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Departamento de Economía

Universidad Carlos III de Madrid

C/ Madrid, 126, 28903 Getafe (Spain)

Fax (34) 916249875

"THE EFFECT OF SPATIAL MOBILITY IN SCIENTIFIC PRODUCTIVITY. SOME EVIDENCE FROM A SET OF HIGHLY PRODUCTIVE ECONOMISTS"

Pedro Albarrán[a], Raquel Carrasco[b], and Javier Ruiz-Castillo[b]

[a] Departamento de Fundamentos del Análisis Económico, Universidad de Alicante

[b] Departamento de Economía, Universidad Carlos III

Abstract. This paper compares the average productivity of those in brain drain (migrants), brain circulation (temporary migrants) and stayers (whose entire career takes place in their country of origin) in a set of 2,530 highly productive economists that work in 2007 in a selection of the top 81 Economics departments worldwide. There are three main findings. Firstly, among nationals from the eleven countries other than the U.S. with at least one department in the sample, migrants are positively selected relative to stayers –exacerbating the brain drain problem from the sending countries point of view. Moreover, those in brain circulation are negatively selected relative to those brain-drained into the U.S. but are also generally more productive than stayers. Secondly, among U.S. nationals, the ranking is very different: brain circulation, followed by stayers, and brain drain. From a global point of view, the selection effects summarized in these two points can be seen as contributing to the best allocation of resources. Thirdly, comparisons between the average productivity of foreigners and stayers in a given geographical area are very much affected by two factors: the quality threshold that defines the base to which foreigners are compared, and the type of department where comparisons take place in a partition into five department categories. For example, in the bottom 56 departments foreigners are more productive than stayers in the total sample, but the two groups are indistinguishable in an elite consisting of 833 economists with above average productivity. In the top 25 U.S. departments the two groups are equally productive, both in the total sample and in the elite.

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I. INTRODUCTION

In all sciences, researchers originate from many countries. However, although spatial mobility is a widespread phenomenon, when we focus on the most productive and influential researchers we observe a clear funneling effect towards the U.S.: in all sciences, a large contingent of scientists working in the top U.S. research institutions have obtained their first college degree in their country of origin.[1] Understandably, this situation can be described as a case of what Hunter *et al.* (2009) calls the *elite brain drain* –a worrisome phenomenon from the point of view of the sending countries.

However, it can be argued that there are benefits in this situation both from a global point of view and from the perspective of the sending countries. Firstly, highly talented scholars in any scientific discipline would tend to cluster, seeking to inspire one another in mutually valuable ways. On the demand side, centers of world excellence would typically attempt to hire several outstanding researchers in as many areas as possible. In so far as this matching process works well, this clustering is efficient and should increase the flow of new knowledge and global welfare. Secondly, the recent literature on immigration emphasizes different channels through which sending countries may benefit from international mobility in a context of increasing globalization of scientific activity. In particular, there is a second group of scientists who study and/or work abroad followed by a return to the home country –a phenomenon known as *brain circulation*. Such people return home with the human capital they would have not acquired if it were not for the possibility of temporary emigration.[2]

Therefore, it is convenient to partition scientists born in any country into three groups: brain drain, brain circulation –which will be referred to as *movers*– and *stayers*, who are those who study and work in

[1] See *inter alia* Ioannidis (2004), Bauwens *et al.* (2008), and Panaretos & Malesios (2012). For a detailed analysis of the characteristics of highly productive researchers in Economics, see our companion paper Albarrán *et al.* (2014).

[2] For a survey of four decades of economics research on the brain drain, see Doquier & Rapoport (2012). Specifically, for the elite brain drain, see Zuckerman (1977), Stephan & Levin (2001), Weinberger & Galeson (2005), Laudel (2003, 2005), and the references in note 1. For a discussion of possible global and national effects of high-skilled international migration for sending and receiving countries, see Regets (2001), Commander *et al.* (2003), Ellerman (2006), and Ali *et al.* (2007). For the recent literature on immigration, see *inter alia* Stark (2005). For early references to brain circulation, see Glaser & Habers (1978), Gaillard & Gaillard (1997), and Johnson & Regets (1998).

their country of origin. This paper studies movers and stayers in a set of 2,530 highly productive economists that work in 2007 in the top 81 Economics departments worldwide according to the Econphd (2004) ranking. We measure individual productivity in terms of a quality index that weights the number of publications from the beginning of everyone's career up to 2007 in four equivalent journal classes. Not surprisingly, 52 out of the 81 departments in our sample are located in the U.S. There are only eleven countries with at least one of the remaining 29 non-U.S. departments in the sample. We refer to them as the Other Sample Countries (OSC hereafter). Individuals working in 2007 in the U.S. or the OSC that have been born elsewhere are said to come from the Rest of the World (RW hereafter).

In this scenario, we investigate two types of issues. In the first place, from the perspective of the sending countries, we are concerned with the following questions: are movers –brain drain and brain circulation– from the OSC positively selected relative to OSC stayers? Within the former, are brain circulation negatively selected relative to brain drain? Similarly, we compare the productivity of brain drain, brain circulation, and stayers among U.S. nationals –an issue never investigated before. In the second place, we study whether the productivity of foreigners is greater or not than the productivity of U.S. nationals. Similarly, our dataset allows us to study the same question for the economists working in 2007 in the OSC. In all comparisons, we control for a relatively rich set of variables: demographic characteristics (age and gender), education (the university where each individual earns her B.A. and Ph.D.), and the university where each holds her first job.

In relation to the first type of issues, we find that the average productivity of scholars born in the OSC working in 2007 in U.S. research institutions is greater than the average productivity of their counterparts pursuing their entire career at home. Moreover, among OSC movers we find that the average productivity of those brain drained into the U.S. is significantly greater than the average productivity of those in brain circulation that study or temporarily work in the U.S. before returning to work in 2007 in their country of origin. Interestingly enough, the latter have a significantly greater productivity than OSC stayers. Conversely, for U.S. nationals, our results indicate that U.S. migrants have lower productivity than those staying at home, and the small contingent of U.S. nationals in brain circulation has greater productivity than the U.S. stayers working outside the top 10 U.S. departments.

Note that these effects are obtained with retrospective data concerning economists' mobility and aggregate productivity viewed from 2007. Thus, it should be recognized at the outset that the endogeneity of individuals' locational choice makes a conclusive interpretation of these correlation results impossible. Fortunately, our review of the literature concerning the inexistence of geographically based spillover effects (Han Kim *et al.*, 2009, Azoulay *et al.*, 2010, Waldinger, 2012, Borjas & Doran, 2014, and Dubois *et al.*, 2014) and the literature that controls for the endogeneity of the locational choices made by temporary or permanent migrants into the U.S. (Kahn & MacGarvie, 2012, and Grogger & Hanson, 2013), allows us to conclude that the productivity differences between economists working in several categories of U.S. departments or the OSC are essentially due to self-selection on the supply side, and the role of meritocratic criteria on the demand side of a highly competitive market.

In relation to the second issue, that is, the existence of productivity differences between foreigners in the U.S. and U.S. nationals, the results in the literature are mixed. Independently of the fact that different studies use different methodologies, as well as different productivity measures for scientists in different fields during different time periods, there are also important differences in the characteristics of the group to whom migrants are compared. For example, Hunter, Oswald & Charlton (2009) –HOC hereafter– study a small sample of 138 highly cited researchers writing in Physics journals between 1981 and 1999. Using a simple formal model, their main conclusion is that, due to low mobility costs, the distribution of talent can be expected to be similar across different countries, and foreigners who move to the U.S. go on to be neither more nor less distinguished than American-born elite physicists. This contradicts the results from two important contributions that are able to control for the fact that migrants are typically positively selected. On one hand, in their study of a panel of

1,180 foreign- and 1,354 native-born Ph.D. economists working in the U.S., McDowell & Singell (2000) find that foreigners are more productive than natives prior to 1941 and from 1975 to 1985. On the other hand, Franzoni *et al.* (2014), using a retrospective questionnaire for a set of 3,160 migrants and 11,139 domestic scientists in Biology, Chemistry, Earth and Environmental Sciences, and Materials Sciences working in 2011 in 16 core countries, find that migrant scientists exhibit superior performance.

In this situation, we make all of our productivity comparisons for two different samples: the original sample of 2,530 economists, and the subset of 833 researchers with above average productivity –referred to as the *elite*. Moreover, we establish that an increase in the cut-off minimum quality threshold in the HOC model –as in the move from the total sample to the elite in our case– implies that the productivity of elite migrants converges to the productivity of elite stayers.

Our results indicate that it is crucial to control for the type of institution where economists work in 2007. Things are very different when we partition the 81 departments into the top 25 U.S. departments (that practically coincide with the top 25 departments in the world), the last 27 U.S. departments, and the 29 non-U.S. institutions in the OSC. In the last two categories, representing 65% of the total sample, foreigners are more productive than stayers. In the elite, however, where these two categories represent 43% of the total, the productivity of foreigners and stayers is statistically indistinguishable. On the other hand, foreigners are more productive than U.S nationals in Harvard and MIT in the total sample and the elite. However, in the remaining top 25 U.S. departments, foreigners and U.S. nationals are similarly productive both in the total sample and the elite.

The rest of the paper consists of five Sections, and two Appendices. Section II briefly reviews the literature on spillover effects, while Section III presents the data, as well as some descriptive statistics for the total sample. Section IV contains the empirical results concerning selection effects between movers and stayers, while Section V presents the results comparing the average productivity of foreigners and stayers in the total sample and the elite. Section VI summarizes the paper and offers some concluding comments. Appendix I contains some extensions of the HOC model, and Appendix II includes some statistical material.

II. LITERATURE REVIEW

II.1. Department spillover effects

The existence of geographical or department spillovers is hard to establish. One needs data of two types absent in our sample. Firstly, data on supply shocks generated by natural experiments, as in Borjas & Doran (2014), who exploit the massive emigration of soviet mathematicians following the collapse of the Soviet Union in 1989, or in Waldinger (2012), who exploits the dismissal of physicists, chemists, and mathematicians by the Nazi government in 1933. Secondly, one can use panel data, as in Han Kim *et al.* (2009), who collect data on research productivity for all individuals in Economics and Finance that have been affiliated with a selection of top 25 universities over the 1970-2001 period, or Dubois *et al.* (2014), who study the productivity patterns of mathematicians over the 1984-2006 period.

The results on the existence of spillover effects are clearly negative. Borjas & Doran (2014) and Waldinger (2012) find that there is no evidence for peer effects at the local level. Dubois *et al.* (2014) report that that university fixed effects are generally small, and are not strongly associated with the quality of the department, whereas Han Kim *et al.* (2009) find that strong positive spillovers emanating from high quality colleagues during the 1970s, weaken in the 1980s, and disappear in the 1990s. According to Borjas & Doran (2014) the relative importance of human capital spillovers depends on which type of peer group is being examined. The evidence they unravel, as well as the results in Waldinger (2010), and Azoulay *et al.* (2010) indicate that: "*Spillovers are more likely to be empirically relevant when two researchers are interacting regularly, and jointly producing new intellectual content, and at least one of them is of extremely high quality. Knowledge spillovers, in effect, are like halos over the heads of the highest-quality knowledge producers, reflecting only on those who work directly with the stars.*"

II.2. Selection effects for scientists in brain drain or brain circulation

The existence of spillover effects justifying that scientists returning home after earning a Ph.D. in the U.S. have a lower productivity than their counterparts who decided to remain in the U.S. is hard to test. As in the previous Section, one needs data on supply shocks generated by natural experiments, as in Khan & MacGarvie (2015), or panel data as in Grogger & Hanson (2013).

Khan & MacGarvie (2015) make use of a dataset of 446 foreign-born scientists in seven broad disciplines who earned a U.S. Ph.D. during the 1990s and early 2000s. The authors exploit the exogenous variation in these people's post-Ph.D. location induced by visa status. They identify pairs of foreign-born U.S.-Ph.D. recipients from the same department, in the same university, graduating during the same period (and, whenever possible, with the same advisor) –one of whom has a J-1 visa and is required by law to leave the U.S. for at least two years after finishing her doctorate as part of the Foreign Fulbright Program, and one of whom faces no such restrictions. When Khan & MacGarvie (2015) omit scientists who have returned to home countries in less wealthy regions, they find that there is essentially no difference in the rate of publication, citations received, and familiarity with recent literature between Fulbrights and Controls. Hence, among researchers from countries with a high GDP *per capita*, Khan & MacGarvie (2015) find no evidence for spillover effects.

Grogger & Hanson (2013) study 174,241 graduates in life sciences, physical sciences, and engineering over the period 1960 to 2008 using the NSF Survey of Earned Doctorates. They observe a number of correlates of ability, including parental education, the student's success in obtaining graduate fellowships, and the ranking of her Ph.D. program and university. Along most of these dimensions, students that appear more able are more likely to desire to stay in the U.S. Moreover, foreign students coming from countries with higher average income levels or that have recently democratized are less likely to remain in the U.S.[3]

However, it should be noted that two other results go in the opposite direction. Firstly, Khan & MacGarvie (2015) find a considerable negative effect of being abroad on publications in top journals both in wealthy and in poor countries. Taking into account that top publications play a large role in our productivity measure, this second finding goes against the above interpretation. Secondly, Gaulé (2014) studies a longitudinal panel of 1,460 chemists between 1993 and 2007, where the incidence of return migration is only 7.0% of the total. In relation to the issue under discussion, although the evidence on the effect of ability on the decision to return is mixed, overall the balance of evidence is more consistent with positive, rather than negative, selection into return migration.

