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The Brain Drain between Knowledge
Based Economies:
the European Human Capital Outflow to the US

Ahmed Tritad

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**THE BRAIN DRAIN BETWEEN KNOWLEDGE-BASED ECONOMIES:
THE EUROPEAN HUMAN CAPITAL OUTFLOW TO THE US**

NON-TECHNICAL SUMMARY

Like secondary education and physical capital investments were crucial to the post-war West-European economy to catch-up, higher education and knowledge investment have become the major factor of growth in the knowledge society. The latter requires an ever-increasing supply of highly-educated, highly-skilled people. In this context, worries about skill shortage are frequently fueling the public debate in Europe. The Third European Report on Science and Technology indicators point out that "Europe produces a large number of university graduates, doctorate recipients and postdoctoral students. But a significant share of them finds work in an occupation outside of European R&D. It may be one of Europe's biggest obstacles in its attempt to becoming the world's most competitive knowledge-based economy [...]". Against this background, this paper assesses the magnitude and nature of European emigration to the US throughout the last three decades using the 1980, 1990, 2000 and 2006 US censuses.

The brain-drain significance depends on the magnitude of migration flows (emigration rate) and the degree of migrants' selectivity along the ladder of labor quality (emigration quality). Hence, at a first stage I document the trend in emigration stocks and flows of Europeans in the US. Results show that European emigrants represent a small share of their source country working age population. However, starting from the 1990s and following the US dot-com bubble this share is increasing. I also provide evidence of a decreasing pattern of return migration for most countries.

At a second stage, I investigate changes in migrant quality over time. Firstly, I establish the degree of selectivity along observable characteristics (age, education, occupations and labor productivity). Migrants are relatively younger than stayers, but still have significant years of labor market experience at the time they enter the US. For most countries, the expatriates-stayers schooling disparities increases over time, and more so for education-scarce countries. The latter reflects a pattern of increasing selection of migrants along educational ladder. This is comforted by looking at long term trends in migrants' occupations which reveal an increasing concentration in occupations that matter the most in a knowledge economy (engineers, researchers, university instructors). As a consequence, the share of US based European researchers has increased in the 1990s. Secondly, using productivity brain-drain indices that weight years of education by their relative wages, I show that the outflow of human capital conveyed by emigrants represent 0.2% up to 0.6% of their source country human capital. After a fall in the 1980s this share has increased in the 1990s reflecting a higher selection along labor productivity ladder.

Lastly, to gain a better understanding of the nature of human capital conveyed by emigrants, their wage performance (i.e. productivity) on the US labor market is investigated. I show that expatriates earn a wage premium compared to a similarly observable US born worker. This premium is higher for the more recent cohorts of migrants. This result is either an indication that Europeans are exceptional performers in the US labor market, or that they are working in leading sectors and occupations within their group of skills, which places high

values on unobservable human capital such as talent. I conclude from this empirical scrutiny that, starting from the US new-economy revival, we are witnessing a surge in the outflow, which has lasted since then, of European human capital that matters the most in knowledge economy.

ABSTRACT

This paper uses the 1980, 1990, 2000 and 2006 U.S. micro censuses data to document the magnitude and nature of European human capital outflow to the United States. I found that while emigration is about a small number of individuals, the share of Europeans who are leaving is increasing as one moves along the educational distribution and ladder of occupations that matter the most in the knowledge economy. Next, using productivity based brain drain indices it is found that aggregate human capital conveyed by emigrants has increased since the 1990s. Finally, as a better understanding on the nature of human capital embodied in European emigrants, I show that the Europeans earn a positive wage premium relative to the US natives. Moreover, this premium is higher for the most recent expatriates cohorts, providing further evidence that the quality of European emigrants has increased.

