtained at a top or supertop U.S. institution are positively and significantly related to the probability of working at a top institution for the first job. Other quality indicators show a similar positive effect, but for co-authoring advisor and pre-PhD publications this is not significant.

We therefore include the quality of the work environment into our analysis of stay rates, and make a distinction between staying at a top institution and staying at a non-top institution, versus returning to a top institution and returning to a non-top institution. Table 3.6 presents the quality indicators by location and prestige of the first job: 29.6% of the researchers in our sample stay in the U.S. at a top institution, whereas 40.8% stay in the U.S. at a non-top institution. Another 5.07% return to a top institution in the EU, compared to 24.53% who return to a non-top institution. Researchers with a top or a supertop PhD are significantly more likely to stay at a top institution and to return to a top institution, and significantly less likely to stay at a non-top institution, however. Those with a highly cited advisor are more likely to stay at a top institution and less likely to stay at a non-top institution, but not more likely to return to a top institution in Europe. Curiously, having a co-authoring advisor (be it during or after the PhD) is associated with a significantly higher probability of staying at a non-top institution. Having a pre-PhD publication is associated to a higher likelihood of staying at a top institution, and a lower probability of returning to a non-top institution in Europe. Finally, the impact factor of the first publication of those who stay at a top institution is significantly higher than that of their peers, while the reverse is true for those who work at a non-top institution in the U.S. or in Europe.

Table 3.6: Quality indicators by location and top/non-top first job

First job	Stay top	Stay non top	Return top	Return non top	Total
All	111	153	19	92	375
%	*29.60*	*40.80*	*5.07*	*24.53*	*100.00*
Top PhD	99	75	17	54	245
%	40.41***	30.61***	6.94**	22.04	*100.00*
Supertop PhD	83	44	13	38	178
%	*46.63****	*24.72****	*7.3**	*21.35*	*100.00*
Highly cited advisor	48	33	7	21	109
%	*44.04****	*30.28****	*6.42*	*19.27*	*100.00*
Co-authoring advisor	26	51	3	16	96
%	*27.08*	*53.13****	*3.13*	*16.67***	100.00
Pre-PhD publications	25	22	2	6	55
	*45.45****	*40*	*3.64*	*10.91***	*100.00*
Pre-PhD co-authoring advisor	8	16	0	2	26
	30.77	*61.54****	*0.00*	*7.69*	*100.00*
Impact factor	1.37***	0.84***	0.95	0.83**	375

note: t-tests comparing the probability of each outcome between researchers with and without that quality characteristic; t-test for impact factor test for significant difference between outcomes

To see how the different quality indicators are related to researchers' outcome in terms of the prestige and location of the first job, we run a series of multinomial logit[47] models with 4 possible outcomes: stay at a top institution, stay at a non-top institution, return to a top institution, and return to a non-top institution. The last option is the base outcome. The results are reported in tables 3.7 and 3.8. The coefficients have been transformed into relative risk ratios, and should therefore be interpreted as the factor increase in the likelihood of an outcome relative to the base outcome. The first model (table 3.7, columns 1a-1c) includes a dummy for a PhD from a top institution, whereas in the second model the top dummy is split into a dummy for a PhD at a supertop institution and a PhD at a midtop institution (table 3.7, columns 2a-2c). The following 4 models include each remaining quality indicator separately, whereas in the last model (table 3.8, columns 3a-3c) all quality indicators are included together to see which quality indicators remain significant when all other indicators are

[47] The multinomial logit model assumes that there is no correlation in the unobserved characteristics of each outcome. This is a strong assumption given that the first two outcomes share unobserved characteristics of the U.S., and the latter two outcomes share unobserved characteristics of Europe. The multinomial probit model does not make this assumption, but is computationally more difficult, and does not converge in the specification used here. Estimating more parsimonious multinomial probit models, either by limiting the number of explanatory variables or by collapsing the two EU outcomes into one outcome produces qualitatively similar results as the multinomial logit model. Moreover, in practice the multinomial logit model produces similarly accurate estimates as the multinomial probit model, even when the Independence of Irrelevant Alternatives assumption is violated (Dow and Endersby, 2003; Kropko, 2010).

accounted for, and specifically, whether the individual-level indicators are more relevant than the institutional-level indicators.

Having a top PhD or a supertop PhD (columns 1a-1c and columns 2a-2c) significantly increases the likelihood to stay at a top institution, but also to return to a top institution: researchers with a top PhD are 7 times more likely to stay at a top institution, and 5.7 times more likely to return to a European top institution compared to their peers without a top PhD, while the relative risk ratios are slightly higher for a supertop PhD. By contrast, in the second model, a PhD from a midtop institution is associated with a higher probability to stay at a top institution, but not to return to a top institution in Europe. The associated coefficients for a top or supertop PhD institution are not significantly different for staying at a top institution and returning to a top institution, suggesting that for top PhD holders, the prestige of the first job is more important than the location. However, a Wald test for combining these two outcomes rejects that these two categories should be combined, indicating that the location of a top institution is also a relevant aspect of the location choice of European researchers.

A highly cited advisor almost doubles the probability to stay at a top institution, but has no significant effect on return to a top institution. Having a co-authoring advisor has no significant effect on the likelihood of any of the options. A publication prior to the PhD significantly increases the likelihood of staying at a top institution almost sevenfold, but also increases the likelihood of staying at a non-top institution by a factor of 2.5. The associated coefficients are statistically different at the 10% level. This suggests that an early publication is a strong signal on the U.S. academic labor market, but less so in Europe. Finally, the impact factor of the first publication is also positively and significantly associated to a higher likelihood of staying at a top institution. Including all quality indicators together reveals that having a top PhD, an early publication and a high impact factor on the first publication are all significantly associated with a higher probability of staying at a top institution, whereas the other quality indicators lose significance when all quality indicators are controlled for. None of the quality indicators remain significant for return to a top institution. This suggests that the most promising students are indeed more likely to stay in the U.S., but only if employed at a top institution[48].

[48] These results are robust to variations in the definitions of top and non-top institutions.

The source of funding for the PhD clearly has an impact on the location of the first job, but less so on the prestige of the employing institution. Researchers who were funded by their host institution are more likely to stay, whereas researchers funded by their home country are more likely to return.

There are few consistent patterns in the home region dummies, but researchers from Anglo-Saxon origin are significantly more likely to stay in the U.S., perhaps due to cultural and linguistic similarities, as well as similarities in their higher education and research systems. However, in some of the models, researchers from Anglo-Saxon countries are also significantly more likely to return to top institutions in Europe. This is probably related to the fact that the UK hosts several of Europe's top institutions.

Table 3.7: Multinomial logit model for the prestige and location of the first job

VARIABLES	(1a) Stay top	(1b) Stay non top	(1c) Return top	(2a) Stay top	(2b) Stay non top	(2c) Return top	(3a) Stay top	(3b) Stay non top	(3c) Return top	(4a) Stay top	(4b) Stay non top	(4c) Return top
PhD in a top institution	7.031***	0.700	5.732**									
	(3.693)	(0.298)	(4.745)									
PhD in supertop institution				7.680***	0.575	6.350**						
				(4.191)	(0.261)	(5.113)						
PhD in midtop institution				4.657***	1.026	4.068						
				(2.515)	(0.459)	(4.260)						
Highly cited advisor							1.901*	0.870	2.081			
							(0.664)	(0.269)	(1.039)			
Co-authoring advisor										1.029	1.466	0.577
										(0.376)	(0.618)	(0.487)
Age at first job	0.900	0.962	0.964	0.901	0.961	0.962	0.870*	0.967	0.941	0.854**	0.974	0.930
	(0.0634)	(0.0554)	(0.110)	(0.0648)	(0.0559)	(0.107)	(0.0631)	(0.0530)	(0.108)	(0.0628)	(0.0543)	(0.112)
Female	0.461**	1.095	0.875	0.492**	1.031	0.944	0.411***	1.104	0.766	0.399***	1.106	0.782
	(0.148)	(0.242)	(0.430)	(0.156)	(0.225)	(0.472)	(0.102)	(0.241)	(0.393)	(0.105)	(0.238)	(0.422)
Funding source: host institution	2.615***	1.766*	1.955	2.485***	1.862**	1.878	2.802***	1.650	1.961	2.935***	1.673*	1.937
	(0.930)	(0.523)	(1.127)	(0.875)	(0.567)	(1.079)	(0.938)	(0.521)	(1.171)	(0.991)	(0.504)	(1.131)
Funding source: other US institution	2.391*	1.287	1.546	2.340	1.345	1.563	2.719*	1.274	1.804	2.969**	1.189	1.909
	(1.232)	(0.471)	(1.024)	(1.211)	(0.491)	(1.033)	(1.453)	(0.527)	(1.157)	(1.496)	(0.494)	(1.190)
Funding source: home country	0.289**	0.192***	0.810	0.288**	0.190***	0.814	0.347**	0.186***	0.995	0.333**	0.186***	0.992
	(0.148)	(0.122)	(0.646)	(0.149)	(0.119)	(0.641)	(0.169)	(0.111)	(0.823)	(0.158)	(0.109)	(0.908)
Cohort 1992-1996	0.498**	0.179***	2.501	0.491**	0.184***	2.505	0.445**	0.185***	2.597	0.441**	0.198***	2.327
	(0.173)	(0.0689)	(2.445)	(0.172)	(0.0708)	(2.478)	(0.151)	(0.0710)	(2.620)	(0.154)	(0.0758)	(2.385)
Cohort 1997-2001	1.246	0.311***	4.240**	1.204	0.329***	4.219**	1.106	0.322***	3.765*	1.137	0.326***	3.828*
	(0.412)	(0.0947)	(2.805)	(0.419)	(0.104)	(2.844)	(0.334)	(0.0969)	(2.683)	(0.348)	(0.0992)	(2.681)
Eastern Europe - non EU	1.086	2.060***	4.27e-07***	1.014	2.082***	1.80e-07***	1.115	2.102***	5.11e-07***	1.028	2.085***	1.46e-07***
	(0.520)	(0.387)	(5.60e-07)	(0.562)	(0.426)	(2.33e-07)	(0.547)	(0.460)	(6.29e-07)	(0.448)	(0.372)	(1.95e-07)
Central Europe - EU	2.531	1.791	5.92e-07***	2.501	1.751	2.77e-07***	2.021	1.942	5.74e-07***	1.793	1.914	1.76e-07***
	(1.874)	(1.431)	(6.83e-07)	(1.817)	(1.403)	(3.15e-07)	(1.264)	(1.656)	(5.93e-07)	(1.071)	(1.624)	(1.92e-07)
Mediterranean countries	0.757	1.276	0.560	0.774	1.236	0.579	0.925	1.180	0.656	0.907	1.155	0.638
	(0.190)	(0.263)	(0.464)	(0.206)	(0.228)	(0.475)	(0.200)	(0.263)	(0.510)	(0.187)	(0.253)	(0.533)
Scandinavian countries	1.173	1.175	0.324	1.150	1.208	0.319	1.667	0.956	0.403	1.639	0.901	0.393
	(0.920)	(0.873)	(0.426)	(0.912)	(0.859)	(0.421)	(1.284)	(0.706)	(0.515)	(1.268)	(0.635)	(0.545)
Anglosaxon countries	2.364***	3.027**	3.785*	2.624***	2.784**	4.156*	2.696***	2.849**	4.162**	2.133***	2.644**	3.599*
	(0.747)	(1.389)	(2.825)	(0.804)	(1.380)	(3.102)	(0.673)	(1.365)	(2.929)	(0.553)	(1.123)	(2.590)
Turkey	0.752	1.645***	4.01e-07***	0.772	1.554**	1.96e-07***	0.665*	1.607**	3.60e-07***	0.551**	1.629***	1.03e-07***
	(0.187)	(0.282)	(4.80e-07)	(0.200)	(0.273)	(2.33e-07)	(0.145)	(0.313)	(4.34e-07)	(0.129)	(0.263)	(1.30e-07)
Israel	0.968	1.142	0.367	0.912	1.112	0.344	1.102	0.996	0.404	0.952	1.019	0.351
	(0.225)	(0.238)	(0.274)	(0.217)	(0.232)	(0.244)	(0.230)	(0.196)	(0.261)	(0.205)	(0.186)	(0.251)
Constant	5.799	18.22*	0.0748	5.937	18.04*	0.0786	52.37*	13.77*	0.406	115.4**	9.880	0.876
	(12.18)	(31.55)	(0.263)	(12.74)	(31.66)	(0.271)	(114.4)	(21.07)	(1.425)	(251.6)	(15.29)	(3.179)
Observations	375	375	375	375	375	375	375	375	375	375	375	375

Table 3.8: Multinomial logit model for the prestige and location of the first job (continued)

VARIABLES	(1a) Stay top	(1b) Stay non top	(1c) Return top	(2a) Stay top	(2b) Stay non top	(2c) Return top	(3a) Stay top	(3b) Stay non top	(3c) Return top
PhD in a top institution							4.625***	0.943	3.589
							(2.587)	(0.428)	(3.754)
PhD in supertop institution							1.503	0.564	1.529
							(0.693)	(0.229)	(0.949)
Highly cited advisor							1.019	1.113	1.450
							(0.331)	(0.387)	(0.638)
Co-authoring advisor							1.327	1.323	0.886
							(0.592)	(0.487)	(0.703)
Pre-PhD publication(s)	6.894***	2.581*	2.286				7.703***	3.301**	1.705
	(4.987)	(1.382)	(2.368)				(5.314)	(1.690)	(1.954)
Impact factor of first publication				1.955**	0.960	1.048	2.269***	1.040	0.982
				(0.513)	(0.277)	(0.260)	(0.659)	(0.319)	(0.299)
Age at first job	0.821***	0.957	0.920	0.887	0.971	0.939	0.898	0.939	0.957
	(0.0586)	(0.0552)	(0.105)	(0.0646)	(0.0531)	(0.108)	(0.0638)	(0.0577)	(0.110)
Female	0.396***	1.080	0.721	0.417***	1.102	0.740	0.500**	0.988	0.996
	(0.109)	(0.246)	(0.364)	(0.0991)	(0.239)	(0.377)	(0.157)	(0.228)	(0.509)
Funding source: host institution	3.381***	1.841*	2.211	2.933***	1.690*	2.010	2.913**	2.159**	1.904
	(1.425)	(0.680)	(1.274)	(1.086)	(0.538)	(1.230)	(1.299)	(0.776)	(0.919)
Funding source: other US institution	2.994**	1.276	1.958	2.911**	1.219	1.971	2.257	1.380	1.705
	(1.560)	(0.533)	(1.261)	(1.422)	(0.501)	(1.283)	(1.206)	(0.546)	(1.136)
Funding source: home country	0.293**	0.168***	0.858	0.309**	0.187***	0.908	0.236**	0.169***	0.759
	(0.155)	(0.104)	(0.769)	(0.145)	(0.113)	(0.797)	(0.134)	(0.107)	(0.629)
Cohort 1992-1996	0.625*	0.200***	2.749	0.476**	0.187***	2.503	0.843	0.217***	2.552
	(0.177)	(0.0780)	(2.879)	(0.171)	(0.0722)	(2.543)	(0.317)	(0.0762)	(2.691)
Cohort 1997-2001	1.575	0.351***	4.249**	1.054	0.334***	3.898**	1.733	0.380***	4.114*
	(0.566)	(0.0978)	(3.064)	(0.308)	(0.0944)	(2.663)	(0.622)	(0.108)	(3.258)
Eastern Europe - non EU	1.331	2.307***	1.51e-07***	1.139	2.184***	1.54e-07***	1.868	2.573***	7.95e-07***
	(0.591)	(0.473)	(1.96e-07)	(0.441)	(0.404)	(2.00e-07)	(0.901)	(0.657)	(9.89e-07)
Central Europe - EU	1.787	1.970	1.44e-07***	1.938	1.966	1.67e-07***	2.994	1.873	1.16e-06***
	(1.045)	(1.567)	(1.49e-07)	(1.210)	(1.657)	(1.80e-07)	(2.292)	(1.460)	(1.31e-06)
Mediterranean countries	0.915	1.205	0.646	0.759	1.198	0.621	0.616	1.288	0.610
	(0.237)	(0.280)	(0.539)	(0.161)	(0.246)	(0.500)	(0.199)	(0.291)	(0.442)
Scandinavian countries	1.478	0.931	0.376	1.809	0.974	0.393	1.196	1.106	0.291
	(1.281)	(0.689)	(0.495)	(1.407)	(0.722)	(0.530)	(1.043)	(0.795)	(0.400)
Anglosaxon countries	1.682*	2.824**	3.017	2.454***	2.979**	3.260	2.154*	2.483*	4.772*
	(0.470)	(1.418)	(2.068)	(0.696)	(1.426)	(2.424)	(0.879)	(1.355)	(3.817)
Turkey	0.581**	1.733***	9.06e-08***	0.665*	1.645***	9.96e-08***	1.041	1.745***	8.24e-07***
	(0.126)	(0.292)	(1.15e-07)	(0.151)	(0.274)	(1.29e-07)	(0.246)	(0.346)	(9.93e-07)
Israel	0.873	0.918	0.317*	0.736	1.018	0.323*	0.688	0.997	0.360*
	(0.207)	(0.211)	(0.210)	(0.160)	(0.194)	(0.217)	(0.186)	(0.318)	(0.194)
Constant	215.1**	15.85*	0.952	19.94	12.04	0.592	1.587	25.72*	0.0845
	(454.7)	(25.26)	(3.257)	(44.50)	(18.43)	(2.096)	(3.621)	(47.96)	(0.317)
Observations	375	375	375	375	375	375	375	375	375

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

3.4.2 Current job

This section deals with the determinants of the prestige and location of the current job. Once researchers start working in a particular location, they may become more embedded in that particular research system over time, making mobility later in the career more costly. Moreover, factors that affect immediate return, such as the source of PhD funding and the quality of the PhD, should no longer immediately affect location decisions at later stages in the career.

For the majority of researchers in our sample, the location of the current job is the same as that of the first job. Table 3.9 contains the location of the current job cross-tabulated with the location of the first job. For the current job, the share of returnees has grown to 36.80%, up from 29.60% for the first job. Of those who returned to Europe for the first job, 81.98% are still in Europe for the current job. The other 18.02% have returned to the U.S. for their current job. Of those who initially stayed, 82.2% are still working in the U.S. or Canada, whereas the remaining 17.8% have returned to Europe in the meantime. Although there is still some mobility after the first job, it is clear that the location choice for the first job is rather persistent for the majority of researchers. A Pearson's Chi square test indeed rejects the hypothesis that the location of the first job and the current job are independent.

Table 3.9: Location of the current job by location of the first job

	Current EU	Current US	Obs.
Return for first job	91	20	111
%	*81.98*	*18.02*	*100.00*
Stay for first job	47	217	264
%	*17.80*	*82.20*	*100.00*
Total	138	237	375
%	*36.80*	*63.20*	*100.00*

Pearson's Chi square test statistic: 138.3936 p-value: 0.000

Given that location choices appear quite persistent, how does the location of the first job affect the probability of a researcher working in a specific location at a top or non-top institution now? Table 3.10 divides the institutions where European PhD holders currently work into four categories: U.S. top institution, U.S. non top institution, EU top institution and

EU non-top institution. We examine what share of researchers in each category held their first job in the U.S. or Canada, at a top or a non-top institution.

Table 3.10: Location and prestige of the current job

	US top	US non top	EU top	EU non top	Total
First job	111	153	19	92	375
%	*29.60*	*40.80*	*5.07*	*24.53*	*100.00*
Current job	105	132	18	120	375
%	*28.00*	*35.20*	*4.80*	*32.00*	*100.00*
First job stay	94	123	7	40	264
%	*35.61****	*46.59****	*2.65****	*15.15****	*100.00*
First job stay top	83	15	3	10	111
%	*74.77****	*13.51****	*2.70*	*9.01****	*100.00*
First job stay non top	11	108	4	30	153
%	*7.19****	*70.59****	*2.61*	*19.61****	*100.00*

Of the 63.20% who hold their current job in the U.S. or Canada, 28% are working at a top institution and 35.20% at a non-top institution. Among the returnees, 4.8% are working at a top institution in Europe, and 32% at a non-top institution. The share of returnees currently working at a non-top institution in Europe has increased compared to the first job, when only 24.53% were working at a non-top institution. It appears that later return mostly happens by researchers who initially stayed in the U.S. at a non-top institution, and who later return to a non-top institution in Europe. On average, however, researchers who initially stayed are significantly more likely to currently work in the U.S. and significantly less likely to work in Europe, regardless of the prestige of the employing institution. More specifically, however, researchers who initially stayed at a top institution are significantly more likely to currently still work at a U.S. top institution, but significantly less likely to work at a U.S. non-top institution. Conversely, researchers who initially stayed at a non-top institution are significantly less likely to be working at a U.S. top institution, and significantly more likely to be working at a U.S. non-top institution, indicating that there is also strong persistence in the prestige of first and later jobs, as reported by other authors (Allison and Long, 1987; Burris, 2007). These researchers are also more likely to currently work at a non-top institution in the EU compared to their peers with a first job at a U.S. top institution.

To further check whether the location of a researcher's first job is persistent, we run two logit regressions with a dummy variable for a current job in the U.S. or Canada as the dependent variable. The first model includes a dummy that is 1 if the researcher stayed in the U.S. or Canada for the first job, whereas the second model splits this dummy variable into staying at

a top institution and staying at a non-top institution, to check whether researchers with a first job at a top institution are more likely to stay in the U.S. compared to their peers in non-top institutions. Table 3.11 reports the results.

Table 3.11: Logit for current U.S. job

VARIABLES	(1) Current US	(2) Current US
First job stay	3.012***	
	(0.271)	
Stay top		3.556***
		(0.420)
Stay non top		2.718***
		(0.267)
Age	-0.0750	-0.0733
	(0.0688)	(0.0661)
Female	-0.250	-0.163
	(0.696)	(0.687)
Married	-0.740	-0.896
	(0.790)	(0.742)
Children	0.817	0.939
	(0.885)	(0.849)
Cohort 1992-1996	-1.855**	-1.960***
	(0.770)	(0.708)
Cohort 1997-2001	-1.200*	-1.314**
	(0.627)	(0.602)
Eastern Europe - non EU	-0.00973	0.0392
	(0.426)	(0.446)
Central Europe - EU	0.312	0.387
	(0.530)	(0.538)
Mediterranean countries	-0.260	-0.254
	(0.271)	(0.287)
Scandinavian countries	-0.299	-0.390
	(0.654)	(0.692)
Anglosaxon countries	1.592***	1.673***
	(0.288)	(0.342)
Turkey	-1.247***	-1.086***
	(0.266)	(0.295)
Israel	0.0189	0.0545
	(0.268)	(0.282)
Constant	3.129	3.119
	(2.607)	(2.493)
	375	375

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 3.11 confirms that the location of the first job is persistent into the current job: researchers who initially stayed in the U.S. upon graduation, are significantly more likely to currently still work in the U.S. Moreover, researcher who initially stayed in a top institution, are more likely to still work in the U.S. compared to their peers who obtained a first job at a

non-top institution in the U.S.: a Wald test indicates that the coefficient for stay top is significantly higher than the coefficient for stay non top at the 5% level.

To further investigate how both the location and the prestige of the first job persist into the current job, we run 3 multinomial logit models to test the descriptive findings in a multivariate framework. The multinomial logit models again have 4 possible outcomes: U.S. top, U.S. non-top, EU top and EU non-top, with the last option as the base outcome. The results are reported in table 3.12. The first model includes a dummy variable that indicates whether the researcher stayed in the U.S. or Canada for the first job, along with all the control variables (columns 1a-1c). The second model splits this dummy variable into two dummies: one for staying at a top institution for the first job, and another for staying at a non-top institution (columns 2a-2c). In the last model, the dummies for staying for the first job and for staying at a top institution for the first job are included together, to check whether staying at a top institution has any additional effect on top of the stay dummy (columns 3a-3c). Instead of coefficients, again relative risk ratios are reported.

The first model confirms that researchers who stay for their first job are significantly more likely to still be in the U.S. or Canada for the current job, both at top and non-top institutions. The relative risk ratios are very high, indicating a very strong effect: initial stayers are 15 times more likely to currently be working at a top U.S. institution, and 26 times more likely to currently work at a non-top institution in the U.S. In the second model, we observe that those who initially stay at a top institution have a very strong likelihood of still working at a top institution, and a smaller, though strongly significant likelihood of currently staying at a non-top institution. These extremely high risk ratios probably also reflect the fact that very little return mobility from the EU back to the U.S. takes place, and particularly from the EU towards top institutions in the U.S. Those who initially stay at a non-top institution are also significantly more likely to currently work at a top institution in the U.S. or Canada, though the relative risk ratio is much smaller than for a first job at a top institution. The coefficient for currently staying at a non-top institution is, in line with previous findings of limited upward mobility, a lot larger. Finally, in the last model we observe that initially staying at a top institution indeed has an additional effect on top of the initial stay dummy, indicating that researchers who stay at a top institution are indeed more likely to stay than their peers who initially stay at a non-top institution, though only for the option of currently staying at a top institution as well.

Table 3.11: Multinomial logit models for location and prestige of the current job

VARIABLES	(1a) US top	(1b) US non top	(1c) EU top	(2a) US top	(2b) US non top	(2c) EU top	(3a) US top	(3b) US non top	(3c) EU top
First job stay	14.85***	26.27***	1.281				2.132*	25.14***	0.830
	(5.209)	(13.23)	(0.568)				(0.914)	(12.44)	(0.468)
Stay top				120.8***	15.75***	2.947*	56.67***	0.626	3.549
				(80.87)	(10.48)	(1.676)	(42.46)	(0.271)	(2.848)
Stay non top				2.132*	25.14***	0.830			
				(0.914)	(12.44)	(0.468)			
Age	0.879*	0.902	0.887	0.888*	0.891*	0.886	0.888*	0.891*	0.886
	(0.0611)	(0.0620)	(0.0719)	(0.0560)	(0.0586)	(0.0676)	(0.0560)	(0.0586)	(0.0676)
Female	0.594	1.357	3.496***	0.783	1.297	3.718***	0.783	1.297	3.718***
	(0.409)	(0.974)	(1.548)	(0.517)	(0.948)	(1.621)	(0.517)	(0.948)	(1.621)
Funding source: host institution	0.654	0.606	0.762	0.333*	0.686	0.688	0.333*	0.686	0.688
	(0.291)	(0.240)	(0.402)	(0.211)	(0.293)	(0.384)	(0.211)	(0.293)	(0.384)
Funding source: other US institution	2.203	1.257	1.047	1.319	1.389	1.023	1.319	1.389	1.023
	(1.134)	(0.479)	(0.726)	(0.925)	(0.554)	(0.740)	(0.925)	(0.554)	(0.740)
Funding source: home country	0.474*	0.248***	1.294	0.373*	0.263***	1.252	0.373*	0.263***	1.252
	(0.209)	(0.0925)	(0.734)	(0.188)	(0.113)	(0.678)	(0.188)	(0.113)	(0.678)
Cohort 1992-1996	0.161**	0.120***	0.599	0.0592***	0.164***	0.528	0.0592***	0.164***	0.528
	(0.140)	(0.0754)	(0.520)	(0.0460)	(0.101)	(0.480)	(0.0460)	(0.101)	(0.480)
Cohort 1997-2001	0.263*	0.223**	0.297*	0.0914**	0.339	0.254*	0.0914**	0.339	0.254*
	(0.203)	(0.142)	(0.191)	(0.0850)	(0.225)	(0.181)	(0.0850)	(0.225)	(0.181)
Eastern Europe - non EU	0.309	1.510	7.71e-07***	0.268	1.487	8.50e-07***	0.268	1.487	8.50e-07***
	(0.289)	(0.634)	(9.20e-07)	(0.265)	(0.645)	(1.00e-06)	(0.265)	(0.645)	(1.00e-06)
Central Europe - EU	0.661	1.547	1.21e-06***	0.473	1.680	1.22e-06***	0.473	1.680	1.22e-06***
	(0.469)	(0.992)	(1.06e-06)	(0.343)	(1.088)	(1.11e-06)	(0.343)	(1.088)	(1.11e-06)
Mediterranean countries	0.741	1.390	0.832	0.714	1.333	0.790	0.714	1.333	0.790
	(0.309)	(0.490)	(0.444)	(0.366)	(0.481)	(0.452)	(0.366)	(0.481)	(0.452)
Scandinavian countries	0.384	1.408	5.86e-07***	0.110	1.798	4.90e-07***	0.110	1.798	4.90e-07***
	(0.441)	(0.840)	(3.50e-07)	(0.207)	(1.110)	(2.98e-07)	(0.207)	(1.110)	(2.98e-07)
Anglosaxon countries	4.783***	9.591***	6.059***	5.527***	9.613***	6.036***	5.527***	9.613***	6.036***
	(1.455)	(4.280)	(3.386)	(2.577)	(4.260)	(3.642)	(2.577)	(4.260)	(3.642)
Turkey	0.0857***	0.415***	0.198***	0.0859***	0.417**	0.200***	0.0859***	0.417**	0.200***
	(0.0304)	(0.121)	(0.0603)	(0.0380)	(0.146)	(0.0625)	(0.0380)	(0.146)	(0.0625)
Israel	0.574	3.565***	10.05***	0.288***	4.103***	8.691***	0.288***	4.103***	8.691***
	(0.208)	(1.019)	(3.922)	(0.117)	(1.447)	(3.281)	(0.117)	(1.447)	(3.281)
Constant	209.5*	43.73	27.31	434.1**	52.22	34.20	434.1**	52.22	34.20
	(611.5)	(122.1)	(91.34)	(1,276)	(145.6)	(110.6)	(1,276)	(145.6)	(110.6)
Observations	375	375	375	375	375	375	375	375	375

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

None of the initial stayers display any significantly higher likelihood of returning to a top institution in Europe. This suggests that top institutions in Europe are not sufficiently attractive to draw top European researchers back once they have started to work in the U.S., especially at top institutions. From the European perspective, it appears that the most promising researchers are indeed attracted to stay in the U.S. at top institutions, and once they decide to do so are not very likely to return to Europe. This suggests that there is indeed an 'elite brain drain' among European economics PhD holders who obtain their degree in the U.S. or Canada.

3.5 CONCLUSION

Many world regions, including Europe, have the perception that their best students and researchers leave to study and work in the United States. This phenomenon has been coined 'the elite brain drain'. With a sample of European students who obtain a PhD in economics in the U.S., we study whether the most promising among them are indeed less likely to return. We find that the better PhD recipients, as measured through graduating from top institutions, or with a highly cited advisor, or a pre-PhD publication or a higher impact factor on their first publication are more likely to stay in the U.S. or Canada *at a top institution*. PhD holders with these quality indicators are not particularly more likely to stay at a non-top institution, but somewhat more likely to return to top institutions in Europe, although this last result is not very robust. This suggests that the quality of the working environment rather than the geographic location is of crucial importance to top researchers, and that the attraction of the U.S. consists in a big part of its many top economics departments.

The location choice made for the first job strongly predicts the location of the current job: 82% of those who initially stayed in the U.S. or Canada are still working there for the first job, while 18% of those who return to Europe for their first job revise that decision and are currently working in the U.S. or Canada again. Researchers who initially stayed at a top institution are significantly more likely to still be working in the U.S. or Canada, particularly at a top institution, compared to European researchers who initially stayed at a non-top institution. Once a top researcher has made the decision to stay, particularly at a top institution, the probability of his or her return becomes very small. This suggest that from the European perspective, there is indeed an 'elite brain drain', with two facets: some of the

most talented students stay in the U.S., attracted by its top institutions, and those who stay initially, once embedded in the North American research system, are not very likely to return.

3.6 APPENDIX

A.3.1 List of definitions

Supertop institution: A dummy variable that is 1 if the university is listed in the top 15 of 3 economics department rankings, i.e.

1. the Coupé ranking based on the productivity of the department's 20 most productive scholars (Coupé, 2003)
2. the National Research's Council (NRC)'s 2010 regression-based ranking of economics PhD programs
3. the 2010 REPEC ranking of economics departments.

A list of supertop institutions can be found in table A.3.1.

Midtop institution: A dummy variable that is 1 if the university is listed in the top 50 of all 3 economics department rankings. As the NRC does not rank foreign universities, non-U.S. institutions are included if they are listed in the top 50 of the other two rankings. A list of midtop institutions can be found in table A.3.1.

Subtop institution: A dummy variable that is 1 if the university is listed in the top 100 of all 3 economics department rankings. As the NRC does not rank foreign universities, non-U.S. institutions are included if they are listed in the top 100 of the other two rankings. A list of subtop institutions can be found in table A.3.1.

US top: A dummy variable that is 1 if the researcher is working at a U.S. university that is either a supertop or a midtop institution.

US non top: A dummy variable that is 1 if the researcher is working at a U.S. university that is neither a supertop nor a midtop institution.

EU top: A dummy variable that is 1 if the researcher is working at a European university that is either a midtop or a subtop institution (as there are no European institutions in the supertop category).

EU non top: A dummy variable that is 1 if the researcher is working at a European university that is neither a midtop nor a subtop institution.