III. DATA, DESCRIPTIVE STATISTICS, AND RESEARCH QUESTIONS

III.1. The data

In this Sub-section, we briefly describe a dataset that was originally constructed to study the elite in Economics (Albarrán *et al.*, 2014). In the first place, we select faculty members in the top 81 departments worldwide according to the Econphd (2004) university ranking. This ranking takes into account the publications in 1993-2003 in the top 63 Economics journals in the Kalaitzidakis *et al.* (2003) weighted journal ranking, where the weights reflect journal citation counts adjusted for factors such as

[3] Several contributions to the early literature on immigration agree with the above results. In a longitudinal study using the 1972-1978 Survey of Natural and Social Scientists and Engineers in the U.S., Borjas (1989) finds that the brain circulation contingent is characterized by poor labor market outcomes. This interpretation is also consistent with the model of Ramos (1992), and Borjas & Bratsberg (1996) where the process of return migration is expected to accentuate the selectivity of the initial step. Finally, brain circulation has been modeled as a consequence of unfulfilled expectations, that is, as a correction made in the light of better information (Da Vanzo & Morrison, 1981, and Lam, 1986).

the annual number of pages and the age of the journal (for further methodological details, see Econphd, 2004).[4]

Searching in the 81 departmental web pages in 2007, we found a total of 2,755 economists. The minimum information we require for each individual includes the nationality, the University where the Ph.D. is obtained, the age, and the publications in the periodical literature up to 2007. The information concerning the country of birth is seldom available. Therefore, we assign the nationality in terms of the country where each individual obtains a B.A. or an equivalent first College degree. Similarly, since people's age is not generally available we use the academic age, namely, the number of years elapsed from the Ph.D. (or equivalent degree) up to 2007. We could not find information about a person's education and/or publications in 50 cases. Therefore, the initial sample consists of only 2,705 economists.

We take the information available in Internet (personal web pages, *RePEc*, *Publish or Perish*, etc.) concerning the publications until 2007 of these 2,705 people. Because of budgetary restrictions, our information on productivity suffers from two limitations. Firstly, the article count in our dataset made no distinction between single and multiple-authorship. Consequently, no correction for co-authorship could be implemented. Secondly, although we know the journal where each article is published, it was impossible to search for the citation impact achieved by every article. Therefore, we are constrained to measuring individual productivity as a function of the number of publications per person. Specifically, we construct a quality index, denoted as Q, which weights the number of articles published by each author in four journal equivalent classes. The first three classes consist of five, 34, and 47 journals, respectively, while the fourth consists of all other journals in the periodical literature. The four classes are assigned

[4] We have compared this list with the first 81 economics departments listed in three other equally acceptable university rankings. The main conclusion is that, apart from differences in the order in which each institution appears in the various rankings, our list has between 70 and 73 departments in common with each of the three other lists (see Albarrán *et al.*, 2014 for further details). On the other hand, the Econphd (2004) department ranking is also used in Oyer (2006).

weights equal to 40, 15, 7, and 1 point, respectively.[5] The listing of the 81 departments, together with information for each institution concerning the number of faculty members (including Emeritus Professors), the number of people without publications, and the remaining scholars' publications in classes A to D, is in Section A in Appendix II.

Out of the 2,705 economists in our dataset, there are 175 faculty members without any publications at all (typically because they are on tenure track). In line with the previous literature on individual productivity, in the sequel we focus on the remaining 2,530 faculty members with at least one publication. They constitute a very productive sample: the average productivity is 307.3 quality points *per capita*, equivalent to more than seven articles of class A or about 20 articles of class B. Alternatively, the average quality index is 16.1 per year during an academic life (the period from the first year after receiving a Ph.D. up to 2007), a quantity that can be compared with the 15 points assigned to one article in class B.[6]

It should be emphasized that the distribution of individual productivity is highly skewed: the average productivity is almost 17 percentage points above the median, and the top 11.7% of economists in the last category account for 43.7% of all quality points. As explained in Section B in Appendix II, this description closely resembles the available evidence concerning comparable productivity distributions in Economics and Business and other broad scientific fields.

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[5] Starting from the top 63 journals in the Kalaitzidakis *et al.* (2003) journal ranking, the different classes have been constructed taking also into account the rankings in Lubrano *et al.* (2003), and Kodrzycki & Yu (2006). Class A includes the *American Economic Review*, *Econometrica*, *Journal of Political Economy*, *Quarterly Journal of Economics*, and *Review of Economic Studies*. By way of example, the following 12 journals are in class B: *Economic Journal*, *Games and Economic Behavior*, *International Economic Review*, *Journal of Econometrics*, *Journal of Economic Growth*, *Journal of Economic Theory*, *Journal of Finance*, *Journal of Labor Economics*, *Journal of Monetary Economics*, *Journal of Public Economics*, *Rand Journal of Economics*, and *Review of Economics and Statistics*. See Albarrán *et al.* (2014) for further details concerning the construction of this index.

[6] In contrast, consider the following three facts concerning larger professional groups: only 42.8% of European academic economists published at least once in *EconLit* during 1971-2000 (Combes and Linnemer, 2003); 122,889 researchers in Economics and Business published only 0.25 articles per year during 2003-2011 (Ruiz-Castillo & Costas, 2014), and only 39% of a sample of 1,600 economists graduating in the period 1969-1988 in the U.S. published at least one article, averaging 0.42 publications per year in 126 journals (Hutchinson & Zivney, 1995).

III.2. Explanatory variables and descriptive statistics

To account for such large differences in individual productivity, we have three types of explanatory variables concerning the academic career, the distinction between movers and stayers, and some demographic variables.

1. As far as the professional career, we only have information concerning the universities where individuals obtained their B.A., and their Ph.D., as well as where they held their first job (FJ hereafter), and their current job (CJ hereafter) in 2007.

For our purposes, it is very important to find a useful partition of the career variables, starting with the CJ in 2007. The 81 departments in the sample are classified into Top and Bottom institutions using the Econphd department ranking (Section A in Appendix II). The first 10 departments in the world are in the U.S. Of the next 19, 15 are also in the U.S.[7] Thus, we define the Top institutions as the 25 first U.S. departments, while the Bottom institutions include the remaining 56 departments.[8] Within the Top, we distinguish between three groups, starting with Harvard and MIT –the two influential universities where 14% of the total sample earned their Ph.D. (Albarrán *et al.*, 2014). The next two groups consist of the next 8 and 15 best departments in the U.S. Within the Bottom, we distinguish between two groups: the last 27 U.S. departments, and the 29 non-U.S. departments located in the OSC. As indicated in note 6, the OSC consist of eight European countries (UK, the Netherlands, Spain, Sweden, France, Germany, Belgium, and Denmark), and three non-European countries (Canada, Israel, and China). We should

[7] The four departments outside the U.S. among the first 25 in the world according to the Econphd ranking are the London School of Economics (12), the University of Toulouse (14), the University of British Columbia (20), and Tilburg University (24).

[8] Of course, which departments are "top 10", "top 25" or "last 27" at any moment is open to debate. Moreover, even if this classification is appropriate for 2004-2007, individual departments are likely to have changed positions over the period of this study prior to 2007. Therefore, it is advisable to take this partition as representative of "top" or "bottom" departments in general.

emphasize that the two Bottom department groups are heterogeneous categories with a large overlapping in terms of the Econphd department ranking.[9]

The distribution of the 2,530 economists in the sample according to their CJ in 2007 is presented in the last two columns in Table 1.A. Naturally, some of these individuals have earned their B.A. or Ph.D., and have held their FJ in other U.S. or non-U.S. universities different from the 81 sample departments. Consequently, the partitions for the distribution of the total sample according to these three career variables have been correspondingly extended by including one more type of *Other* U.S. universities, as well as two types of non-U.S. universities: those located in the 15 countries forming the European Union before 2004 (*EU* hereafter), and those located elsewhere, or *Non-EU* universities (see columns 1 to 6 in Table 1.A).

Table 1 around here

The following three points should be noted. Firstly, U.S. graduate schools are very attractive for this set of highly productive economists. In particular, approximately 44% of them earned their Ph.D. at the ten top U.S. schools. Secondly, because some people went back home after the Ph.D., those holding a FJ in the U.S. are almost 12 percentage points fewer than those graduating there. Thirdly, after a re-shuffling at the next stage, the number of people working in 2007 in the U.S. or in the European OSC somewhat increases, while the number of people working in the non-European OSC decreases. The end result is that only 38.7% of the sample is born in the U.S., but 62.0% end up working there in 2007 –a strong funneling effect towards the U.S. (see Albarrán *et al.*, 2014, for further details).

[9] In particular, the U.S. group consists of nine institutions ranged from the 32 to the 44 position in the Econphd ranking, and 18 departments ranged from the 51 to the 78 position, while the non-U.S. group consists of the four departments in the range 12 to 24 mentioned in note 9, seven departments ranged from the 30 to the 45 position, and 18 departments ranged from the 46 to the 81 positions (Section A in Appendix II).

2. For our purposes, it is important to distinguish between movers –brain circulation and brain drain– and stayers. The distribution of people according to this distinction and the CJ in 2007 is in Table 1.B. Relative to U.S. stayers (column 1), brain circulation (column 2) and brain drain (cell 10) among U.S. natives are small categories, just the opposite of the situation of those born elsewhere, among whom we must distinguish between those born in the OSC or the RW. Firstly, the former are classified into four groups: stayers (cell 7), brain circulation (cell 8), and brain drain; in turn, the latter can be classified into those who migrate to the U.S. (column 5), or to any of the OSC (cell 10). Secondly, those born in the RW can only be brain drained, either to the U.S. (column 4), or to one of the OCS (cell 11).

In this scenario, we investigate two issues. Firstly, we compare the average productivity of movers –brain drain and brain circulation– and stayers born in two geographical areas: the U.S., and the OSC. Consider those born in the OSC. We would like to answer two questions. (i) Are those brained-drained into the U.S. positively selected relative to stayers? (ii) Are those in brain circulation negatively selected relative to the brain drain, and do they exhibit a greater productivity than stayers? By the same token, we would like to answer these selection questions for U.S. nationals. Secondly, assume that migrants from the OSC and elsewhere to the U.S. are positively selected. Does this imply that they are also more productive than U.S. stayers? Finally, we also compare the productivity of migrants and stayers working in 2007 in the OSC.

3. These questions must be answered controlling for the career variables introduced in point 1. On the other hand, our measure of aggregate productivity up to 2007 clearly favors older people. Therefore, it is essential to control for age effects. We also have information about individuals' gender. The mean (and standard deviation) for the demographic and productivity variables for a set of key sub-groups are reported in Table 2. The sub-groups are defined in terms of the mover/stayer distinction and the CJ in 2007. The following five points should be noted.

Table 2 around here

(i) Standard deviations are generally large, so that mean value differences for any variable are not statistically significant. In particular, there are no clear productivity differences between foreigners and stayers in the U.S. (rows 1 to 8 in Table 2), nor between movers and stayers among U.S. or non-U.S. nationals (that is to say, between rows 1, 3, 5, 7, 9, and 10 for the former, and between rows 2, 4, 6, 8, 11, 13, and 14 among the latter). Statistically significant differences will only appear, if at all, in a multiple regression context.

(ii) The proportion of females in the total sample, 14.0%, ranges from a minimum of 7.0% and 11.1% in rows 4 and 1, to a maximum of 18.7% and 17.7% in rows 12 and 8.

(iii) On average, foreigners working in the U.S. in 2007 are systematically younger that U.S. stayers (see rows 1 to 8). Therefore, although the mean *Q* index for the latter is always greater than for the former, the opposite is the case for average *Q/Age* values. This clearly shows the importance of controlling for age effects in any explanation of individual productivity.

(iv) As can be seen in Section A in Appendix II, the first four groups of the partition of the total sample according to the CJ, consisting of the 52 U.S. universities, are hierarchically ordered according to the Econphd ranking (except for the University of Chicago that is ranked number two in this ranking but is placed in the second group in the partition according to the CJ). This hierarchy is confirmed by our productivity measures in the sense that, independently of age effects, average *Q* and *Q/Age* values decrease systematically from Harvard and MIT, all the way down to the last 27 U.S. departments. This should come as no surprise when one realizes that –as pointed out in note 9– together with other rankings, our four journal categories are based on the Kalaitzidakis *et al.* (2003) journal ranking on which the Econphd ranking is entirely based.

(v) Recall that the last 27 U.S. departments and the 29 non-U.S. departments are heterogeneous categories with a large overlapping in terms of the Econphd department ranking. These 56 institutions at the Bottom of the sample, including 1,634 individuals, or almost two thirds of the total, are classified into seven sub-groups in Table 2 (rows 7, 8, and from row 10 to 14). We want to note at this point that the U.S. and non-U.S. stayers (rows 7 and 14) are practically of the same size, and have a very similar low average productivity per year.

IV. PRODUCTIVITY DIFFERENCES BETWEEN MOVERS AND STAYERS

IV.1. Results

The aim of this Section is the comparison of the average productivity of brain drain, brain circulation, and stayers for those born in the OSC and the U.S. In this and the next Section, the dependent variable is always the log of the *Q* index. We distinguish between two types of control variables: demographic characteristics, as well as the variables describing the progression of economists' through their college education and the first part of their academic career.

As far as the role of age, the nature of the data determines what we can study. In the first place, we know the academic rather than the biological age. In the second place, we have information concerning only the productivity of each individual in successive eight-year periods (naturally, for most individuals the last observation period will be typically less than eight years). This leads us to measure individual productivity –the index *Q*– as the sum of all eight-year productivity observations for each individual or, in other words, as the total productivity over her academic career up to 2007. Therefore, ignoring period effects, we are restricted to study two effects: *experience* or (*academic*) *age effects*, as well as *cohort effects*.

To study cohort effects, we introduce a dummy variable, *Young*, that takes the value one for young people, who are defined as those who earn a Ph.D. at most 24 years before 2007. Taking into account that the median age for finishing a Ph.D. is approximately 30 (Scott & Sigfried, 2008), young people in our sample are those with at most 55 years of age in 2007. They represent 67.1% of the total sample. We must recognize that the productivity effect of one more year of academic experience need not be the same after five or ten years of obtaining a Ph.D., when the individual is young, than after thirty or thirty five years, when the individual is old. Therefore, we end up modeling age and cohort effects by including the variables *Age*, Age^2, *Young*, plus the interaction terms (*Age* x *Young*) and (Age^2 x *Young*). Thus, together with gender, we have six demographic variables.