JEL Classification: F22, J24, O15, O52

Keywords: emigration, brain-drain, human capital, knowledge economy, Europe-US

**LA FUITE DES CERVEAUX DANS LES ÉCONOMIES FONDÉES SUR LA CONNAISSANCE :
L'ÉMIGRATION DU CAPITAL HUMAIN EUROPÉEN VERS LES ÉTATS-UNIS**

RESUME NON TECHNIQUE

Tout comme le rattrapage économique de l'Europe d'après-guerre a reposé sur l'investissement (infrastructures, capital physique, etc.) et l'éducation secondaire, son essor dans l'« économie du savoir » passe par un accroissement des dépenses dans l'éducation supérieure et la recherche-développement. A cet égard, des inquiétudes quant aux risques de pénurie de main-d'œuvre hautement qualifiée et d'un exode des compétences s'expriment fréquemment. Le troisième Rapport Européen sur les Sciences et les Technologies souligne par exemple que l'Europe forme un grand nombre de diplômés de l'université, de docteurs et d'étudiants en formation postdoctorale, mais qu'un nombre important d'entre eux est employé ailleurs que dans la recherche-développement en Europe ; selon les termes de ce rapport, cela pourrait faire obstacle à l'objectif de faire de l'Europe l'économie fondée sur le savoir la plus compétitive au monde. En exploitant les données des recensements américains des trente dernières années, notre travail cherche à évaluer l'ampleur, la nature et les évolutions des flux migratoires d'Europe vers les Etats-Unis.

L'intensité de la « fuite des cerveaux » résulte de l'ampleur de l'émigration et de la qualité (qualification, productivité, etc.) des migrants par rapport à la population d'origine. Le brain-drain est d'autant plus important que le poids des migrants dans la population d'origine est élevé (fort taux d'émigration) et que la qualité relative de cette émigration est élevée (forte sélectivité).

Les émigrants européens aux Etats-Unis représentent une proportion faible de la population de leurs pays d'origine. Toutefois, depuis 1990 et le boom technologique aux Etats-Unis, les flux migratoires sont en augmentation et cette progression s'accompagne, pour la plupart des pays, d'une réduction des taux de retour.

La sélectivité de l'émigration européenne est appréhendée par des caractéristiques telles que l'âge, le niveau d'étude, le type d'emploi et la productivité. Les migrants sont relativement plus jeunes que la population d'origine, mais émigrent après un certain nombre d'années d'expérience. La population qui s'expatrie est en moyenne plus éduquée que la population d'origine. Pour de nombreux pays, ce surcroît de qualification est plus élevé en 2006 qu'en 1980 et en particulier pour les états européens où le niveau moyen d'éducation de la population est faible. Les emplois occupés par les migrants révèlent une concentration croissante dans les activités les plus impliquées dans l'innovation, la création et la transmission du savoir (ingénieurs, chercheurs, universitaires) ; les chercheurs européens travaillant aux Etats-Unis sont de plus en plus nombreux relativement aux chercheurs basés en Europe. Enfin, à partir d'un indicateur qui pondère les années d'études par leur « rendement » (salaire) dans le pays d'origine, on estime que le capital humain des Européens aux Etats-Unis représente en 2006, selon les pays, de 0,2 à 0,6 % du capital humain de leur pays d'origine. Après une baisse au cours des années 1980, cette proportion augmente depuis 1990, reflétant une plus grande sélectivité de l'émigration en termes de productivité.

Afin de mieux saisir la nature du capital humain des expatriés, on évalue ensuite leur performance sur le marché du travail aux Etats-Unis. On montre qu'un Européen perçoit un surcroît

de salaire par rapport à un travailleur américain aux caractéristiques observables identiques. Ce surcroît de salaire peut être la marque de talents spécifiques et fortement recherchés, ou la marque d'une « sur-représentation » des Européens dans les secteurs de l'économie à plus forte valeur ajoutée (nouvelles technologies par exemple) qui distribuent les salaires les plus élevés. Quelque soit l'interprétation à privilégier, cette prime étant plus élevée pour les expatriés les plus récents, elle vient confirmer l'augmentation de la qualité du capital humain des Européens travaillant aux Etats-Unis.

Ce travail empirique met donc en évidence que depuis le boom des nouvelles technologies, on assiste à une augmentation de l'émigration vers les Etats-Unis du capital humain européen dont la contribution à l'économie de la connaissance est la plus importante.