The above four definitions are used to create an unordered categorical variable that combines location and employer prestige, and is used to estimate multinomial models.

Highly cited advisor: A dummy variable that is 1 if the researcher's advisor is included in ISI's list of highly cited authors in economics/business, formerly hosted on isihighlycited.com (now integrated into other Thomson Reuters services via www.highlycited.com)

Co-authoring advisor: A dummy variable that is 1 if the PhD recipient co-authors at least 1 ISI publication in her career with the advisor (not necessarily before the PhD is awarded).

Pre-PhD publication: A dummy variable that is 1 if the PhD recipient has an ISI publication published in a year prior to the year in which the PhD degree was obtained. Publications in the same year as the PhD degree are excluded.

Impact factor: The impact factor of the journal in which the PhD recipient's first publication is published, obtained from ISI's Journal Citation Reports (JCR).

Top economics departments per capita: A measure that captures the density of top economics departments in the researcher's home country, to proxy for the opportunities the PhD recipient has to work in a high-quality environment in the home country. The measure is calculated as the weighted sum of economics departments in the top 10% of the REPEC ranking. Departments higher up in the ranking receive a larger weight. By country, the weighted departments are summed, and divided by the country's population to account for size. The indicator is normalized so the U.S. receives a score of 1.

Age: age is calculated at the beginning year of the first job, by subtracting the birth year from the start year of the first job. If the researcher's CV did not explicitly mention the birth year, then the BA year is used to derive age, assuming the BA degree was received at age 22.

Funding source: If the researcher has received a fellowship or grant to finance the PhD, three dummy variables indicate the source of this grant.

1. *Funding source: host*: The fellowship or grant was financed by the PhD-granting institution.
2. *Funding source: other*: The fellowship or grant was financed by another US-based institution, such as Fulbright or the Sloane Foundation.
3. *Funding source: home*: The fellowship or grant was financed by an institution in the PhD recipient's home country. Examples are fellowships by central banks, such as the Bank of Spain, the Bank of Italy and the Bank of Portugal or by research foundations such as the Belgian American Educational Foundation in Belgium or the Ente Luigi Einaudi Fellowship of the Italian Bankers' Association.

Region of origin: PhD recipients' countries of origin within Europe are divided into 6 regions that are culturally and economically similar. These regions are Western Europe (the base region), Central Europe (including the new EU member states that acceded the Union in 2004 and 2007), Eastern Europe (including those Eastern European countries outside the EU), Scandinavia, the Mediterranean and the Anglo-Saxon countries (the UK and Ireland). Separate dummies are included for Turkey and Israel, which do not fit into any of these regions and have sufficient observations to be included on their own.

Table A.3.1: Institutions by tier and location

Tier	US + Canada	Europe	Definition of tier
Supertop	• Harvard University • MIT • University of Chicago • Princeton University • University of Pennsylvania • Stanford University • University of California, Berkeley • Northwestern University • Columbia University • New York University • University of Michigan	/	In top 15 of all 3 rankings
Midtop	• Yale University • University of California, Los Angeles • University of California, San Diego • Duke University • University of Wisconsin - Madison • University of Maryland • University of California, Davis • University of Minnesota • Boston University • Brown University • University of British Columbia • Michigan State University • University of Washington • Queen's University	• London School of Economics • University of Oxford • Tel Aviv University • University of Cambridge • University College London • University of Toulouse • Hebrew University	In top 50 of all 3 rankings
Top U.S.	= supertop + midtop	•	
Subtop	/	• University of Essex • University of Warwick • University of Amsterdam • University of York • Erasmus University Rotterdam • University of Nottingham • Universitat Pompeu Fabra • Stockholm School of Economics	In top 100 of all 3 rankings
Top EU		= midtop + subtop	

Table A.3.2: Correlations between the quality indicators

		1	2	3	4	5	6
1	Top PhD	1.00					
2	Supertop PhD	0.69*	1.00				
3	Highly cited advisor	0.39*	0.33*	1.00			
4	Co-authoring advisor	-0.19*	-0.19*	-0.11	1.00		
5	Pre-PhD publication	0.16*	0.10	0.10	0.02	1.00	
6	Impact factor	0.19*	0.24	0.23	0.05	-0.13	1.00

CHAPTER 4

THE ACADEMIC LABOR MARKET AND FOREIGN STUDENTS' RETURN DECISIONS

ABSTRACT[49]

The U.S. remains the most popular destination for international students, especially at the graduate level. A large part of this influx of bright minds is absorbed into American research institutions: in the last few decades, U.S. science has become increasingly dependent on the substantial inflow of foreign students and researchers. The flip-side of this coin is that net sending countries of foreign students, including many European countries, are concerned that their scientific and innovative capacity is hurt by the outflow of their best and brightest minds. This chapter contributes to the brain drain debate by studying how the state of the academic labor market affects the return decisions of a sample of European PhD recipients in the U.S. We find that European students are more likely to return home in years when there are fewer job openings relative to the number of newly minted PhDs entering the academic labor market. However, the state of the labor market mainly affects PhD recipients who did not graduate from top programs. This might be partly explained by the relatively lower volatility of job listings from top universities compared to listings from lower tier institutions. These results appear to support a labor queue model, where employers rank job candidates along relevant background characteristics and start recruiting at the top of the queue.

[49] This chapter was developed during a research visit to Dr. Paula Stephan at Georgia State University in the spring of 2011. It has benefited from the comments of Reinhilde Veugelers, Dirk Czarnitzki, Otto Toivanen and the participants of the PAI workshop (Mons, December 2011).

4.1 INTRODUCTION

The U.S. remains the most popular destination for international students (OECD, 2010), especially at the graduate level (NSF, 2010). A large part of this influx of bright minds is absorbed into American research institutions: in the last few decades, U.S. science has become increasingly dependent on the substantial inflow of foreign students and researchers (Black and Stephan, 2007). For example, the great expansion of biomedical labs in recent years was in part made possible by the large supply of foreign students willing to work in U.S. labs as doctoral students and postdocs (Stephan, 2010).

The flip-side of this coin is that many countries are net senders of foreign students and researchers. Highly skilled emigration can have positive effects for sending countries, for example by providing additional incentives to acquire education despite imperfect information about the probability to migrate (Mountford, 1997; Beine et al., 2001), or by creating a diaspora network that channels valuable scientific and innovative knowledge to the home country (Agrawal et al., 2011; Kerr, 2008). Outmigration of students and researchers can also be beneficial to the source country if there is sufficient return migration, with returnees bringing home additional human capital and skills, or financial resources and professional connections that can be employed productively in the home country (Commander et al., 2003; Mayr and Peri, 2009; Saxenian, 2002). However, stay rates of foreign PhD recipients in the U.S. are very high, and have increased in the last two decades: in the first year after the completion of their degree, 70% of foreign PhD recipients in 2004 were still in the United States, and five years later the stay rate had only declined modestly to 64% (Finn, 2012). Unsurprisingly, many net sending countries of scientific talent, including many European countries, are concerned that their scientific and innovative capacity is hurt by the outflow of their best and brightest minds (Kapur and McHale, 2005). Therefore both the U.S. and the world's main sending regions have a strong incentive to understand what factors influence foreign students' decisions to stay in the U.S. or to return back home upon completion of their studies.

This chapter contributes to the brain drain debate by studying how the state of the academic labor market affects the return decisions of a sample of European PhD recipients in the U.S. We find that European students are more likely to return home in years when there are fewer

job openings relative to the number of newly minted PhDs entering the academic labor market. However, the state of the labor market mainly affects PhD recipients who did not graduate from top programs.

Previous studies on students' return decisions have focused mostly on the supply side, i.e. on characteristics of the foreign students themselves. Finn (2010) and Black and Stephan (2007) study how stay rates vary over nationalities and fields of study. Gaulé (2010) finds evidence that stay rates are significantly higher for the most productive 20th percentile of foreign chemistry faculty. Several studies address the motivations and influencing factors behind the stay/return decision, and generally find that personal factors are the strongest motivation to return home, whereas professional considerations generally induce students to stay in the U.S. (Alberts and Hazen, 2005; MORE, 2010). Some types of funding are tied to a particular visa status which forces students to return even if they would have preferred to stay in the U.S. (Kahn and MacGarvie, 2008). Finally, some studies look at how the characteristics of the students' home country in comparison to the U.S. influence the return decision. Bratsberg (1995) finds that richer countries tend to attract more of their students back home, and that the selection of returnees is positive if relative rewards for human capital are higher in the home country compared to the U.S., as measured by income inequality.

Few studies, however, have addressed how the demand side comes into play in foreign students' return decisions, i.e. how the academic labor market in the U.S. influences students' decisions to stay or return. Oyer (2006) studies how the academic labor market for newly minted economics PhDs influences their career outcomes and their research productivity. For graduates from seven top economics departments, he finds that when the labor market is loose at the time new PhDs graduate, i.e. when there are fewer jobs for academic economists, students tend to accept employment at lower ranked institutions. Moreover, this disadvantaged starting point has a lasting effect of economists' careers, as they continue in jobs at lower-ranked institutions compared to their peers who graduated in years when the labor market was tight[50]. However, Oyer does not address whether students are more inclined to choose an outside option when the labor market is loose. For American students, a job in industry may become more attractive, or even a necessity, in years when there are few jobs available in academia. Jobs outside academia are clearly not the first

[50] The lasting impact of initial placement on subsequent jobs is a consistent finding in the academic labor market literature, see for example Smeets et al., 2006 and Alison and Long, 1987.

choice of economics PhD graduates: the majority chooses a job in academia (59% from the cohort graduating in 2001-2002) and those with jobs in industry report significantly lower job satisfaction (Siegfried and Stock, 2004). Foreign students, however, have yet another option: return to their home country and take up a job there. Job openings at home that may not seem attractive enough when job openings in the U.S. are plentiful may become an interesting option when attractive jobs in the U.S. are scarce. Of course, some students may have strong preferences for the U.S., whereas others have strong preferences for Europe, and these individuals probably give little weight to the state of the labor market in their location decision. However, for a number of individuals at the margin the state of the labor market might play a significant role in their decision to stay in the United States or to return to Europe. Insofar as the academic labor market in the home country is not tied to the American academic labor market, we might expect to see larger fractions of foreign students returning to their home country in years when the American labor market is loose, i.e. when there are few job openings compared to the number of newly minted PhDs entering the market. By contrast, we expect higher stay rates of foreign students in years when the labor market is tight. Finn (2010) already hinted at this relationship when he reported that stay rates for the 2002-2003 cohort were lower than they had been before, probably due to the dot com recession and the aftermath of 9/11 at the time. After 2003, the short-term stay rates recovered. However, the stay rate for the 2002-2003 cohort was lower at both 2 and 5 years after graduation, indicating that the state of the labor market at the time a cohort enters a market has a lasting effect on mobility decisions (Finn, 2010). If the relationship holds, in a few years we can probably expect to see lower stay rates for the cohorts graduating during the current recession.

Using a unique dataset of European PhD holders in economics who graduated from a U.S. university, we find evidence that the state of the academic labor market indeed influences students' return decisions, with students graduating in a 'bad' year having a significantly higher probability of returning home. However, we find that the state of the labor market is mainly significant for students graduating from lower tier institutions. Students from top institutions do not appear to be affected much by the state of the job market – they can always expect to find a job in American academia. These results appear to support a labor queue model, where employers rank job candidates along relevant background characteristics and start recruiting at the top of the queue. This implies that scarcity of jobs

chiefly affects individuals at the bottom of the labor queue. The remainder of the chapter is outlined as follows: section 2 elaborates the theoretical background. Section 3 presents the data, and section 4 discusses our empirical results. Section 5 discusses our findings and adds a few robustness checks to the analysis. Finally, section 6 concludes.

4.2 THEORETICAL FRAMEWORK: THE LABOR QUEUE MODEL

Lester Thurow (1975) was one of the first labor economists to advance the labor queue model as an alternative to the neo-classical approach to the labor market. The neo-classical approach assumes that wages adjust in the short term to clear the labor market, and supply and demand of labor shift in the long term in response to the signals supplied by wage fluctuations. In reality, we observe unemployment, indicating that labor markets do not always clear, and downward rigidity of wages. A labor queue model can accommodate both of these stylized facts. In the labor queue model, employers rank job candidates according to certain relevant background characteristics, such as education, age, gender, motivations, and so on. The candidates at the top of the queue have more desirable characteristics for a particular job opening than candidates further down the queue. Certain characteristics which may be desirable for one job opening are less desirable for another. For example, a job candidate with a business degree may be highly ranked in the labor queue for a job as a manager, but not highly ranked for a job as an opera singer.

Likewise, job candidates also rank job opportunities along a range of characteristics such as salary, prestige, power, etc. The employers who offer the best job opportunities will have the first pick from the labor queue[51]. At a particular point in time, an employer has a certain number of jobs to fill. He starts by offering a job to those candidates ranked high up in the labor queue, and, depending on the acceptance rate, works his way down the labor queue until every position is filled. In years when there are more jobs to be filled, the employer must lower his hiring standards and hire further down the labor queue to fill all the open positions; in years with fewer open positions, hiring standards rise and employers only recruit higher up the labor queue. The composition of the labor queue can also change over

[51] An interesting illustration that hints at the existence of an 'employer queue' is the anecdotal evidence that some non-top tier universities not always invite the candidates with the best applications for interviews, for fear of spending time and money on a candidate that will probably accept a job at a higher ranked institution anyway (sometimes leading to a situation where a highly qualified applicant finds himself without any job offers if he is unlucky with his applications to higher ranked institutions) (Coles et al., 2010).

time: If a particular group with desirable characteristics shrinks, then employers will have to hire further down the labor queue to fill the same number of open positions. Wages are rigid in the short term, they do not adjust downwards to clear a certain segment of the labor market. It is therefore possible that part of the labor queue will not receive any job offers at a certain time. This also explains why individuals with very similar characteristics can nevertheless end up with different jobs and different earnings: the supply of high earning jobs is limited, and very small differences in individuals' positions in the labor queue can translate into very different economic outcomes.

For individuals, the relative position in the labor queue matters rather than their individual characteristics. For example, a certain person might not find a college education an opportune investment in terms of costs and benefits. But if all his peers decide to get a college education, this person's relative position in the labor queue will worsen unless he gets a college education too. Getting a college education is a rational strategy for this person, even though this means that at the society level there may be an overinvestment in education (Thurow, 1975).

There is some empirical evidence supporting labor queue models in the market for teachers, where traditionally trained teachers are ranked higher and consequently obtain positions in better schools than alternatively trained teachers who are more likely to be channeled into disadvantaged schools (Evans, 2011). Queuing models are also used to explain the stratification of the labor market along ethnic origins, for example in Israel (Lewin-Epstein and Semyonov, 1985) and the United States (Bisping and Fain, 2005).

The labor queue model can be easily applied to the academic labor market for new PhD economists. We know that the prestige of the PhD granting institution has a strong influence on the prestige of the institution where a PhD holder will land her first job, as well as on all subsequent jobs (Alison and Long, 1987; Burris, 2004, Smeets et al., 2006). Therefore we assume that institutions rank newly graduated PhDs into a labor queue based primarily on the prestige of the PhD granting institution[52]. The most prestigious universities presumably offer the most attractive positions, and get the first pick of the labor queue, hiring applicants

[52] Other background characteristics influence a candidate's desirability to employers as well, but for simplicity's sake these are assumed to be collapsed into a single indicator, in this case, the prestige of the PhD institution.

who are graduating from the most prestigious universities[53]. Less prestigious universities are forced to hire further down the labor queue, if all of the most desirable applicants are taken by more prestigious institutions.

In years when university budgets are generous and job opportunities are abundant, institutions will have to recruit further down the labor queue, i.e. among graduates from lower tier universities to fill all their vacant positions. Conversely, during lean years when university budgets are tight, there will be fewer vacant jobs to fill, so institutions will raise their requirements and only hire further up the labor queue. This implies that in such lean years, a larger share of PhD recipients will either have to accept employment below their expectations, or choose an exit option such as a job in industry or, for foreign students, to return home.

Our first hypothesis is therefore that European students have a higher probability of returning home in years when there are fewer job opportunities relative to the number of PhD recipients entering the market. Given that we assume that the prestige of the PhD granting institution is one of the most important characteristics upon which employers base their ranking of candidates, we hypothesize that the state of the labor market is more stringent for PhD recipients from lower tier institutions, who will find themselves lower down in the labor queue[54]. Our second hypothesis is therefore that the availability of jobs matters less in the decision to stay or return for PhDs from top institutions, as they can always find a job in the U.S. regardless of the state of the labor market.

4.3 DATA

4.3.1 Foreign students

The data on foreign students comes from the ProQuest dataset with information on the careers of 375 European researchers who obtained a PhD in economics in the U.S. or Canada between 1992 and 2006, as described in the first chapter.[55]

[53] To illustrate, in sociology, Burris (2004) reports that the top 5 departments hired 56% of their faculty from other top 5 schools, and 91% from the top 20.
[54] In the empirical part, we also check whether other indicators of a student's quality which may be a relevant signal to the labor market play a similar role.
[55] For a detailed description on the construction and limitations of this dataset, please refer to the third section of the first chapter. A list of definitions can be found in appendix in the previous chapter.

4.3.2 The academic labor market

We obtain data on the state of the labor market from the American Economic Association's Job Openings for Economists (JOE)[56]. The JOE listings should give a rather comprehensive overview of available positions in the labor market for academic economists, as the American Economic Association considers it a professional obligation of its members to post their job openings in JOE. Ideally, we would want to count the exact number of job openings, i.e. open positions being offered, but JOE only provides job listings[57]. A job listing may contain several job openings, so the actual variation in the number of job openings may be greater than what is captured by the listings. However, job listings are the closest approximation we have to gauge the number of job openings. We use historic JOE data on the on the number of job listings from U.S. and Canadian academic institutions in a given year. The yearly reports of the editor, however, only provide the total number of academic listings, both American and international. Therefore we crawled the past versions of the monthly JOE reports hosted by Vanderbilt University since 2004 and by the University of Texas previously. The archived JOE pages make the distinction between U.S. academic, foreign academic and nonacademic job listings. These online archives only go back until 1997[58]. From these records, we count the number of U.S. and Canadian academic job listings[59]. As the proportion of U.S./Canadian listings to total listings hovers quite steadily around 79% between 1997 and 2006 (see figure 4.1), we impute the number of U.S./Canadian listings from the total number of listings using the average proportion of U.S./Canadian jobs (79%) for the years 1992 to 1996. To gauge whether the job market is loose or tight, we divide the number of U.S. academic job listings by the total number of U.S. and Canadian economics PhDs graduating in a given year. The number of granted economics PhDs in the United States is reported by the National Science Foundation's

[56] We are grateful to Paul Oyer for providing us with the JOE data up to 2004, and pointing us to the report of the editor of JOE for data on the remaining years, and to Michael P. Albert for helping us retrieve historic JOE records.

[57] It is impossible to count the number of job openings, however, as some listings refer to an unspecified amount of openings, which may or may not be filled depending on the quality of the applicants. The Report of the Editor of JOE reports that in 2005 and 2006, each job listing contained on average 2 job openings.

[58] Prior to that, there are only print archives held at Vanderbilt University, Nashville, USA.

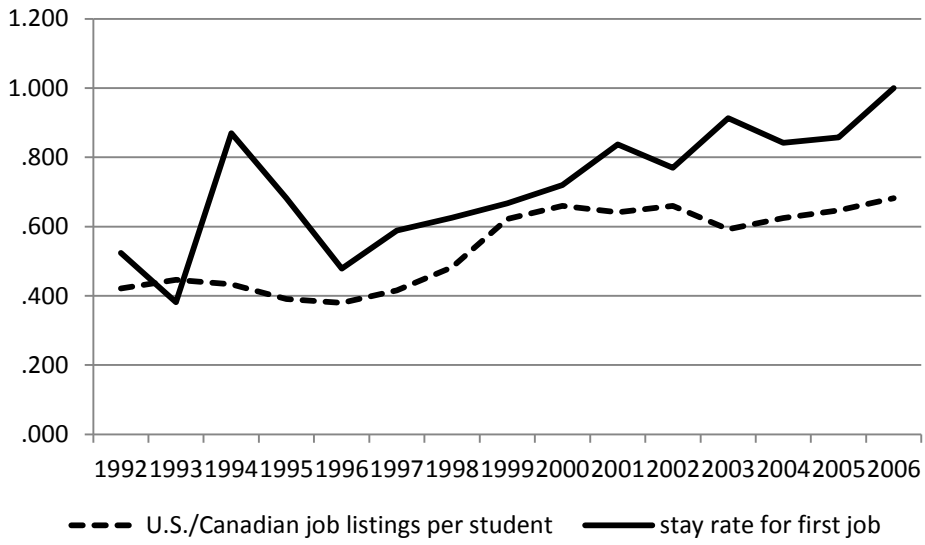
[59] A possible issue is whether these job listings come from attractive institutions. Job listings from PhD granting research universities are more attractive than job listings from small community colleges. Using the list of PhD granting universities from Winkler et al. (2011), we find that in the period 1997-2006, 48.8% of the job listings came from PhD granting universities. In the same period, on average 65% of job listings came from selected liberal arts colleges, master's granting institutions and PhD granting universities.

Survey of Earned Doctorates[60], whereas the data for Canadian economics PhDs were obtained from Statistics Canada.

Figure 4.1: The proportion of US, European and international job listings (1997 – 2006)



Figure 4.2: Academic listings per student and stay rates by year



[60] Available via WebCASPAR on https://webcaspar.nsf.gov/ .

Figure 4.2 plots the number of U.S. academic JOE listings per student and the stay rate immediately after graduation of our European PhD recipient sample each year. Both curves follow a similar shape, disregarding a spike in the stay rate in the early nineties. The general trend for both job listings and stay rates is upwards, although the rise of both slumped in the mid-nineties. We do not see a pronounced dip in stay rates immediately after the dot com crash in 2001 as Finn (2010) reported, although economists were arguably less affected by this recession which mostly hit the tech sector. Both the job market and the stay rate experienced a small dip around 2004-2005, but appear to be on the rise from 2005 onward.

4.3.3 Top institutions

Finally, to test the second hypothesis that the availability of jobs matters less in the decision to stay for PhDs from top institutions, we need to define what universities are considered 'top'. In line with the previous chapter, we compile a list of 'top institutions' using three rankings of economics departments: Coupé's ranking based on the productivity of the 20 most prolific scholars in a department (Coupé, 2003), the National Research Council's regression-based ranking of economics PhD programs (National Research Council, 2010), and the 2010 REPEC ranking of economics departments. We define an institution as top if it features in the top 50 of all three rankings, which results in a list of 33 top institutions. Alternatively, we define a more narrow group of 'supertop' institutions, if they are included in the top 15 of all three rankings; this list contains 11 institutions[61].

The prestige of a job candidate's doctoral institution may not be the only relevant signal of his or her ability. Top institutions often have large doctoral programs, and there may still be considerable heterogeneity among PhD recipients from those institutions. Therefore we use two alternative measures that may also signal a young researcher's ability on the job market: whether the PhD advisor is highly cited, and the impact factor of the first publication. A PhD recipient's advisor may play an important role in a PhD holder's job search by introducing the doctoral student to the right networks and through a 'second-hand reputation effect'. Having a publication in a good journal is an important asset for job candidates as the importance of research performance for hires and promotions increases. A caveat for this last measure is that only 55 researchers in the sample obtain their first publication before

[61] Please refer to the appendix of the previous chapter for a list of these top and supertop institutions.

their PhD, so for those whose first publication is published afterwards the quality of the journal may be influenced by the prestige of the first job.

4.3.4 Control variables

Finally, our models control for a number of factors that may also affect European students' stay rates. First, we include a measure of the quality of the research environment in a student's home country. This indicator is computed as the weighted sum of economics departments in the top 10% of the REPEC ranking divided by the home country's population to account for size. The resulting measure captures the 'density' of high quality economics departments where a researcher might consider working in the home country. The indicator is normalized so that the U.S. has a score of 1. Arguably, researchers from countries with a higher density of high quality economics departments have more suitable employment opportunities at home and are therefore more likely to return. Second, we control for a researcher's gender and age at the time he or she starts the first job. Third, three dummy variables indicate whether a researcher received a fellowship or a grant, and from what source: the PhD granting institution (host institution), another U.S. institution such as, for example, the Sloan foundation (other U.S. institution) or the home country. Certain types of funding may be tied to a contractual obligation to return to the home country, or students who were financed by the home country may simply feel an obligation to return and contribute to their home country's economy. Fourth, we control for the region of origin within Europe. We divide the home countries in our sample into 6 regions, i.e. Western Europe (the base region), Central Europe (including the countries that joined the EU in 2004 and 2007), Eastern Europe, Scandinavia, the Mediterranean countries, the Anglo-Saxon countries (Ireland and the UK). We include separate dummies for Turkey and Israel as well. Finally, cohort dummies are included to capture any other long-term time trends that influence European PhDs' stay rates. As discussed in the previous chapter, we define three 5-year cohort dummies for the cohorts 1992-1996, 1997-2001 and 2002-2006, which broadly correspond to periods of more or less favorable circumstances for economics PhD graduates. General stay rates received an exogenous downward shock due to the terrorist attacks of 2001, after which stay rates dropped for a few years, recovering again in 2006. The most recent cohort is the base group[62].

[62] The results are robust to omitting the cohort dummies, or to replacing them by the degree year.

Table 4.1 presents summary statistics for all the variables. The explanatory variable of interest is the number of U.S./Canadian job listings per student, which is on average 0.55 job listings per student on the market in a given year. The job market measure varies between 0.38 and 0.68 job listings per student within the timespan of our data. In our sample, many students graduate from top institutions: 65% graduate from a top institution, and 48% from a supertop institution. A little less than a third works with a highly cited advisor, and the average impact factor of the first publication is 0.97, although it varies strongly from 0.05 to 4.41.

Table 4.1: Summary statistics

Variable	**type**	**mean**	**std dev**	**max**	**min**
U.S./Canadian jobs per student	continuous	0.55	0.11	0.38	0.68
Top PhD institution	0/1	0.65	-	0	1
Supertop PhD institution	0/1	0.48	-	0	1
Highly cited advisor	0/1	0.29	-	0	1
Impact factor of first publication	continuous	0.97	0.83	0.05	4.41
Top economics departments pc	continuous	0.29	0.36	0	1.46
Female	0/1	0.20	-	0	1
Age at PhD	continuous	29.44	2.40	25	42
Funding source: host	0/1	0.40	-	0	1
Funding source: other	0/1	0.22	-	0	1
Funding source: home	0/1	0.22	-	0	1
Eastern Europe	0/1	0.06	-	0	1
Central Europe	0/1	0.07	-	0	1
Mediterranean	0/1	0.06	-	0	1
Scandinavia	0/1	0.06	-	0	1
Anglo-Saxon countries	0/1	0.04	-	0	1
Turkey	0/1	0.14	-	0	1
Israel	0/1	0.06	-	0	1
Cohort 1992-1996	0/1	0.29	-	0	1
Cohort 1997-2001	0/1	0.50	-	0	1
Cohort 2002-2006	0/1	0.21	-	0	1

4.4 RESULTS

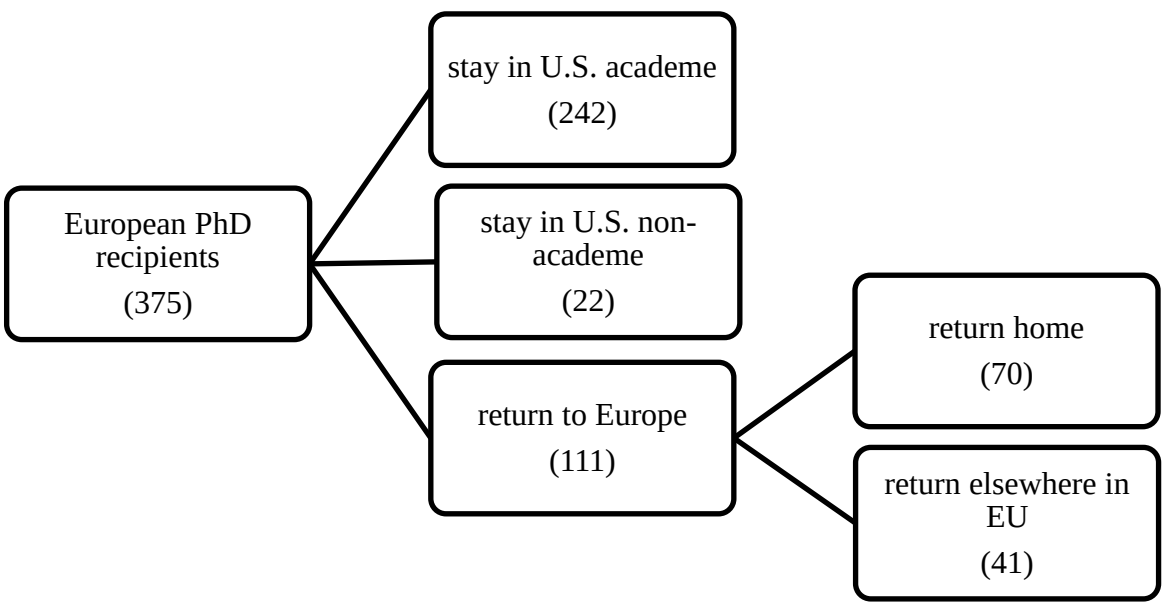
4.4.1 The model: foreign students' first job decision

Our first hypothesis is that European PhD recipients are more likely to return home when the availability of academic jobs in the U.S. and Canada is relatively low. This hypothesis makes two implicit assumptions: first, that a job in U.S. academe is the preferred option of the majority of European PhD recipients, and second, that returning home is the preferred 'plan B' in case the most preferred option is unavailable. From the Survey of Earned Doctorates (National Science Foundation), we know that between 1992 and 2006 on average 60% of the European PhD recipients in the U.S. had definite plans to take a job in academe. A job in academe is clearly the preferred option for the majority.

We also know from the SED that on average 58% of European PhD recipients with definite plans are staying in the U.S., so it is not unreasonable to assume that a job in U.S. academe is the preferred option for the majority of European PhD recipients. Whether returning home is the option chosen more frequently when access to the first option becomes more restricted is what we want to test. However, other 'outside' options besides returning home are available to European students as well. Given that the PhD recipient chooses a research career, working in government is also a possibility. In our sample, jobs at central banks and for international institutions such as the International Monetary Fund, the World Bank and the Interamerican Development Bank are also considered as government jobs, and they often involve a heavy research component. These jobs are often highly regarded, and in certain subfields may even be the top choice for the majority of graduates, and not an 'outside option'. We therefore model the choice of a European PhD recipient as follows: she can stay in U.S. academe (the default option), or alternatively stay in the U.S. outside academe, or return to Europe. For those who return to Europe we do not make the distinction between work in or outside academe – the essential choice for our hypotheses is whether researchers return, not in which specific sector they work if they do. In a second stage, we make the distinction between returning to the home country and returning to another European country. Figure 4.3 visualizes the decision model as well as the number of researchers that choose each option. U.S. academe is the most frequently chosen option for the first job, with 242 researchers of the 375 in our sample. The second most frequent option is to return to Europe, with 111 researchers doing this for their first job. Staying in the U.S. outside academe occurs infrequently, with only 22 researchers choosing this option.

A possible issue is that PhD recipients may be more likely to be 'pushed' into a career in industry in years when there are fewer academic jobs, in which case we no longer observe them. If this is the case, and those who go into industry are more likely to stay in the U.S., then we are overestimating the coefficient of the job market variable in the return equation. If, on the contrary, researchers who go into industry because of a scarcity of academic jobs are more likely to return, then we are underestimating the coefficient of the job market measure in the return equation. We have no information on the propensity of European researchers who go into industry to return or not. However, industry is not a remarkably popular option for newly minted PhD economists: according to the National Science Foundation's Survey of Earned Doctorates, between 1996 and 2006 on average only 15% of European PhD recipients, or fewer than 20 individuals in most years, had definite plans to accept a job in industry at the time they graduated. If PhD holders are 'pushed' into industry when there are fewer academic jobs, then we expect that the correlation of the proportion of students with definite plans to work in industry with our job market measure would be negative. However, for the years 1996-2006, the correlation between working in industry and the number of academic jobs per new graduate is positive (0.49), indicating that industry is, at the very least, not the preferred outside option of European students in a loose American academic labor market.

Figure 4.3: The decision model



4.4.2 Basic model

To see how the job market influences the probability to choose either of these three options (while keeping other factors constant), we use a multinomial logit model with three options: stay in U.S. academe (the base outcome), stay in non-academe and return. The basic model includes the job market measure as well as the control variables discussed in the data section. The standard errors are clustered by nationality, and weights are used to account for the sampling strategy. Table 4.2 displays the results.

We observe that PhD recipients who graduate in a year with relatively more jobs per candidate on the market are less likely to return to Europe, although the coefficient is only significant at the 10% level. The marginal effect of the job market variable for a male, western European PhD recipient of average age and from the most recent cohort is -0.63. This means that a 10% increase in the number of jobs available per graduating student leads, on average, to a 6.3% decrease in the probability of returning to Europe relative to staying in U.S. academe. Relative to a predicted probability of return of 29%, this effect is sizeable. The state of the job market has no significant impact on the probability to stay at a non-academic institution. These results appear to confirm our first hypothesis, that the state of the job market has an effect on the probability of European students to return, although the evidence is not particularly strong.