Next, we define a set of dummy variables that capture the progression of economists' through their college education and the first part of their academic career. Specifically, these variables capture their region of origin (the U.S., the OSC, or the RW), their current job according to the five categories defined in Section III.2. (HMIT, Next-8 U.S., Next-15 U.S., Last-27 U.S., 29 non-U.S departments), and their condition of stayers or movers (brain circulation or brain drained). Since we have five department categories and three national groups, we end up with 15 alternative groups. Moreover, accounting for the distinction between stayers and migrants adds 6 additional groups, giving a total of 21 variables, defined as follows:

• Among the U.S. nationals we can distinguish between the stayers in the four U.S. departamental categories, the brain drained, and the small contingent of brain circulation who studied outside the U.S. Therefore, U.S. nationals are partitioned into six groups.

• Among the nationals from the OSC we can distinguish between those brain drained in the four U.S. departamental categories, the stayers, the brain circulation, and those in what we call *internal brain drain* who are working in 2007 in one of the OSC but outside their country of origin. In addition, in the last two groups it is useful to distinguish between those who attended graduate school inside or outside the U.S. Therefore, nationals from the OSC are partitioned into nine groups.

• Within the nationals from the RW, who are all brain drained, we can distinguish between those working in the four U.S. department categories, and those who are working in the OSC. In the last group, we also distinguish between those who earned a Ph.D. inside or outside the U.S. Therefore, RW nationals are partitioned into six groups.

To save space, the results of the final specification including controls for gender, age and cohort, and B.A., Ph.D, and FJ variables are presented in the left-hand panel of Section B in Appendix II. According to the results, it seems crucial to control for age effects. The following comments are in order.

• Human capital models suggest a humped-shaped progression of individual research productivity with academic age because the stock of human capital needs to be built up at the beginning of the career while, due to the finiteness of life, no new investment offsets depreciation and net investment declines (eventually) over time (see Diamond, 1984, as well as the references in Carrasco & Ruiz-Castillo, 2014). As explained in Section C in Appendix II, this is exactly what we find. Furthermore, the young are less productive than the old but the young's productivity gap decreases with experience. Finally, in line with the literature, the productivity of females is -0.55 smaller than the productivity of males (see Carrasco & Ruiz-Castillo, 2014, for references to this literature).

• The adjusted R^2 when we only include the six demographic variables is 0.44, indicating that their explanatory power is very important.[10] The inclusion of the remaining explanatory variables, capturing the effect of the institution where individuals obtain a college or a graduate degree, and where they held their first job and their current job in 2007, increases the adjusted R^2 to 0.55 (For a detailed analysis of the role of all controls, see Section C in Appendix II). Given the high skewness of the individual productivity distribution, we must conclude that the goodness of fit is satisfactory.

[10] Interestingly, "Years since Ph.D. accounted for 43% of the variance of log(total citations), 48% of the variance in log(*h*), 36% of the variance in log(*e*), and 54% of the variance in log(h_m) [*e* and h_m are variants of the *h* index] (Nosek *et al.*, 2010, p. 1287).

A summary of regression results for the key 21 groups of movers and stayers for the three nationalities is presented in Table 3. We begin by studying the productivity differences between nationals from the OSC who are working in 2007 in the OSC (reference group) with respect to the other categories (brain drained to the four U.S. departments, brain circualtion, and internal brain drain). The first two columns present the regression coefficients and the *t*-values. In addition, we test whether the regression coefficients of any pair of consecutive variables are significantly different. When the null hypothesis that they are statistically undistinguishable is rejected, the *p*-value has an asterisk. Therefore, a low *p*-value –below 0.10– indicates that the two regression coefficients are different, in which case the *p*-value has an asterisk. For example, the regression coefficients for those brain-drained into Harvard or MIT versus the next eight U.S. departments are 1.9552 and 1.2496 (variables 1 and 2). The *p*-value is 0.010*, indicating that they are significantly different. The regression coefficients indicate that all groups considered, except those in brain circulation with a PhD. outside the U.S., have a productivity significantly higher than the stayers in the OSC. Moreover, according to the *p*-values, we find what we call strong *department effects*: the economists working in the four categories of U.S. departments are the ones with higher productivity, followed by those in brain circulation who have earned a Ph.D. in that country (variables 1 to 5 in Table 3).

Table 3 around here

Next, consider the U.S. nationals. We also find evidence of department effects, since the average productivity of those in the top 10 U.S. departments is higher than that for those working in the next 15 U.S. departments, and higher than that for the remaining 56 departments in the sample. Moreover, as opposed to the finding for the OSC nationals, we find that the handful of U.S. scholars in brain circulation are characterized by outstanding productivity, equivalent to the productivity achieved by those at Harvard and MIT.

Finally, consider the economists born in the RW. Judging from the first three *p*-values, the department effects in the four department categories distinguished in the U.S. are strongly confirmed (variables 16 to 19). In turn, the average productivity of those in the top 25 U.S. departments is significantly greater than the productivity of those working in the OSC regardless of whether or not they have earned a Ph.D. in the U.S. Therefore, we conclude that for those born in the RW department effects are also strongly confirmed.

IV.2. Interpretation

The problem is that the interpretation of the above results requires discussing whether higher performing universities contribute to the productivity of individual researchers and/or they simply attract more productive individuals. As reviewed in Section II.1, the results on the existence of spillover effects are clearly negative (Han Kim *et al.*, 2009, Azoulay *et al.*, 2010, Waldinger, 2012, Borjas & Doran, 2014, and Dubois *et al.*, 2014). In particular, in their important contribution to the decline of spillover effects in the top 25 U.S. university economics and finance departments over the 1970-2001 period, Han Kin *et al.* (2009) discard the possibility that several endogenous selection channels inherent in location decisions explain the weakening of university fixed effects from the 1970s to the 1980s, and their disappearance during the 1990s.[11] They also examine the possible role of other factors such as differences in organizational culture, the quality of the Ph.D. program, or the erosion of a possible first mover advantage in the 1970s. Instead, they conclude that the loss of elite university effects is due to advances in communication technology. "*While collaboration across universities was common even in the 1970s, local interaction was vey important. Communication at a distance was costly from a monetary and a technical point of view…Throughout the period, the costs of long-distance telephone calls and airfares declined, easing the burden of voice and*

[11] It should be noted that the list of 25 departments in Han Kim *et al.* (2009) includes our first 15 U.S. departments. Together with the University of British Columbia, located in Canada, three other of their departments appear between positions 16 to 20 in our U.S. ranking, while the remaining six appear in the positions 26, 28, 30, 34, 43, and 46 of that ranking.

person-to-person communication. Early innovations for exchanging written work include faxes and overnight mail deliveries. The arrival of the Internet in the 1990s, however, initiated a new ear of communication and access to others' research" (p. 354). In line with this explanation, Han Kin *et al.* (2009) confirm that co-authorship at a distance rises steadily during the period.[12]

Naturally, the decline of spillover effects is compatible with the permanence of what we call department effects. As Han Kin *et al.* (2009) indicate, "*The difference in average individual productivity between the top 25 universities and the others has increased, not decreased, in the last three decades. Elite universities seem to attract and retain the most productive researchers, even though these universities do not make their faculty more productive*" (p. 355). This is, of course, what we find in our dataset: highly productive economists tend to come together in institutions of high productivity and prestige in a hierarchically ordered manner. Han Kim *et al.* (2009) argue that, on the supply side, top researchers agglomerate in institutions with prestigious undergraduate programs and in departments with high past research reputations. Such agglomeration could be due to the utility and the prestige of co-location with other creative minds. This, together with the role of meritocratic criteria and a reasonable degree of ability in hiring and promoting decisions on the demand side in a highly competitive market, help account for the existence of a clear hierarchical department structure, such as the one revealed in the Econphd department ranking, globally in Table 3, and for the three groups of nationals in our sample in Table 4.

For the OSC nationals, the implication of the results for variables 1 to 4 in Table 4 is clear: given the absence of spillover effects, we conclude that brained-drained economists from these countries into the U.S. are positively selected relative to stayers. Furthermore, the results for the internal brain drain within the OSC (variables 6 and 7 in Table 4) confirm this selection interpretation. For U.S. nationals, we have already seen that the productivity of brain drain economists are indistinguishable with the

[12] According to Han Kin *et al.* (2009), this finding consistent in their view with Laband & Tollison (2000), Rosenblat & Mobius (2004), Goyal *et al.* (2006), and Agrawal & Goldfarb (2008), who show that decreasing communication costs have increased distant collaboration in academia and opened vast research networks.

productivity of U.S. stayers working in the bottom 27 U.S. departments, but are less productive than those working in the top 25 U.S. departments. We interpret the latter finding as indicating that U.S. brain drain economists are negatively selected relative to U.S. stayers at the top, a finding consistent with the first extension of the HOC model introduced in Section C in Appendix I.

Regarding the interpretation of the productivity differences between individuals brain drained and those in brain circulation, again with our data we cannot discriminate between the alternative interpretations, namely, that the reason for the aggregate productivity of OSC nationals in brain circulation being smaller than the average productivity of those who remain in the U.S. is the existence of spillover effects, or the fact that economists in brain circulation are negatively selected. Fortunately, the literature comes partially to the rescue: although some of the evidence goes in the opposite direction (Khan & MacGarvie, 2015, and Gaulé, 2014), most of the results reviewed in Section II.2 indicate that the second interpretation is more likely (Khan & MacGarvie, 2015, Grogger & Hanson, 2013, Borjas, 1989, Da Vanzo & Morrison, 1981, Lam, 1986, Ramos, 1992, and Borjas & Bratsberg, 1996). In particular, Khan & MacGarvie (2015) conclude "*The results suggest that those who remain in the US are at an advantage in terms of higher rates of publications, citations and familiarity with recent literature compared to those in countries with low GDP per capita...However, we cannot reject the hypothesis that those in countries with high GDP per capita – especially those countries in the top decile of GDP per capita – are just as likely to publish, to be cited and to remain current as those remaining in the U.S.*" (p. 41). Except for China, the other ten countries with at least one department in our dataset are wealthy ones. Therefore, in the absence of strong spillover effects that favor the productivity of migrants remaining in the U.S., our finding that the average productivity of economists born in the OSC who return home to work in 2007 is smaller than the average productivity of those who remain in the U.S. will be interpreted as indicating that brain circulation involves negative selection relative to brain drain –a finding consistent with the second extension of the HOC model in Appendix I.

However, among the U.S. nationals we obtain the opposite result: the handful of U.S. scholars that attend graduate school abroad before coming back home are characterized by an outstanding productivity, equivalent to the productivity achieved by those at Harvard and MIT, and significantly greater than the productivity of those working in the remaining 50 departments. In the absence of external effects, we interpret this result as indicating that U.S. brain circulation are positively selected relative to most U.S. stayers.

V. PRODUCTIVITY DIFFERENCES BETWEEN FOREIGNERS AND STAYERS

In this Section we study productivity differences between foreigners and stayers. Given the strong department effects unveiled in the previous subsection, it is essential to make these comparisons conditional on the type of department where each individual is working in 2007. For that purpose, we use the classification into five categories (HMIT, Next 8 U.S. departments, Next 15 U.S. departments, Bottom 27 U.S. departments, and 29 non-U.S. departments). We also find it appropriate to treat all migrants together in each department category independently of their country of origin.

As indicated in the Introduction, a key aspect of this paper is the emphasis on the consequences of changing the quality threshold that defines the base with which we make all comparisons, or the size of the sample under study. Consequently, this Section is organized in three parts. Firstly, we study the total sample consisting of 2,530 economists. As we will presently see, productivity differences between migrants and U.S. stayers depend decisively on the distinction between Top and Bottom departments. Secondly, we briefly discuss the main characteristics of what we call the *elite*, namely, the sample of 833 economists with above average productivity. Thirdly, we study whether the results in the total sample are maintained in the elite.

V.1. Results for the total sample

Complete results for the total sample are presented in the left-hand panel of Section D in Appendix II. A summary of results for the key sub-groups is in the left-hand side of Table 4. Let us begin with the 52 U.S. departments. Our results indicate that, except for Harvard and MIT, incoming scientists in the top 25 U.S. departments are on average of similar quality as stayers. This result can be explained in the context of the HOC model: in a world of decreasing mobility costs as described in Han Kin *et al.* (2009) for a selection of top 25 departments in Economics and Finance over the 1970-2001 period, scientists of more average kind of abilities may find it rational to migrate. Hence mobile incoming scientists will be of similar quality to the average of those working in the receiving countries.

Table 4 around here

Regarding the last 27 U.S. departments, the key fact is the low productivity of U.S. stayers. A possible explanation is that U.S. nationals have to balance the attraction and costs of an academic career with the opportunities that the U.S. economy offers to highly skilled economists outside academia. Judging from their relatively weak performance, those who choose an academic life at the bottom of the scale are less motivated than those who are able to work at the top 25 departments. Instead, foreigners in the last 27 U.S. departments appear to find good reasons to pursue an academic career in the U.S., and strive to maintain a good performance just below what comparable migrants exhibit at the top 25 U.S. departments. As a matter of fact, given that the productivity of U.S. stayers in the last 27 U.S. departments is indistinguishable from the productivity of the stayers in the 29 departments in the OSC, it is the presence of highly motivated foreign economists in the former that explains their superior overall status over the departments in the OSC.

Finally, we must deal with the comparison of foreigners and stayers in the OSC. Judging from its *t*-value, foreigners are significantly more productive than OSC stayers in the reference group. The break down available in Table 4 throws some additional light over this comparison. Independently from where they earned their Ph.D., only the 138 economists in the internal brain drain category (variables 6 and 7 in Table 4) are significantly more productive than the 411 OSC stayers. The productivity of the remaining migrants –56 from the U.S., and 138 from the RW– is indistinguishable from the productivity of the reference group.

V.2. Characteristics of the elite

The main differences between the two samples can be summarized as follows (complete descriptive statistics for the elite, and a more detailed analysis of differences with respect to the total sample are relegated to Section E in Appendix II).