RESUME COURT

Ce papier étudie l'ampleur et la nature des flux de capital humain d'Europe vers les Etats-Unis au cours des 30 dernières années. L'exploitation des données issues des recensements des Etats-Unis de 1980, 1990, 2000 et 2006 révèle que l'émigration Européenne reste relativement faible au regard de la population active d'origine. Cependant, cette émigration est fortement sélective. Ainsi les taux d'émigration augmentent à mesure que l'on progresse dans l'échelle des qualifications et des emplois les plus impliqués dans l'économie de la connaissance (ingénieurs, universitaires, chercheurs). A partir d'un indicateur de brain-drain qui pondère l'éducation par sa productivité dans chaque pays, on montre que la part du capital humain expatriée aux Etats-Unis augmente depuis 1990. Enfin, l'étude des performances des migrants européens sur le marché du travail aux Etats-Unis indique que ceux-ci perçoivent un surcroît de salaire par rapport aux travailleurs américains possédant les mêmes caractéristiques observables. Cette prime à l'expatriation est plus élevée pour les cohortes les plus récentes. Ce dernier résultat confirme que la sélectivité de l'émigration Européenne vers les Etats-Unis est en augmentation.

Classification JEL : F22, J24, O15, O52

Mots clés : émigration, fuite des cerveaux, capital humain, économie de la connaissance, Europe, Etats-Unis

THE BRAIN DRAIN BETWEEN KNOWLEDGE-BASED ECONOMIES

Ahmed TRITAH¹

1. INTRODUCTION

Nowadays, it is widely claimed that Europe, and more generally the wealthier league of nations, will achieve their best in the world competition only through investments in human capital and knowledge creation. This claim is largely echoed by the academic research. Current theories of economic growth stress the importance of investments in knowledge for the more advanced economies (Aghion and Howitt, 1998), as a consequence, many seek to increase their stock of "brainpower" via investments in higher education and, increasingly, by attracting brains worldwide. Indeed, a large part of knowledge investments is embodied in people and it moves with people which both produce and convey knowledge. In this context, what is commonly termed the "Brain Drain" figures at the top of the policy agenda on development. To the layman, this suggests a flow of skilled workers from poor and human capital-scarce countries to the richest and human capital-abundant ones (Docquier et al., 2007).² However, due to the rising demand for high-skilled workers and their perceived shortage, worries about the drain of skilled workers have also emerged in the developed world.³ The Third European Report on Science and Technology Indicators 2003 puts this issue at the forefront: "[...] a likely shortage of highly qualified scientific and technical (S&T) personnel in the research and development (R&D) activities anticipated for the next ten to fifteen years represents undoubtedly, one of the biggest threats to Europe's long term innovative strength, and productivity growth. Europe produces a large number of university graduates, doctorate recipients and postdoctoral students. But a significant share of them find work in an occupation outside of European R&D.

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²According to The New Palgrave Dictionary of Economics (2007) "the term Brain-Drain designates the international transfer of human resources and mainly applies to the migration of relatively educated individuals from developing countries to developed countries".

³Recent reports on the topic are the EU Commission (2003), the EEAG report (2004), the report for the French Senate (2002) and the report by the Germany's Chamber of Commerce (2005) warning that German emigration has reached the highest tally since 1950. Recent contributions in academia are Becker et al. (2003) for Italy and Saint-Paul (2004) which is the first paper to focus specifically on European brain drain to the US.

It may be one of Europe's biggest obstacles in its attempt to become the world's most competitive knowledge-based economy [...]” to which the European Council sets the goals for the European Union in its Lisbon strategy. This report warns that losing embodied scientific capital may be very costly in terms of productivity, growth, and employment. This is further supported by the good growth and employment performance within Europe of countries recording high trends in indicators on high technology and knowledge intensive activities (e.g. Ireland, Sweden, Finland).

While the media and policymakers in Europe frequently ring alarming bells, only few studies bring the brain-drain issue to the data in order to disentangle the "myth from the reality". Most of existing studies are focused on a single country case and over a short period of time. A noticeable exception is the recent contribution of Saint-Paul (2004). The author describes the brain-drain from the large European countries to the US and documents a rising pattern in the 1990s. In speculative computations, Saint-Paul (2004) concludes that "the proportion of European people who "matter" who are in the U.S. could be as high as 50%; that is huge and can in principle have dramatic consequences on Europe's growth potential". If one is interested in the direction of the brain-drain out of Europe, the U.S. is clearly the place where to look for, given its skilled labor-hungry economy as witnessed by the dramatic surge in skilled-based wage differentials since the early 1980s (Autor et al., 2006). Where else could European workers receive the best price for their skills and knowledge if not in the US? For various reasons the US is a magnet for unskilled and skilled workers alike coming from the developing world but also from the rich and relatively skill-abundant Europe as confirmed by the recent OECD data on expatriates.⁴ The latter also shows that the outflows of Europeans are far from being balanced by reverse inflows of US workers to Europe.⁵