The source of funding for the PhD has a significant impact on the probability to return: PhD students funded by their host institution are less likely to return, whereas PhD students funded by their home country are more likely to return. Researchers from Eastern Europe and the Anglo-Saxon countries are less likely to return, whereas researchers form the Anglo-Saxon countries, Turkey and Israel are less likely to take a job in the U.S. outside academe. The middle cohort, who graduated between 1997 and 2001, was more likely to return and somewhat less likely to stay in the U.S. outside academe.

Table 4.2: Basic multinomial logit model

VARIABLES	(1) Stay non-academic	(2) Return
U.S./Canadian JOE listing per student	4.061	-3.597*
	(3.360)	(2.150)
PhD in a top institution	0.999	-0.0447
	(0.741)	(0.370)
Top economics departments p/c relative to U.S.	-0.347	0.212
	(1.089)	(0.403)
Female	-0.0377	0.192
	(0.697)	(0.238)
Age at first job	-0.640	0.329
	(1.448)	(0.725)
Age squared	0.00804	-0.00454
	(0.0234)	(0.0114)
Funding source: host institution	-0.515	-0.580**
	(0.642)	(0.278)
Funding source: other US institution	-0.0940	-0.477
	(0.674)	(0.428)
Funding source: home country	0.229	1.398***
	(0.478)	(0.515)
Eastern Europe - non EU	0.703	-0.627**
	(0.725)	(0.280)
Central Europe - EU	-0.996	-0.842
	(1.288)	(0.691)
Mediterranean countries	-0.239	-0.0906
	(1.228)	(0.325)
Scandinavian countries	-0.303	-0.382
	(0.905)	(0.639)
Anglosaxon countries	-15.26***	-0.744*
	(1.116)	(0.380)
Turkey	-1.315*	-0.302
	(0.682)	(0.219)
Israel	-15.49***	-0.431
	(1.389)	(0.324)
Cohort 1992-1996	-0.0249	0.694
	(0.571)	(0.485)
Cohort 1997-2001	-1.018*	0.644***
	(0.617)	(0.206)
Constant	7.353	-5.057
	(22.77)	(11.08)
Observations	375	375

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

4.4.3 Interaction with student quality

To test the second hypothesis, that the job market affects PhD students from prestigious institutions less, we interact the job market variable with our top PhD dummy (columns 1 & 2). Alternatively, we also interact the job market variable with the 'supertop' PhD dummy (columns 3 & 4), the dummy for a highly cited advisor (columns 5 & 6), and with the impact

factor of the first publication (columns 7 & 8), to check whether these quality indicators have a similar effect. Table 4.3 contains the results.

In all models, the job market has a negative effect on the probability to return, meaning that the more job listings there are per student on the market, the less likely students are to return to Europe (relative to staying in U.S. academe). The effects are highly significant at 1% for the first three models, and at 5% for the last. The interaction terms are also significant, but positive, canceling out the effect of the job market for PhD recipients with a top or supertop PhD or a highly cited advisor. This means that the effect of the job market is indeed different for 'top' and 'non top' PhDs. For those graduating from a top university, for instance, the marginal effect of the job market on the probability of return for a male, western European PhD recipient of average age and from the most recent cohort is -0.00001, or virtually zero. By comparison, for a similar PhD recipient from a non-top university the marginal effect is -0.10, meaning that a 10% increase in the number of job listings per student translates, on average, to a 1% decrease in the probability to return relative to staying in U.S. academe. Similarly, the marginal effect of the job market is 0.10 for PhD recipients with a highly cited advisor, but -0.61 for those without one. Only for the impact factor of the first publication the interaction term is not significant. The coefficients for top and supertop PhDs and for a highly cited advisor are also negative and significant for return, but for the marginal effects they are canceled out by the interaction terms with the job market variable. From these models, we conclude that the job market has a strong and significant effect on the probability to return, but this effect is much smaller for European PhD recipients who can send a strong quality signal to the academic labor market. These students have a good chance to find a suitable academic job in the U.S., even when the academic job market is not favorable.

Taking up a job in the U.S. outside of academe does not appear to be an 'outside option' when there are fewer academic jobs in the U.S. On the contrary, in the first and fourth interaction models the coefficient of the job market variable is positive and significant, indicating that more academic jobs per students actually increase the probability of taking a job in government. This suggests that the nonacademic and academic labor markets in the U.S. are tied to a certain extent.

Table 4.3: Multinomial logit models with interaction terms

VARIABLES	(1) Stay NA	(2) Return	(3) Stay NA	(4) Return	(5) Stay NA	(6) Return	(7) Stay NA	(8) Return
U.S./Canadian JOE listing per student	26.01*	-7.470***	4.138	-6.109***	6.141	-6.825***	8.180**	-5.445**
	(15.04)	(2.020)	(2.829)	(2.176)	(5.863)	(2.404)	(3.182)	(2.557)
PhD in a top institution	15.50*	-3.279***						
	(8.724)	(1.223)						
Top PhD * U.S./Canadian JOE listings per student	-22.72*	6.015**						
	(13.45)	(2.591)						
PhD in supertop institution			0.882	-2.856***				
			(2.260)	(1.066)				
Supertop PhD * U.S./Canadian JOE listings per student			-0.831	5.452**				
			(3.648)	(2.209)				
Highly cited advisor					2.960	-5.108***		
					(2.821)	(1.241)		
Highly cited advisor * U.S./Canadian JOE listings per student					-3.962	9.448***		
					(4.342)	(2.113)		
Impact factor of first publication							2.552*	-1.250
							(1.395)	(0.972)
Impact factor first publication * U.S./Canadian JOE listings per student							-5.286**	1.553
							(2.684)	(1.523)
Top economics departments p/c relative to U.S.	-0.419	0.258	-0.570	0.294	-0.594	0.372	-0.815	0.267
	(1.118)	(0.416)	(1.137)	(0.422)	(1.273)	(0.388)	(1.325)	(0.398)
Female	-0.0703	0.232	-0.129	0.244	-0.0697	0.133	-0.193	0.169
	(0.748)	(0.215)	(0.693)	(0.226)	(0.660)	(0.240)	(0.662)	(0.237)
Age at first job	-0.890	0.150	-0.789	0.148	-0.687	0.151	-1.193	0.347
	(1.511)	(0.698)	(1.382)	(0.658)	(1.371)	(0.706)	(1.428)	(0.825)
Age squared	0.0124	-0.00150	0.0102	-0.00151	0.00865	-0.00146	0.0161	-0.00498
	(0.0243)	(0.0110)	(0.0218)	(0.0104)	(0.0219)	(0.0111)	(0.0222)	(0.0130)
Funding source: host institution	-0.544	-0.621**	-0.384	-0.689**	-0.370	-0.621**	-0.256	-0.551*
	(0.659)	(0.258)	(0.674)	(0.268)	(0.715)	(0.286)	(0.745)	(0.315)
Funding source: other U.S. institution	-0.169	-0.517	0.00352	-0.517	0.0405	-0.550	0.107	-0.473
	(0.657)	(0.429)	(0.697)	(0.424)	(0.714)	(0.424)	(0.737)	(0.428)
Funding source: home country	0.265	1.283**	0.380	1.374***	0.516	1.279***	0.508	1.420***
	(0.509)	(0.499)	(0.459)	(0.471)	(0.428)	(0.454)	(0.409)	(0.463)
Eastern Europe - non EU	0.843	-0.492	0.553	-0.483**	0.620	-0.483*	0.478	-0.737***
	(0.699)	(0.301)	(0.631)	(0.243)	(0.634)	(0.282)	(0.602)	(0.227)
Central Europe - EU	-0.922	-1.045	-1.069	-0.919	-1.039	-0.851	-1.233	-0.927
	(1.290)	(0.652)	(1.183)	(0.649)	(1.173)	(0.649)	(1.145)	(0.730)
Mediterranean countries	-0.167	-0.251	-0.250	-0.162	-0.321	-0.135	-0.448	-0.192
	(1.228)	(0.345)	(1.374)	(0.381)	(1.288)	(0.378)	(1.124)	(0.406)
Scandinavian countries	-0.289	-0.399	-0.201	-0.506	-0.104	-0.281	-0.190	-0.389
	(0.914)	(0.635)	(0.910)	(0.633)	(0.995)	(0.544)	(1.019)	(0.596)
Anglo-Saxon countries	-13.38***	-0.949**	-13.49***	-0.900**	-14.09***	-1.095***	-14.31***	-1.003**
	(1.232)	(0.441)	(1.116)	(0.430)	(1.180)	(0.417)	(1.108)	(0.418)
Turkey	-1.286*	-0.381*	-1.308*	-0.258	-1.235*	-0.199	-1.584***	-0.460**
	(0.684)	(0.216)	(0.673)	(0.224)	(0.655)	(0.242)	(0.590)	(0.208)
Israel	-14.01***	-0.655*	-13.61***	-0.551	-14.26***	-0.617*	-14.37***	-0.399
	(1.399)	(0.377)	(1.423)	(0.364)	(1.469)	(0.319)	(1.536)	(0.316)
Cohort 1992-1996	-0.112	0.689	-0.0412	0.683	0.0286	0.553	-0.0599	0.593
	(0.614)	(0.490)	(0.575)	(0.480)	(0.624)	(0.525)	(0.549)	(0.466)
Cohort 1997-2001	-0.970	0.644***	-0.960	0.582***	-0.961	0.638***	-0.828	0.725***
	(0.628)	(0.181)	(0.603)	(0.189)	(0.619)	(0.178)	(0.645)	(0.198)
Constant	-3.088	-0.271	10.23	-1.018	7.296	-0.736	15.19	-3.862
	(26.86)	(11.01)	(21.55)	(10.10)	(23.00)	(10.67)	(22.90)	(12.27)
Observations	375	375	375	375	375	375	375	375

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

The interaction terms are also significant but with the opposite sign and a comparable coefficient, indicating that again the effect is canceled out for PhD recipients from top institutions or with a high impact factor for their first publication.

These results appear to support the labor queue model presented in the theory section: PhD holders ranked higher up the labor queue have more and better job offers to choose from compared to lower-ranked peers, and are less affected by labor market fluctuations. When the job market is unfavorable, though, academic institutions hire less PhDs and thus raise their requirements, hiring only higher up the labor queue. This implies that from the European perspective, European universities can hire better PhD holders from the U.S. when the American academic job market is unfavorable, because PhD recipients higher up the labor queue are getting fewer attractive job offers in the U.S. compared to the offers they might get in a year when academic jobs are more plentiful.

4.4.4 Return home versus return elsewhere in Europe

Finally, we also unravel how the job market affects return to the home country versus return to another European country. In this model the option 'return' is split into 'return home' and 'return EU', the latter indicating a return to Europe but not to the home country. Both a basic multinomial logit model (columns 1, 2 and 3) and a model with an interaction term with a top PhD are estimated (columns 4,5 and 6); the results are reported in table 4.4.

In the first model, the job market variable is no longer significant for either of the three 'outside options' compared to staying in U.S. academe. In the second model with the interaction term, however, the job market variable is negative and significant for return to the home country, but not significant for return to another EU country. As before, the interaction term is positive and significant and cancels out the job market variable for researchers with a top PhD. These results indicate that returning to another European country is not perceived as a 'plan B' in case the academic job market in the U.S. is not favorable. Rather, most researchers appear to move to another European country to work at a top European institution: 29% of them are at a university that is classified in the top 100 of Tom Coupé's ranking based on the productivity of the 20 most prolific scholars in a department and the REPEC ranking of economics departments, compared to only 10% of those who return to their home country. More than half of the 'EU' returnees are working at

only 9 European institutions which could be considered 'top' in economics in Europe: London School of Economics, INSEAD, Université Catholique de Louvain, Tilburg University, Hebrew University, London Business School, Universidad Carlos III de Madrid, Universitat Pompeu Fabra and, in the non-academic sector, the European Central Bank. Working at a top institution in Europe is arguably an attractive job prospect even when an academic job in the U.S. is also a possibility.

4.4.5 Long term effects

Location choices made for the first job are often permanent. Seven years after graduation, only 18 of the 111 researchers, or 16%, who initially returned to Europe are working in the U.S. or Canada (see table 4.5). For the current job, only 20 researchers, or 18%, have reversed their initial return decision. Most researchers, once they have returned, stay in Europe for the remainder of their career. This implies that researchers who return because of an unfavorable job market in the U.S. are unlikely to return to the U.S. later when jobs are more plentiful.

We check whether the state of the job market at the time of graduation also affects location and sector choices 7 years after graduation (the point at which the tenure decision has usually been made) and for the current job. However, in the multinomial logit models for the sector and location choice 7 years after graduation (table 4.6) and for the current job (table 4.7) the job market variable is not significant in the return equation. The job market variable is positive and significant for the probability to stay in the U.S. outside academe, but very few individuals actually choose this option (13 researchers 7 years after graduation, 15 for the current job).

Table 4.4: Multinomial logit models with return home versus return to another European country

VARIABLES	(1) Stay non academic	(2) Return home	(3) Return EU	(4) Stay non academic	(5) Return home	(6) Return EU
U.S./Canadian JOE listing per student	4.012	-4.170	-2.801	25.98*	-8.702***	-4.381
	(3.337)	(2.777)	(2.242)	(15.40)	(2.732)	(3.576)
PhD in a top institution	1.004	-0.0179	-0.0598	15.54*	-3.874***	-1.423
	(0.743)	(0.393)	(0.461)	(8.956)	(1.446)	(2.322)
Top PhD * U.S./Canadian JOE listings per student				-22.79*	7.315**	2.444
				(13.80)	(3.222)	(4.233)
Top economics departments p/c relative to U.S.	-0.361	-0.240	0.570	-0.432	-0.128	0.582
	(1.129)	(0.624)	(0.502)	(1.154)	(0.623)	(0.514)
Female	-0.0290	0.246	0.181	-0.0626	0.295	0.197
	(0.699)	(0.336)	(0.439)	(0.749)	(0.324)	(0.435)
Age at first job	-0.661	0.260	1.545	-0.912	0.0986	1.510
	(1.477)	(0.818)	(1.628)	(1.545)	(0.811)	(1.618)
Age squared	0.00845	-0.00253	-0.0264	0.0128	0.000315	-0.0258
	(0.0239)	(0.0126)	(0.0273)	(0.0249)	(0.0126)	(0.0271)
Funding source: host institution	-0.522	-0.918***	-0.220	-0.551	-0.946***	-0.234
	(0.641)	(0.256)	(0.403)	(0.658)	(0.236)	(0.396)
Funding source: other U.S. institution	-0.0893	-0.258	-0.775	-0.163	-0.313	-0.788
	(0.677)	(0.439)	(0.536)	(0.658)	(0.439)	(0.545)
Funding source: home country	0.226	1.664***	0.941	0.264	1.529***	0.891
	(0.479)	(0.499)	(0.659)	(0.508)	(0.505)	(0.645)
Eastern Europe - non EU	0.694	-0.361	-1.437***	0.835	-0.180	-1.393***
	(0.726)	(0.323)	(0.432)	(0.702)	(0.352)	(0.446)
Central Europe - EU	-1.002	-1.092*	-0.590	-0.921	-1.400**	-0.647
	(1.284)	(0.615)	(1.047)	(1.284)	(0.585)	(1.017)
Mediterranean countries	-0.242	-0.148	-0.0333	-0.164	-0.382	-0.0836
	(1.227)	(0.520)	(0.323)	(1.224)	(0.595)	(0.326)
Scandinavian countries	-0.282	0.0491	-0.981	-0.269	0.00761	-0.986
	(0.915)	(0.648)	(0.783)	(0.921)	(0.643)	(0.794)
Anglo-Saxon countries	-14.58***	0.0578	-15.52***	-13.84***	-0.193	-15.37***
	(1.122)	(0.533)	(0.938)	(1.233)	(0.591)	(0.951)
Turkey	-1.315*	0.216	-1.606***	-1.285*	0.120	-1.613***
	(0.680)	(0.345)	(0.398)	(0.684)	(0.369)	(0.389)
Israel	-14.79***	-0.912*	-0.239	-14.34***	-1.179**	-0.340
	(1.417)	(0.536)	(0.399)	(1.431)	(0.580)	(0.469)
Cohort 1992-1996	-0.0547	0.656	0.685	-0.146	0.710	0.676
	(0.564)	(0.611)	(0.585)	(0.607)	(0.619)	(0.582)
Cohort 1997-2001	-1.024*	0.151	1.302***	-0.980	0.209	1.287***
	(0.618)	(0.335)	(0.452)	(0.627)	(0.324)	(0.437)
Constant	7.666	-4.836	-23.48	-2.800	-0.124	-22.04
	(23.18)	(12.48)	(24.01)	(27.64)	(12.49)	(23.82)
Observations	375	375	375	375	375	375

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 4.5: Location and sector 7 years after graduation and for the current job

	first job			
7 years after graduation	stay academic	stay non-academic	return	total
stay academic	207	10	18	235
%	*85.54*	*45.45*	*16.22*	*62.67*
stay non-academic	4	9	0	13
%	*1.65*	*40.91*	*0.00*	*3.47*
Return	31	3	93	127
%	*12.81*	*13.64*	*83.78*	*33.87*
Total	242	22	111	375
%	*100.00*	*100.00*	*100.00*	*100.00*
current job				
stay academic	191	11	20	222
%	*78.93*	*50.00*	*18.02*	*59.20*
stay non-academic	7	8	0	15
%	*2.89*	*36.36*	*0.00*	*4.00*
Return	44	3	91	138
%	*18.18*	*13.64*	*81.98*	*36.80*
Total	242	22	111	375
%	*100.00*	*100.00*	*100.00*	*100.00*

Table 4.6: Multinomial logit model 7 years after graduation

VARIABLES	(1) Stay non academic	(2) Return home	(3) Stay non academic	(4) Return home
U.S./Canadian JOE listing per student	9.587**	-1.990	29.45*	-3.544
	(4.354)	(1.978)	(16.41)	(2.595)
PhD in a top institution	0.536	0.218	14.10	-1.056
	(0.889)	(0.256)	(9.989)	(1.262)
Top PhD * U.S./Canadian JOE listings per student			-21.30	2.355
			(15.76)	(2.202)
Top economics departments p/c relative to U.S.	0.313	0.0272	0.345	0.0505
	(0.553)	(0.413)	(0.575)	(0.420)
Female	-1.432	0.200	-1.451	0.214
	(1.004)	(0.474)	(1.066)	(0.475)
Age at first job	5.677	-0.112	5.555	-0.153
	(5.338)	(0.476)	(4.528)	(0.494)
Age squared	-0.0955	0.00417	-0.0931	0.00489
	(0.0903)	(0.00757)	(0.0763)	(0.00792)
Funding source: host institution	-2.675***	-0.188	-2.834**	-0.193
	(1.010)	(0.231)	(1.149)	(0.234)
Funding source: other U.S. institution	-0.837	-0.719*	-0.838	-0.738*
	(0.826)	(0.374)	(0.852)	(0.379)
Funding source: home country	-0.350	1.285***	-0.297	1.246***
	(0.671)	(0.356)	(0.657)	(0.353)
Eastern Europe - non EU	-0.255	-0.287	-0.0515	-0.238
	(1.717)	(0.338)	(1.644)	(0.359)
Central Europe - EU	-14.29***	-0.484	-15.42***	-0.541
	(0.692)	(0.661)	(0.654)	(0.624)
Mediterranean countries	1.445	0.799**	1.793*	0.750**
	(1.111)	(0.363)	(0.961)	(0.377)
Scandinavian countries	-0.755	0.0910	-0.729	0.0897
	(1.456)	(0.687)	(1.439)	(0.684)
Anglo-Saxon countries	-13.83***	-0.586	-14.57***	-0.662*
	(1.140)	(0.371)	(1.190)	(0.389)
Turkey	-1.855***	0.821***	-1.809***	0.820***
	(0.575)	(0.308)	(0.575)	(0.300)
Israel	-14.23***	-0.323	-15.23***	-0.413
	(1.277)	(0.313)	(1.228)	(0.329)
Cohort 1992-1996	0.325	1.808***	0.386	1.821***
	(1.740)	(0.413)	(1.697)	(0.408)
Cohort 1997-2001	0.219	1.470***	0.315	1.484***
	(0.760)	(0.387)	(0.734)	(0.396)
Constant	-91.95	-1.701	-103.2	-0.287
	(78.98)	(7.397)	(72.13)	(7.981)
Observations	375	375	375	375

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 4.7: Multinomial logit model for the current job

VARIABLES	(1) Stay non academic	(2) Return home	(3) Stay non academic	(4) Return home
U.S./Canadian JOE listing per student	3.860	-1.044	23.27*	-1.781
	(4.796)	(1.904)	(12.18)	(2.615)
PhD in a top institution	0.334	0.327	13.51*	-0.233
	(0.897)	(0.263)	(6.979)	(1.226)
Top PhD * U.S./Canadian JOE listings per student			-21.03*	1.059
			(11.09)	(2.067)
Top economics departments p/c relative to U.S.	0.305	0.373	0.296	0.381
	(0.696)	(0.483)	(0.755)	(0.488)
Female	-0.688	0.293	-0.722	0.298
	(0.684)	(0.504)	(0.749)	(0.504)
Age at first job	6.493	0.107	6.004	0.0809
	(5.187)	(0.416)	(4.328)	(0.427)
Age squared	-0.109	0.000469	-0.100	0.000936
	(0.0884)	(0.00650)	(0.0735)	(0.00673)
Funding source: host institution	-1.461	-0.176	-1.529	-0.176
	(1.017)	(0.235)	(1.138)	(0.236)
Funding source: other U.S. institution	-0.575	-0.628*	-0.564	-0.641*
	(0.841)	(0.350)	(0.852)	(0.355)
Funding source: home country	0.493	1.501***	0.602	1.487***
	(0.538)	(0.317)	(0.525)	(0.316)
Eastern Europe - non EU	-0.469	-0.242	-0.390	-0.213
	(1.558)	(0.359)	(1.544)	(0.369)
Central Europe - EU	-15.70***	-0.417	-14.19***	-0.436
	(0.699)	(0.669)	(0.635)	(0.648)
Mediterranean countries	0.722	1.172***	1.154	1.146***
	(1.058)	(0.362)	(1.082)	(0.372)
Scandinavian countries	-0.852	-0.192	-0.821	-0.191
	(1.225)	(0.739)	(1.228)	(0.736)
Anglosaxon countries	-16.13***	-1.311***	-14.21***	-1.336***
	(0.975)	(0.360)	(1.156)	(0.377)
Turkey	-1.598***	0.883***	-1.531***	0.889***
	(0.485)	(0.257)	(0.473)	(0.254)
Israel	-15.97***	-0.167	-14.29***	-0.204
	(1.206)	(0.366)	(1.192)	(0.392)
Cohort 1992-1996	0.625	2.255***	0.726	2.258***
	(1.510)	(0.502)	(1.529)	(0.499)
Cohort 1997-2001	0.0316	1.459***	0.159	1.469***
	(0.755)	(0.388)	(0.722)	(0.388)
Constant	-100.7	-5.694	-106.2	-4.927
	(77.05)	(6.463)	(67.30)	(6.967)
Observations	375	375	375	375

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

4.5 DISCUSSION AND ROBUSTNESS CHECKS

Our hypothesis that European students from second tier universities have a higher propensity to return home in years when the American academic job market is unfavorable hinges on the implicit assumption that a degree from a second tier American university is sufficient to guarantee a job in the home country. These returning students face competition of PhD recipients from European top universities such as the London School of Economics or the University of Toulouse. However, many American 'subtop' universities are still highly ranked: 66 of the top 100 economics departments according to Tom Coupé's ranking based on each department's 20 most productive scholars are American, versus 25 European ones (Coupé, 2003). Of the top 250 economics departments of the REPEC ranking, 164 are American, compared to 127 European departments. American dominance is even more visible in the top 100, with 79 American departments versus only 35 European ones[63]. Moreover, the American departments are, on average, more highly ranked than the European ones: the median rank of American departments in the top 100 is 48, whereas the median for Europe is 65. Clearly, second tier institutions in the U.S. still place their PhD recipients in a good position to compete with many PhD granting institutions in Europe. Moreover, top and second tier institutions tend to have relatively large PhD programmes and turn out the majority of the students in our sample: 330 of the 375 have a PhD from an institution in the top 100 of Tom Coupé's previously mentioned ranking. This is partly the result of our sampling method, but partly also reflects the fact that Europeans tend to be overrepresented in highly ranked American programmes compared to students from other regions of the world (Bound, Turner and Walsh, 2009). In short, we believe that the European PhD recipients in our sample who do not graduate from a top institution, and who are thus most affected by labor market fluctuations in the U.S., are still relatively well-positioned in the European labor market.

As an alternative strategy, PhD students may put off graduating in years when there are fewer jobs on the academic labor market in the hope that the labor market will be better the next year. If this is the case, our results would be biased downwards because 'to hold off graduating' is another exit option besides returning home. However, in our data, the state of

[63] The number of departments do not add up to 100 because of ties where two or more departments can be included in the top 100 with the same rank.

the job market has no significant effect on time to degree[64]. It therefore does not seem to be the case that an unfavorable labor market induces the average student to postpone graduating.

Our result that that job market affects graduates from top institutions less than graduates from non-top institutions could have two different interpretations. On the one hand, it could imply that students from top institutions accept jobs in lower ranked institutions in years when the academic labor market is unfavorable, 'pushing' graduates from non-top institutions into jobs at even lower-ranked institutions, or out of U.S. academe. However, in the previous chapter we found that students who graduate from top universities are not more likely to stay in the U.S. than non-top graduates, unless they work at a top institution. Top graduates moving into lower-ranked jobs when the job market is unfavorable can be interpreted as a contradiction to this finding. On the other hand, our results could also mean that the 'top' academic labor market, which is mostly only accessible to students from top universities, is less volatile than the non-top market, and that fluctuations in job listings per student occur mostly in the non-top segment, therefore affecting graduates from non-top segments more.

To check the plausibility of the latter interpretation, we would ideally want to count the number of job openings from top institutions and non-top institutions, and compare these to the number of new graduates applying in each segment over the time period under study. However, we do not observe actual job openings, only job listings, which can contain one or more vacant positions and therefore are likely to underestimate the number of job openings. Conversely, there is anecdotal evidence that some universities, particularly in the top segment, post a job listing every year without necessarily having a vacant post, but rather to 'screen' the market for exceptionally talented candidates. This could result in an overcount of actual job openings.

Panel A of figure 4.3 shows the job listings of top and non-top institutions for the period 1997-2006. It illustrates that the top segment is comparatively small, and only responsible

[64] Time to degree is measured as the difference between the starting year and the graduation year if explicitly mentioned on the CV, or the difference between the year the MA was obtained and the graduation year if the MA was not obtained at the same institution as the PhD within three years prior to the PhD, in which case the start date of the MA is used as the starting point

for on average 13% of all job listings in this period. Other than a moderate growth trend, the top-market appears quite stable, with only one substantial decrease in job listings in 1999. By contrast, the non-top market is a lot larger, and appears more volatile, with a clear downward movement between 2000 and 2003 and upward swings in the periods 1997-2000 and 2003-2005, with an apparent stagnation afterwards.

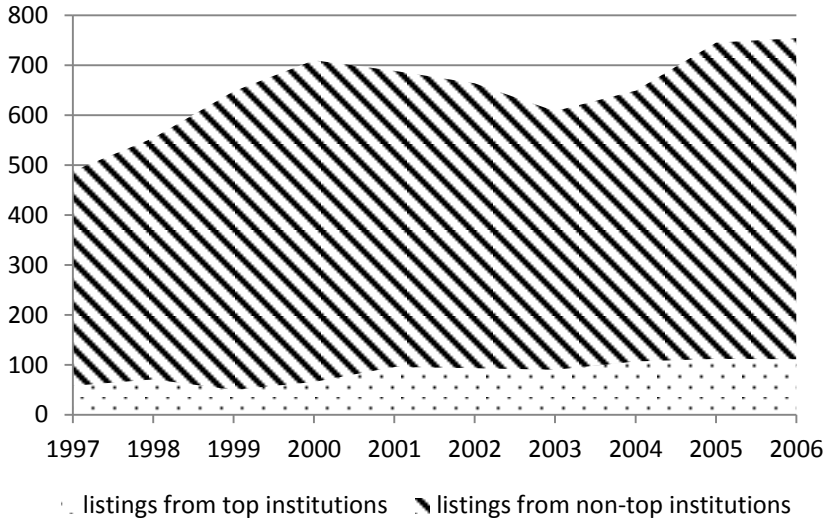
To evaluate the volatility of the top and non-top labor markets, we need to control for the number of applicants in each segment each year. However, we do not observe how many graduates effectively apply in the top and non-top segments. It is known that there is very little upward prestige mobility, suggesting that only graduates from top universities can apply in the top segment of the academic labor market (Burris, 2004; Allison and Long, 1987). Therefore we make the simplifying assumption that graduates from top universities only apply in the top segment, and whereas graduates from both top and non-top universities can apply in the non-top segment, consistent with queuing theory. We divide the number of U.S. job listings posted by the 23 U.S. universities in our list of top institutions by the number of economics PhD recipients who graduate from the same group of institutions, and compare it to the number of U.S. job listings posted by all other institutions divided by all U.S. economics PhD recipients. Panel B of figure 4.3 shows the evolution of the number of listings per student on the market by 'quality segment'.

The top segment appears less favorable for job applicants than the non-top segment: there are on average 0.19 top job listings for every top PhD recipient on the market, compared to on average 0.86 non-top job listings for every non-top graduate. Not surprisingly, only 40% of the top graduates in our sample find employment at a top institution – the other 60% end up at non-top institutions. The top segment appears somewhat less volatile than the non-top segment: after a slight dip in 1999, it shows a moderate upward trend for the rest of the period. The non-top segment experiences stronger fluctuations, rising sharply from under 0.4 listings per graduate in 1997 to 0.6 listings per graduate in 2000, then declining again to 0.5 listings per graduate in 2003, and recovering to 0.55 listings per graduate by 2006. This illustrates that the non-top market segment is probably more volatile than the top segment[65].

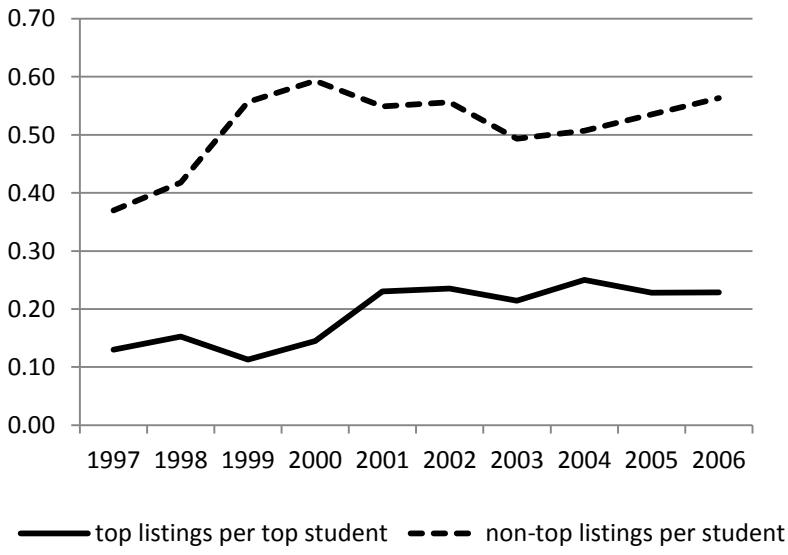
[65] The coefficient of variation (the standard deviation over the sample mean) is actually larger in the top segment (0.25) than in the non-top segment (0.13), but it is sensitive to small changes in the mean if the mean is close to zero, and probably not a good measure of volatility in this case.

Figure 4.3: Top versus non-top academic labor market

Panel A: Total job listings by top/non-top segment



Panel B: Top (non-top) job listings per top (non-top) student



Moreover, the state of the labor market does not appear to have an effect on the probability of getting a first job at a top institution, neither for top graduates, nor for all graduates in the sample (holding other factors constant). This also suggests that the top segment of the market is less affected by fluctuations in the overall academic labor market. Although some top graduates undoubtedly take up jobs at lower-ranked institutions in years with fewer job listings per student, the relative stability of the top market segment relative to the non-top

segment arguably also goes a considerable way towards explaining our finding that top graduates are less affected by labor market fluctuations.

Another point of discussion is whether our results can be extended to PhD students from other world regions, notably to Asia which in the last few decades has grown to be the major source region of foreign students in the U.S. Though the mechanisms at work may be similar, we doubt that our results can readily be transferred to other world regions. Finn (2010) already indicates that stay rates vary considerably by country of origin, with Asian students displaying the highest stay rates. The return option is, on average, more attractive for a European than for an Asian student, because after the U.S., Europe boasts most top and middle tier universities. The opportunity cost of returning is higher for students from other world regions because their home countries have fewer high quality institutions that offer attractive jobs. As a consequence, students from other world regions are willing to accept jobs at lower ranked institutions than Europeans, who have a higher quality outside option available. As an illustration, the only countries outside the U.S. and Europe that have at least one institution in the top 100 of the REPEC ranking are Australia and Canada. In the top 250, Chile, Japan, Singapore and South Korea are represented as well. In the last few years, many Asian universities have started a fast-paced catch-up process, notably in China. Their progress is illustrated by their increasing presence in international university rankings. As these countries' research systems develop further, we may see similar patterns of return mobility develop as we observe today for Europe. However, without a doubt more research is needed to understand the factors that drive return mobility and how they vary across countries and world regions.