• Although 50.3% of the elite are born in the U.S., the proportion working there in 2007 is 76.8% - a funneling effect of 26.5% of a similar order of magnitude than the 23.3% observed in the total sample.

• From the point of view of geographic mobility, the proportion of stayers increases by 6.3%, while the proportion of brain drain and brain circulation decreases by 5.3% and 1%. Given the increase of people working in 2007 in the U.S., and given that the proportion of U.S. movers is even smaller than before, the main change in this respect is the 14.1% increase in the proportion of U.S. stayers. On the other hand, the proportion of migrants into the U.S. slightly increases up to 28.1%, so that the brain drain to the OSC decreases. Finally, the proportion of stayers outside the U.S. also decreases. These changes are illustrated in Figure 1.A.

• Given the partition of the 81 departments we have considered so far, we must emphasize the increasing role of the top 25 U.S. departments, with a 19.6% increase, offset by a decrease of 4.7% and 14.9% in the last 27 U.S. departments and the 29 non-U.S. institutions, respectively. The situation is illustrated in Figure 1.B.

Figure 1 around here

For our purpose, it is particularly important to examine the changes in the distribution of economists between foreigners and stayers. Relative to the total sample, in the elite the proportion of the stayers increases by 2.9% in the OSC, and by 4.2% in the U.S. This increase is particularly large in the top 25 U.S. departments. However, recall the low average productivity of U.S. stayers in the total sample in the bottom 27 U.S. departments. Consequently, contrary to what we have seen in the top three groups, the proportion of U.S. stayers in that last 27 U.S. departments decreases in the elite. The situation is illustrated in Figure 2.

Figure 2 around here

V.3. Results for the elite

In comparison with the total sample, the distribution of the *Q* index for the elite is somewhat less skewed.[13] Complete regression results are presented in the right-hand panel of Section D in Appendix II. Although some of the findings concerning department effects and demographic variables in accounting for individual productivity are interesting, they are not central to the role of the elite in this paper. Therefore, we relegate these findings to Section F in Appendix II, while in this Section we exclusively focus on the comparison of the productivity of foreigners and stayers in the U.S. and the OSC. A summary of regression results for the elite appears in the right-hand panel of Table 4.

Intuitively, increasing the quality threshold and reducing the sample size, would tend to make elite members more homogeneous among each other in each of the department categories of the partition we have been studying, that is, controlling for individuals' CJ in 2007. As a matter of fact, our third extension of the HOC model establishes that the higher the quality threshold considered, the closer is the average productivity of foreigners and stayers expected to be (Section B in Appendix I). As

[13] The mean is fifteen points to the right of the median, and 13.3% of elite economists with outstanding productivity above the second mean accounts for 30.8% of all *Q* points –whereas these figures were 11.5% and 43.6% in the total sample (Table B.3 in Section B in Appendix II).

can be observed in the right-hand side of Table 4, this is exactly what happens in the two types of Bottom departments where foreigners, who were more productive than stayers in the total sample, are now indistinguishable from stayers in the last 27 U.S. departments and the 29 non-U.S. departments in the OSC.

On the other hand, relative to the total sample, there is no change in the Top departments: migrants remain more productive than U.S. stayers in Harvard and MIT, while the two groups remain indistinguishable in the next eight and 15 U.S. departments.

To appreciate the importance of controlling for department effects, consider the maximum possible aggregation level with a single department category. In this case, foreigners are significantly more productive than stayers in both the total sample and the elite (see Section G in Appendix II). In the total sample, this is an expected result: foreigners are more productive than stayers in 58 out of 81 departments. Even so, the different situation in the remaining 23 top U.S. departments is completely lost of sight. In the elite, the apparent foreigners' superiority is mainly explained by the extraordinary relative performance in Harvard and MIT and other top ten U.S. departments. We conclude that the CJ in 2007 is a variable that cannot be omitted without causing serious distortions.

In brief –coming back to Table 4–, except for Harvard and MIT, in the elite foreigners are indistinguishable from stayers in the remaining 79 departments in our dataset, whose members represents 92.6% of the total in the elite (and 96.5% in the total sample). This is essentially the same result as in Hunter *et al.* (2009) for an elite consisting of 138 highly cited physicists between 1981 and 1999. However, as we pointed out in the Introduction, this at variance with the main finding in McDowell & Singell (2000), and Franzoni *et al.* (2014) who were able to control for the selection effects associated to foreigners locational choices. We find two possible explanations. The first lies in the nature of the population being investigated. McDowell & Singell (2000) find that foreigners are more productive than natives prior to 1941 and from 1975 to 1985 in a panel of 1,180 foreign- and 1,354 native-born Ph.D. economists working in the U.S., whereas Franzoni *et al.* (2014) find that 3,160 migrant scientists exhibit superior performance than 11,139 domestic scientists in 16 countries. Instead, Hunter *et al.*'s (2009) dataset and our elite focus on a reduced group of outstanding scientists. In the second place, McDowell & Singell (2000) do not control for department effects. Ignoring these effects, we also find that foreigners are generally more productive than U.S. nationals.

VI. SUMMARY AND CONCLUSIONS

Generally, individual productivity is a variable difficult to measure in all sectors. However, the reward structure of science around the priority of discovery provides a powerful incentive for scientists in all disciplines to publish the results of their research. The fact that publications, as well as their impact through citations, are observable facilitates the measurement of an important aspect of scientific productivity. In this paper, we have measured the individual productivity of a set of highly productive economists in terms of a quality index that weights the number of publications from the beginning of everyone's academic career up to 2007 in four equivalent journal classes.

Individual productivity distributions in all scientific fields are highly skewed regardless of the size of the population studied. Accounting for such large differences for highly productive economists constitutes the thread that runs throughout the paper. The most important explanatory variables can be classified into two groups.

1. Cohort, gender, and non-linear academic age effects. These demographic variables prove to be very important determinants of our accumulated productivity measure in the total sample. Among the elite, age and gender effects are much less important.

2. The type of department where one works in 2007. We distinguish between five department categories. With few exceptions, department effects are present for the three types of people distinguished according to where they have earned their first college degree: the U.S., the eleven OSC, and all other countries in the RW. Our reading of the literature concerning the non existence of

geographically-based spillover effects, leads us to conclude that these department effects are essentially due to selection factors operating from the demand for and the supply of highly productive economists.

In this scenario, the paper has reflected upon two issues. The comparison of the productivity of movers –brain drain, and brain circulation– and stayers for people born in a given geographical area, and the comparison of the productivity of foreigners (brain drain) and stayers working in the same geographical area.

With regard to the first issue, our major finding related to the economists born in the OSC is the following: except for the economists in brain circulation that did not earn their Ph.D. in the U.S., the productivity of movers born in the OSC is hierarchically ordered in the department categories we have distinguished and are positively selected relative to those conducting their entire careers in their country of origin. This has two interesting policy implications.

- From the point of view of the sending countries, there are reasons for concern about the consequences of the brain drain. As Laudel (2005) has emphasized for narrowly defined specialties, the consequences for any country from losing elite members typically means that the national specialty becomes uncoupled from frontier science; quality standards might no longer be enforced nationally; the country may no longer be able to recruit or train the best young scientists in the field (a country needs elites to generate elites), and an important channel of communicating societal interests to those who govern the specialty is lost.

- As pointed out by Velema (2012), besides facilitating knowledge exchange and access to international knowledge networks and communities, scientists in brain circulation can contribute to the national science system in several ways. Some of these would be facilitating access to foreign resources, improving the reputation and international profile of their country of origin, contributing to the international orientation of colleagues or students in the local scientific community, and contributing to the creation of an institutional environment in which science and research can prosper. In our dataset, although economists in brain circulation who have earned their Ph.D. in the U.S. are negatively selected relative to those who remain in the U.S., their average productivity is greater than the productivity of stayers. Thus, together with the potential benefits just emphasized, brain circulation appears to be a channel through which the productivity of national systems might be increased.

Of course, these policy implications are the consequence of results obtained using a very specific dataset of highly productive departments worldwide. To better understand the situation, consider the possibility of extending the dataset in order to include, say, the top six departments in some countries of a certain size among the OSC, such as France, Germany, or Spain, as well as the top three departments in smaller countries such as Belgium, Sweden, Denmark, or Israel. Naturally, the brain drain into the U.S. will remain the same. The internal brain drain and the brain circulation may increase somewhat. But, essentially, we will witness a large increase in OSC stayers, as well as a decrease in the average productivity of that key reference group. Therefore, we expect that the superior performance of movers of all types relative to stayers will become stronger than in the present paper, reinforcing the policy implications just analyzed.

On the other hand, it is worth noting that the comparison of movers and stayers among U.S. nationals leads to a very different picture. The small contingent of U.S. brain circulation in the total sample has outstanding productivity equivalent to the productivity of U.S. stayers in Harvard and MIT. Instead, economists constituting the U.S. brain drain are negatively selected relative to U.S. stayers in the top 25 U.S. departments.

Our second issue is whether foreigners are more productive than stayers. A key aspect of our findings is that it is crucial to distinguish between what happens in the Top 25 U.S. departments and the Bottom 56 departments in our sample.

1. The decrease in communication costs is possibly the most important factor driving the disappearance of geographical spillover effects that has led us to conclude that the department effects we estimate are essentially due to selection factors. But at the same time, this decrease is part of a general reduction in moving costs of all sorts that, in the HOC model, leads to the convergence between the average productivity of foreigners and stayers. We conjecture that this is an important reason for the productivity of migrants working in the majority of the top 25 U.S. departments, except Harvard and MIT, to be indistinguishable from the productivity of U.S. stayers. The fact that foreigners in Harvard and MIT are more productive than U.S. stayers simply means that –according to the productivity measure used in this paper– some of the best economists in the world happen to be foreigners that have been attracted by these prestigious departments.

2. Things are different at the Bottom. The last 27 in the U.S. and the 29 non-U.S. departments in the OSC are overlapping categories in terms of the Econphd department ranking. Consequently, they are comparable in several respects, including that fact that in both cases foreigners are significantly more productive than stayers in the total sample. Being part of academic life inside or outside the top departments in the world provides very different incentives for high quality work. In this context, the existence of a wide array of professional opportunities for high-skilled people outside of academia in the U.S. economy constitutes a channel worth exploring for understanding the relatively low average productivity of stayers in the last 27 U.S. departments. On the other hand, the economists born in one of the OSC who work in 2007 in a different country from this group –what we have called internal brain drain– constitute the sub-group responsible for the average productivity of all foreigners being greater than the average productivity of stayers in the OSC in the total sample. Understanding what makes this sub-group so special may require probing into the specific nationality of these economists and the type of university they migrate to.

In any case, although in these 56 departments foreigners are more productive than stayers in the total sample, this productivity difference disappears when we move to the elite. This serves to establish one of the distinct points of the paper, namely, that the nature of the base to which migrants are compared matters. In turn, this makes compatible apparently divergent results in the literature for datasets of scientists of very different productivity.

Before finishing, it should be noted that, as long as the concentration of talent in the U.S. results from the working of a highly competitive market worldwide, from a global point of view efficiency is well served. Moreover, we should take into account that migrants decide where to live in a voluntary way. There are two objections to this view. Firstly, a number of illuminating contributions –written from a European perspective– explain this situation in terms of differences in resources and university governance at both sides of the Atlantic (Ali *et al.*, 2007, Bauwens *et al.*, 2008, Aghion *et al.*, 2008, Veugelers & Van der Ploeg, 2008, and Drèze and Estevan, 2009; for the Israeli case, see Ben-David, 2008). From this perspective, it might be argued that that the degree of concentration of the best talent in the U.S. constitutes only a second best. Better governance and some additional resources in the EU and the RW may give rise to an improved global situation with the highly productive less concentrated in the U.S. Secondly, other qualified economists question whether the concentration of the best talent working and/or studying in a few U.S. universities has gone too far.[14] Evaluating the second best nature of the present situation, the homogeneity danger, or the possible endogamy associated to the clustering of the best minds in a few institutions is a difficult empirical task beyond the scope of this paper.

[14] On one hand, Jacques Drèze states: "*It is thought provoking that worldwide economic research is being pursued under the leadership of a couple hundred university professors trained and employed by a handful of U.S. departments.*" (Drèze and Estevan, 2007, p. 286). On the other hand, Oswald (2007a, p.2) has pointed out that great discoveries often come from unconventional ways of thinking. "*This makes me believe that dropping so many of Planet Earth's scientists into the same American part of the globe may make them worryingly homogeneous. Such intellectual homogeneity could, in the long run, be bad for scientific knowledge and thus for human welfare on our planet.*"

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APPENDIX I. THEORETICAL ISSUES

A. The HOC model

Consider a world in which scientists vary in their innate ability and productivity. Let q be an individual's productivity that is defined to lie between 0 and 1. The talent distribution is described by a density function $f(q)$. 'Highly productive' scientists have productivity greater than a minimum threshold of quality, q^*. Such scientists can choose whether or not to move to a host country, where they are assumed to perceive a percentage wage premium, p, compared to the home country. More generally, p can include a percentage non-wage premium derived from superior research facilities, and the prevalence of meritocratic practices in hiring and promotion policies in the host country that may be lacking in the home country. To help the intuition, assume that the rich country is the U.S. There is a cost of movement, c, capturing any continuing cultural and personal cost caused by living abroad.

The net utility levels of potential movers and stayers in the original country are given by a simple additive form:

$$\textit{Utility of a mover} = (1 + p)q - c$$

$$\textit{Utility of a stayer} = q.$$

An individual will choose to move if

$$(1 + p)q - c - q = pq - c > 0, \text{ or } q > c/p.$$

The average productivity of migrants is

$$M = \int_{c/p}^{1} qf(q)\mathrm{d}q / \int_{c/p}^{1} f(q)\mathrm{d}q, \quad (1)$$

while the average productivity of stayers is

$$S = \int_{q^*}^{1} qf(q)\mathrm{d}q / \int_{q^*}^{1} f(q)\mathrm{d}q. \quad (2)$$

It can be shown that the difference in mean productivities,

$$M - S = D(c, p, q^*), \quad (3)$$

is an increasing function of the mobility cost c, and a decreasing function of the premium p.