Against this background, the aim of this paper is, first, to give a clear and concise statistical description of the magnitude and nature of human capital leaving Europe in absolute and relative terms. I complement the description made by Saint-Paul (2004) with longer term trends, more recent data since the 1980 and the 2006 censuses are added, and with a further emphasis on knowledge workers. Moreover, I provide a first tentative look at the importance of return migration and the characteristics of

⁴For instance, half the American who won Nobel prizes in physics in the past seven years were born abroad. More than half the people with PhDs working in America are immigrants. Such success stories as Intel, Sun Microsystems, Yahoo, E-bay or Google were all founded or co-founded by immigrants.

⁵OECD data shows that there are 5 times more French expatriates in the US than US expatriates in France and 15 times more German in the US, than American expatriates in Germany (Dumont and Lemaître, 2005)! Hence even if US expatriates were all highly skilled and only half of French and German expatriates were highly skilled there would still be a large skill imbalance in the exchange of labor services of Germany and France with the US. Computations for other E.U. countries lead to similar conclusions.

returnees. To the degree it is important, the second objective is to gauge the economic significance of the brain-drain in term of output and productivity. More precisely, rather than giving a precise measure of its impact on output and productivity, the aim is to use appropriate indices to measure the human capital embodied in emigrants and to highlight differences across countries and over time. Finally, to gain a deeper understanding of the nature of European emigrants' human capital, I use information on expatriates' performance in the US labour market. Based on these data, I provide preliminary evidence on 'talents', defined as the set of unobservable characteristics that command higher wages.

To proceed, I use the 1980, 1990, 2000 and 2006 US censuses to establish statistical evidence regarding the size and the nature of the flows. Next, taking the perspective of the origin countries, I compute brain drain indices along the neoclassical growth tradition whereby I distinguish between human capital and raw labor as proposed in the extension of the Robert Solow's growth model (Solow, 1956) by (Mankiw et al., 1992). Hence, I evaluate the human capital of emigrants within a production function framework in which workers of different skills are assumed to be perfectly substitutable and the technology is skill-neutral. Lately, with the use of Mincerian wage regressions I document the wage premium received by successive cohorts of recent emigrants.

Several findings emerge from this empirical scrutiny. First, as far as the magnitude of flows from Europe to the US are concerned, the brain-drain involved a relatively small number of individuals. Second, for almost all European countries emigrants are increasingly drawn from the top of the distribution of skills and ladder of occupations that matter the most in the knowledge economy (engineers, researchers and university instructors). As for the share of human capital leaving Europe, it has accelerated in the 1990s compared to the previous decades and in particular for human capital-scarce European countries (Southern European countries). Finally, wage regressions reveal that Europeans receive a positive wage premium on the US labor market which has increased for the most recent emigrants cohorts.

The remainder of the paper is organized as follows. In section 2, I describe the indices used to measure the "drain" of human capital. In section 3, I provide the empirical evidence on the magnitude and the nature of the flows. In section 4, I present the relative and aggregate human capital of emigrants using the indices. The fifth section documents the European wage premium in the US labor market. The last section concludes.

2. THE HUMAN CAPITAL OF EMIGRANTS

2.1. Productivity based brain-drain indices

What quantity of human capital does European expatriates convey to the US and how should it be evaluated across time and countries? To answer this question, I convert embodied years of education into human capital. The latter is measured by evaluating the contribution of schooling to output in the emigrants' source countries. Effectively, the aim is to develop productivity based brain-drain indices, so that one can establish in what circumstances higher emigration is detrimental and by how much. Because of its importance as a determinant of workers productivity and macroeconomic performance, the emigrants' human capital is a very appealing concept to discuss issues surrounding the brain-drain. On the one hand, the life cycle human capital theory predicts that individuals accumulate human capital by investing in formal education and through working life training and learning by doing - work experience - (Becker, 1964; Mincer, 1974). These investments raise workers efficiency and, in a competitive economy, command higher wages in the labor market. On the other hand, the human capital, together with physical capital and technology is one of the three fundamental factor of production. According to the classical theory of growth, in a competitive economy in which production factors are paid their marginal product (Solow, 1956; Mankiw et al., 1992), per capita income is a function of per capita level of factors. *Ceteris paribus*, an increase in human capital per worker implies an increase in productivity which translates into higher income per worker. Conversely, if emigrants have higher average human capital than stayers then their outflow decreases the average human capital per worker. Likewise, productivity and income per worker in the source country decrease. As for the growth rate, the neoclassical tradition argues that a one-off permanent increase in the human capital stock is associated with a one-off increase in the economy's growth rate until productivity per worker hour has reached its new, and permanently higher, steady state level. New growth theories predict even higher gains since the same one-off increase in the human capital will be associated with a permanent increase in the output growth rate. The social benefit of having more human capital and thus the costs of losing skilled workers is much larger in this case.