Finally, the current economic contraction, which was (until now) more pronounced in the United States than in Europe, might provide an interesting experiment for our theory. Budget cuts for academe have been more aggressive in the U.S. than in Europe, so compared to the European market, there have been relatively fewer academic job openings since 2008. Several hiring officers from European universities confirm that their applicant pool has grown in recent years, as well as improved in quality. The German newspaper Handelsblatt reports that several top economists have returned to Germany because of the financial crisis, and German institutions are receiving more applications from U.S.-trained PhD holders. According to Gerard van den Berg, a Dutch econometrician working at the University of

Mannheim, *"[t]he situation is a unique chance for European universities to close the gap with the United States."* (Handelsblatt, March 1st, 2010).

6 CONCLUSION

Stay rates of foreign students in the U.S. are not only affected by supply factors, i.e. by characteristics of students and their cohorts, but also by demand factors. We find evidence that the state of the academic labor market at the time a cohort graduates has a significant effect on the probability of return of newly minted PhD economists: when there are fewer academic job listings per graduating student, the European students in our sample have a higher probability of returning home. This effect is strongest for students who do not graduate from top institutions, however. This result suggests that the academic labor market is characterized by a labor queue, where employing institutions rank PhD recipients by the prestige of their PhD institution and hire first among the most highly ranked, thus ensuring that students from top institutions virtually always find employment, while students from second tier institutions are more strongly affected by the state of the labor market.

For U.S. policy, our findings imply that a lack of jobs in a particular year may result in a loss of valuable foreign human capital, on which U.S. science has increasingly come to rely. For the U.S. government and funding agencies, this should be an incentive to minimize fluctuations in the academic labor market by providing sufficient and continuous funding for junior research positions. However, it appears that the U.S. manages to attract and retain the best PhD recipients regardless of the state of the labor market, chiefly thanks to the draw of its top institutions. As students from lower ranked institutions are more likely to leave due to labor market fluctuations, the policy problem is not as pressing from the U.S. perspective.

From the European perspective, institutions and governments should make use of the fluctuations in the U.S. labor market to recruit more aggressively in years with fewer academic jobs in the U.S.. PhD recipients from relatively better ranked institutions should become 'available' for the European market as American institutions only recruit further up the labor queue. However, to attract top PhD holders Europe should not rest on its laurels and wait for fluctuations in the American labor market to make Europeans flock back home.

Active policies that address both the availability of sufficient funding and the creation of centers of excellence are needed to recruit Europe's top researchers back home.

CHAPTER 5

DESTINATIONS OF MOBILE EUROPEAN RESEARCHERS: EUROPE VERSUS THE UNITED STATES

ABSTRACT[66]

Using a sample of 998 European-born researchers who obtained their PhD in Europe and are internationally mobile, we study the differences in personal characteristics, motivations and perceived external influencing factors between those researchers who choose Europe versus those who choose the U.S. as their destination. We find that career motivations are more strongly related to mobility to the United States, which suggests that Europe is indeed losing its most career motivated researchers to the United States. However, researchers with previous PhD mobility experience within Europe are more likely to remain internationally mobile within Europe. Conversely, researchers who leave their birth country to obtain their PhD in a European country with a stronger scientific performance are more likely to become mobile to the United States later in their career.

[66] This chapter is joint work with Reinhilde Veugelers and Elissavet Lykogianni. It has benefited from the comments of Dirk Czarnitzki, Otto Toivanen and the participants of the ENID STI Conference (Rome, September 2011) and the TEMPO Conference (Vienna, November 2011).

5.1 INTRODUCTION

Many world regions, including newly emerging markets like China, have raised their ambitions to become knowledge based economies. To realize these ambitions, the search for scientifically skilled talents has become a global competition. Europe, in its EU2020 Strategy and its Innovation Union Flagship, identifies the supply of scientific talents as a potential bottleneck for its innovation based growth strategy. To this end, it recognizes the importance of not only increasing investment in higher education, but also to attract and retain talent in Europe during their research career.

Although Europe trains more PhDs than the United States and has recently overtaken the U.S. in sheer volume of scientific publications (Veugelers, 2011), policy makers still voice concerns that Europe is being outdone in the global war for talents, losing its best brains to the U.S. while failing to attract the best scientific talent from abroad.

The European Union's policy to establish an integrated research area (ERA) focuses most attention on improving the mobility of researchers inside the EU. Policy initiatives provide funding for intra-EU mobility (e.g. the Marie Curie fellowships) and try to reduce the regulatory burdens for intra-EU mobility. These policies are bearing fruit, as intra-EU mobility is on the rise (Parey and Waldinger, 2008; Lowell, 2007).

A much more sensitive issue in the global competition for talent is extra-EU mobility of researchers, and particularly the large mobility flows to the United States. To which extent does Europe keep on losing its scientific talent to the U.S.? And how much of this outward mobility involves return mobility at a later stage? The perspectives on this issue are, however, clouded by a lack of good data. We know very little about the size of and trends in the outgoing and return flows of researchers between the EU and the U.S., nor about the motivations and impediments underpinning these mobility decisions.

This paper contributes to our understanding of the factors that drive intra-EU and EU-U.S. researcher mobility. Using unique survey data on internationally mobile European researchers, we compare the differences in personal characteristics, motivations and external influencing factors of researchers who are mobile within Europe and researchers who choose

to become mobile to the United States. We find that intra-EU mobility experience as PhD students motivates researchers to remain mobile within the EU. 'Post-PhD' mobility to the United States is driven to a larger extent by career motivations.

The remainder of the paper is organized as follows: section 2 reviews the literature on researcher mobility, analyzing both the statistical sources for mobility and the existing literature on the motivations and influencing factors that drive mobility. Section 3 presents the data, while section 4 presents the results, both descriptive and econometric. Section 5 concludes.

5.2 A REVIEW OF THE EVIDENCE AND ANALYSES OF INTERNATIONAL RESEARCHER MOBILITY

5.2.1 Literature review

Although it is widely recognized that human capital mobility is instrumental in the development and dissemination of new ideas and technologies (Goldin et al., 2011), there is still a lack of comprehensive data and analysis on international mobility of the highly skilled and of researchers in particular. Data on the size and direction of migration flows is an important first step in understanding international researcher mobility. Additionally, it is also important to study the factors that drive mobility decisions at various career stages. This section will review the existing evidence and analysis on both.

Perhaps the best documented dimension of international researcher mobility is international student mobility. Several sources provide information on the international movements of tertiary students. The OECD in its latest 2010 Education at a Glance Edition reports that 6.7% of all tertiary students in the OECD are international students. The total number of foreign students enrolled outside their country of origin stood at 3.3 million in 2008, which is an increase of 70% compared to 2000. The ten most popular European countries[67] together receive about 35% of all foreign students. Nevertheless, looking at individual countries, the U.S. is clearly the top destination, receiving almost 19% of all foreign students. 11.2% of all

[67] United Kingdom, Germany, France, Italy, Spain, Austria, Switzerland, Belgium, the Netherlands and Sweden.

international students in the U.S. are from Europe, though China and India are the top source countries.

Studies on researcher mobility often focus on PhD students, as they are very likely to be internationally mobile[68] and their education involves a heavy research component. In a study of mobility of PhD students, IISER (2007) reports that 5.5% of doctoral candidates in the EU are studying in a member state of which they do not hold the nationality, whereas 16.9% come from outside the EU. Asia and Africa are the largest regions of origin of these extra-EU PhD students. For the United States, the National Science Foundation (NSF) collects detailed information on graduating PhD students, including foreign PhD recipients, through its Survey of Earned Doctorates (SED). In its latest Science and Engineering Indicators report, the NSF reports that 33% of all PhD recipients in science and engineering fields were temporary residents. The proportion is more than half in fields like engineering, mathematics, computer sciences and economics (NSF, 2010). Between 2003 and 2009, 61% of all foreign PhD recipients in the U.S. were from South or East Asia, versus 13% from Europe (NSF, 2010). Black and Stephan (2007) report that the increased inflow of foreign students in the 1980s and 1990s have fuelled much of the growth of U.S. PhD and postdoc programs, and consequently the proportion of foreigners in PhD programs has increased dramatically: in 1981, 20% of all doctoral students held a temporary visa, compared to 38.4% by 1992 (Black and Stephan, 2007). By 2006, this proportion had risen to almost 1 in 2 PhD students (Stephan, 2011).

Though a large number of foreign researchers enter their destination country as students and stay to work (temporarily or permanently), a significant number also move after finishing their PhD education (Stephan and Levin, 2007). Keeping track of foreign post-PhD researchers is harder because they can work in a multitude of institutions in academia, the private sector or the government. In the U.S., 35% of all faculty at four-year colleges, universities and medical schools in 2003 were known to be foreign born, although this number is probably an upper bound of the real proportion of foreigners as it also includes faculty who may have migrated to the U.S. as children (Stephan, 2011). The National Survey of College Graduates reports that 33.1% of foreign PhD holders in the U.S. are foreign-educated (NSF, 2010). The Association of American Medical Colleges reports that

[68] According to the OECD Education at a Glance(2010) statistics, the proportion of PhD students which are internationally mobile stands at 18.2% in 2008.

in 2000, 18% of the faculty at U.S. medical schools were foreign-educated (AAMC, 2003). For some countries, the outflow of faculty constitutes a considerable loss: about 20% of Israeli economic faculty were residing in the U.S., compared to only 10% for Canada, the country with the second-to-highest proportion of faculty in the U.S. (Ben-David, 2007).

A number of studies focus on international mobility in specific scientific disciplines. In a study of 10 top economics departments in the U.S., Oswald and Rahlsmark (2008) find that 62% of their assistant professors had moved to the U.S. after their bachelor's degree, and 13% after their PhD. Gaulé (2010) studies a sample of foreign chemistry faculty who hold a faculty position in the U.S. and finds that 53% of the foreign faculty come to the U.S. as PhD students, 34% as postdocs and 13% as faculty.

A growing literature addresses the factors and motivations that drive student mobility. Many macro-studies on labor migration emphasize the importance of 'classic' migration factors such as relative market size, geographic and cultural distance, colonial and trade ties, relative economic strength and income differences (Lee and Tan, 1984; Cummings, 1984; Agarwal and Winkler, 1985; McMahon, 1992; Bessey, 2007). Although obtaining a degree in an industrialized country is often a first step for permanent migration into that country (Borjas, 2002; Tremblay, 2001), there are other specific factors that affect student mobility. Many students go abroad in search of a higher-quality education than they could have obtained at home (Van Bouwel and Veugelers, 2011; Alberts and Hazen, 2005). A lack of availability of places at home in the desired program is also a push-factor for students to seek education abroad (Van Bouwel and Veugelers, 2011; Lee and Tan, 1984).

There are few studies that address the motivations and influencing factors of mobility of researchers after the PhD. Rindicate (2008) surveyed academic researchers in 8 European countries on their international mobility and what factors were perceived as barriers to mobility. They found that 46% of their sample had been mobile and another 35% were interested in becoming mobile in the future. A broad array of factors were perceived as inhibitors to mobility: lack of funding for mobility, salary concerns, lack of open recruitment, misalignment in social security benefits, personal relationships, and practical things such as concerns about accommodation and health insurance. Researchers who had not yet been internationally mobile expressed most concern about the lack of recognition of

mobility for career progression and the lack of funding for mobility (Rindicate, 2008). A study carried out in the context of the 7th Framework Program on 'European Careers for Researchers' in 8 European countries asked respondents, among other things, about their experience with and motives for international mobility. Of the researchers included in the study, 59% indicated having participated in an international mobility program in the past. The researchers indicated that the possibility for future career development, working on an interesting research topic and participation in a collaborative research project were among the most important motives for mobility, although the reputation of the host institutions also plays a significant role. Major obstacles for mobility are family and other personal connections, as well as the complex administration of relocation and lack of support from the home institution (Ivancheva and Gourova, 2011). De Grip et al. (2009) study the factors that influence European science and engineering graduates in becoming internationally mobile right after their studies and 5 years later. They find that a strong R&D sector is a key attractive factor of destination countries, and that previous experience with mobility is a strong predictor of future mobility, especially for intra-EU mobility.

Other authors confirm that student mobility indeed increases the probability of future labor mobility. King and Ruiz-Gelices (2003) survey UK students who have spent a year abroad during their undergraduate studies as well as a control group of their class mates who did not, and find that the mobile group are significantly more likely to indicate interest in working abroad later, particularly in the country where the exchange year was spent. Dreher and Poutvaara (2005) examine the impact of student flows to the United States on subsequent migration there and find that student mobility is a significant predictor of migration. Within Europe, Parey and Waldinger (2008) study the effect of the introduction of the ERASMUS program in Germany on international labor market mobility later in life and find a significant link: studying abroad increases an individual's probability of working abroad by 15-20%. This suggests that the ERASMUS program is an effective policy instrument to stimulate international labor market mobility within Europe.

Whereas these studies look at the factors and motivations that influence the probability to become mobile, they do not differentiate these determinants among destinations. Do researchers differ in their motivations and external influencing factors depending on where they are mobile to? Does prior mobility experience to a certain destination influence the

probability to become internationally mobile, or the probability to become internationally mobile to a particular destination? This study addresses how researchers mobile to the United States differ from researchers mobile within the EU in terms of personal characteristics, PhD mobility history, motivations and external influencing factors. It does not address which researchers become mobile and which do not, but rather contributes to our understanding of the determinants of mobility by studying how researchers mobile to two prominent destinations differ in various respects.

5.2.2 Hypothesis development

The goal of this chapter is to understand the factors that influence mobile European researchers' destination choices between intra-EU mobility and mobility to the United States. In the human capital perspective, mobility is treated as an investment decision: a researcher will become internationally mobile if the net benefits of such a move, discounted over time, exceed the costs (Ehrenberg and Smith, 2011). In short, a researcher will become mobile if the present value of the net benefits, expressed as

$$\sum_{t=1}^{T} \frac{B_t}{(1+i)^t} - C$$

is positive, with B_t the net benefit of mobility in time period t, C the mobility costs incurred at the beginning of the move, *i* the discount factor and *T* the number of periods over which the researcher incurs benefits. The benefits and costs of mobility are influenced by characteristics of the destination country, the source country and of the researcher herself. Most variables included in models of international mobility can be thought of as increasing or decreasing the benefits or costs of moving to a particular destination. With this framework in mind, we address two main research questions.

First, how do intra-EU mobile researchers differ from researchers mobile to the United States in their personal characteristics, motivations and external influencing factors for mobility? Do particular characteristics or motivations increase the likelihood of choosing the United States as a destination over another European country? For policy makers, understanding why researchers choose a particular destination is crucial for optimal policy design. If researchers mobile to the United States indicate that this is primarily because of financial motivations (meaning the benefits of U.S.-mobility exceed that of EU-mobility in

that respect), then funding for research and researchers' salaries in Europe need to be addressed; if, by contrast, a concern with administrative barriers is hindering intra-EU mobility (which can be interpreted as the costs of intra-EU mobility exceeding those of mobility to the U.S.), then removing these may be the primary policy goal. We find that researchers mobile to the U.S. are significantly more career-motivated than researchers mobile within the EU. This suggests that the United States continues to be seen as a better destination to advance one's career and research interests, and might also reflect the fact that in Europe, little has been done as of yet to harmonize research careers (Haeck, 2012).

Second, does previous degree-mobility experience within the EU affect the likelihood of remaining mobile within the EU compared to becoming mobile to the United States? In other words, does intra-EU student mobility lower the costs of intra-EU mobility for these researchers? And if so, what are the mechanisms behind this decrease in mobility costs? Are the effects of motivations and influencing factors different for researchers with degree mobility experience? As discussed in the literature review, student mobility is often a precursor for subsequent labor mobility. We examine whether this is also the case in our data, and specifically whether intra-EU degree mobility makes students more likely to remain mobile within the EU. Perhaps intra-EU degree mobile students acquire essential language and cultural skills and establish networks that make further intra-EU mobility less costly for them. Additionally, degree mobility could trigger a learning process that alters students' motivations for mobility or their perceptions of external influencing factors. By contrast, intra-EU degree mobility could also serve as a stepping stone for mobility to the United States, if a degree from a more prestigious university is perceived as an intermediate step to the American labor market.

5.3 DATA: THE MORE SURVEY

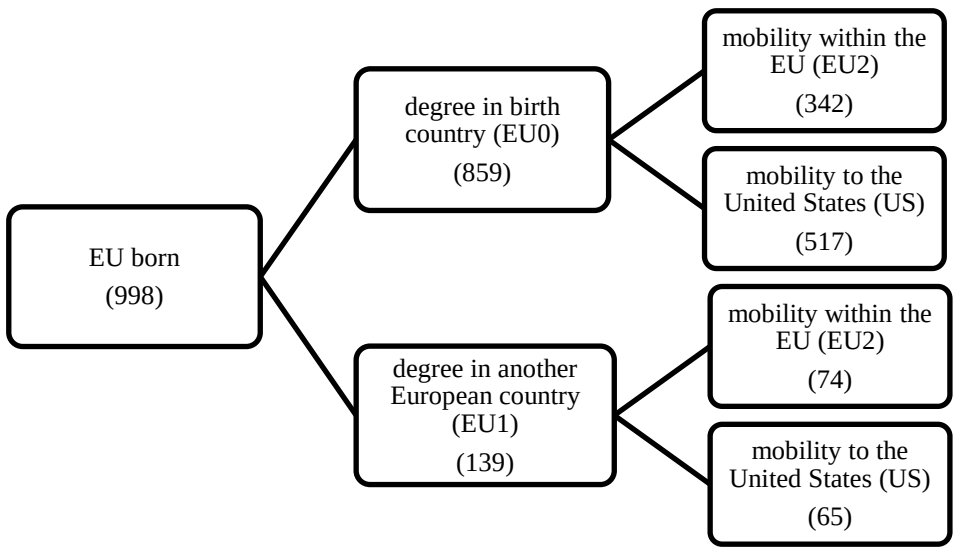
5.3.1 The sample

This chapter is based on survey data from the MORE project, as described in the first chapter. It uses the subsample of EU-born PhD researchers with mobility experience from the EU to the U.S. or within the EU. A researcher is considered mobile if she spends at least 3 months in a country other than the country where she obtained her highest degree (PhD). Although the MORE survey also included non-mobile researchers among the respondents, it

worded survey questions on motives and barriers differently for mobile and non-mobile researchers, making the information from these questions incomparable between both groups. As these questions contain information for key explanatory variables in our analysis, we could not include the non-mobile researchers from the sample. We retain only those researchers who obtained their PhD in Europe, be it in their birth country (EU0) or in another European country (EU1), and who become mobile as researchers within Europe (EU0-EU2 or EU1-EU2) or to the United States (EU0-US or EU1-US)[69]. There are 998 researchers in this subsample.

Figure 5.1 illustrates the breakdown of our sample into the various mobility groups. The number of respondents in each group and subgroup is included.

Figure 5.1: Mobility groups in the sample



The major drawback of this sample is that it is not representative of the population of EU researchers, because non-mobile researchers are not covered by the sample, but also because the MORE survey specifically targeted EU-U.S. mobile researchers, which means this group is probably overrepresented in our sample relative to the population of mobile EU-born researchers. As there are no comprehensive datasets that track the population of EU-born researchers, we have no way to correct our sample for this bias[70]. The non-representativeness of our sample affects the alternative-specific constants in our models, but

[69] A small number of researchers are mobile to other countries, such as Australia, but these are omitted from the analysis. Canada was originally considered together with the U.S. as one destination, North America, but after cleaning no European researchers mobile to Canada remained in the sample.

[70] Please refer to the third section of the first chapter for a broad discussion of possible datasets with which to compare our sample, and their drawbacks.

not necessarily the estimates for the determinants of mobility destination outcomes (Train, 2002). Nevertheless, results should be interpreted with caution, especially the descriptive statistics which are not corrected for the bias towards EU-U.S. mobile researchers, and should thus not be taken as representative of the population of mobile European researchers.

Table 5.1 contains the different regions in Europe where the respondents in our sample obtained their PhD, as well as the major degree countries. Western Europe and the Mediterranean are the largest source regions, representing 34% of the sample each. Anglo-Saxon Europe (the UK and Ireland) is the third largest degree region. Scandinavia and Central and Eastern Europe represent 10% and 9% of the sample, respectively. Of the major individual degree countries, Italy is the largest source country of mobile researchers with 190 individuals in the sample. Germany, Spain and the UK make up the top 4 with 136, 127 and 119 researchers respectively.

Table 5.1: PhD Degree regions and major countries

PhD Degree region	Frequency	Percent
Western Europe	341	0.34
Central and Eastern Europe	91	0.09
Mediterranean	340	0.34
Scandinavia	102	0.10
Anglo-Saxon Europe	124	0.12
Major PhD degree country	Frequency	Percent
Italy	190	0.19
Germany	136	0.14
Spain	127	0.13
United Kingdom	119	0.12
France	65	0.07
Netherlands	48	0.05
Austria	33	0.03
Sweden	31	0.03
Belgium	30	0.03

Table 5.2 shows the different destination regions in North America and in Europe, as well as the major destination countries. North America is the most popular destination region, with

all 58% of all mobile researchers going to the United States. The second major destination region is Western Europe which receives 21% of the sample. Anglo-Saxon Europe, though the smallest region in our sample, comes in third with 9%. This is explained by the particular attraction of the United Kingdom: after the United States, it is the most popular destination country, receiving 89 researchers from our sample. Germany, France and the Netherlands complete the top 5 of the most frequent destination countries.

Table 5.2: Post-doc destination regions and major countries

Destination region	Frequency	Percent
North America	582	0.58
Western Europe	208	0.21
Anglo-Saxon Europe	94	0.09
Mediterranean	63	0.06
	42	0.04
Central and Eastern Europe	9	0.01

Major destination country	Frequency	Percent
United States of America	582	0.58
United Kingdom	89	0.09
Germany	60	0.06
France	58	0.06
Netherlands	32	0.03
Spain	32	0.03
Switzerland	25	0.03
Italy	22	0.02

The source and destination countries reveal interesting information about mobility patterns, but say little about particular links between specific countries. Are researchers from, say, Italy more likely to be mobile to particular countries in Europe? Or are researchers from the UK more likely to be mobile to the U.S., perhaps because of the language link?

Table 5.3 presents the major degree country – destination country dyads, and includes the relative share of the degree country in a destination country's inflow of researchers. For example, the UK may attract 10% of all researchers in the sample, but 20% of all Italians – this means that the relative share of Italians in the UK's inflow is twice as high as expected, and suggests that Italians have a specific preference for the UK (or the UK has a preference for incoming Italian researchers). A relative share above 1 indicates that the inflow from a particular country is larger than expected given the average inflow into the destination

country. The relative share is only calculated for mobility flows of at least 10 individuals, because smaller flows tend to cause strong variation in this measure.

Table 5.3: Major PhD degree country – Post-PhD mobility destination country dyads

degree country	destination country	Freq.	Percent	Relative share
Italy	United States of America	96	9.62	0.87
Germany	United States of America	84	8.42	1.06
United Kingdom	United States of America	83	8.32	1.20
Spain	United States of America	83	8.32	1.12
France	United States of America	38	3.81	1.00
Netherlands	United States of America	29	2.91	1.04
Austria	United States of America	24	2.4	1.25
Belgium	United States of America	21	2.1	1.20
Italy	United Kingdom	20	2	1.18
Sweden	United States of America	19	1.9	1.05
Denmark	United States of America	18	1.8	1.06
Switzerland	United States of America	17	1.7	1.01
Italy	Spain	14	1.4	2.30
Italy	Germany	14	1.4	1.23
Finland	United States of America	14	1.4	0.86
Italy	France	13	1.3	1.18
Spain	United Kingdom	12	1.2	1.06
Germany	United Kingdom	12	1.2	0.99
Poland	United States of America	11	1.1	0.86
top 5 home degree country - destination country dyads				
Italy	United States of America	91	10.59	0.82
Spain	United States of America	82	9.55	1.11
Germany	United States of America	77	8.96	0.97
United Kingdom	United States of America	59	6.87	0.85
France	United States of America	34	3.96	0.90
top 5 EU degree country - destination country dyads				
United Kingdom	United States of America	24	17.27	0.35
Germany	United States of America	7	5.04	0.09
Netherlands	United States of America	7	5.04	0.25
Switzerland	United States of America	7	5.04	0.41
Italy	United States of America	5	3.6	0.05

The flow of Italians to Spain is 2.3 times larger than expected given Spain's average attractiveness. This special link may be due to similarities in language and culture. Certain degree countries also have relatively larger flows to the United States, such as Austria,

Belgium and the United Kingdom. Other countries send relatively fewer researchers to the United States, among which Italy, Poland and Finland. For Italy, this is partly explained by a disproportionate preference for mobility within Europe, in particular to the UK, Germany, France and Spain, as already mentioned.

The two lower panels of table 5.3 contain the 5 most important dyads for researchers who obtained their PhD in their birth country and outside their birth country, respectively. For researchers with a home degree, the Italy – U.S. and Spain – U.S. dyads are the most important. For researchers who obtain their degree outside their birth country, by contrast, the flow between the United Kingdom and the U.S. is the largest, indicating that the UK functions as a 'stepping stone' for mobility from other European regions to the U.S. To a lesser extent, Germany, the Netherlands and Switzerland fulfill the same role.

5.4 RESULTS

5.4.1 Mobility statistics

We first present some descriptive statistics on the post-PhD mobility patterns in the sample. In line with our data description above, we define four groups: researchers who obtain their PhD degree in their birth country and become intra-EU mobile (EU0-EU2) or mobile to the United States (EU0-US) and researchers who obtain their PhD degree in another European country and are mobile within Europe (EU1-EU2) or to the U.S. (EU1-US). Table 5.4 illustrates how the 998 researchers in our mobile sample are divided over these four groups.

Table 5.4: Composition of the sample in mobility groups

	degree in …		
	EU0 (birth country)	EU1 (other EU)	Total
Intra-EU mobility	342	74	416
%	*39.81*	*53.2*	*41.7*
Mobility to The United States	517	65	582
%	*60.19*	*46.8*	*58.3*
Total	859	139	998
%	*100*	*100*	*100*

Looking at the total sample of post-PhD mobile EU researchers, the majority, 58.3% or 582 researchers, are mobile to the U.S., while only 41.7% are mobile within the EU. However, looking only at the group of researchers who obtained their degree from another EU country, the likelihood of being mobile within the EU is significantly higher (53.2% or 139 researchers) compared to their peers with a degree from their birth country (39.8% or 859 researchers). A Pearson's chi square test confirms that degree mobility and intra-EU mobility are indeed related. The data thus confirm that intra-EU PhD mobility enhances intra-EU mobility at later stages of the research career. For EU researchers who obtained their PhD in another EU country, the EU becomes a more attractive destination than the U.S. for post-PhD mobility, as compared to non-PhD mobile researchers.

5.4.2 Factors influencing mobility

This section reports descriptive statistics on the factors which respondents indicated as having influenced their mobility decisions. Three sets of factors are considered: personal characteristics, motivations and external influencing factors. We will compare these factors across the four mobility groups: researchers with a degree from their birth country who move within Europe (EU0-EU2) and who move to the United States (EU0-US), and researchers with a degree from another European country who move within Europe (EU1-EU2) and to the United States (EU1-US). T-tests comparing the degree mobility groups (EU0 versus EU1) and comparing intra-EU mobility to U.S.-mobility within degree mobility groups are also reported.

A first set of variables include the personal characteristics of researchers: gender, age, marital status, children and type of employer (academic versus industry). Most personal characteristics probably influence the costs of mobility: researchers who are married or cohabiting often need to take the preferences of the spouse into account in their mobility decision. For example, several types of temporary visas in the United States allow researchers to bring dependents but do not automatically grant them a work permit, whereas within the European Union there is no such work permit restriction for mobile EU nationals. Children also increase mobility costs, bringing considerations of school quality and availability of accommodation into the equation. By contrast, age influences the period over which the benefits of mobility can be enjoyed: younger researchers can enjoy the benefits of mobility over a longer time period than their older colleagues. Type of employer probably

influences both the benefits and costs of mobility: in academe, mobility is often expected of researchers, and can lead to large benefits, and the labor market for academic researchers tends to be international, inducing cross-border mobility. By contrast, opportunities for mobility are probably more restricted for researchers working in the private sector, unless if they move internationally within a large multinational firm, for example.

Table 5.5 compares these characteristics for the 4 mobility groups. In the total sample, 73% of respondents are male, 80% are married and 64% have children, and the average respondent is a little over 44 years old. Few significant differences arise across the different mobility groups, with the exception of age and employer. Researchers with a PhD degree obtained in another European country are significantly younger and less likely to currently be working for an academic employer, as compared to researchers with a degree from the birth country. Compared to researchers with a birth country degree who are intra-EU mobile after their PhD, researchers who are mobile to the United States are significantly older as well as more likely to be working for an academic employer.

Table 5.5: Personal characteristics by mobility groups

Mobility categories	Male	Age	Married/cohabiting	Children	Academic employer
EU0	0.74	44.93	0.81	0.64	0.76
EU0-EU2	0.75	43.75	0.8	0.65	0.73
EU0-US	0.73	45.72***	0.82	0.64	0.79**
EU1	0.68	41.71°°°	0.75°	0.64	0.68°°
EU1-EU2	0.68	42.37	0.78	0.68	0.64
EU1-US	0.66	40.97	0.72	0.60	0.74
Total	0.73	44.48	0.80	0.64	0.75

Note:* t-tests done comparing intra-EU and US mobility within degree mobility groups;
° t-tests done comparing EU0 degree to EU1 degree

The second set of variables of interest is the researcher's motivations for mobility. The survey asked researchers to score 7 motivations on a scale from 1 to 5, ranging from not important at all to extremely important. These motivations are

1. personal education and/or research agenda (i.e. the content and direction of the respondent's research)
2. career progression goals (the possibility for the respondent's career as a researcher to evolve further)

3. getting access to the facilities or equipment necessary for the respondent's research
4. the prospect to work with leading experts ('star scientists') in the respondent's field of research at (or close to) the respondent's new employer
5. personal/family factors
6. personal interest in the culture of the country
7. salary and other financial incentives

A principal component analysis was done to check whether these motivations could be regrouped into a smaller number of factors. The individual motivations are grouped into 3 composite motivations: career motivations, comprised of the first four motivations, personal motivations, of the next two, and financial motivations.

Career motivations and financial motivations arguably influence the benefit side of mobility: career motivated or financially motivated researchers probably expect higher professional benefits from mobility than researchers who move for personal or family reasons. Therefore researchers who care more about career advancement or financial rewards should be attracted more to destinations which offer better opportunities to realize these ambitions. Additionally, if the costs of mobility are higher, then stronger career motivations or financial motivations may be needed to offset the costs. If mobility costs are correlated with distance, as is often assumed in migration studies, this would imply that researchers mobile to the U.S. should have higher career or financial motivations than researchers mobile within the EU.

Table 5.6: Motivations by mobility groups

Mobility categories	Mean career motivations	Mean personal motivations	Mean financial motivations
EU0	3.87	2.48	2.63
EU0-EU2	3.71	2.43	2.65
EU0-US	3.97**	2.52	2.62
EU1	3.81	2.47	3.02°°°
EU1-EU2	3.55	2.48	2.89
EU1-US	4.12**	2.51	3.2
Total	3.86	2.49	2.69

Note:* t-tests done comparing intra-EU and US mobility within degree mobility groups;
° t-tests done comparing EU0 degree to EU1 degree

Career related motivations are the most important motivations for mobility for all groups, dominating financial motivations as well as personal motivations. This suggests that the expectation of furthering one's career goals or improving access to resources that can help to achieve this seem the most important factor to explain migration flows. Comparing the motivations between EU- and U.S.-mobile groups reveals that researchers mobile to the U.S. report significantly higher career motivations, regardless of where they obtained their PhD. Researchers with PhD mobility experience are more likely to be motivated by financial reasons, regardless of their destination, compared to researchers with a PhD from their home country. Surprisingly, salary motivations are not significantly higher for U.S.-mobile researchers, although in Europe the perception seems to be that low salaries and a lack of flexibility in terms of wage offers is a significant handicap in attracting and retaining talented researchers. The other motivations are not significantly different across groups.

The third group of explanatory variables covers external influencing factors in the decision to become mobile. Again, the survey asked respondents to score 8 external influencing factors on a scale from 1 to 5. These external influencing factors are:

1. immigration regulations (e.g. immigration law, labor permission law, law of residence permission)
2. pension and social care provisions in the destination country
3. obtaining funding for own research
4. potential loss of contacts with the respondent's professional network at the location where he or she previously worked
5. work permission for partner (and other family members)
6. availability of adequate schools for children
7. quality and cost of accommodation
8. language

The external influencing factors were also regrouped into a few composite factors: regulatory factors, which include factors 1 and 2, and personal factors, including factors 5, 6 and 7. The remaining influencing factors are included individually.