If the cost of mobility and the premium are both positive, $c < p$, and c is sufficiently large, then $q^* < c/p < 1$, so that the difference D is positive and the quality of movers, on average, will exceed the quality of stayers. In other words, if it is very costly to leave one's country and the premium is sufficiently high, only absolutely outstanding scientists will find it worth their while. Consequently, brain drain migrants would be positively selected relative to stayers in the home country. However, as c declines, the difference D approaches zero, and highly productive migrants and stayers come from approximately the same section of the underlying talent distribution, so that they will have similar observed productivity levels.

B. Extensions

The next three extensions are useful for our purposes.

1. Consider the case of a mover into the U.S. that, at some point, decides to come back to her country of origin, that is, the situation we call brain circulation. Presumably, the costs of remaining in the U.S. increase to a level $c' > c$, or the premium decreases to a level $p' < p$, so that $(c'/p') > (c/p)$. For these scientists to come back home, we must have:

$$(1 + p')q - c' - q = p'q - c' < 0, \text{ or } q < c'/ p'.$$

The average productivity for brain circulation is

$$B = \int_{c/p}^{c'/p'} qf(q)\mathrm{d}q / \int_{c/p}^{c'/p'} f(q)\mathrm{d}q.$$

Therefore, their productivity will be smaller than those migrants who remain in the rich country with the average productivity M in equation 1.

2. Consider the case of a citizen of the rich country where a premium p is paid –the U.S.–, which is considering moving abroad. A necessary condition for this move to take place is that the scientist enjoys some positive utility a for being abroad. In that case, assuming that the costs of moving are the same as before, we have

$$\textit{Utility of a mover from the rich country} = a + q - c$$

$$\textit{Utility of a stayer in the rich country} = (1 + p)q.$$

For the move to take place, we need

$$a + q - c - (1 + p)q = a - c - pq > 0, \text{ or } q < (a - c)/p.$$

If $pq^* + c < a < p + c$, then $q^* < (a - c)/p < 1$, meaning that there will be highly productive scientists with productivity greater than q^* willing to move abroad from the rich country. Their average productivity M' is given by

$$M' = \int_{q^*}^{(a-c)/p} qf(q)\mathrm{d}q \int_{q^*}^{(a-c)/p} f(q)\mathrm{d}q.$$

Therefore, migrants from the U.S. would be negatively selected relative to stayers in the rich country.

3. As q^* increases, q^* becomes closer to c/p, so that the difference D in expression 2 decreases. In other words, as the minimum quality threshold increases and we move from the set of highly productive scientists towards what we call the elite, elite migrants and stayers come from approximately the same section of the underlying talent distribution, so that they will have similar observed productivity levels.

APPENDIX II. SUPPLEMENTARY STATISTICAL MATERIAL

SECTION A. PUBLICATIONS IN JOURNALS OF CLASS A, B, C AND D, AND QUALITY INDEX FOR 2,705 FACULTY MEMBERS AT 81 ECONOMICS DEPARTMENTS AND 75 ECONOMETRIC SOCIETY FELLOWS AT OTHER INSTITUTIONS IN 2007

		Number of scholars		Number of publications					
		Total	Without any Publication	A	B	C	D	Total	Quality Index, Q
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	81 TOP ECONOMICS DEPARTMENTS:								
	Ordered according to the Econphd (2004) ranking	**2,705**	**175**	**9,595**	**20,261**	**10,260**	**28,255**	**68,371**	**777,530**
	U.S. DEPARTMENTS								
	Top ten								
1	Harvard University	55	0	842	914	299	862	2,917	50,046
2	University of Chicago	30	1	291	294	110	254	949	16,964
3	MIT	40	2	602	593	208	948	2,351	35,171
4	U. of California, Berkley	58	1	463	660	286	754	2,163	30,890
5	Princeton University	54	4	509	642	172	826	2,149	31,848
6	Stanford University	42	4	314	316	100	318	1,048	18,218
7	Northwestern University	35	4	230	307	87	279	903	14,606
8	University of Pennsylvania	30	1	215	358	89	162	824	14,666
9	Yale University	42	6	350	518	145	706	1,719	23,346
10	New York University	44	1	348	529	129	524	1,530	23,153
	Next 15								
11	U. of California, LA	45	2	213	250	182	379	1,024	13,741
13	Columbia University	45	0	388	529	209	565	1,691	25,274
14	U. of Wisconsin, Madison	30	5	86	238	74	154	552	7,608
15	Cornell University	32	1	156	393	182	472	1,203	13,699
16	University of Michigan	54	6	216	348	145	443	1,152	15,173
17	University of Maryland	39	2	145	257	229	304	935	11,333
19	U. of Texas, Austin	33	2	114	243	120	328	805	9,253
21	U. of Cal., San Diego	40	3	180	394	103	318	995	14,046
22	University of Rochester	19	3	57	101	51	100	309	4,201
23	Ohio State University	39	2	139	292	170	344	945	11,304
25	U. of Illinois, Urbana	27	2	45	176	91	209	521	5,195
26	Boston University	38	4	157	240	129	189	715	10,843
27	Brown University	28	3	125	184	150	128	587	8,788
28	U. California, Davis	31	1	55	191	158	240	644	6,253
29	University of Minnesota	26	3	126	191	50	101	468	8,306
	Last 27								
32	U. of Southern California	31	4	87	285	160	652	1,184	9,367
33	Michigan State U.	44	1	101	328	182	340	951	10,392
35	Duke University	43	0	148	296	174	554	1,172	11,958
38	PA State University	24	2	65	154	84	191	494	5,605
40	Carnegie Mellon U.	23	1	57	103	31	74	265	4,085
41	U. of North Carolina	24	2	22	144	69	240	475	3,694

42	Boston College	26	1	69	223	114	222	628	7,011
43	CA Institute of Technology	17	0	88	162	74	136	460	6,530
44	Texas A and M	25	1	50	161	103	183	497	5,216
49	University of Indiana	26	2	27	140	111	159	437	4,005
51	Johns Hopkins	14	0	80	171	54	104	409	6,193
52	Rutgers University	33	1	41	153	157	336	687	5,213
53	University of Virginia	32	4	67	157	126	142	492	5,933
54	Vanderbilt University	34	1	95	275	227	529	1,126	9,816
55	Georgetown University	25	2	45	175	63	73	356	4,876
56	Arizona State University	28	3	59	244	171	344	818	7,390
57	University of Arizona	25	6	39	87	72	103	301	3,400
58	Dartmouth College	29	2	45	136	123	234	538	4,812
60	University of Washington	25	1	82	271	140	181	674	8,366
62	Iowa State University	44	0	34	218	362	809	1,423	7,611
63	Washington U., St Louis	30	1	133	246	177	220	776	10,292
67	Purdue University	20	5	29	87	86	184	386	3,165
70	University of Pittsburgh	25	5	36	142	50	174	402	4,044
72	University of Iowa	18	3	31	139	53	77	300	3,720
75	Rice University	19	1	63	151	91	206	511	5,537
77	U. of California, Irvine	25	3	23	143	136	238	540	4,119
78	University of Florida	18	1	30	109	93	269	501	3,662
	NON-U.S. DEPARTMENTS IN OTHER SAMPLE COUNTRIES								
	European Union								
12	London Sch. of Economics	55	4	189	421	116	441	1,167	15,012
18	Toulouse University	78	0	126	421	203	830	1,580	13,403
24	Tilburg University	54	2	39	377	301	1,238	1,955	10,259
31	Oxford University	44	1	153	395	177	634	1,359	13,741
34	University of Warwick	44	2	88	393	204	375	1,060	11,014
37	University of Amsterdam	39	1	19	202	125	333	679	4,873
39	Cambridge University	31	1	70	207	73	342	692	6,685
45	European Institute	12	1	23	152	49	161	385	3,655
46	U. Carlos III, Spain	56	5	15	191	81	377	664	4,328
47	Univ. College London	35	2	120	292	103	376	891	10,174
48	University of Essex	30	2	30	148	73	95	346	3,953
59	Stockholm University	18	0	23	86	51	216	376	2,732
65	University of York	42	1	24	139	87	398	648	3,965
66	U. Pompeu Fabra	39	3	48	143	54	428	673	4,817
68	University of Nottingham	47	0	30	305	211	847	1,393	7,888
71	Stockholm School of Ecs.	15	1	16	86	68	332	502	2,670
73	Erasmus University	22	1	15	149	95	410	669	3,815
74	University of Copenhagen	46	4	10	179	71	317	577	3,828
76	Catholic Univ. of Louvain	40	0	24	221	140	678	1,063	5,793
79	U. Autónoma, Barcelona	37	4	15	98	68	416	597	2,894
80	Free Univ. of Amsterdam	23	2	11	115	55	183	364	2,678
81	University of Bonn	26	5	56	147	104	517	824	5,586
	Other: Canada, China, and Israel								
20	Univ. of British Columbia	30	3	73	188	110	160	531	6,560

30	Queen's University	26	3	42	213	120	143	518	5,738
36	University of Tel Aviv	16	1	58	205	70	122	455	5,937
50	University of Montreal	23	1	18	160	122	155	455	4,007
51	University of Toronto	53	8	99	255	190	402	946	9,327
54	Hebrew University	26	0	133	219	157	408	917	9,955
59	Hong Kong University	15	1	16	97	31	40	184	2,321

SECTION B. THE SKEWNESS OF PRODUCTIVITY DISTRIBUTIONS

We find useful to analyze the skewness of productivity distributions using the size- and scale-independent technique known as Characteristic Scores and Scales (CSS hereafter). Let μ_1 be the mean of the productivity distribution, and let μ_2 the mean productivity of individuals with productivity above μ_1. Consider the partition of the distribution into three classes: relatively low productivity, smaller than or equal to μ_1; intermediate productivity, between μ_1 and μ_2, and remarkable or outstanding productivity, above μ_2. Panel 1 includes the percentage of individuals in the three classes, as well as the percentages of the total quality points accounted for by each. The results clearly illustrate the high skewness of the productivity distribution: the average productivity is almost 17 percentage points above the median, and the top 11.7% of economists in the last category account for 43.7% of all quality points.

This description closely resembles the available evidence concerning comparable productivity distributions. Ruiz-Castillo & Costas (2014) study the productivity of 17 million authors, of which 132,336 belong to the Economics & Business field. Individual productivity is measured as the number of articles published in the periodical literature in the period 2003-2011 in 30 broadly defined scientific fields. However, as many as 65.8% economists publish only one article in this nine year period –a feature shared with all other fields (the average of this percentage over the 30 fields is 68.1%). Therefore, Ruiz-Castillo & Costas (2014) focus on the so-called successful authors, namely, scholars with above average publications (equal to 2.26 articles in the nine years from 2003 to 2011). The partition of authors into three classes in Economics & Business is remarkably similar to our own, which illustrates the fractal nature of productivity distributions in our field. Moreover, this partition is very similar to the average over the 30 fields (see Panel 2).[15] Finally, as documented in Ruiz-Castillo & Costas (2014), this is essentially the same partition that we find in other bibliometric contexts for citation distributions at different aggregation levels. Thus, the high skewness of the individual productivity distribution in our total sample is of the same type of what we find in the previous literature –a reassuring fact regarding the adequacy of our data (for the high concentration of research productivity in economics, see also Conley *et al.* 2013). On the other hand, such skewness coupled with the fractal nature of productivity distributions makes our sample of highly productive economists ideal for studying the determinants of individual productivity.

For later reference, we include in Panel 3 the same information for the elite.

Table B.1. The skewness of the productivity distribution for the total sample (N = 2,530)

	Percentage of individuals in category:			Percentage of quality points accounted for by category:		
	1	2	3	1	2	3
Quality Index, *Q*	67.1	21.4	11.5	24.2	32.2	43.6

Category 1 = individuals with low productivity, smaller than or equal to μ_1 = 307.3
Category 2 = individuals with an intermediate productivity, above μ_1 and smaller or equal to μ_2 = 707.4
Category 3 = individuals with an outstanding productivity above μ_2,

where: μ_1 = mean of the productivity distribution;
μ_2 = mean productivity of individuals with productivity above μ_1.

[15] Note that the set of scholars with a number of publications below (above) the mean in Economics & Business accounts for a relatively large (small) percentage of all articles. The same is the case for the average over all fields. However, recall that individual productivity in our case is not measured as the number of publications, but in terms of a quality index that weights publications in four equivalent classes according to a rather elitist weighting scheme. Therefore, the above situation is compatible with the fact that economists in our sample with a number of quality points below (above) the mean account for a relatively small (large) percentage of all quality points.

Table B.2. The case of Economics & Business and other scientific fields in Ruiz-Castillo & Costas (2014) when productivity is measured as the number of articles per author. Successful authors with productivity above the mean

	Percentage of individuals in category:			Percentage of total articles accounted for by category:		
	1	**2**	**3**	**1**	**2**	**3**
• **Economics & Business (25,911 successful authors)**	68.7	20.8	10.5	43.3	27.8	28.9
• **Average over 30 fields (Standard deviation)**	71.4 (2.4)	19.8 (1.7)	8.8 (1.1)	41.4 (4.1)	27.4 (1.5)	31.1 (3.5)

Table B.3. The skewness of the productivity distribution for the elite (N = 833)

	Percentage of individuals in category:			Percentage of quality points accounted for by category:		
	1	**2**	**3**	**1**	**2**	**3**
Quality Index, *Q*	65.1	21.6	13.3	42.4	26.7	30.8

Category 1 = individuals with low productivity, smaller than or equal to μ_1 = 707.4
Category 2 = individuals with an intermediate productivity, above μ_1 and smaller or equal to μ_2 = 1,165.2
Category 3 = individuals with an outstanding productivity above μ_2,

where: μ_1 = mean of the productivity distribution;
μ_2 = mean productivity of individuals with productivity above μ_1

SECTION C. THE ROLE OF DIFFERENT TYPES OF EXPLANATORY VARIABLES

In this Section we investigate the contribution of the different types of explanatory variables in accounting for individual productivity differences in the total sample.