The cross country and time trend indices developed in this section are rooted in the micro-economic human capital theory and the macro-economic growth accounting exercises (aggregate production function). The key advantage of this approach is to allow for a consistent productivity based assessment of human capital embodied in labor outflows across time and countries. As a first step, one has to describe within an aggregate production function the relationship between aggregate output and ag-

gregate human and physical capital. Currently most research on growth accounting adopt a Cobb-Douglas specification (Hall and Jones, 1999). Therefore assume that, the country c output at period t , $Y_{c,t}$ is produced according to:

$$Y_{c,t} = K_{c,t}^\alpha (A_{c,t}(M_{c,t}h_{c,t}^m + N_{c,t}h_{c,t}^n))^{1-\alpha} \quad (1)$$

where $K_{c,t}$ denotes the stock of physical capital, $M_{c,t}$ and $N_{c,t}$ the raw quantity of labor supplied by "future" emigrants and stayers and $h_{c,t}^m$ and $h_{c,t}^n$ their respective average human capital. Hence, $M_{c,t}h_{c,t}^m$ and $N_{c,t}h_{c,t}^n$ is respectively the amount of human capital which is supplied by emigrants, before they emigrate, and by stayers. I denote by $A_{c,t}$ the labor augmenting measure of productivity. Using (1) the labor productivity of emigrants and stayers is a linear function of their respective human capital:

$$\frac{\partial Y_{c,t}}{\partial M_{c,t}} = (1 - \alpha) (\kappa_c)^{\frac{\alpha}{1-\alpha}} h_{c,t}^m A_{c,t} = w(h_{c,t}^m) \quad (2)$$

and

$$\frac{\partial Y_{c,t}}{\partial N_{c,t}} = (1 - \alpha) (\kappa_c)^{\frac{\alpha}{1-\alpha}} h_{c,t}^n A_{c,t} = w(h_{c,t}^n) \quad (3)$$

where κ_c is the constant capital output ratio K_c/Y_c .⁶ Thus, given capital endowment, labor productivity depends only on the average human capital of workers. The relative productivity of an emigrant is then:

$$\Phi_{c,t} = \frac{w(h_{c,t}^m)}{w(h_{c,t}^n)} = \frac{h_{c,t}^m}{h_{c,t}^n} \quad (4)$$

$\Phi_{c,t}$ is a productivity based index measuring the quantity of "brain-drain" per expatriate. Clearly, output per worker in the home country is lower once emigrants are excluded from the workforce if $h_{c,t}^m > h_{c,t}^n$. A well established empirical regularity in labor economics is the log linearity of wages with years of education, such that:⁷

$$\log w(h_{c,t}^m) = C_{c,t} + \beta_{c,t} S_{c,t}^m \text{ and } \log w(h_{c,t}^n) = C_{c,t} + \beta_{c,t} S_{c,t}^n$$

where $C_{c,t}$ is a country and time specific dummy.⁸ The coefficient $\beta_{c,t}$ is the return to an additional year of education, $S_{c,t}^m$ or $S_{c,t}^n$ which is varying across countries and time period. The returns on years of education for each country and time period, $\beta_{c,t}$,

⁶I choose to write the output per worker in terms of capital-output ratio rather than capital-labor ratio since along a balanced growth path the capital-output ratio is proportional to the (fixed) investment rate. So as shown in Hall and Jones (1999) one can discard any effect of emigration on the capital labor ratio.

⁷See Card, (1999) for a survey.