Most external influencing factors probably influence the cost side of the mobility decision. Researchers who report stronger concern about these factors may experience higher mobility costs than researchers who report weaker concerns with external influencing factors. Given

that our sample consists only of mobile researchers, we expect that most researchers will on average indicate that external influencing factors were not very important in their mobility decision. Insofar as particular influencing factors are deemed important, it is interesting to see if there any significant differences between the EU and the U.S. on this cost side.

In general, obtaining research funding is the most important external factor influencing mobility, closely followed by language, while regulatory factors are the least important. Note, however, that all external influencing factors are on average rated as unimportant with scores below 3. Researchers who obtained their PhD in another EU country and move to the U.S. are more likely to attach importance to obtaining funding for their own research compared to their peers who remain mobile within the EU. Researchers mobile from their birth country to the U.S. attach more importance to personal factors. Concerns about language receive a larger weight in the mobility decision of U.S.-mobile researchers, regardless of PhD-mobility. This might reflect the fact that English may present a lower language barrier for the United States than other languages within Europe – even though French and German speakers may have various mobility opportunities within Europe that do not require learning a new language.

Table 5.7: External influencing factors by mobility groups

Mobility categories	Mean regulatory factors	Mean funding	Mean loss of contacts	Mean personal factors	Mean language
EU0	1.75	2.82	2.08	2.1	2.76
EU0-EU2	1.75	2.85	2.06	2	2.5
EU0-US	1.75	2.8	2.1	2.16**	2.93***
EU1	1.91°°	2.97	2.18	2.13	2.57°
EU1-EU2	1.92	2.72	2.22	2.05	2.28
EU1-US	1.91	3.29**	2.12	2.26	2.91***
Total	1.77	2.84	2.1	2.1	2.73

Note:* t-tests done comparing intra-EU and US mobility within degree mobility groups;
° t-tests done comparing EU0 degree to EU1 degree

5.4.3 Regression analysis

In this section, we examine econometrically whether researchers mobile to the United States differ in their personal characteristics, motivations and external influencing factors compared to their peers who are mobile within Europe.

We use a logit model with the probability to become mobile to the U.S. relative to the EU as the dependent variable. The main explanatory variables of interest are the motivations and external influencing factors. To test whether mobility during the PhD influences the post-doc mobility destination, we also include a dummy for researchers who have obtained their degree in a European country other than their birth country. The results of the logit analysis are reported in Table 5.8. To further test the influence of pre-doc mobility, we perform a split logit analysis with separate regressions for PhD-mobile and non-PhD-mobile researchers. These results are reported in Table 5.9.

As control variables we include age, gender, time since degree, a dummy for a current job in industry, research field, dummies for different regions of birth within Europe, and a quality indicator for the published research of the degree country[71]. Marital status and children are not included in the regressions, because these were reported at the time of the survey, as opposed to the time of mobility. Researchers who are married now might not have been married at the time of the mobility event, and coefficients for these variables, if included, would probably be biased downwards.

Researchers are divided into cohorts based on when they obtained their PhD degree. As the timespan covered by the survey is rather wide, we aggregate the cohort effects into three 10-year windows for researchers who obtained their PhD less than 10 years ago, between 10 and 20 years ago, and between 20 and 30 years ago. A fourth cohort dummy is included for researchers who obtained their PhD more than 30 years ago. The most recent cohort serves as the base group. Ten-year cohort windows may be too wide to capture all the events and short-term trends that affect researchers mobility outcomes. However, they should capture broad trends such as the progress in European integration and the long-term evolutions in the general working conditions of researchers in the United States and Europe. As a robustness check, we also include a continuous time since degree variable instead of cohorts.

The dummies for research fields capture the four broad fields of researchers' PhD degrees: the exact sciences, the life sciences, social sciences and humanities (the base group). Opportunities for and expectations of mobility differ strongly across disciplines, as

[71] Please refer to the appendix of chapter 2 for a list of definitions.

discussed in the section on institutional context in the first chapter. Mobility is often a necessity in certain fields in exact sciences, like particle physics or astronomy, to be able to access certain specialized equipment which is only present in a few countries. By contrast, possibilities for mobility may be restricted in the humanities, which are often strongly embedded in local culture.

Likewise, researchers from different birth countries, or in this case, birth regions in Europe face different possibilities and constraints for mobility. For example, Eastern European countries tend to specialize in exact sciences such as mathematics and chemistry, whereas Western Europe and the United States are more strongly specialized in the life sciences. This also creates and limits opportunities for researchers in particular fields to move to countries with a certain specialization profile. We include dummies for 4 birth regions within Europe, i.e. Scandinavia, the Mediterranean countries, Central and Eastern European countries, and the Anglo-Saxon countries (Ireland and the UK). Western Europe serves as the base region.

Finally, we include a measure for the strength of the research environment in the degree country, measured as the relative impact of the degree country's publications. This measures is computed at the share of the degree country's citations in total world citations, divided by the share of the degree country's publications, divided by total world publications. The relative impact intends to capture whether the average publication in the degree country receives more or less citations than the average world publication. Researchers who obtained a degree in a country with a strong research performance have probably enjoyed a higher quality graduate education, and may have more opportunities for international mobility than researchers with a degree from a country with a weaker scientific performance.

Researchers who obtained their PhD degree in another European country than their birth country are less likely to be mobile to the United States. The marginal effect of being intra-EU degree mobile for the average male, western European researcher in the exact sciences and from the most recent cohort is a 9% decrease in the probability of mobility to the U.S. This confirms, as also found in the descriptive statistics, that degree mobility within Europe creates a precedent for follow-up intra-EU mobility as a researcher. Perhaps intra-EU mobility experience as a student lowers the costs of mobility within Europe relative to mobility to the United States, for example by establishing networks. It could also be that the

motivations to become mobile in Europe as a student are similar to the motivations to stay mobile in Europe as a researcher, for example if researchers become mobile to a European country that is more specialized in a particular subdiscipline than the United States, or geographically or culturally closer. It is also possible that degree mobility changes researchers' motivations and perceptions of external influencing factors – something we check later in this section.

The econometric results further confirm the importance of career motivations for mobility to the U.S.: researchers who indicate that career motivations were important in their decision to become mobile are more likely to be mobile to the United States than intra-EU. The marginal effect for an average researcher of a one-unit increase in career motivations is a 13% increase in the probability to become mobile to the United States. This could be because stronger career motivations are needed to offset the potentially larger cost of mobility to the United States due to the longer distance and stronger immigration barriers. It could also reflect that the United States is seen as a better destination than the EU for researchers who want to advance their career and further their research agenda. The other two motivation components, personal and financial, are not significantly different between the two mobility groups. Once career motivations are controlled for, financial motivations are not more likely to lead to mobility to the U.S. compared to intra-EU mobility.

Mobile researchers do not appear to differ significantly in their personal characteristics: neither gender, nor age, nor cohort, nor a current job in industry are significantly related to an increased probability of mobility to either destination. Replacing the cohort dummies with a single continuous variable measuring time since degree reveals that more recently graduated researchers are more likely to be mobile within the EU, which suggests that intra-EU mobility is on the rise in recent years (see appendix table A.5.1).

Replacing the composite career motivations variable with its constituent individual motivations (column 2) suggests that career progression goals and the prospects to work with leading experts ('star scientists') in their field are the significant motivations that direct researchers towards the United States rather than to another EU country. Star scientists are indeed more concentrated in the United States (Laudel, 2003), so researchers who are motivated by the prospect to work with them are primarily oriented towards the U.S. With

respect to career progression goals, compared to the U.S., there is still relatively substantial heterogeneity in Europe in terms of internal governance and typical career progression (Haeck, 2012), which could hinder mobility within Europe through a lack of comparability of job titles and promotion practices.

Concerns about obtaining funding for their own research make researchers significantly less likely to choose the United States rather than the EU as destination for post-PhD mobility: a one-unit increase in concern about funding reduces the probability to go the U.S. by 3%. This suggests that the initiatives taken by the European Union and Member States to make enough funding available for mobility have the result of increasing mobility within Europe, diverting mobility away from the U.S.

Regulatory influencing factors make researchers less likely to choose the United States rather than the EU as a destination for post-PhD mobility: a one-unit increase in concerns about regulatory factors decreases the probability of mobility to the U.S. for an average researcher by 4%. This suggests that the initiatives taken by the European Union and Member States to reduce administrative barriers to mobility have helped to stimulate mobility within Europe, diverting mobility away from the U.S. This holds particularly for pension and social care regulations (column 2). The more researchers are concerned with pensions and social care provisions, the less likely they are to be mobile to the U.S. Indeed, pension and social care provisions tend to be more generous in Europe than in the United States, so it makes sense for researchers who attach greater importance to these things to remain mobile within Europe. By contrast, the more weight researchers give to immigration regulations, the more likely they are to be mobile to the U.S. However, from the questionnaire it is not clear whether respondents interpreted immigration regulations as a hindrance to be overcome ("I became mobile to the U.S. despite the immigration regulations") or a factor limiting their destination options ("I became mobile to the U.S. because immigration regulations prohibited me from becoming mobile within the EU"). As the latter interpretation seems unlikely, given that within the European Union there should be next to no immigration regulations for EU citizens, we suspect that the positive coefficient on immigration regulations reflects the fact that immigration regulations necessarily received more weight in the mobility choice of researchers who ended up becoming mobile to the United States.

Personal influencing factors make researchers more likely to become mobile to the United States. Apparently researchers find it easier to move their families to the United States than within Europe[72]. Language is also a positively contributing factor for the U.S. destination, probably because English is the *lingua franca* in science as well as most people's second language.

Researchers from the Mediterranean and from Central and Eastern Europe are less likely to become mobile to the United States, all else equal. Mediterranean countries and Eastern Europe tend to specialize in different disciplines than the United States and Western Europe, putting a stronger accent on exact sciences such as mathematics and chemistry and less on 'capital-intensive' disciplines such as life sciences. Additionally, cultural differences with the United States might be bigger from the perspective of these regions compared to other regions of Europe. By contrast, researchers from the Anglo-Saxon countries are more likely to be mobile to the U.S., perhaps because of cultural similarities, beyond language. It could be that researchers from countries with a weaker scientific performance do not have the necessary skills to move to research institutions in the United States, which is at the technology frontier. However, this is not confirmed by our measure for the relative impact of the publications of a researcher's degree country, which fails to have a significant impact on the destination choice.

A Chow test indicates that PhD-mobile and non-PhD-mobile researchers do not have jointly significantly different coefficients. Wald tests for separate groups of explanatory variables also indicate no significant differences between these two groups: neither the personal characteristics, nor the motivations nor the external influencing factors are jointly significantly different for these two groups. However, this does not preclude certain factors from differing individually between PhD-mobile and non-PhD-mobile researchers. To further investigate the difference between those researchers who obtained their PhD degree in another European country versus in their birth country, we run the econometric analysis on a split sample. This allows us to check whether the influence of personal characteristics,

[72] Surprisingly, none of the components of personal influencing factors were individually significant. A Wald test confirms that work permission for the spouse, adequate schools and accommodation are not jointly significant.

motivations and external influencing factors affect the destination choice differently for both subgroups. Results are reported in Table 5.9.

The importance of career motivations to move to the U.S. rather than within the EU holds for both groups, as do the personal influencing factors. The importance of access to funding, favoring the EU rather than the U.S. as destination, is only significant for the group of researchers with a PhD from the birth country. This would suggest that it is particularly national funding access that crowds out mobility to the U.S.

Potential loss of contacts is a significant concern for choosing the EU rather than the U.S. as a destination for those with a PhD from another EU country. Perhaps researchers who are mobile as students have to make more efforts to build a network in their host country, and are more fearful to lose these new contacts if they move away too far[73].

Finally, language is a factor increasing the probability to choose the U.S. rather than another EU country as destination only for researchers with a degree from the home country, while language is no significant factor in destination choice for researchers with a degree from another EU country. This suggests that mobility experience within Europe lowers language barriers[74].

Researchers from Central and Eastern Europe and from the Mediterranean who obtain their PhD in their birth country are less likely to move to the United States, which may reflect differences in field specialization, as well as that the difference in terms of distance to the knowledge frontier between both research systems might be too large to bridge. Researchers from these regions who obtained their degree in another EU country, however, experience no such barriers. For Central and Eastern Europe and the Mediterranean, degree mobility within Europe could be a stepping stone for later mobility to the United States. The Anglo-Saxon preference for the U.S. holds significantly only for those with a PhD from their birth country. For researchers who have intra-EU degree mobility experience no geographic effects are significant.

[73] An interaction term between EU-degree mobility and funding in the full sample is significantly different from zero at the 5% level, for the potential loss of contacts at the 10% level, respectively (results not reported here).

[74] These results are however not very strong. An interaction term between EU-degree mobility and language in the full sample is not significantly different from zero

For researchers who have obtained their PhD degree elsewhere in Europe, the relative research strength of the PhD degree country matters for the destination choice of the post-PhD mobility: the higher the research strength of the PhD degree country, as measured by the more citations its publications attract on average, the higher the odds that this researcher will be mobile to the U.S. rather than to another EU country. This implies that although intra-EU degree mobility appears to divert mobility in later stages of the research career from the U.S. to the EU, this diversion away from the U.S. is mitigated when the PhD degree is obtained in a country with a strong science environment. In the full sample model, the interaction between the EU-PhD dummy and the relative impact of the degree country's publications is also positive and significant at the 5%-level (results not reported here).

Table 5.8: Logit model for mobility to the U.S.

VARIABLES	(1) Mobility to US	(2) Mobility to US
1 if male	-0.212	-0.210
	(0.165)	(0.168)
Age in years	0.00257	0.00696
	(0.0155)	(0.0159)
Cohort 10-19	-0.0631	-0.0250
	(0.214)	(0.220)
Cohort 20-29	-0.0464	-0.0551
	(0.354)	(0.361)
Cohort 30-49	0.727	0.827*
	(0.489)	(0.501)
Industry	0.0851	0.0209
	(0.399)	(0.412)
Degree in other EU country	-0.387*	-0.363
	(0.225)	(0.230)
Career motivations	0.582***	
	(0.0999)	
Education/research agenda		0.00295
		(0.0793)
Career progression goals		0.336***
		(0.0778)
Access to facilities		0.0191
		(0.0641)
Star scientists		0.273***
		(0.0736)
Personal motivations	-0.0178	0.0322
	(0.0849)	(0.0875)
Money motivations	-0.0100	-0.00499
	(0.0648)	(0.0679)
Regulatory influencing factors	-0.169*	
	(0.0995)	
Pension/social care provision		-0.481***
		(0.110)

(Table 5.8 continued)

Immigration regulations		0.285***
		(0.106)
Research funding	-0.120**	-0.117*
	(0.0594)	(0.0607)
Loss of contacts	-0.0883	-0.0864
	(0.0725)	(0.0744)
Personal influencing factors	0.193**	
	(0.0898)	
Work permission partner		0.0782
		(0.0761)
Adequate schools		0.116
		(0.0806)
Accommodation		-0.0458
		(0.0880)
Language	0.358***	0.341***
	(0.0652)	(0.0666)
Exact Sciences	0.122	-0.0397
	(0.268)	(0.278)
Life Sciences	0.387	0.249
	(0.336)	(0.344)
Social Sciences	-0.176	-0.302
	(0.284)	(0.294)
Mediterranean	-0.428**	-0.410**
	(0.195)	(0.200)
Anglo-Saxon Europe	0.725**	0.709**
	(0.321)	(0.327)
Scandinavia	-0.290	-0.323
	(0.253)	(0.260)
Central and Eastern Europe	-0.655*	-0.622*
	(0.348)	(0.354)
Relative impact per degree country publication	0.430	0.369
	(0.580)	(0.592)
Constant	-2.575**	-2.835***
	(1.007)	(1.038)
Observations	998	998
Pseudo R^2	0.1047	0.1310

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 5.9: Logit models for mobility to the U.S.: EU degree versus home degree

VARIABLES	EU0 Mobility to US	EU1 Mobility to US
1 if male	-0.235	-0.290
	(0.182)	(0.480)
Age in years	0.00810	-0.0322
	(0.0167)	(0.0537)
Cohort 10-19	-0.0952	0.337
	(0.232)	(0.704)
Cohort 20-29	-0.0590	-1.381
	(0.378)	(1.577)
Cohort 30-49	0.654	0.469
	(0.524)	(1.824)
Industry	0.253	-0.536
	(0.472)	(0.968)
Career motivations	0.562***	0.657**
	(0.110)	(0.306)
Personal motivations	0.00763	-0.195
	(0.0932)	(0.242)
Money motivations	-0.0109	0.191
	(0.0717)	(0.190)
Regulatory influencing factors	-0.150	-0.424
	(0.110)	(0.292)
Research funding	-0.182***	0.180
	(0.0645)	(0.197)
Loss of contacts	-0.0331	-0.567**
	(0.0791)	(0.234)
Personal influencing factors	0.177*	0.500*
	(0.0992)	(0.272)
Language	0.370***	0.317
	(0.0717)	(0.196)
Exact Sciences	0.0732	-0.186
	(0.294)	(0.825)
Life Sciences	0.508	-1.112
	(0.366)	(1.143)
Social Sciences	-0.148	-1.082
	(0.313)	(0.829)
Mediterranean	-0.743***	-0.122
	(0.239)	(0.526)
Anglosaxon Europe	0.756**	1.958
	(0.340)	(1.245)
Scandinavia	-0.310	0.360
	(0.266)	(1.087)
Central and Eastern Europe	-1.686***	0.139
	(0.511)	(0.589)
Relative impact per degree country publication	-1.183	3.368**
	(0.794)	(1.654)
Constant	-1.032	-4.697
	(1.225)	(3.126)
Observations	859	139
Pseudo R^2	0.1051	0.2190

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

5.5 CONCLUSION

Using a sample of 998 European-born researchers who obtained their PhD in Europe, we study the differences in personal characteristics, motivations and perceived external influencing factors between researchers who are internationally mobile within Europe or internationally mobile to the United States. We find that career motivations are more strongly related to mobility to the United States. This suggests that the U.S. is still perceived as a strong destination country for advancing one's research career. However, researchers with previous mobility experience as PhD students within Europe are more likely to remain internationally mobile within Europe. These researchers have a different perception of external influencing factors, in particular of the potential loss of contacts and access to funding. Personal influencing factors, which includes things like obtaining a work permission for a spouse, availability of adequate schools for children and the quality and cost of accommodation, are linked to mobility to the United States, suggesting that it is easier for researchers to move a family to the United States than within Europe. Financial motivations are not significant in determining the location choice for post-doc mobility. Language barriers continue to hinder intra-EU mobility. Finally, intra-EU degree mobility is apparently also used as a 'stepping stone' for later mobility to the U.S.: researchers who leave their birth country to obtain their PhD in a European country with a strong scientific performance are more likely to become mobile to the United States later in their career.

This analysis suffers from several drawbacks. First, although it is interesting to know how certain factors relate to mobile researchers' destination outcomes, we cannot answer the logically preceding question, which is what factors are related to researchers' choice to become internationally mobile or not. Which factors are a motivation for mobility, and which factors are perceived as a barrier? And are the motivations and barriers for mobility to the U.S. perceived as lower or higher than within the EU? To answer these questions, the survey should have been organized in such a way that the mobility outcome does not determine the wording of the questions, and hence, how these questions are interpreted by respondents. This would have allowed us to compare the non-mobile respondents in the sample to the mobile respondents.

A related drawback is that it is not always clear precisely how respondents interpret certain questions. For example, respondents were asked to what extent language was an important

factor in their decision to become mobile. This question asks respondents to assess the weight of language in the mobility decision, but it is not clear ex ante whether language enters the consideration positively (i.e. 'I became mobile to improve my language skills' or 'I chose the United States because I already speak English') or negatively ('I perceive overcoming language barriers as a cost of mobility'). The ambivalence of whether certain factors enter the mobility decision positively or negatively limits the scope of interpretation of our results, and leaves many question marks. Future versions of the survey might benefit from asking respondents to indicate whether a particular factor was considered a benefit or a cost besides asking to indicate the weight of that particular factor in the overall decision.

Finally, a few key variables that might influence mobility outcomes were not or only partially controlled for. One aspect is researchers' ability: presumably, researchers of high ability have more opportunities to become mobile, if their visibility and reputation aids them in getting international job offers or invitations for extended research stays. An interesting research question that we cannot answer is whether ability is related to researchers' destination choices. For example, are the most talented researchers more likely to become mobile to the United States, as is suggested by the 'elite brain drain' literature (Hunter et al., 2009; Laudel, 2003)? Another factor that would have been useful to include in the analysis is the family situation *at the time of mobility*, as opposed to the current family situation. The survey asked respondents to indicate the weight of family factors in their mobility decision, but again this do not capture whether family considerations entered the equation positively or negatively, and what particular aspects of family life influence mobility.

In conclusion, there are still many aspects of mobility, and of researcher mobility in particular, that remain underexplored or on which the evidence is inconclusive. To further our understanding of the factors that drive researchers to become mobile, indicators should continue to be improved and further extensive data collection is needed.

5.6 APPENDIX

Table A.5.1: Logit model with time since degree instead of cohorts

VARIABLES	Mobility to U.S.
1 if male	-0.250
	(0.166)
Age in years	-0.0212
	(0.0189)
Years since graduation	0.0402**
	(0.0189)
Industry	0.131
	(0.399)
Degree in other EU country	-0.362
	(0.225)
Career motivations	0.577***
	(0.0995)
Personal motivations	-0.00442
	(0.0852)
Money motivations	-0.0182
	(0.0647)
Regulatory influencing factors	-0.157
	(0.0993)
Research funding	-0.119**
	(0.0593)
Loss of contacts	-0.0824
	(0.0725)
Personal influencing factors	0.174*
	(0.0899)
Language	0.363***
	(0.0651)
Exact Sciences	0.127
	(0.268)
Life Sciences	0.401
	(0.335)
Social Sciences	-0.103
	(0.282)
Mediterranean	-0.427**
	(0.195)
Anglosaxon Europe	0.655**
	(0.321)
Scandinavia	-0.219
	(0.254)
Central and Eastern Europe	-0.646*
	(0.348)
Relative impact per degree country publication	0.377
	(0.582)
Constant	-1.980*
	(1.047)
Observations	998

CHAPTER 6

THE EFFECTS OF INTERNATIONAL MOBILITY ON RESEARCHERS: INTRA-EU MOBILITY VERSUS MOBILITY TO THE UNITED STATES

ABSTRACT[75]

Policy makers and scholars often assume that international mobility of researchers has positive effects, and should therefore be encouraged. Using unique survey data on European-born and European-educated researchers who are internationally mobile within Europe or to the United States, we find that researchers report positive effects from international mobility on a range of facets, including scientific productivity, research environment and future job opportunities. Researchers mobile to the United States consistently report stronger positive effects than their peers who are mobile within the EU. This apparent 'U.S. premium', however, is almost entirely due to selection.

[75] This chapter is joint work with Reinhilde Veugelers and Elissavet Lykogianni. It has benefited from the comments of Dirk Czarnitzki, Otto Toivanen and the participants of the ENID STI Conference (Rome, September 2011), the TEMPO Conference (Vienna, November 2011) and the BRICK Workshop (Turin, April 2012).

6.1 INTRODUCTION

International mobility of researchers is on the rise (Guellec and Cervantes, 2001), particularly as more and more countries introduce policies to selectively admit more highly skilled migrants or to stimulate native researchers to be mobile (OECD, 2008). This policy interest is on the presumption that international mobility is good for the research productivity of the mobile researcher herself, but also that it creates positive spillovers to the host country, and possibly also to the home country.

Mobility can affect research productivity positively through various channels: by improving the match between the researcher and her environment, through exposure to new ideas and methods, and by broadening the scope for complementarities and synergies with other researchers. There is experimental evidence that living abroad enhances various facets of creativity (Maddux and Galinsky, 2009). The effects of mobility will also depend on who becomes mobile: the most talented researchers who look to improve their performance further, or rather researchers from less prolific environments who become mobile to 'catch up' with the state of the art. Similarly, the quality of the research environment of the researcher's origin and destination are likely to mediate the effects of mobility.

Although the effects of mobility are an essential element of our appraisal of researcher mobility, we know relatively little of the empirical magnitude of the effects. Very few studies tackle this subject, and most are small-scale and focus on a particular destination, mostly the United States. In this paper, we provide evidence on the perceived effects of international mobility from a large survey on European researchers who have been mobile either to other European countries or to the U.S. The survey allows us to address several questions. First, what are the effects of international mobility of researchers, and are they positive as is often assumed? Second, are the effects of mobility mediated by a researchers' personal characteristics and geographic roots? And third, are the effects of mobility dependent on its specific destination?

These are important questions for policy making in Europe. Stimulating international mobility of researchers has been high on the policy agenda in Europe, implying that Europe anticipates positive effects from mobility on researchers' career development and

productivity. EU policy has tended to focus on stimulating intra-EU mobility, promoting the further integration of the European Research and Higher Education Area.

A more sensitive issue is the perceived outflow of talented European researchers to the United States. This raises the question whether the perceived effects of mobility to the United States are more positive than the effects of mobility within Europe. And if so, which are the specific areas in which the EU or the U.S. offer better 'returns to mobility'? And is this 'effect premium' due to a better research environment, or due to a selection process whereby the best and most motivated researchers are more likely to move?

We find that researchers report positive effects from international mobility on a range of facets, including scientific productivity, improvement of the working environment and future job opportunities. Researchers mobile to the United States consistently report stronger positive effects than their peers who are mobile within the EU. This apparent 'U.S. premium', however, is almost entirely due to selection: researchers mobile to the U.S. are more strongly career motivated and generally older, and have obtained their PhD degree in European countries with stronger science performances on average. Once this selection is accounted for, there are hardly any differences in the effects reported by U.S.-mobile and EU-mobile researchers. There are two exceptions to this finding, however: U.S.-mobile researchers continue to signal significant improvements in their access to infrastructure, and U.S. mobility still has a significant additional impact on the probability of strongly positive effects on patent output and professional experience.

The remainder of the paper is organized as follows: section 2 reviews the relevant literature on the effects of mobility, the possibility of a 'premium' for researchers mobile to the U.S. and how selection issues are dealt with by other authors. The third section describes the survey data. The fourth section presents the results, the fifth section concludes.

6.2 LITERATURE REVIEW

International mobility can be seen as an investment in human capital: an individual moves to a country or region where her talents can be put to more productive use. Increased productivity generates additional income which offsets the costs of the move (Becker, 1962).

There are several possible mechanisms that suggest how mobility can result in higher productivity or better career outcomes, some of which apply specifically to researchers.

Mobility can result in a better match between employer an employee, and researchers may be more productive in an environment that better matches their interests and abilities (Hoisl, 2007; Topel and Ward, 1992). Moreover, there is some evidence that in universities, immobility has a negative impact on research productivity. Researchers who remain employed at the institution where they obtained their PhD produce less publications, and collaborate less with researchers outside their own university (Horta et al., 2010).

International mobility is one of the prime mechanisms in the spreading of ideas (Goldin et al., 2011). For example, Azoulay et al. (2011) show that articles published before a scientist moves to a new location receive more citations from the destination after the move has occurred. The increased visibility of a researcher's work can broaden her professional network and enhance her general recognition in the field. The increase in citations also illustrates the positive spillovers of mobility on the destination environment, as new ideas are introduced to the mobile researcher's colleagues (Azoulay et al., 2011). Moreover, many foreign-born researchers make exceptional contributions to U.S. science, more than expected given their share in the population of scientists (Stephan and Levin, 2001).

The literature clearly suggests that international mobility will affect a researcher's productivity and career directly or indirectly. But does the destination of mobility determine the direction or the size of the effects, or are effects caused by the act of mobility itself? More specifically, is it true that mobility to the United States yields more beneficial effects for researchers compared to mobility within Europe?

In terms of top research performance, the United States continues to provide the most prolific environment. While the EU has been catching up with the U.S. in terms of quantity of publications, the United States nevertheless outperforms Europe when it comes to high-impact research in many scientific disciplines. Among the top-cited scientific publications (99^{th} percentile), the U.S. continues to represent more than half of the world's publications. In recent years, this position has been eroding only slightly (see table 6.1).

Table 6.1: Trends in publication shares across the quality distribution

All Fields	Share in all articles		Share in articles in top1 citation pc	
	1998	2008	1998	2008
US	34	29	62	52
EU	35	33	25	30

Source: Own calculations based on National Science Foundation, S&E Indicators 2010
Note: Top1: 99th percentile of citations received; 1998 are all 94-96 articles cited by 1998 articles; 2008 are all 04-06 articles cited by 2008 articles

Several authors hint that researchers located in the United States indeed perform better than researchers working elsewhere. Kahn and MacGarvie (2008) study the publication productivity of foreign-born researchers with a U.S. PhD, and compare a group of PhD recipients who were funded by the Foreign Fulbright program, which requires students to leave the U.S. upon completion of the program, to a comparable group of control researchers who did not receive this type of funding with a return requirement. They find that researchers who return to poorer countries publish less and are cited less, whereas returnees from richer countries have similar publication and citation records as their peers who remain in the U.S. All returnees, regardless of the wealth of their home country, collaborate less with American co-authors and more with home country co-authors (Kahn and MacGarvie, 2008). This indicates that U.S. location indeed matters in terms of opportunities for collaboration with U.S. scientists, and for researchers from certain countries, U.S. location has a significant impact on scientific productivity.

Hunter et al. (2009) study the migration patterns and scientific productivity of a sample of highly cited physicists, and find that internationally mobile physicists do not have a higher h-index compared to non-mobile peers, but U.S.-located physicists, be it U.S.-born or foreign-born, have a significantly higher h-index, by 13-19%. Similarly, Cardoso et al. (2009) study the early research performance of recent PhD recipients in labor economics, both from American and European universities. They find no significant difference between graduates from U.S. or European institutions, but graduates who are placed at U.S. institutions, and particularly at top institutions, publish significantly more quality adjusted articles. However, Cardoso et al. (2009) cannot distinguish whether this is because U.S. top institutions provide a better environment and more incentives to publish in high-quality journals, or because these institutions are able to attract the best researchers.

This observation touches on one of the biggest challenges in measuring effects of mobility: how to separate the effects of mobility and/or location from selection effects. If it is the case that the most talented and motivated researchers are more likely to become mobile or to move to the United States, then any positive effects we observe after mobility may be entirely due to this initial selection.

There are indications that the United States indeed attracts the best and brightest researchers, a phenomenon which has been coined the 'elite brain drain' (Hunter et al., 2009; Laudel, 2005). Among European students who receive a PhD in economics in the U.S., the best students are indeed more likely to stay in the U.S. to work at a top institution (see chapter 3). Similarly, Black and Stephan (2007) find that in several science and engineering fields, foreign PhD recipients who attended a top 10 program are significantly more likely to indicate an intention to stay for the first job. Gaulé (2010) observes that the 20% most productive foreign chemistry faculty in the U.S. are significantly less likely to return later in their career. Kahn and MacGarvie (2008) also assume a selection effect among PhD recipients who return, for which they try to correct by instrumenting return with funding and visa information.

In this paper, we examine how mobility of European researchers within Europe and to the United States affects several aspects of researchers' careers, ranging from research output to career development. On the basis of the arguments presented above, we expect to observe positive effects of mobility on researchers' publishing productivity and general recognition. We also check whether this is linked to improvements in the researcher's research environment, such as access to infrastructure or a network of professionals in the field, or in the researcher's professional experience. Finally, we also ask whether mobility improves researchers' future job opportunities, and whether it affects the technology transfer capabilities of those researchers involved in such projects.

Secondly, we check whether mobility to the United States is associated with more positive effects than mobility within Europe, as suggested by the literature. We find that mobility to the United States is indeed associated with significantly more positive effects, but this difference is almost entirely due to selection: researchers who become mobile to the United

States are, amongst other things, significantly more career motivated than their peers who remain mobile within the EU. Once this selection is controlled for, hardly any difference in effects of mobility to the United States and within Europe remains. The next section details the data we use for our analysis.

6.3 DATA

This paper is based on the same sample from the MORE survey data as in the previous chapter. In the survey, only the respondents who had experienced international mobility were asked to indicate whether a number of outputs had increased or decreased as a consequence of that mobility. The survey's setup has two important consequences. First, it does not allow the comparison of the effects of international mobility compared to immobility. We can only compare how the effects of mobility differ among different destinations of mobility (intra-EU mobility versus mobility to the United States). Second, the mobility effects measured in the survey are perceived effects, as opposed to objective, quantifiable effects. We do not know whether moving to the United States instead of moving to another European country will on average yield x more publications to a researcher compared to the counterfactual situation. We can only compare whether researchers *perceive* different effects on their publication output depending on where they move. An advantage of using self-reported, subjective effects is that it allows to study the effects of mobility on concepts that are hard to quantify with objective data, such as 'future career opportunities'. However, these effects are subjective and may be subjected to biases such as central tendency bias, i.e. avoiding extreme response categories, or social desirability bias, i.e. respondents portraying themselves in a more favorable light. Asking mobile researchers about the effects of mobility will likely result in a bias towards positive responses, as only researchers who expect positive effects from mobility are likely to become mobile. Therefore the descriptive statistics must be interpreted with care, as we do not correct for these possible biases. In the econometric analysis, however, we focus on the differences in responses between groups instead of the absolute values of the Likert scales, eliminating the need to correct for biases that we assume do not vary between the groups we study.