1. *Demographic characteristics*

As far as the role of age in social studies, we should take into account the obvious impossibility of observing two individuals at the same point in time who have the same (biological) age but were born at different dates. This makes impossible the identification of age, cohort, and time or period effects in productivity studies. As emphasized by Hall *et al.* (2007), empirical tests or *a priori* information are usually needed in order to ignore some of these dimensions and identify the rest.

In our case, as explained in the text, we consider two effects: experience or (academic) age effects, and cohort effects. To study the latter, we distinguish between the Young and the Old, where the former are defined as those who earn a Ph.D. at most 24 years before 2007. The productivity of the Young and the Old cohorts is as follows.

Table C.1. Mean values (and standard deviations) for the number of publications by journal category, and for the productivity measures

	Number of publications:					Productivity measures:	
	A	**B**	**C**	**D**	**Total**	***Q* index**	***Q*/Age**
Young	2.2	5.9	2.7	6.6	17.4	200.9	16.4
1,697	(3.9)	(7.1)	(4.0)	(12.3)	(19.8)	(245.6)	(15.3)
Old	7.0	12.3	6.8	20.5	46.6	524.2	15.5
833	(9.3)	(12.7)	(7.4)	(28.2)	(42.8)	(539.8)	(14.9)

Of course, on average the total number of publications of the old is 2.7 times greater than the total number for the young. Since the aggregate acceptance rate for publishing in the top journals has sharply fallen with the passage of time (Card & DellaVigna, 2013), this ratio becomes 3.2 for publications in category A. However, since the old publish much more in class D, the ratio of the average *Q* index for the two cohorts is 2.6. After normalization by age, the average productivity per year is very similar for both cohorts.

We begin our study of individual productivity differences with an exploratory analysis including the variables *Age*, Age^2, and *Young*. The results are the following:

Table C.2. Exploratory analysis of the role of age variables

Dependent variable = log *Q*

	Total sample		**Young**		**Old**	
	Coeff.	**t-value**	**Coeff.**	**t-value**	**Coeff.**	**t-value**
Constant	1.8367	14.6*	2.1539	23.0*	6.7158	7.4*
Age	0.1914	29.0*	0.3348	21.7*	-0.0831	-1.7
Age²	-0.0022	-15.7*	-0.0082	-13.3*	0.0015	2.3*
Young	0.8944	9.6*				
N	2,530		1,697		833	

Adjusted R²	0.396	0.460	0.026

Note that the age variables indicate that, as expected, productivity increases with age but at a decreasing rate. The cohort dummy is positive and highly significant indicating that, on average, the productivity of young people is considerably greater than the productivity of those with more than 50 years of age. However, as indicated in the text, the productivity effect of one more year of academic experience need not be the same after five or ten years of obtaining a Ph.D., when the individual is young, than after thirty or thirty five years, when the individual is old. On the other hand, when we partition the sample into the two cohorts, the expected non-linear relationship between productivity and age is only clearly established for the young; for the old, age effects exhibit the opposite curvature and the coefficient of *Age* is non significant. Therefore, we end up modeling age and cohort effects as indicated in column 1 in the left-hand side in Table C.3.

In the first place, note that

$$\text{Log}\, Q = \alpha + \beta_1 \text{Age} + \beta_2 \text{Age}^2 + \beta_3(\text{Young x Age}) + \beta_4(\text{Young x Age}^2) + \beta_5\text{Young}$$

$$= \alpha + (\beta_1 + \beta_3\text{Young})\,\text{Age} + (\beta_2 + \beta_4\text{Young})\,\text{Age}^2 + \beta_5\text{Young}. \quad (1)$$

Recall that the mean value of the dummy variable Young is $\mu_Y = 0.671$. Therefore, the coefficients of the variables *Age* and *Age*^{2} in equation 1 are $\beta_1 + \beta_3\, \mu_Y = 0.2153$ and $\beta_2 + \beta_4\, \mu_Y = -0.0061$, so that the expected non-linear age effect is obtained.

Next, the effect of being Young is given by $\beta_3\, Age + \beta_4\, Age^2 + \beta_5$. This expression is negative for all ages, indicating that the young are less productive than the old. However, for people with academic age equal to 10 and 20 years, for example, this expression is equal to –1.3 and –0.07 indicating that, *ceteris paribus*, the young's productivity gap with the old decreases with experience.

On the other hand, we find clear evidence that the productivity of females is smaller than the productivity of males.

It should be emphasized that all demographic variables are highly significant and, judging from the adjusted R^2 = 0.44, their explanatory power is very important.

2. The role of other career variables

Next, we study the existence of what we call ***global department effects***, namely, we study whether there are systematic productivity differences between the five categories in the partition by CJ introduced in Section III.2. The reference group consists of all economists working in the OSC. Similarly, for the other three career variables we use the partitions into seven categories also introduced in Section III.2 (see Table 1.A for descriptive statistics). Complete results, including all other controls, are presented in column 2 in the right-hand side in Table C.3.

Quite apart from the results on global department effects analyzed in the text, the following point should be noted.

• Four of the six demographic variables are significant, and the size of the coefficients in column 2 in Table C.3 is very similar to the coefficient sizes in column 1 in that same Table. Thus, age and cohort effects are essentially as discussed above.

• Seven out of the remaining 18 control variables –where the reference group consists always of the EU universities– are statistically significant. The main results can be summarized as follows.

(i) Having earned a B.A. in the top 10 or the last 27 U.S. universities, or in a non-European country has no significant effect. Individuals having earned a B.A. in the remaining U.S. universities –representing 21.6% of the sample– have a smaller productivity in 2007 than the reference group.

(ii) Individuals having earned a Ph.D. in the top 25 U.S. universities or in the non-European universities have a significantly greater productivity.

(iii) After controlling for the CJ, where one holds a FJ has essentially no effect. Only those holding a FJ in eight of the top 10 U.S. universities have a greater productivity than those in the reference group.

Table C.3. REGRESSION RESULTS FOR THE TOTAL SAMPLE. GLOBAL DEPARTMENT EFFECTS, THE ROLE OF DEMOGRAPHIC VARIABLES, AND OTHER CONTROLS

Dependent variable: Log *Q*

	TOTAL SAMPLE		**ELITE**	
	Coeff.	**t-value**	**Coeff.**	**t-value**
I. KEY EXPLANATORY VARIABLES				
A. Nationals from the OSC				
1. Bain drain, HMIT	1.9552	7.2*	1.0368	6.5*
2. Bain drain, Next-8	1.2496	7.9*	0.4307	4.5*
3. Bain drain, Next-15	0.7934	5.8*	0.2810	3.1*
4. Bain drain, Last-27	0.5200	4.0*	0.1597	1.8
5. Brain circ., Ph.D. = U.S.	0.2934	2.0*	0.1985	1.9
6. Int. b. drain, Ph.D. = U.S.	0.4088	2.1*	0.1385	0.7
7. Int. b. drain, Ph.D. ≠ U.S.	0.2871	2.5*	0.1975	1.8
8. Brain circ., Ph.D. ≠ U.S.	0.1485	1.0	0.2236	1.4
<u>9. Reference group</u> = Stayers				
B. U.S. nationals				
10. U.S. brain circulation	1.1892	3.2*	0.7675	3.8
11. U.S. stayers, HMIT	1.3557	6.6*	0.5876	5.1*
12. U.S. stayers, Next-8, U.S.	1.1920	7.6*	0.3449	3.4*
13. U.S. stayers, Next-15, U.S.	0.7116	4.9*	0.1274	1.3
14. U.S. stayers, Last-27, U.S.	0.1720	1.2	0.0805	0.8
15. U.S. brain drain	0.3388	1.86	0.1199	0.8
C. Nationals from the RW (all brain drain)				
16. HMIT	1.7440	6.5*	0.5935	3.7*
17. Next-8	1.1123	6.3*	0.4795	4.2*
18. Next-15	0.7736	5.1*	0.1445	1.3
19. Last-27	0.4488	3.1*	0.0674	0.6

20. OCS, Ph.D. = U.S.	0.2495	1.6	0.0174	0.1
21. OSC, Ph.D. ≠ U.S.	-0.0139	-0.1	0.0270	0.2
II. CONTROL VARIABLES				
A. Demographic variables				
1.Age	-0.0533	-1.3	0.0128	0.7
2. Age^2	0.0009	1.7	0.0000	0.0
3. Young x Age	0.4199	9.9*	0.0769	2.0*
4. Young x Age^2	-0.0103	-13.1*	-0.0016	-1.6
5. Young	-4.3140	-5.9*	-0.9519	-2.1*
6. Female	-0.5557	-9.3*	-0.1513	-2.3*
B. First College degree				
U.S.				
1. HMIT	-0.0063	-0.1	0.1496	2.1*
2. Next-8	0.1475	1.5	0.1012	1.8
3. Next-15	-0.0502	-0.5	0.0781	1.3
4. Last-27	0.1099	1.1	0.0181	0.3
Outside U.S.				
5. Reference group = EU + Other U.S.				
6. RW	0.0951	1.3	0.0004	0.0
C. Graduate studies				
U.S.				
1. HMIT	0.1647	1.3	-0.0335	-0.4
2. Next-8	-0.0060	-0.1	-0.2142	-2.3*
3. Next-15	0.0149	0.1	-0.1924	-2.2*
4. Last-27	-0.1655	-1.2	-0.1936	-2.0*
5. Other U.S.	-0.2561	-1.4	-0.0019	-0.0
Outside U.S.				
6. Reference group = EU				
7. RW	0.4124	3.3*	-0.0356	-0.4

D. First job

U.S.				
1. HMIT	0.1693	1.4	0.0377	0.5
2. Next-8	0.1841	2.0*	0.0273	0.4
3. Next-15	0.1014	1.1	0.0204	0.3
4. Last-27	-0.0305	-0.3	-0.0559	-0.8
5. Other U.S.	-0.0916	-0.9	-0.0349	-0.4
Outside U.S.				
6. Reference group = EU + Missing				
7. RW	-0.1233	-1.6	-0.0687	-1.1
Constant	5.8861	8.1*	6.0035	16.3*
N	2,530		833	
Adjusted-R^2	0.552		0.343	

SECTION D. THE PRODUCTIVITY OF FOREIGNERS AND STAYERS IN THE TOTAL SAMPLE AND THE ELITE

	TOTAL SAMPLE		ELITE	
	Coeff.	t-value	Coeff.	t-value
I. KEY VARIABLES				
1. U.S. brain circulation	1.1900	3.2*	0.7600	3.8*
I. Harvard and MIT				
2. U.S. stayers	1.2612	6.6*	0.5847	5.3*
3. Foreigners, brain drain	1.7764	8.9*	0.8256	6.8*
II. Next 8 U.S. departments				
4. U.S. stayers	1.0994	8.0*	0.3465	3.7*
5. Foreigners, brain drain	1.1248	8.8*	0.4560	5.5*
III. Next 15 U.S. departments				
6. U.S. stayers	0.6173	4.9*	0.1288	1.4
7. Foreigners, brain drain	0.7244	6.5*	0.2410	3.0*
IV. Bottom 27 U.S. departments				
8. U.S. stayers & b. circulation	0.0689	0.6	0.1068	1.2
9. Foreigners, brain drain	0.4433	4.2*	0.1654	2.0*
V. Bottom 29 Non-U.S. departments in the OSC				
10. Brain circulation	0.1941	1.8	0.2237	2.5*
11. Foreigners, brain drain	0.2019	2.4*	0.1212	1.6
12. Reference group = Non-U.S. stayers				
II. CONTROL VARIABLES				
A. Demographic variables				
1.Age	-0.0539	-1.4	0.0131	0.7
2. Age^2	0.0009	1.7	0.0000	0.0
3. Young x Age	0.4215	10.0*	0.0842	2.2*
4. Young x Age^2	-0.0104	-13.2*	-0.0018	-1.8
5. Young	-4.3353	-5.9*	-1.0161	-2.3*
6. Female	-0.5574	-9.3*	-0.1495	-2.3*
B. First College degree				

U.S.				
1. HMIT	-0.0071	-0.1	0.1476	2.1*
2. Next-8	0.1477	1.5	0.1006	1.8
3. Next-15	-0.0502	-0.5	0.0770	1.3
4. Last-27	0.1094	1.1	0.0199	0.3
Outside U.S.				
5. Reference group = EU + Other U.S.				
6. RW	0.0714	1.0	-0.0269	-0.5
C. Graduate studies				
U.S.				
1. HMIT	0.2648	2.7*	-0.0348	-0.4
2. Next-8	0.0943	1.1	-0.2149	-2.9*
3. Next-15	0.1167	1.2	-0.1892	-2.4*
4. Last-27	-0.0656	-0.6	-0.2004	-2.2*
5. Other U.S.	-0.1452	-0.9	-0.0139	-0.1
Outside U.S.				
6. Reference group = EU				
7. RW	0.4283	3.5*	-0.0240	-0.3
D. First job				
U.S.				
1. HMIT	0.1648	1.4	0.0475	0.6
2. Next-8	0.1739	1.9	0.0248	0.4
3. Next-15	0.0937	1.1	0.0151	0.2
4. Last-27	-0.0373	-0.4	-0.0586	-0.8
5. Other U.S.	-0.0969	-0.9	-0.0434	-0.5
Outside U.S.				
6. Reference group = EU + Missing				
7. RW	-0.1167	-1.6	-0.0561	-0.9
Constant	5.900	8.1*	6.0022	16.3*
N	2,530		833	

Adjusted-R^2	0.553	0.343

SECTION E.1. DESCRIPTIVE STATISTICS FOR THE CAREER VARIABLES IN THE ELITE

	B.A.	%	Ph.D.	%	FJ [a]	%	CJ [b]	%
All U.S. departments	**419**	**50.3**	**653**	**78.4**	**572**	**68.7**	**640**	**76.8**
HMIT [c]	53	6.4	178	21.4	85	10.2	65	7.8
Next-8	94	11.3	273	32.8	206	24.7	187	22.4
Next-15	70	8.4	133	16.0	139	16.7	205	24.6
Last-27	49	5.9	58	6.9	99	11.9	183	22.0
Other	153	18.4	11	1.3	42	5.1	-	
Missing	-	-	-	-	1	0.0	-	-
Non-U.S. departments	**414**	**49.7**	**180**	**21.6**	**261**	**31.3**	**193**	**23.2**
European	222	26.6	147	17.6	160	19.2	143 [d]	17.2
Non-European	192	23.1	33	4.0	101	12.1	50 [e]	6.0
Total	**833**	**100.0**	**833**	**100.0**	**833**	**100.0**	**833**	**100.0**

[a] **FJ =** First job; [b] **CJ =** Current job in 2007; [c] **HMIT =** Harvard and MIT;

[d] **21 Departments in eight European countries**: UK (8), Netherlands (4), Spain (3), Sweden (2), Belgium (1), Denmark (1), France (1), Germany (1);

[e] **8 Departments in three non-European countries**: Canada (5), Israel (2), China (1);

[f] **OSC** = eleven Other Sample Countries with at least one department in the sample: UK, Netherlands, Spain, Sweden, Belgium, Denmark, France, Germany, Canada, Israel, and China;

[g] **RW =** Countries from the Rest of the World.