⁸For instance, this dummy catches the country level of technological progress ($A_{c,t}$)

correspond to the coefficients of a Mincerian wage regression and $\Phi_{c,t}$ can then be written as:

$$\Phi_{c,t} = e^{\hat{\beta}_{c,t}(S_{c,t}^m - S_{c,t}^n)} \quad (5)$$

where $\hat{\beta}_{c,t}$ is the estimated wage return to an additional year of education. Hence, following the common practice in growth accounting (Caselli, 2005), I assume that the educational attainment of emigrants and stayers is weighted by the returns to years of education in the labor market. The index $\Phi_{c,t}$ which is measured over a given period and cohort of emigrants characterises a brain-drain situation if it is higher than one. The microeconomic foundation for the specification of human capital as an exponential function of schooling into a Cobb-Douglas aggregate production function has been first proposed by Heckman and Klenow (1997). It has later been used by Hall and Jones (1999) to investigate sources of cross country income differences and by Bils and Klenow (2000), it is now becoming a common practice in macroeconomics.⁹ Knowing the human capital content per emigrant it is straightforward to obtain their relative aggregate human capital, which is in percentage term:

$$\Omega_{c,t} = 100 * \frac{M_{c,t} * w(h_{c,t}^m)}{N_{c,t} * w(h_{c,t}^n)} = 100 * em_{c,t} * \Phi_{c,t}. \quad (6)$$

The aggregate human capital of emigrants is the product of their relative endowment in raw labor, that is the emigration rate $em_{c,t} = M_{c,t}/N_{c,t}$, with their relative endowment in human capital, $\Phi_{c,t}$. Hence, the human capital outflow increases because either more workers are leaving or their quality increases. Another interpretation of $\Omega_{c,t}$ is that it represents the emigrants embodied share of output.

2.2. Indices based on higher education levels

While the average human capital is an appropriate measure to assess the relative productivity of emigrants it may not be the most relevant margin to discuss potential threats in a knowledge economy context. Indeed, in their survey of education and economic growth, Krueger and Lindahl (2001) find that "education is statistically significantly and positively associated with subsequent growth only for the countries with the lowest level of education". This is the case for instance if, as it is argued by Grossman and Helpman (1991), poor countries have a comparative advantage in adopting already existing technology since it requires a less educated laborforce. Instead for the most advanced countries, Vandenbussche et al. (2006) consider that the

⁹See Topel (1999) and Caselli (2005) for a recent surveys.

source of technological progress is dual, it is the result of not only the adoption of existing technologies but also of pure innovation, the latter activity being more intensive in highly-educated workers. Using a panel dataset covering 19 OECD countries, the authors show that in advanced economies unskilled human capital indeed contributes little to technological improvement and that the relevant margin is that of *skilled* human capital. They obtain that differences in the share of college educated workforce has been an important source of growth divergence among OECD countries. Therefore, I take a look at the outflows of highly educated workers - that is those with at least a college degree over time for each country in average and in per worker term. Let's $Col_{t,c}^e$, and $Col_{t,c}$ denote respectively the share of college graduates among expatriates and stayers as of period t . The ratio

$$\eta_{c,t} = \frac{Col_{c,t}^e}{Col_{c,t}} \quad (7)$$

is the appropriate index to determine whether emigration hampers the accumulation of college type human capital. This ratio measures the quantity of college education embodied in emigrants relative to stayers. The index varies between 0 and ∞ and if it is higher than 1, emigration lowers the accumulation of college type education. Similarly to the index defined in (6), one can measure the aggregate loss of college graduates as:

$$e_{c,t}^{col} = 100 * em_{c,t} * \eta_{c,t} \quad (8)$$

This index corresponds to the emigration rate multiplied by the relative quantity of college education of an emigrant.

3. INSPECTING THE EXPATRIATES POPULATION

3.1. The data

Expatriates sample. Data on European expatriates in the US are from the 1980's, 1990's, 2000's 5% US censuses and from the 2006's 1% US census, all are provided by the Minnesota Population Center (IPUMS). Populations estimates are derived from each sample by using the personal weights included in each census. To be included in my sample of European expatriates a person should be in the labor force and between 25 and 64 years old. Expatriates are identified by their birth place and their parents' citizenship status. A person is a European immigrant if he is born of a non American parent in any European country considered.¹⁰ For comparison