Specifically, the survey asks respondents to indicate whether they experienced a decrease or an increase as a consequence of mobility on 8 items, which we structure into 4 categories:

Chief output

1. Publication output
2. General recognition in the research community as a researcher

Research environment & research skills

3. Access to infrastructure and know-how
4. Access to an international network of professionals active in your field (or related fields)
5. Professional experience as a researcher

Career development

6. Future job opportunities in the country where you have previously worked/studied

Science-industry links

7. Patent output
8. Ability to work in the industrial sector

The first two effects, publication output and general recognition, are the chief output variables that hold our primary interest: do mobile researchers publish more, and does the impact of their work, in the form of general recognition by the research community, increase? The next three effects can be interpreted as indirectly enhancing a researcher's productivity by improving the researcher's working conditions: does the environment in which mobile researchers work improve, in terms of access to infrastructure and human resources? Or does mobility enhance their professional experience as a researcher? The sixth effect is straightforward: does mobility enhance researchers' future job prospects in the source country? Finally, effects 7 and 8 intend to capture whether researchers with science-industry links manage to patent more or find that their prospects to work in industry have improved.

In the survey, respondents were asked to indicate whether a particular item had strongly decreased, decreased, remained the same, increased or strongly increased, using a Likert scale from 1 to 5. Respondents had the option of answering 'not applicable' if a particular

item did not apply to them. Not all effects are relevant to all researchers in all fields. Patents, for example, are more common in the exact sciences than in humanities[76]. All effects are positively correlated, though few correlations exceed 0.50. The effects are clearly most strongly correlated within the four groups, however.

Table 6.2: Correlations between effects

		1	2	3	4	5	6	7	8
1	Publication output	1							
2	General recognitions	0.4581	1						
3	Access to infrastructure	0.3576	0.3772	1					
4	International network	0.3674	0.4823	0.4823	1				
5	Professional experience	0.4006	0.4694	0.4403	0.5199	1			
6	Future job opportunities	0.2023	0.3226	0.1554	0.2596	0.2686	1		
7	Patent output	0.3593	0.2686	0.2172	0.1297	0.1035	0.0588	1	
8	Ability to work in industry	0.2186	0.1998	0.3341	0.1929	0.1974	0.1708	0.4680	1

For this paper, we only study a subsample of the original survey of European-born and European educated researchers who become mobile within the EU or to the United States. The survey does not consider student mobility as a mobility event, only international moves after the highest degree was obtained. Since we cannot assess the effects of mobility to the U.S. or within the EU as a student, we choose to study only researchers who obtain their PhD in Europe, to keep our sample comparable with respect to educational achievements. Including European researchers with a PhD degree from the United States would entail studying the effects of mobility from the U.S. back to Europe, and this is difficult to compare to the effects of mobility in the opposite direction.

Our final sample for this paper consists of 998 European researchers with a European PhD degree, 582 of which are mobile to the United States and 416 who are mobile within Europe[77].

[76] More than half of the respondents responded that effects on patent output and ability to work in industry were not applicable to them. A little over a hundred researchers also did not indicate an effect on their access to infrastructure.

[77] Please refer to the previous chapter for more descriptive statistics on the sample.

6.4 RESULTS

6.4.1 Descriptive statistics

As mentioned in the data section, we only consider researchers with outward mobility experience, i.e. who move to the United States or within Europe after obtaining their degree in Europe, either in their birth country or in another European country.

Table 6.3 summarizes the frequency and percentage shares of each value the effects can take (from strongly decreased to strongly increased) for the 8 mobility effects covered in the survey, as well as the modus of each effect. On the whole, the majority of researchers perceive positive to very positive effects from mobility. The most frequently chosen value for most effects was 4, which corresponds with 'increased'. The effects related to industry-science links are most frequently perceived as neutral and/or negative: only 22% and 42% report positive to very positive effects on their patent output and their ability to work in the industrial sector, respectively. A small share of researchers report negative effects: 14% feel their future job opportunities have decreased, of which 4% feel they have strongly decreased, and 9% perceive a decrease in their patent output, of which 3% a strong decrease. Fewer than 6% of researchers report any negative effects on the remaining items. Given that there are so few observations with strongly negative and negative effects, we combine these two categories for the remainder of the analysis.

Table 6.4 displays the means of four dummy variables for negative, neutral, positive and strongly positive effects for the 8 different effects by destination of mobility. Mobility to the United States leads to positive effects more frequently than intra-EU mobility. A series of t-tests show that researchers mobile to the United States report positive effects (including positive and strongly positive effects) more frequently than researchers mobile within Europe. The effects of mobility to the U.S. are also significantly more likely to be strongly positive: for some effects, like patent output and general recognition, the difference between intra-EU mobile and U.S. mobile researchers is only significant at 10% for positive effects, but significant at the 1%-level for strongly positive effects.

At first sight, this suggests that mobility to the United States has larger perceived benefits for researchers in terms of productivity and career advancement. From a human capital perspective, it could be that these higher benefits are needed to offset the greater costs of moving across the Atlantic.

Table 6.3: Frequency of positive, negative and neutral effects

		strongly decreased	decreased	neutral	increased	strongly increased	total	modus
publication output	freq	6	46	237	481	217	987	4
	pct	*0.01*	*0.05*	*0.24*	*0.49*	*0.22*		
general recognition	freq	1	19	120	563	288	991	4
	pct	*0.00*	*0.02*	*0.12*	*0.57*	*0.29*		
access to infrastructure and know-how	freq	3	18	178	483	195	877	4
	pct	*0.00*	*0.02*	*0.20*	*0.55*	*0.22*		
access to an international network	freq	3	14	134	493	344	988	4
	pct	*0.00*	*0.01*	*0.14*	*0.50*	*0.35*		
professional experience	freq	3	9	39	481	461	993	4
	pct	*0.00*	*0.01*	*0.04*	*0.48*	*0.46*		
future job opportunities	freq	35	98	279	371	164	947	4
	pct	*0.04*	*0.10*	*0.29*	*0.39*	*0.17*		
patent output	freq	8	17	214	50	17	306	3
	pct	0.03	0.06	0.70	0.16	0.06		
ability to work in the industrial sector	freq	6	20	228	149	38	441	3
	pct	0.01	0.05	0.52	0.34	0.09		

Table 6.4: Probability of negative-neutral-positive-strongly positive effects by destination of mobility

		intra-EU	US	total
		%	%	
publication output	decreased	7.58	3.63	5.27
	neutral	25.67	22.84	24.01
	increased	48.41	48.96**	48.73
	strongly increased	18.34	24.57**	21.99
general recognition	decreased	2.93	1.38	2.02
	neutral	13.66	11.02	12.11
	increased	62.20	53.01*	56.81
	strongly increased	21.22	34.60***	29.06
access to infrastructure	decreased	4.13	1.17	2.39
	neutral	24.79	17.12	20.30
	increased	53.72	56.03***	55.07
	strongly increased	17.36	25.68****	22.23
access to professional network	decreased	3.18	0.69	1.72
	neutral	16.38	11.57	13.56
	increased	50.86	49.22***	49.90
	strongly increased	29.58	38.51***	34.82
professional experience	decreased	1.95	0.69	1.21
	neutral	5.11	3.09	3.93
	increased	54.26	44.33**	48.44
	strongly increased	38.69	51.89***	46.42
job opportunities	decreased	13.14	14.67	14.04
	neutral	35.05	25.58	29.46
	increased	38.40	39.71**	39.18
	strongly increased	13.40	20.04***	17.32
patent output	decreased	8.76	7.69	8.17
	neutral	74.45	66.27	69.93
	increased	14.60	17.75*	16.34
	strongly increased	2.19	8.28**	5.56
ability to work in industry	decreased	8.79	3.86	5.90
	neutral	55.49	49.03	51.70
	Increased	30.77	35.91**	33.79
	strongly increased	4.95	11.2**	8.62

Note: *** p<0.01, ** p<0.05, * p<0.1 for t-tests. For ‘increased’, the t-tests include the strongly increased category as well

6.4.2 Logit analysis

In this section, we verify whether the descriptive findings still hold up in a multivariate analysis. Does mobility for EU researchers to the United States still have stronger effects

compared to intra-EU mobility once other factors such as cohort and birth region are controlled for? We run a series of ordered logit regressions with the Likert scale from 1 to 4 (with the original categories 'strongly decreased' and 'decreased' collapsed into one) on each of the 8 items in the questionnaire as the dependent variables. The explanatory variable of interest is a dummy variable that is one if the researcher was mobile to the U.S. The base group of researchers is mobile within the EU. The results, along with a description of the control variables, are reported in appendix table A.6.1. The multivariate analysis confirms our earlier findings in the descriptive section. Mobility to the United States is significantly related to stronger positive effects across the board compared to mobility within Europe, even when other personal characteristics are controlled for.

We also check if mobility to the U.S. is mostly associated with the likelihood of experiencing positive effects instead of no effects, or with a greater likelihood of reporting strongly positive effects instead of merely positive effects or, by contrast, a smaller likelihood of negative effects compared to mobility within Europe. To examine this, we estimate a multinomial logit model with four possible outcomes: negative effects, neutral effects (the base outcome), positive effects and strongly positive effects. We again include the same explanatory variables as in the previous model. Table 6.5 contains the relative risk ratios for mobility to the U.S. – the complete regression tables can be found in appendix (tables A.6.2 and A.6.3). The relative risk ratios are the exponentiated coefficients, and are interpreted as the factor change in the relative probability of an outcome relative to the base outcome for a one-unit change in the associated explanatory variable.

The effect of mobility to the U.S. differs across various effects. For the ability to work in industry, access to infrastructure and access to an international network of professionals, mobility to the U.S. is associated with a lower probability of negative effects and higher probabilities of positive and strongly positive effects. For patent output, professional experience and general recognition mobility to the U.S. is only significantly related to a higher probability of strongly positive effects; it does not affect the likelihood of reporting negative or positive effects relative to neutral ones. For future job opportunities, mobility to the U.S. is associated with a higher probability of reporting positive effects, be they positive or strongly positive, compared to neutral effects. Finally, for publication output mobility to the U.S. works at the extremes: it decreases the probability of a negative effect, and

increases the likelihood of a strongly positive effect, but not of a positive effect relative to a neutral one. For all effects, mobility to the U.S. is clearly associated with a higher probability of strongly positive effects, and these effects are quite large: for example, U.S.-mobile researchers are 60% more likely to report strong increases in publication output, and 2.4 times more likely to indicate a strong increase in general recognition.

Table 6.5: Multinomial logit for negative, positive and strongly positive effects relative to neutral effects - relative risk ratios for mobility to the US

	decreased	increased	strongly increased
publication output	0.425***	1.188	1.600***
general recognition	0.473	1.121	2.079***
access to infrastructure	0.382*	1.722***	2.477***
international network	0.293*	1.563**	2.043***
professional experience	0.645	1.501	2.601***
future job opportunities	1.433	1.584***	2.113**
patent output	0.947	1.537	4.266**
ability to work in industry	0.371**	1.460*	2.405**

The regression models clearly indicate that mobility to the United States is associated with stronger positive effects of mobility. The question remains why. Do the United States provide a considerably better research environment, that helps researchers realize more of their potential than in Europe? Or do the United States manage to attract the most talented and motivated researchers, who report better effects of mobility because of their inherent ability, and not because the U.S. environment is better? The next section addresses these questions.

6.4.3 Propensity score matching

In this section, we check whether mobility to North America indeed has additional positive effects compared to mobility within Europe, or whether the positive effects we observe are due to selection, with more talented or motivated researchers having a higher probability to move to the U.S. We consider ‘mobility to the U.S.’ as a treatment (and, consequently, researchers mobile within Europe as the untreated control group), and use a matching model to match each ‘treated’ researcher to an ‘untreated’ one that is as similar as possible in his or her observed characteristics. We use propensity score matching, matching U.S.-mobile researchers to EU-mobile researchers with a similar propensity to move to North America.

We then calculate the differences in mobility effects between the matched treated and untreated groups, and check whether the differences remain significant.

To calculate the propensity score, we run a logit model for the probability of being mobile to the U.S. We use the first model from the previous paper, which includes age, gender, cohort, a dummy for current job in industry, scientific field, a dummy for an EU-degree outside the country of birth, the region of birth, motivations and external influencing factors and the relative impact of the degree country's publications, to proxy for the quality of the doctoral education the researcher received. The motivations include career motivations, personal motivations and financial motivations, whereas the external influencing factors are comprised of regulatory factors, personal factors, concerns about funding, potential loss of contacts and language[78].

The propensity score for each researcher is calculated as the predicted probability for U.S. mobility. We use kernel matching: each U.S.-mobile researcher is matched to all EU-mobile researchers, but those EU-mobile researchers with the most similar propensity score receive a larger weight, whereas those with a strongly differing propensity score get a smaller weight. This approach is more efficient than nearest-neighbor matching because it uses all available information[79]. It does, however, increase the standard errors because researchers who are very different from the treated group still receive a positive weight. The treated and untreated groups should be very similar in their observed characteristics after matching. Table 6.6 compares researchers' characteristics prior to and after matching.

Prior to matching, there are several significant differences between U.S.-mobile and EU-mobile researchers, as discussed also in the previous paper. U.S.-mobile researchers are significantly older, and consequently also from earlier cohorts. They are less likely to have been mobile within the EU for their PhD. U.S.-mobile researchers are more likely to be working in the life sciences, less likely to be from Mediterranean or Central and Eastern European countries, but more likely to come from an Anglo-Saxon country.

[78] Please refer to the previous chapter for more information on these variables.
[79] As a robustness check we also do nearest-neighbor matching. Although the outcomes are very similar, nearest-neighbor matching does not result in a 'perfect match', in the sense that some significant differences between the treated and untreated groups remain. Therefore we choose to use Kernel matching instead.

A number of factors hint at U.S.-mobile researchers being more motivated and/or talented. Although they are more concerned with personal influencing factors and language in their mobility decision, they are significantly more career motivated. U.S.-mobile researchers also obtained their PhD in countries whose publications have a relatively higher average impact compared to the degree countries of EU-mobile researchers. The kernel matching, however, manages to eliminate all significant differences between the treated group and the control group: no significant differences in observable factors are left after matching.

Table 6.6: Comparison of observable characteristics prior to and after matching (kernel matching)

	unmatched		matched	
variable	treated	untreated	treated	untreated
male	0.73	0.75	0.73	0.74
age	45.16	43.56**	45.13	45.04
cohort 10-19	0.29	0.35*	0.29	0.31
cohort 20-29	0.15	0.14	0.15	0.15
cohort 30-49	0.15	0.07***	0.15	0.14
industry	0.03	0.03	0.03	0.04
EU degree	0.11	0.18***	0.11	0.12
career motivations	3.99	3.69***	3.99	3.99
personal motivations	2.52	2.43	2.52	2.57
financial motivations	2.69	2.69	2.69	2.72
regulatory influencing factors	1.77	1.79	1.77	1.84
funding	2.96	2.84	2.96	2.91
loss of contacts	2.10	2.10	2.10	2.14
personal influencing factors	2.17	2.00**	2.17	2.25
language	2.92	2.46***	2.92	2.95
exact sciences	0.59	0.58	0.59	0.59
life sciences	0.12	0.08**	0.12	0.12
social sciences	0.22	0.26	0.22	0.22
Mediterranean countries	0.35	0.41	0.35	0.35
Anglo-Saxon countries	0.11	0.04***	0.11	0.10
Scandinavia	0.09	0.10	0.09	0.10
Central and Eastern Europe	0.09	0.15***	0.09	0.09
relative impact of degree country publications	0.94	0.91***	0.94	0.94

The matching procedure does not guarantee that heterogeneity between the treated and untreated groups is eliminated, as unobserved heterogeneity which is correlated with the mobility effects might remain unaccounted for. One important characteristic that remains

unobserved is the researcher's ability. If researchers with greater talent for research are more likely to move to the United States, then any positive effect from U.S. mobility could be attributable to this selection that we cannot control for directly. Researchers' ability is captured indirectly in such variables as the quality of the degree country or career motivations (assuming that more talented researchers are more likely to be mobile with the goals of furthering their research agenda or for education goals). However, ideally we would want to control for ability directly to be able to match researchers of similar ability. Unfortunately, the survey does not provide a direct measure of ability.

Table 6.7 compares the mean effects of U.S.-mobile and EU-mobile researchers before and after matching. Before matching, U.S.-mobile researchers report significantly higher effects across the board, as suggested by the analysis in the previous section. After matching, however, the U.S.-mobile researchers still have somewhat higher mobility effects compared to EU mobile researchers, but most differences are no longer significant. Researchers mobile to the United States still perceive more positive effects in their access to infrastructure and professional experience as a researcher. However, these advancements do not appear to translate into higher scientific output or increased general recognition, the main 'output' effects. Most positive differences in effects observed prior to matching are due to the selection of researchers with particular characteristics to the U.S. This suggests that there is no 'U.S.-effect' that makes mobility to the U.S. pay off more than mobility within the EU, but rather, the U.S. manages to attract the most motivated and talented researchers who are bound to experience positive effects from mobility anyway.

To check whether the significant differences in access to infrastructure and professional experience differ across fields, we redo the matching for three of the four fields separately: exact sciences, life sciences and social sciences. The results are reported in appendix tables A.6.4 to A.6.7. Matching could not be redone for the humanities, because it is the smallest group of researchers with only 77 respondents. After matching, the strongest differences in effects are found in exact sciences: in this field, researchers mobile to the U.S. report stronger positive effects on their access to infrastructure, professional experience, as well as a difference in publication output (although this difference is only significant at the 10%-level) compared to their peers mobile within the EU. In the life sciences, no significant differences in effects between EU-mobile and U.S.-mobile remain after matching. In the

social sciences, U.S.-mobile researchers report a significantly stronger increase in their perceived job opportunities compared to EU-mobile researchers. There appear to be significant differences in how researchers from different fields experience mobility effects, with researchers in the exact sciences reporting the most significant differences in effects between U.S. mobility and EU mobility. These results should be interpreted with caution, however, since the sample contains only 103 researchers in the life sciences and 236 in the social sciences, which is relatively little for a matching model.

Table 6.7: Propensity score matching (kernel): differences in effects

effect	NA mobile (treated)	EU mobile (untreated)	difference	t-stat
prior to matching				
publication output	3.94	3.76***	0.18	3.39
general recognition	4.21	4.01***	0.19	4.37
access to infrastructure	4.06	3.83***	0.23	4.58
international network	4.25	4.06***	0.19	4.14
professional experience	4.47	4.29***	0.18	4.42
job opportunities	3.61	3.49*	0.12	1.87
patent output	3.24	3.07**	0.17	2.06
work in industry	3.53	3.3***	0.23	3.13
after matching				
publication output	3.94	3.84	0.10	1.54
general recognition	4.21	4.16	0.05	0.95
access to infrastructure	4.06	3.90***	0.16	2.62
international network	4.25	4.19	0.06	1.08
professional experience	4.47	4.36**	0.11	2.12
job opportunities	3.61	3.58	0.03	0.39
patent output	3.24	3.13	0.11	1.07
work in industry	3.54	3.42	0.11	1.20

The multinomial logit model in the previous section indicated that U.S. mobility is consistently associated with a higher likelihood of strongly positive effects. Instead of using the ‘average effect’ on a scale from 1 to 5 as the outcome variable, we use a dummy variable that is 1 if the researcher reports a strongly positive effect. Table 6.8 displays the results for this kernel matching model for strongly positive effects.

Prior to matching, there are strongly significant differences in the probability of reporting strongly positive effects between U.S.-mobile and EU-mobile researchers. After matching,

several significant differences remain. Researchers mobile to the U.S. are significantly more likely to report strong increases in their patent output, a factor related to science-industry links, which are purportedly stronger in the U.S. The share of researchers reporting these strong effects is small, however: 8% of U.S.-mobile researchers report strong increases in patent output, compared to 1% of EU-mobile researchers. Also significantly higher, though only at the 10% level, is a strong increase in professional experience. There is no significant difference in the share of researchers who report strong increases in their access to infrastructure.

In conclusion, on average there does not appear to be a 'U.S. effect' for mobile European researchers, with the exception of access to certain research infrastructure and professional experience. Moreover, this result appears to be driven by researchers in the exact sciences. Finally, researchers mobile to the U.S. are more likely to experience strongly positive effects in patent output and professional experience compared to their peers mobile within the EU.

Table 6.8: Propensity score matching for strongly positive effects

effect	NA mobile (treated)	EU mobile (untreated)	difference	t-stat
prior to matching				
publication output	0.24	0.18***	0.06	2.33
general recognition	0.35	0.21***	0.13	4.61
access to infrastructure	0.26	0.17***	0.08	2.93
international network	0.38	0.29***	0.09	2.91
professional experience	0.52	0.38***	0.13	4.14
job opportunities	0.20	0.13***	0.07	2.66
patent output	0.08	0.02***	0.06	2.33
work in industry	0.11	0.05***	0.06	2.31
after matching				
publication output	0.24	0.22	0.02	0.67
general recognition	0.35	0.30	0.05	1.42
access to infrastructure	0.26	0.21	0.05	1.52
international network	0.38	0.38	0.00	0.20
professional experience	0.52	0.45*	0.07	1.87
job opportunities	0.20	0.17	0.03	0.96
patent output	0.08	0.01***	0.07	2.43
work in industry	0.11	0.06	0.05	1.55

6.5 CONCLUSION

Policy makers and scholars often assume that international mobility of researchers has positive effects, and should therefore be encouraged. However, to date the evidence of the effects of researcher mobility on researchers themselves remains limited. Using unique survey data on European-born and European-educated researchers who are internationally mobile within Europe or to the United States, we find that researchers report positive effects from international mobility on a range of facets, including scientific productivity, career development and future job opportunities. Very few researchers report negative effects of international mobility; most often signaled is a decrease of future job opportunities in the previous country of residence.

Researchers mobile to the United States consistently report stronger positive effects than their peers who are mobile within the EU. This apparent 'U.S. premium', however, is almost entirely due to selection: researchers mobile to the U.S. are more strongly career motivated and generally older, and have obtained their PhD degree in European countries with stronger science performances on average. After accounting for this selection with a propensity score matching model, there are hardly any differences in the effects reported by U.S.-mobile and EU-mobile researchers, with the exception of access to infrastructure. This suggests that Europe still needs to improve its scientific infrastructure if European researchers want to benefit equally from EU-mobility as from U.S.-mobility, particularly in the exact sciences More importantly, however, Europe needs to address this selection issue, and find out why the most motivated researchers go to the U.S. where they benefit more from mobility.

Moreover, although the average effects of mobility to the United States and within Europe are the same once the selection of researchers is accounted for, researchers mobile to the United States are significantly more likely to experience strongly positive effects on their patent output and professional experience. This suggests that the U.S. not only attracts the best researchers, but that these researchers are also more likely to achieve extraordinary progress by moving to the U.S. If Europe wants to continue to address the gap in scientific and technological performance with the United States, further research is needed to understand why certain researchers experience stronger positive effects in the U.S., and how policy can address these differences.

This research suffers from a few drawbacks, most notably because the effect measurements are based on self-reported survey data. This implies that the effects we observe are based on subjective evaluations of respondents, which might have difficulty to correctly assess the impact of mobility in the absence of a counterfactual. It is not straightforward to estimate how publication output or future job opportunities would have evolved had the researcher not become mobile. Moreover, survey respondents may have a tendency to provide high responses on rating scales (Sauermann and Roach, 2012), which could lead to an overestimation of effects.

To avoid the possible biases inherent to survey data in the measurement of mobility effects, one could use quantitative data such as publications, citations, and international collaborations. However, selection remains a major issue in this type of study, and is not easily controlled for, especially in the absence of good measures of researcher ability (Kahn and MacGarvie, 2008; Gaulé, 2010). Natural experiments or instruments which provide an exogenous source of variation in possibilities for international mobility are also not readily available.

Nevertheless, it is important to continue expanding and refining the data collection on researcher mobility, and particularly on the effects of mobility, to verify whether possibly expensive policies to stimulate mobility or to attract researchers from abroad have the positive effects they are often assumed to have.

6.6 APPENDIX

6.6.1 Ordered logit analysis of effects

In the first section of the appendix, we verify whether the descriptive findings of higher average effects of U.S. mobile researchers compared to intra-EU mobile researchers still hold up in a multivariate analysis. Does mobility for EU researchers to the United States still have stronger effects compared to intra-EU mobility once other factors such as cohort and birth region are controlled for? We run a series of ordered logit regressions with the Likert scale from 1 to 4 (with the original categories 'strongly decreased' and 'decreased' collapsed into one) on each of the 8 items in the questionnaire as the dependent variables. The explanatory variable of interest is a dummy variable that is one if the researcher was mobile to the U.S. The base group of researchers is mobile within the EU. The results of the ordered logit model are reported in table A.6.1.

As control variables, we only include variables which we consider as 'exogenous' to the mobility event[80]. These include gender, age, cohort, the field in which researchers obtained their highest degree, dummies for the different European regions of birth, and the impact of the degree country's published research. Scientific field may matter because of differences in the propensity to collaborate on publications and in mobility requirements for promotion. Also, in certain fields researchers may be forced to be mobile to be able to work in a specific subfield. Particle physicists, for example, often need access to a particle accelerator which not all countries possess. The degree fields are grouped into four major fields: exact sciences, life sciences, social sciences and the humanities (the base group). The birth region dummies should capture cultural and linguistic differences between different European regions which may hamper or facilitate mobility. Researchers from Mediterranean countries or Central and Eastern European countries may experience larger cultural differences and language barriers with the United States, for example, and make them less likely to move there. Finally, the last control variable – the impact of the degree country's research - is measured as the share of a country's citations in total world citations relative to the share of a country's publications in total world publications. It should capture the visibility of the

[80] The survey also includes data on motivations for mobility and external influencing factors, but these may be endogenous to the perceived effects of mobility.

degree country's research, and is a proxy for the quality of the training a researcher has received as a doctoral student.

As discussed in the main text, mobility to the United States is significantly related to stronger positive effects across the board compared to mobility within Europe, even when other personal characteristics are controlled for. There are few strong patterns in the control variables. Researchers in exact sciences, life sciences and the social sciences are more likely to experience positive effects on their ability to work in industry compared to researchers in the humanities, the base group. Researchers from the Anglo-Saxon countries are less likely to experience positive effects on their ability to work in industry, while researchers from Scandinavia are less likely to see their publication and patent output increase. Researchers from Central and Eastern Europe, by contrast, are more likely to experience positive effects on their access to infrastructure and professional experience.

Table A.6.1: Ordered logit for the effects of outward mobility

VARIABLES	(1) Publication output	(2) Recognition	(3) Access infrastructure	(4) International Network	(5) Professional experience	(6) Job opportunities	(7) Patent output	(8) Work in industry
Mobility to US	0.427***	0.555***	0.659***	0.484***	0.614***	0.328***	0.531**	0.632***
	(0.125)	(0.131)	(0.138)	(0.127)	(0.132)	(0.123)	(0.257)	(0.194)
1 if male	0.156	0.209	-0.177	-0.114	-0.0497	0.342**	-0.178	-0.0527
	(0.140)	(0.149)	(0.155)	(0.144)	(0.149)	(0.141)	(0.284)	(0.230)
Age in years	0.00851	-0.0188	-0.00782	-0.0102	-0.0221	-0.0228*	0.00661	-0.0105
	(0.0133)	(0.0137)	(0.0144)	(0.0134)	(0.0139)	(0.0129)	(0.0302)	(0.0197)
Cohort 10-19	0.312*	0.491**	-0.107	0.178	0.0955	-0.00717	0.226	0.116
	(0.187)	(0.195)	(0.204)	(0.190)	(0.196)	(0.183)	(0.417)	(0.274)
Cohort 20-29	0.210	0.502	-0.0437	0.322	0.562*	-0.184	-0.401	0.246
	(0.308)	(0.317)	(0.331)	(0.309)	(0.322)	(0.297)	(0.656)	(0.452)
Cohort 30-49	0.219	0.693	-0.469	-0.0313	0.262	-0.00619	0.0721	0.338
	(0.416)	(0.434)	(0.457)	(0.423)	(0.436)	(0.405)	(0.958)	(0.640)
Exact Sciences	-0.122	-0.391	-0.00315	0.0782	0.203	0.172	0.0253	1.221*
	(0.231)	(0.246)	(0.267)	(0.235)	(0.244)	(0.233)	(0.688)	(0.682)
Life Sciences	-0.143	-0.343	-0.00392	0.240	0.421	-0.0124	-0.342	1.300*
	(0.286)	(0.301)	(0.321)	(0.290)	(0.303)	(0.288)	(0.736)	(0.712)
Social Sciences	0.114	-0.371	-0.315	0.316	0.0930	0.304	0.291	1.583**
	(0.247)	(0.262)	(0.289)	(0.252)	(0.261)	(0.248)	(0.773)	(0.718)
Mediterranean	0.261	0.0842	0.108	-0.00525	0.201	0.0420	-0.0278	-0.270
	(0.165)	(0.171)	(0.181)	(0.168)	(0.175)	(0.165)	(0.351)	(0.258)
Anglosaxon Europe	-0.0494	-0.00442	-0.0230	0.00533	0.0197	-0.0661	-0.345	-0.787**
	(0.245)	(0.257)	(0.267)	(0.251)	(0.252)	(0.249)	(0.577)	(0.388)
Scandinavia	-0.652***	-0.284	-0.235	-0.187	0.0929	0.187	-1.003*	-0.324
	(0.222)	(0.228)	(0.247)	(0.221)	(0.230)	(0.210)	(0.551)	(0.351)
Central and Eastern Europe	0.344	0.202	0.578*	-0.187	0.586*	0.0302	0.131	-0.188
	(0.290)	(0.295)	(0.313)	(0.289)	(0.309)	(0.286)	(0.534)	(0.419)
relative impact per degree country publication	-0.723	0.473	-0.120	-0.389	-0.212	0.152	0.290	0.0253
	(0.465)	(0.485)	(0.505)	(0.464)	(0.498)	(0.465)	(0.860)	(0.672)
cut1								
Constant	-2.738***	-3.880***	-4.084***	-4.499***	-4.854***	-2.103***	-1.883	-1.827
	(0.768)	(0.815)	(0.871)	(0.808)	(0.851)	(0.756)	(1.738)	(1.342)
cut2								
Constant	-0.669	-1.790**	-1.549*	-2.151***	-3.362***	-0.518	1.939	1.343
	(0.758)	(0.788)	(0.846)	(0.775)	(0.813)	(0.752)	(1.737)	(1.344)
Cut3								
Constant	1.565**	0.986	1.037	0.233	-0.228	1.357*	3.532**	3.445**
	(0.759)	(0.787)	(0.845)	(0.771)	(0.801)	(0.754)	(1.749)	(1.351)
Observations	987	991	877	988	993	947	306	441

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A.6.2: Multinomial logit model for negative, positive and strongly positive effects relative to neutral effects (1-4) – relative risk ratios