SECTION E.2. MOVERS AND STAYERS, CLASSIFIED BY CURRENT JOB IN 2007. ELITE

	Stayers	Brain circ.	Brain drain from: OSC [f]	Brain drain from: RW [g]	Total brain drain	ALL
	(1)	(2)	(3)	(4)	(5) = 3 + 4	(6) = 1 + 2 + 5
CJ = U.S.	**401**	**5**	**140**	**94**	**234**	**640**
HMIT	44	3	9	9	18	65
Next-8	114	1	45	27	72	187
Next-15	134	1	42	28	70	205
Last-27	109	0	44	30	74	183

	Stayers	Brain circ.	Brain drain from: U.S.	Brain drain from: OSC	Brain drain from: RW	Total brain drain	ALL
	(7)	(8)	(9)	(10)	(11)	(12) = 9 + 10 + 11	(12) = 7 + 8 + 12
CJ = OSC	**88**	**49**	**13**	**23**	**20**	**56**	**193**

	TOTAL STAYERS 1 + 7	TOTAL BRAIN CIRC. 2 + 8	TOTAL BRAIN DRAIN 5 + 11	TOTAL 6 + 12
ALL	**489**	**54**	**290**	**883**

In relation to the remaining the B.A., the Ph.D., and the FJ, the following differences between the elite and the total sample should be noted:

• The proportion of Europeans decreases by 10.9%, while the proportion of U.S. nationals increases by 11.6%. However, the distribution of the latter by the university where they earn a B.A. does not change much.

• The proportion of economists earning a Ph.D. in the U.S. increases by 9.2%, while the proportion of those attending the top 10 U.S. departments reaches 54.2% of the total –an increase of 10.7%.

• Similarly, the proportion of people holding a FJ in the U.S. increases by 11.1%, but those hired by the top 10 U.S. departments increases by 13.6%.

SECTION F. REGRESSION RESULTS FOR THE ELITE

The final specification including six demographic variables, five B.A. variables, and six variables for each of the Ph.D. and FJ variables, are presented in the right-hand panel of Section D in Appendix II.

1. Department effects, and other selection effects

Moving from the total sample to the elite has simplifying consequences for department effects. Essentially, the distinction between what happens in Top and Bottom departments becomes more pronounced. In the first place, the productivity of everyone working in the last 27 U.S. departments (variables 4, 14, and 19) and everyone working in the 29 non-U.S. departments (variables 5 to 9, 15, 20, and 21) is indistinguishable. Thus, the 56 Bottom departments – whose overlapping in terms of the Econphd department ranking has been already emphasized– becomes more homogeneous than in the total sample. In the second place, there is no question that the average productivity at the Top is significantly greater than at the Bottom. Furthermore, the average productivity of those working in Harvard or MIT, the next 8, and the last 15 U.S. departments is generally hierarchically ordered. Thus, as long as we switch the attention to the partition of the 81 departments into four categories, consisting of the three groups at the Top, and the 56 departments at the Bottom, department effects are still clearly established.

On the other hand, as far as the brain circulation phenomenon is concerned, results are similar to what we found for the total sample: nationals from the OSC are negatively selected relative to those working in the top 25 U.S departments, whereas U.S. nationals are positively selected relative to all other U.S. stayers.

2. The role of other explanatory variables

As far as the role of demographic variables and the other three career variables, the main differences between the elite and the total sample are the following five.

(i) Age effects are rather different. Taking into account that the young represent 44.0% of the elite, the coefficients for the variables *Age* and *Age*^{2} in expression (1) in Section C in Appendix II are: $\beta_1 + \beta_4 \mu_Y = 0.0338$, and $\beta_2 + \beta_5 \mu_Y = -0.0014$. Therefore, the size of the age effects in the elite is much smaller than for the total sample (0.2153, and –0.0061, respectively). Given previous results concerning the differences between the young and the old, and taking into account that the proportion of the young is much smaller in the elite, these results come as no surprise.

Two other factors might also help explaining this pattern. Firstly, a stronger taste for "puzzle solving" for top researchers, a factor that when added to the objective function produces a flattening of the productivity profile (Levin and Stephan, 1991), or a stronger taste for peer recognition and monetary rewards. Secondly, institutional explanatory variables – such as research funding and promotion policies– may operate differentially across the distribution of scientific performance favoring those on the top (Kelchtermans and Veugelers, 2011).[16]

(ii) Cohort effects are not very different from what we find in the total sample. For people with academic age equal to 10 and 20 years, for example, the expression $\beta_4 Age + \beta_5 Age^2 + \beta_3$ is equal to –0.34 and –0.05 (versus –1.3 and –0.07 in the total sample) indicating that, *ceteris paribus*, the young's productivity gap with the old decreases with experience.

(iii) The productivity of females is still smaller than the productivity of males, but the gender effect in the elite is considerably smaller than in the total sample. This is in line with the careful study of top research performance and its persistence over time by Kelchtermans and Veugelers (2012). These authors find that, although females are significantly less likely to reach first top performance, once they manage to do that no gender bias hinders them in the future.

(iv) In the presence of the CJ and mover/stayer effects, only the following four of the seventeen dummy variables relating to the B.A., the Ph.D., and the FJ are significant in Section D in Appendix II. Earning a B.A. in Harvard or MIT has a significant positive effect relative to earning it in the EU or other U.S. departments outside the 52 in our sample, while earning a Ph.D. in any of the 50 schools different from Harvard and MIT has a negative significant effect relative to earning it in the EU.

[16] For a discussion of a literature that abounds with cases of heterogeneity in patterns of productivity over time, see Carrasco & Ruiz-Castillo (2014).

(v) The adjusted R^2 is 0.343, versus 0.552 in the total sample.

SECTION G. THE PRODUCTIVITY OF FOREIGNERS VERSUS STAYERS IN THE TOTAL SAMPLE AND THE ELITE. AGGREGATE VERSIONS

Dependent variable: Log *Q*

	TOTAL SAMPLE		**ELITE**	
	Coeff.	***t*-value**	**Coeff.**	***t*-value**
1. Brain circulation	0.0052	0.1	0.1255	1.8
2. Foreigners, brain drain	0.2518	4.3*	0.1464	3.3*
3. Reference group = Stayers in all departments				
Constant	5.8694	7.8*	5.9833	15.5*
N	2,530		833	
Adjusted-R^2	0.516		0.268	

Table 1.A. DESCRIPTIVE STATISTICS FOR THE CAREER VARIABLES IN THE TOTAL SAMPLE

	B.A.	%	Ph.D.	%	FJ [a]	%	CJ [b]	%
U.S. departments	**980**	**38.7**	**1,750**	**69.2**	**1,457**	**57.6**	**1,568**	**62.0**
HMIT [c]	131	5.2	352	13.9	144	5.7	93	3.7
Next-8	168	6.6	749	29.6	394	15.6	313	12.4
Next-15	144	5.7	416	16.5	369	14.6	487	19.2
Last-27	134	5.3	181	7.2	363	14.3	675	26.7
Other	403	15.9	52	2.0	174	6.9	-	
Missing	-	-	-	-	13	0.5	-	-
Non-U.S. departments	**1,550**	**61.3**	**780**	**30.8**	**1,073**	**42.4**	**962**	**38.0**
European	948	37.5	680	26.9	682	27.0	791 [d]	31.2
Non-European	602	23.8	100	3.9	391	15.4	171 [e]	6.8
Total	**2,530**	**100.0**	**2,530**	**100.0**	**2,530**	**100.0**	**2,530**	**100.0**

[a] **FJ** = First job; [b] **CJ** = Current job in 2007; [c] **HMIT** = Harvard and MIT;

[d] **21 Departments in eight European countries**: UK (8), Netherlands (4), Spain (3), Sweden (2), Belgium (1), Denmark (1), France (1), Germany (1);

[e] **8 Departments in three non-European countries**: Canada (5), Israel (2), China (1);

[f] **OSC** = eleven Other Sample Countries with at least one department in the sample: UK, Netherlands, Spain, Sweden, Belgium, Denmark, France, Germany, Canada, Israel, and China;

[g] **RW** = Countries from the Rest of the World.

Table 1.B. MOVERS AND STAYERS, CLASSIFIED BY CURRENT JOB IN 2007. TOTAL SAMPLE

	Stayers (1)	Brain circ. (2)	Brain drain from: OSC [f] (3)	Brain drain from: RW [g] (4)	Total brain drain (5) = 3 + 4	ALL (6) = 1 + 2 + 5
CJ = U.S.	**916**	**8**	**342**	**302**	**644**	**1,568**
1. HMIT	54	3	18	18	36	93
2. Next-8	170	1	80	62	142	313
3. Next-15	280	1	111	95	206	487
4. Last-27	412	3	133	127	260	675

	Stayers (7)	Brain circ. (8)	Brain drain from: U.S. (9)	Brain drain from: OSC (10)	Brain drain from: RW (11)	Total brain drain (12) = 9 + 10 +11	ALL (13) = 7 + 8 + 12
5. CJ = OSC	**411**	**181**	**56**	**138**	**176**	**370**	**962**

	TOTAL STAYERS 1 + 7	TOTAL BRAIN CIRC. 2 + 8	TOTAL BRAIN DRAIN 5 + 12	TOTAL 6 + 13
ALL	1,327	189	1,014	2,53

Table 2. Mean values (and standard deviations) for demographic variables and individual productivity. Movers and stayers classified by current job in 2007. Total sample

	Number	% Female	Age	*Q* index	*Q*/Age
A. 52 U.S. departments	**1,568**	**13.8** (34.5)	**20.5** (13.1)	**376.6** (452.3)	**19.0** (16.8)
1. HMIT, U.S. stayers	54	11.1 (31.7)	27.9 (14.6)	1,020.3 (871.3)	39.0 (25.2)
2. HMIT, Foreigners	36	16.7 (37.8)	13.1 (13.1)	629.6 (671.8)	49.3 (30.3)
3. Next-8, U.S. stayers	170	12.9 (33.7)	24.7 (14.2)	627.9 (499.3)	28.1 (18.0)
4. Next-8, Foreigners	142	7.0 (25.7)	15.4 (12.7)	466.5 (491.3)	29.6 (18.0)
5. Next-15, U.S. stayers	280	14.6 (35.4)	22.2 (12.9)	373.4 (414.1)	17.3 (12.6)
6. Next-15, Foreigners	206	15.5 (36.3)	14.6 (12.1)	289.0 (323.9)	19.0 (12.6)
7. Last-27, U.S. stayers	412	12.8 (33.5)	25.0 (11.2)	256.7 (279.6)	10.5 (9.3)
8. Last-27, Foreigners	260	17.7 (38.2)	15.6 (11.2)	232.2 (274.5)	13.9 (10.4)
9. Brain circulation	8	12.5 (35.3)	28.6 (8.1)	1,195.5 (1,332.9)	37.1 (35.6)
B. 29 Non-U.S. depts. in OCS	**962**	**14.3** (35.1)	**16.0** (10.7)	**194.4** (255.6)	**11.5** (10.6)
10. U.S. brain drain	56	16.1 (37.1)	17.9 (11.8)	235.6 (281.3)	12.4 (10.2)
11. OSC brain drain to other countries ≠ U.S.	138	15.2 (36.1)	12.8 (9.3)	181.4 (230.2)	12.9 (10.6)
12. RW brain drain to other countries ≠ U.S.	176	18.7 (39.1)	10.8 (9.0)	124.6 (174.8)	10.4 (8.5)
13. OSC brain circulation	181	12.7 (33.4)	18.4 (10.7)	258.8 (330.7)	13.0 (13.3)
14. OSC stayers	411	12.6 (33.3)	18.0 (10.6)	194.7 (244.0)	10.7 (10.2)
Total = A + B	**2,530**	**14.0** (34.8)	**18.8** (12.4)	**307.3** (399.2)	**16.1** (15.2)

Table 3. Summary of regression results for the key 21 groups of movers and stayers of the three nationalities

Dependent variable: Log *Q*

A. Nationals from the OSC

	Coeff.	**t-value**	***p*-value**
1. Bain drain, HMIT	1.9552	7.2*	
			0.010*
2. Bain drain, Next-8 U.S.	1.2496	7.9*	
			0.003*
3. Bain drain, Next-15 U.S.	0.7934	5.8*	
			0.041*
4. Bain drain, Last-27 U.S.	0.5200	4.0*	
			0.090*
5. Brain circulation, Ph.D. = U.S.	0.2934	2.0*	
			0.356
6. Internal brain drain, Ph.D. = U.S.	0.4088	2.1*	
			0.574
7. Internal brain drain, Ph.D. ≠ U.S.	0.2871	2.5*	
			0.437
8. Brain circulation, Ph.D. ≠ U.S.	0.1485	1.0	
9. Reference group = Stayers	-		
B. U.S. nationals			
10. U.S. brain circulation	1.1892	3.2*	
			0.680
11. U.S. stayers, HMIT	1.3557	6.6*	
			0.336
12. U.S. stayers, Next-8, U.S.	1.1920	7.6*	
			0.000*
13. U.S. stayers, Next-15, U.S.	0.7116	4.9*	