VARIABLES	Publication output			General recognition			Access to infrastructure			International network		
	decreased	increased	strongly increased	decreased	increased	strongly increased	decreased	increased	strongly increased	decreased	increased	strongly increased
Mobility to US	0.425***	1.188	1.600**	0.473	1.121	2.079***	0.382*	1.722***	2.477***	0.293*	1.563**	2.043***
	(0.139)	(0.199)	(0.323)	(0.246)	(0.234)	(0.481)	(0.204)	(0.318)	(0.555)	(0.187)	(0.319)	(0.439)
1 if male	0.715	0.777	1.284	0.968	1.568**	1.570*	1.056	1.016	0.788	3.484	1.053	0.962
	(0.259)	(0.149)	(0.308)	(0.520)	(0.357)	(0.393)	(0.608)	(0.220)	(0.196)	(2.813)	(0.248)	(0.235)
Age in years	0.945	1.007	1.001	0.947	0.970	0.958*	0.893*	0.974	0.975	0.960	0.994	0.982
	(0.0379)	(0.0182)	(0.0213)	(0.0540)	(0.0213)	(0.0233)	(0.0560)	(0.0188)	(0.0224)	(0.0571)	(0.0216)	(0.0225)
Cohort 10-19	1.144	1.287	1.675*	1.774	1.526	2.408**	2.225	1.256	0.915	0.482	1.319	1.338
	(0.590)	(0.325)	(0.505)	(1.327)	(0.480)	(0.827)	(1.795)	(0.348)	(0.301)	(0.419)	(0.406)	(0.432)
Cohort 20-29	1.798	0.779	1.614	0.609	1.797	2.422	3.932	1.178	1.063	0	1.296	1.527
	(1.584)	(0.321)	(0.773)	(0.917)	(0.896)	(1.334)	(5.510)	(0.514)	(0.553)	(2.05e-08)	(0.648)	(0.801)
Cohort 30-49	3.756	1.301	1.773	3.286	2.850	4.299*	23.86*	1.232	0.684	1.698	0.885	0.959
	(4.652)	(0.739)	(1.188)	(5.977)	(1.981)	(3.304)	(43.71)	(0.736)	(0.500)	(2.999)	(0.592)	(0.680)
Exact Sciences	1.755	0.779	0.942	1.119	0.932	0.589	0.529	0.742	0.850	7.117e+07***	1.006	1.170
	(1.386)	(0.248)	(0.366)	(1.266)	(0.379)	(0.251)	(0.606)	(0.290)	(0.392)	(2.142e+08)	(0.364)	(0.458)
Life Sciences	3.647	0.810	1.100	1.439	0.878	0.631	0.951	0.646	0.929	6.857e+07***	1.143	1.529
	(3.157)	(0.321)	(0.517)	(1.900)	(0.432)	(0.326)	(1.246)	(0.298)	(0.500)	(2.213e+08)	(0.532)	(0.754)
Social Sciences	0.941	0.870	1.161	1.389	1.239	0.685	1.612	0.606	0.658	1.154e+08***	1.506	1.991
	(0.800)	(0.295)	(0.480)	(1.652)	(0.536)	(0.313)	(1.828)	(0.250)	(0.323)	(3.549e+08)	(0.609)	(0.860)
Mediterranean	0.707	1.392	1.326	0.341	0.961	1.018	1.562	1.503	1.194	0.797	1.270	1.078
	(0.317)	(0.308)	(0.348)	(0.233)	(0.275)	(0.314)	(1.082)	(0.374)	(0.351)	(0.601)	(0.345)	(0.307)
Anglosaxon Europe	1.821	1.220	1.095	2.726	0.798	1.006	1.528	1.088	1.001	2.481	0.646	0.898
	(0.994)	(0.402)	(0.416)	(2.100)	(0.342)	(0.448)	(1.412)	(0.380)	(0.423)	(2.401)	(0.239)	(0.336)
Scandinavia	1.147	0.584*	0.423**	0	0.746	0.514*	2.836	0.958	0.859	1.866	1.704	1.008
	(0.533)	(0.161)	(0.156)	(1.39e-09)	(0.252)	(0.200)	(1.913)	(0.299)	(0.331)	(1.739)	(0.639)	(0.413)
Central and Eastern Europe	0.537	1.287	1.574	0.205	2.461	1.743	0	1.785	2.501*	1.296	1.267	0.882
	(0.477)	(0.508)	(0.717)	(0.321)	(1.390)	(1.067)	(3.07e-08)	(0.818)	(1.291)	(1.449)	(0.595)	(0.442)
Relative impact per degree country publication	4.159	0.407	0.480	0.208	1.588	2.239	15.02	0.786	0.996	0.433	0.935	0.542
	(5.209)	(0.258)	(0.356)	(0.466)	(1.351)	(2.068)	(34.00)	(0.573)	(0.827)	(0.805)	(0.710)	(0.438)
Constant	0.580	3.832	0.721	11.82	5.716	3.181	0.572	8.305*	2.654	1.34e-08	2.718	4.544
	(1.235)	(3.969)	(0.881)	(39.58)	(7.670)	(4.629)	(2.042)	(9.888)	(3.678)	(0)	(3.386)	(5.961)
Observations	987	987	987	991	991	991	877	877	877	988	988	988

Standard error eform in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A.6.3: Multinomial logit model for negative, positive and strongly positive effects relative to neutral effects (5-8) – relative risk ratios

VARIABLES	Professional experience			Future job opportunities			Patent output			Ability to work in industry		
	decreased	increased	strongly increased	decreased	increased	strongly increased	decreased	increased	strongly increased	decreased	increased	strongly increased
Mobility to US	0.645	1.501	2.601***	1.433	1.584***	2.113***	0.947	1.537	4.266**	0.371**	1.460*	2.405**
	(0.458)	(0.522)	(0.910)	(0.324)	(0.265)	(0.456)	(0.420)	(0.523)	(2.940)	(0.174)	(0.328)	(1.005)
1 if male	1.485	1.751	1.497	0.895	1.501**	1.401	1.486	0.590	7.313*	0.849	1.086	0.701
	(1.177)	(0.649)	(0.555)	(0.222)	(0.290)	(0.337)	(0.829)	(0.209)	(8.128)	(0.426)	(0.293)	(0.299)
Age in years	1.052	1.042	1.013	0.997	0.972	0.965	0.979	1.016	0.886	1.004	0.992	0.971
	(0.0785)	(0.0423)	(0.0413)	(0.0243)	(0.0170)	(0.0225)	(0.0547)	(0.0393)	(0.0786)	(0.0435)	(0.0229)	(0.0410)
Cohort 10-19	0.892	1.288	1.350	1.026	1.088	0.996	2.032	1.352	7.673*	1.359	1.088	1.963
	(0.961)	(0.712)	(0.751)	(0.344)	(0.271)	(0.312)	(1.453)	(0.702)	(8.246)	(0.856)	(0.351)	(1.118)
Cohort 20-29	0.736	0.472	0.972	1.161	1.079	0.792	2.409	0.809	4.390	0.683	1.031	2.177
	(1.225)	(0.422)	(0.873)	(0.622)	(0.434)	(0.426)	(2.744)	(0.687)	(8.313)	(0.724)	(0.552)	(2.087)
Cohort 30-49	0.744	0.469	0.695	0.407	0.717	0.656	1.508	0.667	58.54	1.103	0.730	5.160
	(1.672)	(0.593)	(0.886)	(0.316)	(0.392)	(0.483)	(2.691)	(0.835)	(164.2)	(1.533)	(0.554)	(6.632)
Exact Sciences	1.658e+08***	1.175	1.531	1.510	1.081	2.417*	0.0978***	0.184**	2.720e+08***	0.0982***	3.425	0.557
	(6.695e+08)	(0.699)	(0.922)	(0.635)	(0.334)	(1.186)	(0.0850)	(0.134)	(1.007e+09)	(0.0834)	(3.775)	(0.505)
Life Sciences	4.138e+08***	1.114	1.912	0.879	0.460**	1.900	0.199*	0.247*	5.765e+07***	0.141**	3.737	0.750
	(1.753e+09)	(0.900)	(1.551)	(0.444)	(0.179)	(1.039)	(0.182)	(0.195)	(2.199e+08)	(0.138)	(4.213)	(0.722)
Social Sciences	3.889e+08***	1.205	1.462	0.833	1.134	1.972	0.0702**	0.367	2.56e-06	0.224	7.686*	0.802
	(1.617e+09)	(0.769)	(0.945)	(0.387)	(0.372)	(1.014)	(0.0917)	(0.304)	(25.84)	(0.213)	(8.698)	(0.829)
Mediterranean	2.002	1.358	1.623	0.870	1.206	0.865	0.677	1.339	0.420	0.503	0.615	0.670
	(1.757)	(0.603)	(0.722)	(0.254)	(0.274)	(0.238)	(0.421)	(0.624)	(0.313)	(0.321)	(0.187)	(0.332)
Anglosaxon Europe	0	1.085	1.027	1.816	1.576	1.343	1.259	0.804	0.709	2.702	0.632	0.451
	(8.19e-08)	(0.667)	(0.634)	(0.736)	(0.569)	(0.563)	(1.138)	(0.689)	(0.641)	(2.004)	(0.287)	(0.326)
Scandinavia	1.805	2.849	2.628	0.236***	1.092	0.560	1.202	0.279	0	1.562	0.794	0.795
	(2.464)	(2.194)	(2.041)	(0.122)	(0.310)	(0.212)	(1.064)	(0.309)	(3.36e-08)	(1.114)	(0.322)	(0.508)
Central and Eastern Europe	0.860	0.875	1.669	0.767	1.541	0.563	0.855	2.036	0.293	1.206	0.806	0.681
	(1.449)	(0.689)	(1.305)	(0.418)	(0.604)	(0.300)	(0.841)	(1.415)	(0.367)	(1.135)	(0.394)	(0.574)
Relative impact per degree country publication	0.210	0.161	0.175	7.677**	2.470	4.557*	0.803	1.712	1.089	1.167	0.669	2.020
	(0.547)	(0.199)	(0.215)	(6.630)	(1.586)	(3.772)	(1.288)	(1.866)	(2.247)	(1.867)	(0.531)	(2.717)
Constant	5.16e-10	5.180	7.687	0.0727*	0.999	0.205	1.713	0.287	1.86e-09	1.080	0.343	0.285
	(0)	(10.86)	(16.15)	(0.101)	(1.023)	(0.277)	(5.153)	(0.619)	(0)	(2.937)	(0.599)	(0.715)
Observations	993	993	993	947	947	947	306	306	306	441	441	441

Standard error eform in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A.6.4: Kernel matching for exact sciences

effect	US mobile (treated)	EU mobile (untreated)	difference	t-stat
prior to matching				
publication output	3.94	3.73	0.21***	2.96
general recognition	4.21	3.99	0.22***	3.69
access to infrastructure	4.09	3.85	0.24***	3.95
international network	4.22	4.04	0.18***	2.90
professional experience	4.48	4.31	0.17***	3.32
job opportunities	3.56	3.53	0.03	0.38
patent output	3.29	3.06	0.22**	2.24
work in industry	3.51	3.31	0.20**	2.31
after matching				
publication output	3.93	3.78	0.16*	1.74
general recognition	4.21	4.11	0.10	1.40
access to infrastructure	4.09	3.85	0.24***	3.11
international network	4.22	4.14	0.08	1.05
professional experience	4.48	4.34	0.15**	2.28
job opportunities	3.56	3.60	-0.04	-0.46
patent output	3.29	3.12	0.16	1.35
work in industry	3.51	3.37	0.14	1.42
observations	*582*			

Table A.6.5: Kernel matching for life sciences

effect	US mobile (treated)	EU mobile (untreated)	difference	t-stat
prior to matching				
publication output	4.03	3.67	0.36**	2.02
general recognition	4.30	3.90	0.4***	2.66
access to infrastructure	4.13	3.81	0.31*	1.86
international network	4.36	3.96	0.4***	2.69
professional experience	4.57	4.23	0.34**	2.40
job opportunities	3.50	3.56	-0.06	-0.28
patent output	3.21	2.94	0.27	1.46
work in industry	3.59	3.25	0.34*	1.66
after matching				
publication output	3.95	4.02	-0.07	-0.32
general recognition	4.29	4.08	0.20	1.00
access to infrastructure	4.13	4.19	-0.06	-0.24
international network	4.36	4.24	0.06	0.26
professional experience	4.55	4.42	0.13	0.76
job opportunities	3.50	3.90	-0.40	-1.17
patent output	3.25	3.00	0.25	1.00
work in industry	3.75	3.64	0.11	0.33
observations	*103*			

Table A.6.7: Kernel matching for social sciences

effect	US mobile (treated)	EU mobile (untreated)	difference	t-stat
prior to matching				
publication output	3.92	3.87	0.05	0.50
general recognition	4.12	4.07	0.05	0.59
access to infrastructure	3.91	3.79	0.12	1.02
international network	4.31	4.10	0.21**	2.21
professional experience	4.41	4.24	0.17*	1.87
job opportunities	3.84	3.41	0.43***	3.63
patent output	.	.	.	.
work in industry	3.70	3.30	0.4*	1.94
after matching				
publication output	3.92	3.87	0.05	0.31
general recognition	4.12	4.10	0.02	0.13
access to infrastructure	3.89	3.79	0.10	0.59
international network	4.31	4.21	0.11	0.73
professional experience	4.41	4.45	-0.03	-0.23
job opportunities	3.84	3.47	0.37**	2.13
patent output	.	.	.	.
work in industry	3.67	3.32	0.34	0.86
observations	*236*			

GENERAL CONCLUSION

1 Summary and contributions

Most studies of international mobility go no further than mapping the migratory flows between particular countries, and characterizing them along basic dimensions like age, education and gender. Although there are still significant advancements to be made in this type of data collection and analysis, this dissertation takes a different perspective. Instead of a broad but perhaps 'shallow' analysis of mobility, this dissertation studies the international movements of a small, well-defined group of highly skilled workers in depth. In particular, this dissertation makes an effort to contribute to a deeper understanding of certain factors that drive mobility outcomes of researchers, and of the effects that international mobility has on researchers. Throughout the dissertation, the focus lies on the role of the quality dimension in mobility, considering both the quality of researchers' study and work environment and the quality of the researchers themselves. In this general conclusion, I summarize the main findings of each chapter, and I highlight how the chapters differ and complement each other.

The second chapter studies the mobility decisions of European doctoral students. Whereas most studies of student mobility consider either the attractiveness of (or within) the European higher education market (Van Bouwel and Veugelers, 2011; Bessey, 2007; Naidoo, 2007) or of the United States (McMahon, 1992; Agarwal and Winkler, 1985, Cummings, 1984) separately, this study considers both destinations together in one model, and allows to identify how European students in each destination differ in their personal characteristics. The focus of this chapter, however, is on studying how the science and innovation environment in researchers' birth countries influences the decision to seek doctoral education abroad. We hypothesize that students from countries with a weaker science and innovation environment are more likely to go abroad for a PhD. There may be fewer opportunities for research careers in their home country and a PhD abroad could be a first step to enter the labor market in countries with stronger science and innovation records. In short, the expected benefits of PhD mobility are presumably higher for students from countries with a weaker science and innovation environment. Moreover, we check whether the effect of the science and innovation environment on the probability of a PhD abroad

differs for mobility with Europe or mobility to North America. We find that European students from countries with a weaker science and innovation record are indeed more likely to seek doctoral education abroad. Moreover, students from these countries are more likely to study in another European country than to pursue a PhD in the United States or Canada. It appears that intra-EU mobility of doctoral students is driven to a greater extent by push factors in the home country than mobility to North America. Further data collection and analysis is needed to study whether mobility to North America is driven more by pull factors (e.g. higher quality education) than by push factors (e.g. lack of opportunities at home) compared to mobility within Europe, and what the implications of such differences in driving factors are for the selection of students to both destinations.

The third chapter examines the return decisions of European economists who receive a PhD in the United States, and particularly focuses on the question whether top students are less likely to return. Few studies about the return of foreign students explicitly factor in the students' ability, focusing instead on differences in return rates among nationalities, cohorts and disciplines (Finn, 2010; Black and Stephan, 2007). Moreover, few studies are able to identify at which institutions students work, whether they return to Europe or stay in the United States. Using a unique, hand-collected dataset based on CV-data of European economics PhD recipients in the United States, this chapter develops a broad array of quality indicators, including the prestige of the doctoral institution, the reputation of the advisor and early research performance. Using these quality indicators, we find that top European students are not more likely to stay in the United States per se. Rather, top students are more likely to stay in the U.S. if they can work at one of its many top institutions. Top students are also attracted back to Europe to work at European top institutions, but this result is less robust which probably owes to the fact that although Europe hosts a number of top economics departments, it does not (yet) compare to the United States in quantity nor in quality. In short: the best students go to the best institutions, and the majority of these are located in the United States, resulting in a higher prevalence of top placements in the United States. If the prestige of the first job is an additional indicator of a researcher's ability, then these results support the notion of an 'elite brain drain' from Europe to the United States, at least among PhD economists. A second finding is that most return mobility of European economics PhD holders occurs immediately after the PhD. There is some mobility in later stages of economists' careers, in both directions: later return from the U.S. to Europe, and

some remigration from Europe back to the United States. For the majority, however, the location of the first job strongly determines the location of the current job.

The fourth chapter studies how the state of the academic labor market affects foreign PhD students' return decisions. In the analysis of the probability of return, the previous chapter controls for such factors as age, nationality and cohort. Controlling for cohorts is important because different cohorts may have different propensities to return or may face different job market conditions. In the fourth chapter, one of the factors that is controlled for by the cohort variables in the third chapter is analyzed in more detail, i.e. the state of the labor market at the time of graduation. Most studies on foreign students' return rates focus on characteristics of the 'supply' of foreign students, such as differences in nationality, cohort, field, and quality, as in the second chapter. This study explicitly factors in a 'demand' side variable, namely the demand for academic economists in the U.S. This chapter finds that European PhD recipients in economics are more likely to return to Europe if they graduate in a year when there are relatively fewer academic job listings in the U.S. compared to the number of students entering the market. Students graduating from top universities or with a highly cited advisor, however, are less affected by fluctuations in the labor market. The latter finding can have two interpretations: either top students are more likely to take jobs at lower ranked institutions in years with a loose labor market, thus 'pushing' non top students out of the U.S. academic market, or top students are less affected by labor market fluctuations because the top segment of the academic labor market is more stable and less volatile compared to the non-top segment. The former interpretation might contradict the finding of the previous chapter, that top students stay to work at top institutions, but otherwise are not more likely to remain in the United States compared to their non-top peers. However, the chapter provides some evidence for the latter interpretation: the top segment of the academic labor market for economists is less volatile, and top students are not less likely to take a job at a top institution in years with fewer academic job listings.

Whereas the third and fourth chapter study the return mobility of European researchers who obtain their PhD in the United States, the fifth and sixth chapter study the mobility outcomes of European researchers who obtain their PhD in Europe. The fifth chapter examines how European researchers who are internationally mobile within Europe differ from European researchers who become mobile to the United States. Within a policy context of increasing

support to stimulate researcher mobility within Europe, but at the same time concern about the outflow of talented researchers to the United States, it is important to understand which factors drive researcher mobility, and how these factors differ for intra-EU mobile and U.S.-mobile researchers. In particular, we examine differences in personal characteristics, such as age, gender, cohort, field and region of birth, as well as differences in motivations for mobility and in perceived importance of external influencing factors, using unique survey data collected by the MORE project. Researchers mobile to the United States are more career motivated, which could imply a negative selection of mobile researchers within Europe: researchers who become mobile with the explicit goal of furthering their research or personal education agenda will probably benefit more from mobility and are possibly also more talented and productive – although more research is needed to check how motivations, ability and productivity are related. Researchers with intra-EU mobility experience as graduate students, however, are more likely to remain mobile within Europe. This suggests that intra-EU mobility experience encourages follow-up mobility with Europe. Some researchers, however, appear to see intra-EU mobility during their PhD as a stepping stone to later mobility to the United States, particularly if that degree mobility was directed to European countries with a strong research and innovation performance.

Finally, the sixth chapter addresses the effects of researcher mobility, and how they differ between EU-mobile and U.S.-mobile European researchers. Much of the brain drain literature focuses on the effects of researcher mobility on the host country and on the source country, but few studies address the effects of mobility on researchers themselves. International mobility is often assumed to have positive effects on researchers' productivity and career development. Using the same unique survey data as the previous chapter, this chapter finds that mobile researchers generally report positive effects from mobility on a range of factors, such as publication output, general recognition, working conditions, future job opportunities and technology transfer capabilities. Researchers mobile to the U.S., however, report consistently stronger positive effects than intra-EU mobile researchers. However, this apparent 'U.S. premium' appears to be almost entirely due to selection: researchers who are more strongly career motivated and who hold a PhD from a country with a stronger research performance are more likely to become mobile to the United States, and once this selection is accounted for, most differences in effects between U.S.-mobile and EU-mobile researchers vanish. There are two exceptions, however: U.S.-mobile researchers

still report significantly stronger effects on their access to infrastructure, and U.S.-mobile researchers are also more likely to report strongly positive effects on their patent output and professional experience. These significant 'U.S.'-effects appear to be field-dependent, however: for researchers in the exact sciences, mobility to the U.S. is, on average, related to a significant improvement in access to infrastructure and in professional experience, whereas researchers in the social sciences report a stronger increase in their future job opportunities in the home country after mobility to the United States. For policy makers on both sides of the Atlantic, it is important to know what effects mobile researchers experience from mobility – although further research is needed to disentangle what effects researcher expect, and how the mobility experience matches up to those expectations for different destinations.

2 Limitations and suggestions for further research

The research in this dissertation suffers from several limitations, among which are sampling and data collection issues with implications for the representativeness of the data. These issues are discussed at length in the chapters, with particular attention for the data limitations in chapter 1. In this general conclusion, I focus instead on three major drawbacks that afflict many mobility studies, including the work in this dissertation: a lack of clear definitions, a lack of a unified theoretical framework, and a lack of good data. In what follows, I will discuss these three drawbacks and point out how they apply to this work, and what has been done to mitigate them as much as possible.

In a study of international mobility of researchers, with a focus on quality, three crucial concepts must be defined: researchers, international mobility and quality. We use a definition of researchers that is often used in applied work, namely those who hold a PhD. The advantage of using a PhD as a defining characteristic for a researcher is that it is clear cut, and makes it possible to separate researchers from non-researchers unambiguously. However, there are many people without a PhD who work in research and who contribute actively to knowledge creation and innovation, but who are not considered researchers by this definition. The MORE survey, which is used as the primary source for chapters 1, 4 and 5, defines respondents as researchers if they carry out or supervise research or are involved in the development of new products or processes. However, opportunities for mobility probably differ strongly for PhD holders, who on average work on a more independent basis

and are more likely to work in academia, and for non-PhD holders, who are more likely to work as part of a team and in a private company. To avoid the implications of these very different contexts for mobility, we opted to keep the samples we study as homogeneous as possible with respect to educational attainment, and only study PhD holders (or PhD students).

Defining international mobility is also not straightforward. When is a stay abroad defined as international mobility? Does that definition depend on the length of the stay, or on the professional context in which the researcher worked abroad? In this dissertation, two different definitions are used. In chapters 3 and 4, which use the CV data on European economists with a U.S. PhD, international mobility is defined as taking up a permanent position in another country. Visiting positions are excluded from this definition. In the other chapters, international mobility is defined as a stay abroad of minimum 3 months. However, there are other forms of international mobility that have an impact on researchers, including short research visits, attending international conferences, international collaborations that do not necessarily entail international mobility, and so on. It is important to keep in mind that there are other good definitions of international mobility, and future work on mobility should continue to elaborate how to characterize different types of mobility flows and their consequences.

Finally, a very tricky concept to define is quality. What makes a researcher talented? How does one researcher differ in ability from another researcher? Researchers differ strongly in their productivity, and only a few researchers make extraordinary contributions to science in terms of publication output and impact. But this can only be observed ex-post, whereas we study mobility decisions of relatively young PhD students and researchers – indeed, most international mobility takes place at a relatively early stage of the career (Laudel, 2005). Therefore we need measures that indicate scientific talent at an early stage. These quality indicators suffer from a double drawback: measuring ‘talent’ at an early age is no guarantee for future research productivity, which is what ultimately counts in terms of economic impact, and finding good measures for talent is much more difficult than finding measures for research productivity ex post. In this dissertation different quality indicators are used, some also common in the literature, such as the prestige of the doctoral institution, others less common, like the reputation of the advisor. That these quality indicators all point in the

same direction in our analyses is reassuring. However, in future research it is important to continue working on developing better indicators for researcher quality, and to evolve towards a consensus of which indicators are best used in empirical research, as has been done for measuring research productivity.

Another drawback of studying international researcher mobility is the lack of a unified theoretical framework from which to approach empirical questions and derive hypotheses. Several theoretical frameworks lend themselves to studying this particular type of mobility – as discussed in the first chapter - but none include all the relevant concepts and variables needed to approach this topic. Migration theory contributes relevant insights, as mobile researchers are ultimately migrants as well, and are influenced to a certain extent by similar factors. The push-pull framework, for example, is a useful tool for organizing influencing factors at the level of the source country and the destination country. Although many insights into general migration flows are relevant for researcher mobility as well, researchers also operate in a very different environment than, say, low-skilled workers, and some factors in the migration decision of researchers are very particular to the highly skilled labor market, or even the academic labor market.

The human capital theory also provides relevant insights, as mobility can be approached as an investment in human capital with certain costs and benefits. Insights from economics of information, such as approaching higher education as a signal to the labor market, are also useful. Search and matching models are relevant for studying researchers whose mobility may in part depend on the outcome of a complex labor market process. However, to date there is no unified theoretical approach for studying international mobility of students and researchers that incorporates both insights on what motivates researchers and how this influences their career decisions on the one hand, and how characteristics of the source and the destination influence migration decisions on the other hand. Efforts have been made to approach certain facets of highly skilled mobility theoretically, such as the effects of brain drain and brain circulation (Mayr and Peri, 2009) and the effect of migration on the transferability of human capital (Mechtenberg, 2010). However, more theoretical development would certainly be useful and informative for empirical research about student and researcher mobility.

Finally, empirical research on international researcher mobility is often thwarted by a lack of good data. Flows of international trade and finance are fairly well recorded, but despite the fact that the knowledge economy is making human capital an increasingly scarce good, worldwide migration, specifically of students and researchers, is not yet comprehensively mapped. Knowing how many researchers migrate and where to is already a formidable challenge. Most data are either unilateral, in the sense that it is collected for one destination country, like the National Science Foundation which collects data on foreign students and researchers for the United States, or from ad-hoc samples of large-scale surveys which suffer from representativeness issues, like the data collected by the OECD on Careers of Doctorate Holders or by the European Commission for the Mobility of Researchers (MORE) project. This last data source is used for chapters 2, 5 and 6, and as discussed in these chapters, these data are not representative of the underlying population of European researchers. However, a lack of a better, comprehensive database makes it impossible to correct for the possible biases in the data. This means all results should be interpreted with care.

Studies that aim to dig deeper than just mapping migratory flows of researchers must often make a trade-off between the 'depth' of the data and the representativeness and/or the generalizability of the sample. Studies of the driving factors or the effects of mobility often use small, very specific samples within one discipline or geographic region. This is the case for chapters 3 and 4 in this dissertation, which study mobility choices of European economists who obtain a PhD in the United States or Canada. This makes it hard to generalize these results to a broader population, and makes any policy recommendations less dependable.

To mitigate these data constraints for future research, governments or multilateral organizations should start gathering comprehensive and representative data on international migration flows of students and researchers. As the importance of human capital grows as an indispensable asset in the knowledge economy, hopefully statistical agencies will soon realize the value of recording human capital formation, inflows and outflows in national accounting statistics.

3 Policy implications

The overarching policy implication of this dissertation is undoubtedly that in addressing researcher mobility from a policy perspective, quality matters. One quality aspect is the quality of the work environment of researchers: this work has shown that PhD students are more likely to leave countries with weak science and innovation performance. Moreover, the fact that the U.S. hosts so many top institutions makes it especially attractive for researchers, and as such the U.S. seems to be able to attract the most talented and most motivated researchers. Another quality aspect is that of the researcher. In this dissertation, we find that top European PhD recipients are more likely to stay in the U.S. if they can work at one of its top institutions, and that top PhD recipients are not affected by academic labor market fluctuations in the U.S. to the same extent as non-top students.

For policy makers who want to design an efficient policy to attract good researchers or students to a particular place, these findings imply that the quality of the work environment must always be taken into account, and should arguably be one of the priority targets for policy. However, to inform policy better, further research is needed to uncover what features are essential for a good work environment, what factors make a given location more or less attractive, and what characteristics of a scientific work environment are conducive to high productivity.

Moreover, if it is an explicit policy target to attract top researchers currently residing abroad back to the home country, a targeted policy for these top researchers is needed. This dissertation has given some evidence that top researchers react differently to factors that drive mobility flows of 'average' researchers. It is therefore unlikely that top researchers will be attracted to a certain country or region by policies intended for 'the average researcher', at least not in the short run when these policies have not yet had the chance to fundamentally change the research environment. Rather, targeted policies like the Odysseus funding in Flanders and the Marie Curie return fellowships are probably more appropriate. Further research is also needed on what attracts top researchers to a particular location for more effective policy design. Also important is identifying and quantifying the impact of a top researcher on her environment and on the productivity of other researchers, to permit

suitable cost-benefit analyses of the often expensive policies designed to bring top researchers back to their home countries.

From the European perspective, a positive policy conclusion from this research is that intra-EU mobility of students and researchers appear to be on the rise in recent years, suggesting that policies to unify higher education and research in Europe, like the European Research Area and the European Higher Education Area, are paying off. Also, mobility experience within the EU as a doctoral student appears to stimulate further intra-EU mobility as a researcher, indicating that mobility precedents lower barriers for future mobility. However, more research is needed to understand whether the increase in intra-EU mobility is indeed due to these policy implementations, or due to other – perhaps external – factors, like the tightening of student visa restrictions in the United States after the events of 9/11.

Less rosy news for Europe is that our results indicate that there is a negative quality selection for intra-EU mobility: students from catch-up countries in terms of research and innovation are more likely to be mobile within Europe as students, while student mobility to the U.S. appears less driven by these push factors. Moreover, researchers with strong career motivations for mobility are more likely to be mobile to the United States. Finally, top European PhDs who obtain their degree in the U.S. are less likely to return to Europe if they can work at a top U.S. institution. All these findings indicate that the best European researchers still prefer the U.S. as a destination, whereas in Europe there appears to be a larger share of 'catch-up' migration, which is important for economic convergence within Europe, but probably less conducive to the production of scientific breakthroughs that will give Europe a technological and economic edge in the near future. To be able to address this effectively, more research is needed to understand what specific areas Europe must improve to attract the best students and researchers.

Finally, this dissertation also presents evidence that most mobility appears to occur immediately after the completion of the PhD: in chapter 3, we find that for our sample of European PhD economists, the majority who return do so immediately upon completion of their degree. Later in the career, the costs of mobility appear to rise, as researchers become more embedded in their research environment. This means that if Europe wants to attract talented European researchers back from the United States, it should target young

researchers who have recently completed their PhD. Our findings also suggest that it should be easier to attract more and better researchers back in years when the U.S. academic labor market is unfavorable. This is something that European policy makers and hiring officers of European institutions should exploit more actively. There are already indications that the current economic contraction, which, until now, has had a more profound impact on academic research budget in the U.S. than in Europe, is driving a number of talented European researchers to return to their home countries. European policy makers should take this unique opportunity to strengthen the European science base, as this could have a profound impact on Europe's future economic prosperity.

A question that remains is whether stimulating the return of European researchers abroad is indeed the best policy target. If European researchers are more productive working in centers of excellence abroad, then Europe might benefit more by encouraging international collaborations and stimulating other channels to tap into the links that this diaspora has with the knowledge frontier around the world. For example, Kuhn and McAusland (2006) develop a model where emigrating knowledge workers become more productive in creating knowledge, which is considered a public good, in the destination country. They show that a beneficial brain drain is possible, meaning that both the destination country and the source country benefit, even if some of the knowledge is 'lost in translation' back to the source country (Kuhn and McAusland, 2006). Agrawal et al. (2011) find that Indian researchers working abroad channel valuable information from the knowledge frontier to inventors back home. Similarly, Kerr (2008) finds that knowledge diffuses through ethnic networks, and that countries with a stronger scientific integration with the U.S. benefit in terms of manufacturing productivity. From the European perspective, these benefits of European researcher mobility to the U.S. may decrease if mobility is increasingly diverted away from the U.S. to intra-EU mobility, or if efforts to bring European researchers 'back home' strongly diminish the share of European researchers working overseas. For example, Kahn and MacGarvie (2008) find that foreign PhD recipients who leave the U.S. are significantly less likely to collaborate with U.S. co-authors – an indication that return mobility may, perhaps, attenuate the links with the knowledge frontier. The overarching conclusion of this dissertation must therefore, at the moment, remain that there is a wealth of interesting research questions with high relevance to policy makers around the world that are waiting to

be answered by future research. With this dissertation, I hope to have contributed a few small pieces of the puzzle, as well as pointed out interesting avenues for future research.

REFERENCES

Ackers, Louise, (2005), 'Moving People and Knowledge: Scientific Mobility in the European Union', *International Migration*, vol.43, no.5, pp.99-131.

Adams, James D. , (1990), 'Fundamental Stocks of Knowledge and Productivity Growth', *The Journal of Political Economy*, vol.98, no.4, pp.673-702.

Agarwal, Vinod B. and Donald R. Winkler, (1985), 'Foreign Demand for United States Higher Education: A Study of Developing Countries in the Eastern Hemisphere', *Economic Development and Cultural Change*, vol.33, no.3, pp.623-644.

Aghion, Philippe, Mathias Dewatripont, Caroline Hoxby, Andreu Mas-Colell, and André Sapir, (2010), 'The governance and performance of universities: Evidence from Europe and the U.S.', *Economic Policy*, vol.25, January, pp.7-59.

Aghion, Philippe, Mathias Dewatripont, Caroline Hoxby, Andreu Mas-Collel and André Sapir, (2007), 'Why Reform Europe's Universities?', *Bruegel Policy Brief*, issue 2007/4 (September), pp.1-9.

Agrawal, Ajay K., Devesh Kapur, John McHale and Alexander Oettl, (2011), 'Brain drain or brain bank? The impact of skilled emigration on poor-country innovation', *Journal of Urban Economics*, vol.69, pp.43-55.

Agrawal, Ajay K., Ian M. Cockburn and John McHale, (2006), 'Gone but not forgotten: Labor flows, knowledge spillovers and enduring social capital', *Journal of Economic Geography*, vol.6, no.5, pp. 571-591.

Alberts, Heike C. and Helen D. Hazen, (2005), '"There are always two voices…": International Students' Intentions to Stay in the United States or to Return to Their Home Countries', *International Migration*, vol.43, no.3, pp.131-145.

Allison, Paul D. and J. Scott Long, (1987), 'Interuniversity Mobility of Academic Scientists', *American Sociological Review*, vol.52, no.5, pp.643-652.

Aslanbeigui, Nahid and Veroncia Montecinos, (1998), 'Foreign Students in U.S. Doctoral Programs', *Journal of Economic Perspectives*, vol.12, no.3, 171-182.

Association of American Medical Colleges, (2003), 'Trends Among Foreign-Graduate Faculty in U.S. Medical Schools, 1981-2000', *Analysis in Brief*, vol.3, no.1.

Attiyeh, Gregory and Richard Attiyeh, (1997), 'Testing for Bias in Graduate School Admissions', *Journal of Human Resources*, vol.32, no.3, pp.524-548.

Audretsch, David B. and T. Taylor Aldridge, (2009), 'Scientist Commercialization as Conduit of Knowledge Spillovers', *The Annals of Regional Science*, vol.43, no.4, pp.897-905.

Baker, George and Bengt Holmstrom, (1995), 'Internal Labor Markets: Too Many Theories, Too Few Facts', *American Economic Review*, papers and proceedings, pp.255-259.

Becker, Gary S., (1962), 'Investment in Human Capital: A Theoretical Analysis', *The Journal of Political Economy*, vol.70, no.5, pp.9-49.

Beine, Michel, Frédéric Docquier and Hillel Rapoport, (2001), 'Brain drain and economic growth: theory and evidence', *Journal of Development Economics*, vol.64, pp.275-289.

Bekhradnia, B. and T. Sastry, (2005), *Migration of Academic Staff to and from the UK*, Higher Education Policy Institute report.

Ben-David, Daniel, (2007), 'Soaring Minds: The Flight of Israel's Economists', *CEPR Discussion paper no.6338.*

Bessey, Donata, (2007), 'International Student Migration to Germany', *Swiss Leading House working paper no.6.*

Bisping, Timothy O. and James R. Fain, (2005), 'The Current State of the Labor Queue: National and Regional Evidence', *Journal of Labor Research*, vol.26, no.2, pp.351-361.

Black, Grant and Paula E. Stephan, (2007), 'The Importance of Foreign Ph.D. Students to U.S. Science', in: *Science and the University*, eds. Paula E. Stephan and Ronald G. Ehrenberg, The University of Wisconsin Press, Madison, Wisconsin.

Black, Grant and Paula E. Stephan, (2008), 'The Economics of University Lab Science and the Role of Foreign Graduate Students and Postdoctoral Scholars', in: *American Universities in a Global Market*, ed. Charles Clotfelter, University of Chicago Press, 2010, pp.129-162.

Borjas, George J. and Bernt Bratsberg, (1996), 'Who Leaves? The Outmigration of the Foreign-Born', *The Review of Economics and Statistics*, vol. 78, no. 1, pp. 165-176.

Borjas, George J., (2002), 'An Evaluation of the Foreign Student Program', *Center for Immigration Studies Backgrounder, June 2002.*

Bound, John, Sarah Turner and Patrick Walsh, (2009), 'Internationalization of U.S. Doctorate Education', in: *Science and Engineering Careers in the United States, An Analysis of Markets and Employment*, eds. Richard B. Freeman and Daniel L. Goroff, The University of Chicago Press.

Bourke, Ann, (2000), 'A Model of the Determinants of International Trade in Higher Education', *The Service Industries Journal*, vol.20, no.1, pp.110-138.

Bratsberg, Brent, (1995), 'The Incidence of Non-Return Among Foreign Students in the United States', *Economics of Education Review*, vol.14, no.4, pp.373-384.

Burris, Val, (2004), 'The Academic Caste System: Prestige Hierarchies in PhD Exchange Networks', *American Sociological Review*, vol.69, no.2, pp.239-264.

Card, David and Thomas Lemieux, (2001), 'Can Falling Supply Explain the Rising Return to College for Young Men? A Cohort-Based Analysis', *Quarterly Journal of Economics*, vol.116, no.2, pp.705-746.

Cardoso, Ana Rute, Paulo Guimarães and Klaus F. Zimmerman, (2008), 'Comparing the Early Research Performance of PhD Graduates in Labor Economics in Europe and the USA', *IZA Discussion Paper no.3898.*

Cassarino, Jean-Pierre, (2004), 'Theorising Return Migration: A Conceptual Approach to Return Migrants', *EUI Working Papers RSCAS no.2004/02.*

Chellaraj, Gnanaraj, Keith E. Maskus and Aaditya Mattoo, (2005), 'The Contribution of Skilled Immigration and International Graduate Students to U.S. Innovation', *World Bank Policy Research Working Paper 3588.*

CHEPS, (2008), *The Bologna Process Independent Assessment: The First Decade of Working on the European Higher Education Area - volume 1 Detailed Assessment Report*, report prepared by Don. F. Westerheijden and co-authors for the Directorate General for Education and Culture of the European Commission, EU.

Coles, Melvyn G. and Eric Smith, (1996), 'Cross-Section Estimation of the Matching Function: Evidence from England and Wales', *Economica*, vol.63, no.252, pp. 589-597.

Coles, Peter, John Cawley, Philip B. Levine, Muriel Niederle, Alvin E. Roth and John J. Siegfried, (2010), 'The Job Market for New Economists: A Market Design Perspective', *Journal of Economic Perspectives*, vol.24, no.4, pp.187-206.

Commander, Simon, Mari Kangasniemi and L. Alan Winters, (2003), 'The Brain Drain: Curse or Boon?', *IZA Discussion paper no. 809.*

Corredoira, Rafael A. and Lori Rosenkopf, (2010), 'Should auld acquaintance be forgot? The reverse transfer of knowlegde through mobility ties', *Strategic Management Journal*, vol.31, pp.159-181

Coupé, Tom, (2003), 'Revealed Performances: Worldwide Rankings of Economists and Economics Departments 1969-2000', *Journal of the European Economic Association*, vol.1, no.6, pp.1309-1345.

Cruz-Castro, Laura and Luis Sanz-Menéndez, (2009), 'Mobility versus Job Stability: Assessing Tenure and Productivity Outcomes', *Research Policy,* vol.39, no.1, pp.27-38.

Cummings, William K., (1984), 'Going Overseas for Higher Education: The Asian Experience', *Comparative Education Review*, vol.28, no.2, pp.241-257.

De Grip, Andries, Didier Fouarge and Jan Sauermann, (2009), 'What affects international migration of European science and engineering graduates?', *IZA discussion paper no.4268.*

Docquier, Frédéric and Abdeslam Marfouk, (2006), 'International Migration by Education Attainment (1990-2000) - Release 1.1', update of *World Bank Policy Research Working Paper No. 3381,* available at SSRN: http://ssrn.com/abstract=625258.

Docquier, Frédéric and Hillel Rapoport, (2007), 'Skilled Migration: The Perspective of Developing Countries', *IZA Discussion paper no.2873.*

Doeringer, Peter B. and Michael J. Piore, (1971), *Internal Labor Markets and Manpower Analysis*, M.E. Sharpe, Inc.

Dow, Jay K. and James W. Endersby, (2003), 'Multinomial Probit and Multinomial Logit: A Comparison of Choice Models for Voting Research', *Electoral Studies*, vol.23, no.1, pp.107-122.

Dreher, Axel and Panu Poutvaara, (2006), 'Student Flows and Migration: An Empirical Analysis', *KOF-Arbeitspapiere/Working Papers No. 142*, July, Zurich.

Ehrenberg, Ronald G. and Robert S. Smith, (2011), *Modern Labor Economics: Theory and Public Policy* (eleventh edition), Pearson, Boston.

European Commission, (2003), *The Brain Drain to the US: Challenges and Answers*, Snapshots Brain Drain Study, European Commisson, EU.

European Commission, (2003), *Third European Report on Science and Technology Indicators 2003*, EUR 20025, European Commission, Brussels. ISBN 92-894-1795-1.

Evans, Lorraine, (2011), 'Job Queues, Certification Status, and the Education Labor Market', *Educational Policy*, vol.25, no.2, pp.267-298.

Finn, Michael G., (2010), *Stay Rates of Foreign Doctorate Recipients from U.S. Universities, 2007*, Oak Ridge Institute for Science and Education

Finn, Michael G., (2012), *Stay Rates of Foreign Doctorate Recipients in the U.S., 2009*, Oak Ridge Institution for Science and Education

Florida, Richard, (2002), 'The Economic Geography of Talent', *Annals of the American Association of Geographers*, vol.92, no.4, pp.743-755.

Freeman, Richard B., Tanwin Chang and Hanley Chiang, (2009), 'Supporting "The Best and Brightest" in Science and Engineering, NSF Graduate Research Fellowships', in: *Science and Engineering Careers in the United States, An Analysis of Markets and Employment*, eds. Richard B. Freeman and Daniel L. Goroff, The University of Chicago Press

Gaughan, Monica, (2007), 'Location of birth unknown: what we can learn by studying CV's', paper prepared for the NBER Conference 'Career patterns of Foreign-born scientists and engineers, trained and/or working in the U.S.', November 7th, 2007.

Gaulé, Patrick, (2010), 'Return Migration: Evidence from Academic Scientists', working paper presented at NBER productivity lunch seminar on November 16th, 2010, Boston, MA.

Gibson, John and David McKenzie, (2011), 'Eight Questions About Brain Drain', *Journal of Economic Perspectives*, vol.25, no.3, pp.107-128.

Glänzel, Wolfgang, (2000), 'Science in Scandinavia: A Scientometric Approach', *Scientometrics*, vol.48, no.2, pp.121-150.

Glänzel, Wolfgang, (2001), 'National Characteristics in International Co-Authorship', *Scientometrics*, vol.51, no.1, pp.69-115.

Goldin, Ian, Geoffrey Cameron and Meera Balarajan, (2011), *Exceptional People: How Migration Shaped Our World and Will Define Our Future*, Princeton University Press, Princeton, New Jersey.

Gordon, Jean and Jean-Pierre Jallade, (1996), 'Spontaneous' Student Mobility in the European Union: A Statistical Survey', *European Journal of Education*, vol.31, no.2, pp.133-151.

Grossman, Gene M. and Elhanan Helpman, (1994), 'Endogenous Innovation in the Theory of Growth', *Journal of Economic Perspectives*, vol.8, no.1, pp.23-44.

Guellec, Dominique and Mario Cervantes, (2001), 'International Mobility of Highly Skilled Workers: From Statistical Analysis to Policy Formulation', in *International Mobility of the Highly Skilled*, OECD, 2001.

Gurmu, Shiferaw, Paula E. Stephan and Grant Black, (2008), 'The Knowledge Production Function for University Patenting', *Economic Enquiry*, vol.48, no.1, pp.192-213

Haddal, Chad H., (2008), 'Foreign Students in the United States: Policy and Legislation', *CRS Report for Congress RL 31146.*

Haeck, Catherine and Frank Verboven, (2012), 'The Internal Economics of a University – Evidence from Personnel Data', *Journal of Labor Economics* (forthcoming).

Hatton, Timothy J. and Jeffrey G. Williamson, (2002), 'What Fundamentals Drive World Migration?', *NBER working paper 9159.*

Helppie, Brooke and Martha Murray-Close, (2010), '*Moving Out or Moving Up? New Economists Sacrifice Job Opportunities for Proximity to Significant Others -- and Vice Versa'*, working paper, Department of Economics, University of Michigan.

Hoisl, Karin, (2007), 'Does mobility increase the productivity of inventors?', *Journal of Technology Transfer*, vol.32, no.2, pp.212-225.

Hoisl, Karin, (2007), 'Tracing Mobile Inventors - The Causality Between Inventor Mobility and Inventor Productivity', *Research Policy*, vol.36, issue 5, pp.619-636.

Horta, Hugo, Francisco M. Veloso and Rócio Grediaga, (2010), 'Navel Gazing: Academic Inbreeding and Scientific Productivity', *Management Science*, vol.56, no.3, pp.414-429.

Hoxby, Caroline M., (2002), 'The Effects of Geographic Integration and Increasing Competition in the Market for College Education', mimeo, Department of Economics, Harvard University.

Hunt, Jennifer and Marjolaine Gauthier-Loiselle, (2009), 'How much does immigration boost innovation?', *IZA discussion paper 3921.*

Hunter, Rosalind S., Oswald, Andrew J. and Charlton, Bruce G., (2009), 'The Elite Brain Drain', *Research Policy*, vol.36, issue 5, pp.619-636.

IDEA Consult, (2008), 'Evidence on the Main Factors Inhibiting Mobility and Career Development of Researchers', Rindicate report for the European Commission, EU.

IISER, (2007), 'Intra-EU Mobility of Researchers', IPTS – Institute for Prospective Technological Studies jointly with European Commission, Joint Research Centre.

Ince, Martin, (2007), 'The Times Higher Education Supplement: World University Rankings', *The Times Higher-QS World University Rankings*, November 9, 2007.

Ivancheva, Ludmila and Elissaveta Gourova, (2011), 'Challenges for Career and Mobility of Researchers in Europe', *Science and Public Policy*, vol.38, no.3, pp.185-198.

Jacobs, Bas and Frederick Van der Ploeg, (2005), 'Guide fo reform of higher education: a European perspective', *Economic Policy*, vol.21, no.47, pp.535-592.

Jaffe, Adam B., (1989), 'Real Effects of Academic Research', *The American Economic Review*, vol.79, no.5, pp.957-970.

Johnson, Steven, (2010), *Where Good Ideas Come From: The Natural History of Innovation*, Riverhead Books, New York, USA

Jöns, Heike, (2007), 'Transnational Mobility and the Spaces of Knowledge Production: A Comparison of Global Patterns, Motivations and Collaborations in Different Academic Fields', *Social Geography*, vol.2, pp.97-114.

Kahn, Shulamit and Megan MacGarvie, (2008), 'How important is U.S. Location for Research in Science?', paper presented at the Atlanta Conference on Science and Innovation Policy 2009, March 3rd 2009, Atlanta, Georgia.

Kalaitzidakis, Pantelis, Theofanis P. Mamuneas and Thanasis Stengos, (2003), 'Ranking of Academic Journals and Institutions in Economics', *Journal of the European Economic Association*, vol.1, no.6, pp.1346-1366.

Kapur, Devesh and John McHale, (2005), *Give Us Your Best and Brightest: The Global Hunt for Talent and its Impact on the Developing World*, Center for Global Development, Washington D.C.

Kemp, S., Madden, G. and Simpson, M., (1998), 'Emerging Australian Education Markets: A Discrete Choice Model of Taiwanese and Indonesian Student Intended Study Destination', *Education Economics*, vol.6, no.2, pp.159-169.

Kerr, William R., (2008), 'Ethnic Scientific Communities and International Technology Diffusion', *Review of Economics and Statistics*, vol.90, no.3, pp.518-537.

King, Russel and Enric Ruiz-Gelices, (2003), 'International Student Migration and the European "Year Abroad": Effects on European Identity and Subsequent Migration Behaviour', *International Journal of Population Geography*, vol.9, no.3, pp.229-252.

Kropko, Jonathan, (2010), 'A Comparison of Three Discrete Choice Estimators', in "New Approaches to Discrete Choice and Time Series Cross Section Methodology for Political Research", PhD thesis, University of North Carolina, Chapel Hill, North Carolina.

Kuhn, Peter and Carol McAusland, (2006), 'The International Migration of Knowledge Workers: When is Brain Drain Beneficial?', *IZA Discussion paper no.2493.*

Laudel, Grit, (2003), 'Studying the Brain Drain: Can Bibliometric Methods Help?', *Scientometrics*, vol.57, no.2, pp.215-237.

Laudel, Grit, (2005), 'Migration currents among the scientific elite', *Minerva*, vol.43, no.4, pp.377-395.

Lee, Kiong Hock and Jee Peng Tan, (1984), 'The International Flow of Third Level Lesser Developed Country Students to Developed Countries: Determinants and Implications', *Higher Education*, vol.13, no.6, pp.687-707.

Lewin-Epstein, Noah and Moshe Semyonov, (1985), 'Noncitizen Arabs in the Israeli Labor Market: Entry and Permeation', *Social Problems*, vol.33, no.1, pp.56-66.

Lowell, Lindsay B., (2007), 'Trends in International Migration Flows and Stocks, 1975-2007', *OECD Social, Employment and Migration Working Papers (58).*

Luukkonen, Terttu, (2010), 'The European Research Council in the European Research Area', Eurecia deliverable 7.1.

MacGarvie, Megan, (2007), 'Using Published Dissertations to Identify Graduates' Country of Origin', paper prepared for the NBER Conference 'Career patterns of Foreign-born scientists and engineers, trained and/or working in the U.S.', November 7th, 2007.

Maddux, William M. and Adam D. Galinsky, (2009), 'Cultural Borders and Mental Barriers: The Relationship Between Living Abroad and Creativity', *Journal of Personality and Social Psychology*, vol.96, no.5, pp.1047-1061.

Mahroum, Sami, (1999), 'Patterns of Academic Inflow into the Higher Education System of the United Kingdom', *Higher Education in Europe*, vol.24, no.1, pp.119-129.

Mahroum, Sami, (2000), 'Highly skilled globetrotters: Mapping the international migration of human capital', *R&D Management*, vol.30, no.1, pp.23-31.

Maier, Guther, Bernard Kurka and Michaela Trippl, (2007), 'Knowledge spillover agents and regional development - spatial distribution and mobility of star scientists', *DYNREG Working Paper 17/2007*

Mansfield, Edwin, (1991), 'Academic Research and Industrial Innovation', *Research Policy*, vol. 20, no.1, pp. 1-12

Martinelli, Daniel, (2001), 'A Brain Drain Among Young Ph.D.s: Mirage or Reality?', in: *International Mobility of the Highly Skilled*, OECD, France.

Mayr, Karin and Giovanni Peri, (2009), 'Brain Drain and Brain Return: Theory and Application to Eastern-Western Europe', *The B.E. Journal of Economic Analysis & Policy*, vol.9, no.1, pp.49.

Mazzarol, Tim and Geoffrey Soutar, (2000), '"Push-pull" Factors Influencing International Students Destination Choice', *The International Journal of Educational Management*, vol.16, no.2, pp.82-90.

McKinsey, (2007), 'The Organizational Challenges of Global Trends: A McKinsey Global Survey', *McKinsey Quarterly*, 2007/4

McMahon, Mary E., (1992), 'Higher Education in a World Market: An Historical Look at the Global Context of International Study', *Higher Education*, vol.24, no.4, pp.465-482.

Mechtenberg, Lydia and Roland Strausz, (2011), 'Migration of the Talented: Can Europe Catch Up with the U.S.?', *Journal of Public Economic Theory* (forthcoming).

Mercer, (2011), *2011 Quality of Life Worldwide City Rankings* – Mercer Survey, available online at http://www.mercer.com/press-releases/quality-of-living-report-2011 [accessed on March 14th, 2012].

Moguérou, Philippe, (2006), 'The Brain Drain of Ph.D.s from Europe to the United States: What We Know and What We Would Like to Know', *EUI Working Paper RSCAS no.2006/11*.

MORE, (2010), *Study on mobility patterns and career paths of EU researchers, final technical report 3: Extra-EU mobility pilot study*, Report prepared for the European Commission, Research Directorate-General, EU.

MORE, (2010), *Study on mobility patterns and career paths of EU researchers, TECHNICAL REPORT 2 – Part I: Mobility Survey of the Higher Education Sector*, Report prepared for the European Commission, Research Directorate-General, EU.

Mortensen, Dale T., (1970), 'Job Search, the Duration of Unemployment, and the Phillips Curve', *American Economic Review*, vol.60, no.5, pp.847-862.

Mortensen, Dale T., (1977), 'Unemployment Insurance and Job Search Decisions', *Industrial and Labor Relations Review*, vol.30, pp.505-517.

Mountford, Andrew, (1997), 'Can a Brain Drain Be Good for Growth in the Source Economy?', *Journal of Development Economics*, vol.53, no.2, pp.287-303.

Musselin, Christine, (2004), 'Towards a European Academic Labour Market? Some lessons drawn from empirical studies on academic mobility', *Higher Education*, vol.48, no.1, pp.55-78.

Naidoo, Vikash, (2007), 'Research on the Flow of International Students to UK Universities: Determinants and Implications', *Journal of Research in International Education*, vol.6, no.3, 287-307.

National Science Foundation, (2010), *Doctorate Recipients from US Universities: Summary report 2007-2008*, NSF 10-309, Arlington, Virginia.

National Science Foundation, (2010), *Science and Engineering Indicators 2010*, NSB 10-01, Arlington, Virginia.

National Science Foundation, (2011), *Doctorate Recipients from US Universities: 2009*, NSF 11-306, Arlington, Virginia.

OECD, (2008), *The Global Competition for Talent: Mobility of the Highly Skilled*, OECD 2008, Paris, France.

OECD, (2009), *The Future of International Migration to OECD Countries*, OECD report, Paris, France.

OECD, (2010), *Education at a Glance 2010: OECD indicators*, OECD Publications, Paris, France.

Oettl, Alexander and Ajay K. Agrawal, (2008), 'International Labor Mobility and Knowledge Flow Externalities', *Journal of International Business Studies*, vol.39, no.8, pp.1242-1260.

Oswald, Andrew J. and Hilda Rahlsmark, (2008), 'Some Evidence on the Future of Economics', *Warwick Economic Research Papers*.

Parey, Mathias and Fabian Waldinger, (2008), 'Studying Abroad and the Effect on International Labor Market Mobility: Evidence from the Introduction of ERASMUS', *IZA discussion paper No.3430*.

Petrongolo, Barbara and Christopher A. Pissarides, (2001), 'Looking into the Black Box: A Survey of the Matching Function', *Journal of Economic Literature*, vol.39, no.2, pp.390-431.

Roach, Michael and Henry Sauermann, (2010), 'A Taste for Science? PhD Scientists' Academic Orientation and Self-Selection into Research Careers in Industry', *Research Policy*, vol. 39, no.3, pp.422-434.

Rodriguez Gonzalez, Carlos, Ricardo Bustillo Mesanza and Petr Mariel, (2010), 'The Determinants of International Student Mobility Flows: An Empirical Study on the Erasmus Programme', *Higher Education*, vol.62, pp.413-430.

Romer, Paul D., (1990), 'Endogenous Technological Change', *The Journal of Political Economy*, vol.98, no.5, pp.71-102.

Rosenberg, Nathan, (1974), 'Science, Invention, and Economic Growth', *The Economic Journal*, vol.84, no.333, pp.90-108.

Sá, Carla, Raymond J.G.M. Florax and Piet Rietveld, (2004), 'Determinants of the Regional Demand for Higher Education in The Netherlands: A Gravity Model Approach', *Regional Studies*, vol.38, no.4, pp.375-392.

Sauermann, Henry and Michael Roach, (2012), 'Taste for Science, Taste for Commercialization, and Hybrid Scientists', working paper presented at KU Leuven on April 19th, 2012.

Saxenian, AnnaLee, (2002), 'Brain Circulation: How high-skill migration makes everyone better off', *The Brookings Review*, vol.20, no.1, pp.28-31.

Siegfried, John J. and Wendy A. Stock, (1999), 'The Labor Market for New PhD Economists', *Journal of Economic Perspectives*, vol.13, no.3, pp.115-134.

Siegfried, John J. and Wendy A. Stock, (2004), 'The Market for New Ph.D. Economists in 2002', *American Economic Review*, 2004, vol. 94, pp.272-285.

Smeets, Valérie, Frédéric Warzynski and Tom Coupé, (2006), 'Does the Academic Labor Market Initially Allocate New Graduates Efficiently?', *Journal of Economic Perspectives*, vol.20, no.3, pp.161-172.

Solimano, Andres, (2008), 'Causes and consequences of talent mobility', in Solimano, A.(ed.). *The international mobility of talent. Types, causes and development impact*. New York: Oxford University Press, pp.1-19.

Solow, Robert M., (1957), 'Technical Change and the Aggregate Production Function', *The Review of Economics and Statistics*, vol.39, no.3n pp.312-320.

Spence, Michael, (1973), 'Job Market Signaling', *Quarterly Journal of Economics*, vol.87, pp.355-374.

Stephan, Paula E. and Sharon G. Levin, (2001), 'Exceptional contributions to U.S. science by the foreign-born and foreign-educated', *Population Research and Policy Review*, vol. 20, no.1-2, pp.59-79.

Stephan, Paula E. and Sharon G. Levin, (2001), *Striking the Mother Lode: The Importance of Age, Place and Time*, Oxford University Press, New York.

Stephan, Paula E. and Sharon G. Levin, (2007), 'Foreign Scholars in U.S. Science: Contributions and Costs', in: *Science and The University*, eds. Paula E. Stephan and Ronald C. Ehrenberg, the University of Wisconsin Press.

Stephan, Paula E., (2010), 'The Biomedical Workforce in the U.S.: An Example of Positive Feedbacks', *ICER working paper 11/2010*

Stephan, Paula E., (2012), *How Economics Shapes Science*, Harvard University Press, Cambridge, Massachusetts.

Storbeck, Olaf, (2010), 'Wer Deutschlands Top-Ökonomen Sind', Handelsblatt [appeared online on 01.03.2010, accessed on 19.12.2011 on http://www.handelsblatt.com/politik/oekonomie/vwl-ranking/wer-deutschlands-top-oekonomen-sind/3380502.html]

Sumell, Albert J., (2006), 'The Role of Amenities in the Location Decision of PhD Recipients in Science and Engineering', Economics Dissertations, Paper 10. Georgia State University, Atlanta, GA, USA. Available at http://digitalarchive.gsu.edu/cgi/viewcontent.cgi?article=1009&context=econ_diss [accessed on March 14th, 2012].

Sumell, Albert J., Paula E. Stephan and James D. Adams, (2009), 'Capturing Knowledge: The Location Decisions of New Ph.D.s Working in Industry', in: *Science and Engineering Careers in the United States: An Analysis of Markets and Employment*, eds. Richard B. Freeman and Daniel L. Goroff, The University of Chicago Press.

Szelényi, Katalin, (2006), 'Students without Borders? Migratory Decision-Making among International Graduate Students in the U.S.', *Knowledge, Technology & Policy*, vol.19, no.3, pp.64-86.

The Economist, (May 14th, 2002), *Accuracy is Addictive*, Technology Quarterly Q1, available at http://www.economist.com/node/1020779 [accessed on January 4th, 2012].

Thomas, Duncan A., (2011), 'Developing Indicators and Typologies of Frontier-potential Researchers to Explore Impacts of the ERC's Starting Independent Researcher Grant', paper presented at the Science and Technology Indicators Conference of the European Network of Indicators Designers, 7-9 September 2011, CNR, Rome, Italy.

Thurow, Lester, (1975), *Generating Inequality: Mechanisms of Distribution in the U.S. Economy*, Basic Books, Inc.

Topel, Robert H. and Michael P. Ward, (1992), 'Job Mobility and the Careers of Young Men', *The Quarterly Journal of Economics*, vol.107, no.2, pp.439-479.

Train, Kenneth E., (2002), *Discrete Choice Models with Simulation*, Cambridge University Press.

Tremblay, Karin, (2001), 'Student Mobility Between and Towards OECD Countries in 2001: A Comparative Analysis', in: *International Mobility of the Highly Skilled*, OECD, Paris, pp.39-67.

Van Bouwel, Linda and Reinhilde Veugelers, (2011), 'Does University Quality Drive International Student Flows?', *CEPR working paper 7657.*

Van Bouwel, Linda and Reinhilde Veugelers, (2011), An 'Elite' Brain Drain: Are Foreign Top PhDs in the U.S. Less Likely to Return Home?, *MSI working paper series 1205.*

Van der Ploeg, Frederick and Reinhilde Veugelers, (2008), 'Towards Evidence-based Reform of European Universities', *CESifo Economic Studies*, vol. 52, no. 2, pp. 99-120.

Veugelers, Reinhilde, (2008), 'Towards A Multipolar Science World: Trends and Impact', *Scientometrics*, vol. 82, no. 2, pp.439-456.

Veugelers, Reinhilde, (2011), 'A G-2 for Science?', *Bruegel Policy Brief 2011/03.*

Wadhwa, Vivek, AnnaLee Saxenian, Richard Freeman and Alex Salkever, (2009), 'Losing the World's Best and Brightest', *America's New Immigrant Entrepreneurs, part V*, available at SSRN: http://ssrn.com/abstract=1362012.

Weitzman, Martin L., (1998), 'Recombinant Growth', *The Quarterly Journal of Economics*, vol.113, no.2,pp.331-360.

Winkler, Anne E., Sharon G. Levin, Paula E. Stephan and Wolfgang Glänzel, (2011), 'Publishing Trends in Economics across Colleges and Universities: 1991-2007', *IZA Discussion paper no.6082.*

Zucker, Lynne G. and Michael R. Darby, (2006), 'Movement of Star Scientists and Engineers and High-Tech Firm Entry', *NBER working paper 12172.*

LIST OF TABLES

Table 2.1: Distribution over degree fields and degree regions 88
Table 2.2: Personal characteristics by degree region 88
Table 2.3: Outflow of doctoral students by birth region/country 90
Table 2.4: Foreign inflow by degree region/country 90
Table 2.5: Science and innovation indicators: descriptive statistics 92
Table 2.6: Logit for degree country: degree at home (EU0) or abroad (EU1 or NA) 94
Table 2.7: Multinomial logit for degree country (base outcome: degree at home) 97
Table A.2.1: Variables and definitions 100
Table A.2.2: Multinomial logit model with time since degree instead of cohort dummies 102
Table 3.1: Summary statistics of the explanatory variables 113
Table 3.2: First job location by home region and home country 114
Table 3.3: Quality indicators by stay/return for the first job 116
Table 3.4: Logit models for the probability to stay (first job) 118
Table 3.5: Logit models for the probability of a top first job 119
Table 3.6: Quality indicators by location and top/non-top first job 121
Table 3.7: Multinomial logit model for the prestige and location of the first job 124
Table 3.8: Multinomial logit model for the prestige and location of the first job (continued) 125
Table 3.9: Location of the current job by location of the first job 126
Table 3.10: Location and prestige of the current job 127
Table 3.11: Logit for for current U.S. job 128
Table 3.11: Multinomial logit models for location and prestige of the current job 130
Table A.3.1: Institutions by tier and location 135
Table A.3.2: Correlations between the quality indicators 136
Table 4.1: Summary statistics 148
Table 4.2: Basic multinomial logit model 152
Table 4.3: Multinomial logit models with interaction terms 154
Table 4.4: Multinomial logit models with return home versus return to another European country 157
Table 4.5: Location and sector 7 years after graduation and for the current job 158
Table 4.6: Multinomial logit model 7 years after graduation 159
Table 4.7: Multinomial logit model for the current job 160
Table 5.1: PhD Degree regions and major countries 178
Table 5.2: Post-doc destination regions and major countries 179
Table 5.3: Major PhD degree country – Post-PhD mobility destination country dyads 180
Table 5.4: Composition of the sample in mobility groups 181
Table 5.5: Personal characteristics by mobility groups 183
Table 5.6: Motivations by mobility groups 184
Table 5.7: External influencing factors by mobility groups 186
Table 5.8: Logit model for mobility to the U.S. 193
Table 5.9: Logit models for mobility to the U.S.: EU degree versus home degree 195
Table A.5.1: Logit model with time since degree instead of cohorts 198
Table 6.1: Trends in publication shares across the quality distribution 203
Table 6.2: Correlations between effects 207
Table 6.3: Frequency of positive, negative and neutral effects 209
Table 6.4: Probability of negative-neutral-positive-strongly positive effects by destination of mobility 210

Table 6.5: Multinomial logit for negative, positive and strongly positive effects relative to neutral effects - relative risk ratios for mobility to the US 212
Table 6.6: Comparison of observable characteristics prior to and after matching (kernel matching) 214
Table 6.7: Propensity score matching (kernel): differences in effects..... 216
Table 6.8: Propensity score matching for strongly positive effects..... 217
Table A.6.1: Ordered logit for the effects of outward mobility..... 222
Table A.6.2: Multinomial logit model for negative, positive and strongly positive effects relative to neutral effects (1-4) – relative risk ratios..... 223
Table A.6.3: Multinomial logit model for negative, positive and strongly positive effects relative to neutral effects (5-8) – relative risk ratios..... 224
Table A.6.4: Kernel matching for exact sciences 225
Table A.6.5: Kernel matching for life sciences 226
Table A.6.7: Kernel matching for social sciences 227

LIST OF FIGURES

Figure 1: Chronological order of the chapters 19
Figure 1.1: PhD graduates in Europe 41
Figure 2.1: Graduation groups 86
Figure 4.1: The proportion of US, European and international job listings (1997 – 2006). 145
Figure 4.2: Academic listings per student and stay rates by year 145
Figure 4.3: The decision model 150
Figure 5.1: Mobility groups in the sample 177

DOCTORAL DISSERTATIONS FROM THE FACULTY OF BUSINESS AND ECONOMICS

Doctoral dissertations from the Faculty of Business and Economics, see:
http://www.kuleuven.ac.be/doctoraatsverdediging/archief.htm