			0.000*
14. U.S. stayers, Last-27, U.S.	0.1720	1.2	
			0.275
15. U.S. brain drain	0.3388	1.86	
C. Nationals from the RW (all groups are brain drain)			
16. HMIT	1.7440	6.5*	
			0.023*
17. Next-8 U.S	1.1123	6.3*	
			0.049*
18. Next-15 U.S.	0.7736	5.1*	
			0.023*
19. Last-27 U.S.	0.4488	3.1*	
			0.175
20. OSC, Ph.D. = U.S.	0.2495	1.6	
			0.158
21. OSC, Ph.D. ≠ U.S.	-0.0139	-0.1	
N	2,530		
Adjusted-R^2	0.552		

Table 4. The productivity of foreigners and domestic stayers in the total sample and the elite

	TOTAL SAMPLE			ELITE		
	Coeff.	***t*-value**	***p*-value**	**Coeff.**	***t*-value**	***p*-value**
1. U.S. brain circulation	1.1900	3.2*		0.7600	3.8*	
I. Harvard and MIT						
2. U.S. stayers	1.2612	6.6*		0.5847	5.3*	
			0.026*			0.056*
3. Foreigners, brain drain	1.7764	8.9*		0.8256	6.8*	
II. Next 8 U.S. departments						
4. U.S. stayers	1.0994	8.0*		0.3465	3.7*	
			0.848			0.134
5. Foreigners, brain drain	1.1248	8.8*		0.4560	5.5*	
III. Next 15 U.S. departments						
6. U.S. stayers	0.6173	4.9*		0.1288	1.4	
			0.351			0.147
7. Foreigners, brain drain	0.7244	6.5*		0.2410	3.0*	
IV. Bottom 27 U.S. departments						
3. U.S. stayers & b. circulation	0.0689	0.6		0.1068	1.2	
			0.002*			0.468
4. Foreigners, brain drain	0.4433	4.2*		0.1654	2.0*	
V. Bottom 29 Non-U.S. departments in the OSC						
5. Brain circulation	0.1941	1.8		0.2237	2.5*	
6. Foreigners, brain drain	0.2019	2.4*		0.1212	1.6	
7. Reference group = Non-U.S. stayers						
Constant	5.9005	8.1*		6.0022	16.3*	
N	2,530			833		
Adjusted-R^2	0.553			0.343		

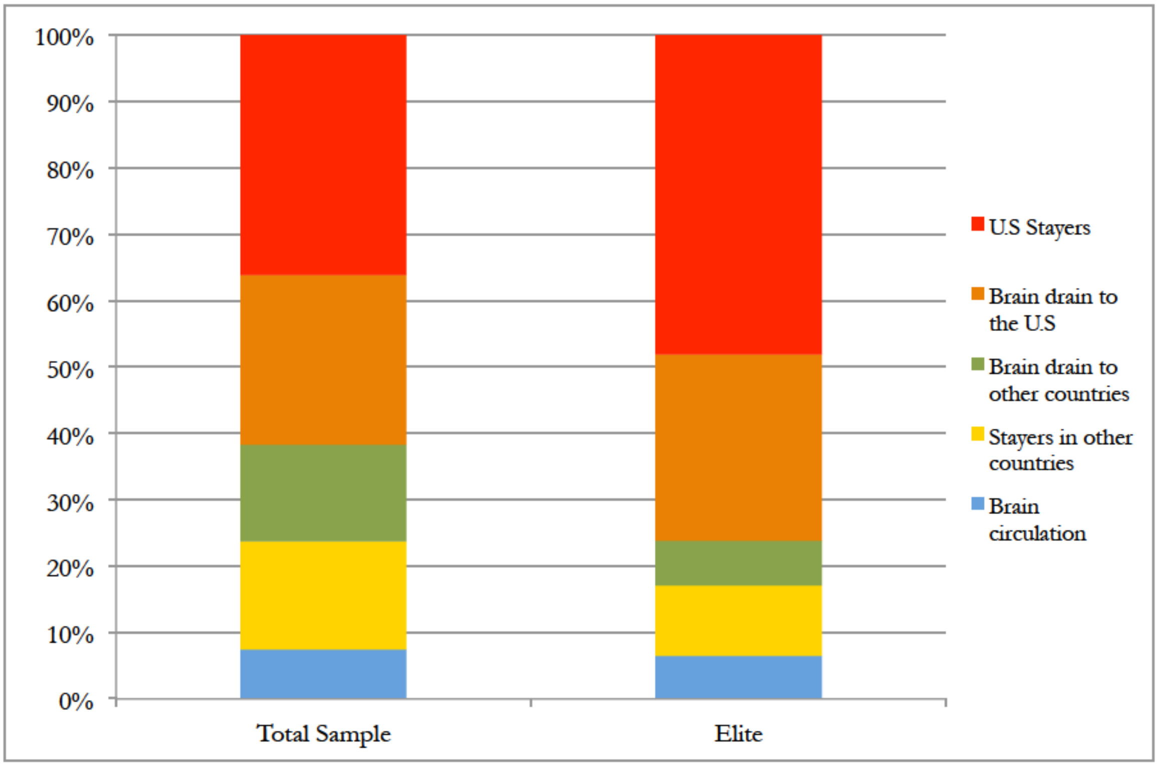


Figure 1.B. From the total sample to the elite: changes in the stayers/brain drain/brain circulation distinction

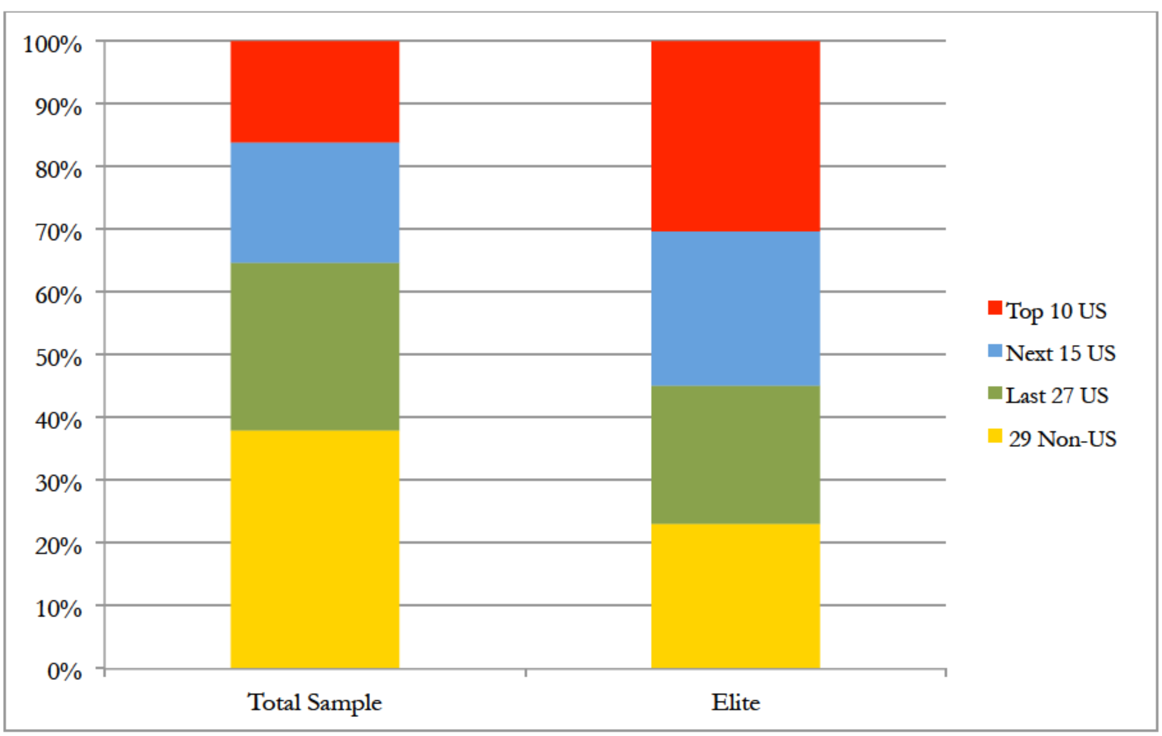
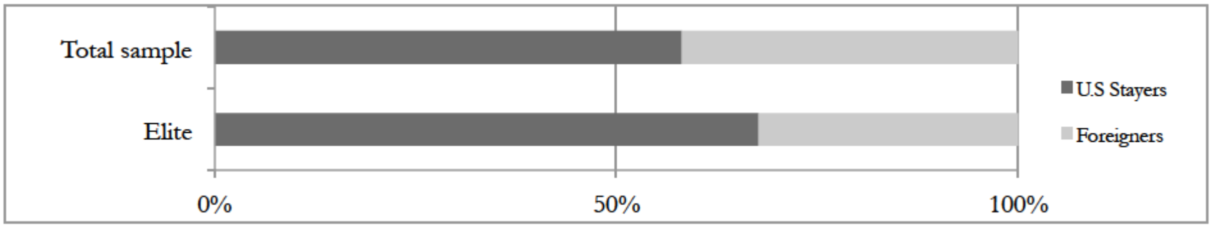
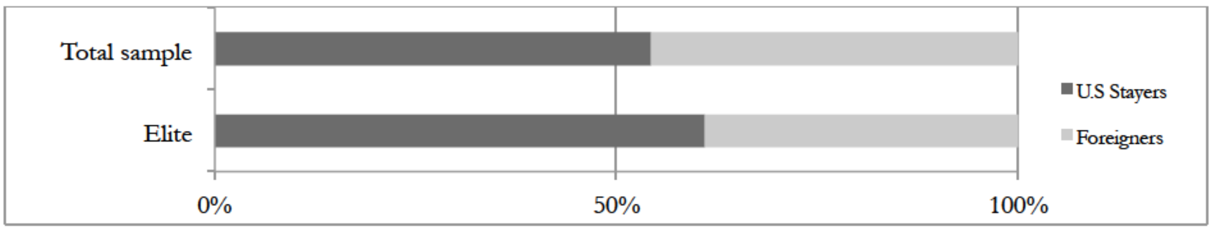


Figure 1.B. From the total sample to the elite: departmental changes

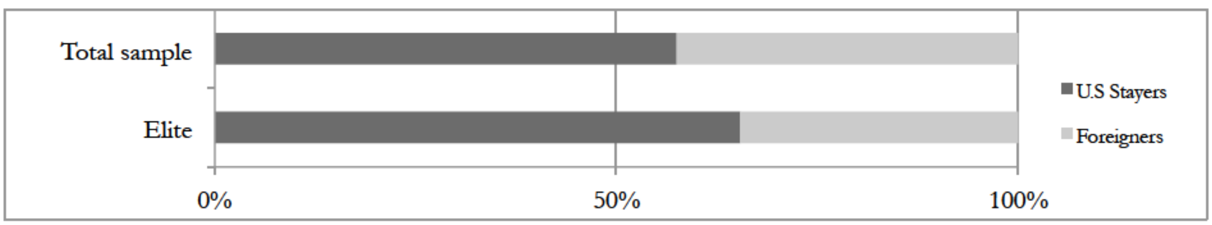
1. Harvard and MIT



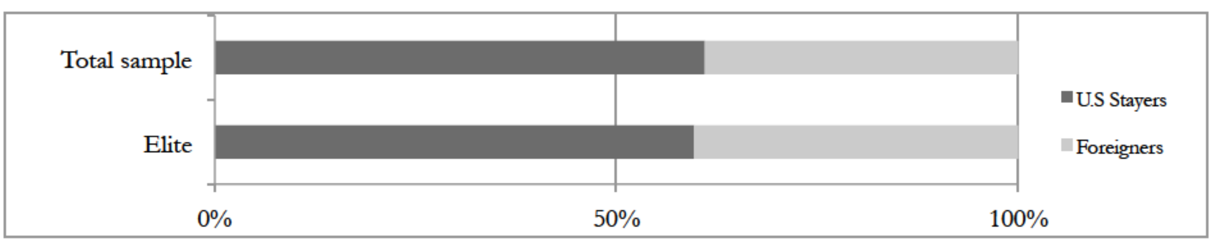
2. Next 8 U.S departments



3. Next 15 U.S departments



4. Last 27 U.S departments



5. 29 Non- U.S departments in the OSC

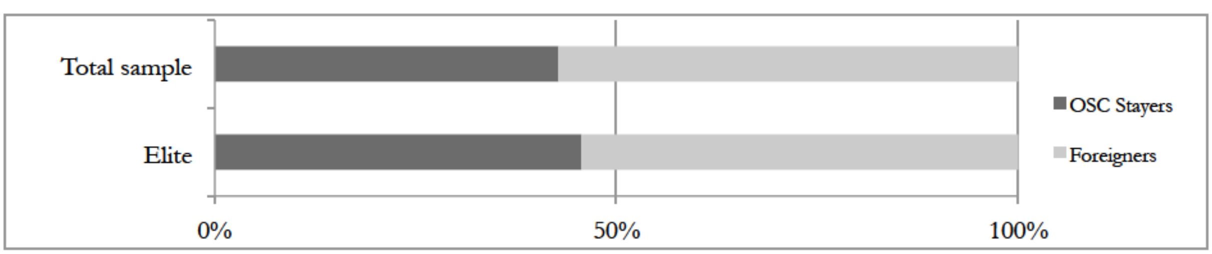


Figure 2. Proportion of foreigners and stayers working in 2007 in the U.S. and the OSC. Evidence for the total sample and the elite