¹⁰These countries are Austria, Belgium, Denmark, France, Finland, Germany, Greece, Ireland, Italy, The Netherland, Norway, Portugal, Spain, Sweden, Switzerland, and the Great-Britain.

purposes, I also include Canadian emigrants. Since the aim of the paper is a comparative assessment of migration flows across European countries and over time, on top of emigrants stock I also consider the aggregate flows over a 10 or a 5 years period preceding the corresponding census. For instance, for the year 2000 my decennial flows of European expatriates sample are Europeans that migrated in the 1990s and that are still working in the US by the year 1999. Unavoidably, the true aggregate flows over the period are understated as some migrants actually return home, while other leave the labor force because they retire or die.¹¹ However, focusing on recent emigrants flows presents some advantage over stocks. First, unlike stocks which are an amalgam of current and past mobility decisions, decennial or quinquennial flows are less liable to the initial demographic composition of the populations such that one can better grasp the dynamics of outflows and their differences across countries. Next, one should bear in mind that the longer the time an individual has lived overseas the less likely he is to return back. Hence, from a policy point of view, to identify the most drainable workers it is more relevant to gather information on those who left recently as they are more likely to resemble potential leavers than are older emigrants. Moreover, as it is reasonable that recent emigrants are more sensitive to changes in their home country labor market conditions it is important to know about this population in order to better design incentives policies for return migration.

Education data. I use a common dataset for both expatriates and non expatriates. Average years of education for the non expatriates population of each country are constructed from Cohen and Soto (2007). This dataset gives the share of the population aged 25-64 into 6 educational categories: Primary non completed, Primary completed, Secondary non completed, Secondary completed, Tertiary non completed, Tertiary completed. To determine years of education, I complement these data with the duration of schooling for each category obtained from Caselli and Coleman (2006) for the primary and secondary education, and from OECD (2007) for the university level education. Average years of schooling are computed by multiplying the population share in each educational category by the number of years necessary to complete that category and by summing over categories.¹² As for the expatriates sample, the US censuses provide a detailed variable so that the educational attainment of emigrants can be matched with each of the six educational groups present in Cohen and Soto (2007) to compute average years of education.¹³ Hence, I end up with a comparable measure of years of education in the expatriates working-age

¹¹The problem is largely mitigated by the fact that it concerns workers between 55 and 64 years old, while the overwhelming majority of European emigrants left their home countries before the age of 55.

¹²For the non completed educational categories, I assume that half of the curriculum is completed.

¹³Results on average years of education for the US workers are very close if I use instead a direct measure of years of education derived from the census. For consistency, I choose a common method to compute average years of education in the source country of expatriates and in the US.

population and their peers in source countries.

Mincerian returns. To compute the productivity indices it is necessary to have in hand estimates of returns to schooling in emigrants' country of origin at each period of time. Until recently, such information was not available. Hopefully, consistent cross-country estimations of returns to years of education have been assembled by a number of researchers. Most estimates for marginal returns to years of education in 1980 and 1990 are from the dataset assembled by Hendricks (2006).¹⁴ For the year 2000, I use the estimates presented in Harmon et al. (2001). These returns correspond to the coefficient $\hat{\beta}_{c,t}$ in (5). For each country, I use the estimates which are the closest to the census year considered.¹⁵ I should mention that pre-tax wages are used as the dependent variable, as it is the case for almost all Mincerian wage regressions in the literature (Card, 1999). We have check for countries for which we have long enough time series estimates of return to education that the three yearly estimates reflect the long term trend in the returns to education.¹⁶ Hence time trend in the $\hat{\beta}_{c,t}$ does not depend on the specific years used to estimate the returns to education.

3.2. Magnitude and nature of flows

In this section I provide an overview of the representation of European expatriates in the US workforce and their characteristics. The figure 1 plots the number of 25-64 years old (from now on defined as the workforce) Italian, French, German, British and Spanish immigrants in the US. The German and the British are by far the most numerous. The number of European expatriates has increased throughout the three decades except for Italians. However, the stock of European immigrants is weighted heavily by the history of the volume and character of past migration flows. For these reasons a look at aggregate flows over 5-years period should provide more insights on recent dynamics. These are depicted in the right hand panel of figure 1, and indicate that the number of workers leaving Europe has increased since the 1980s and

¹⁴The author has assembled these estimates from various sources and notably from Psacharopoulos and Patrinos (2004).

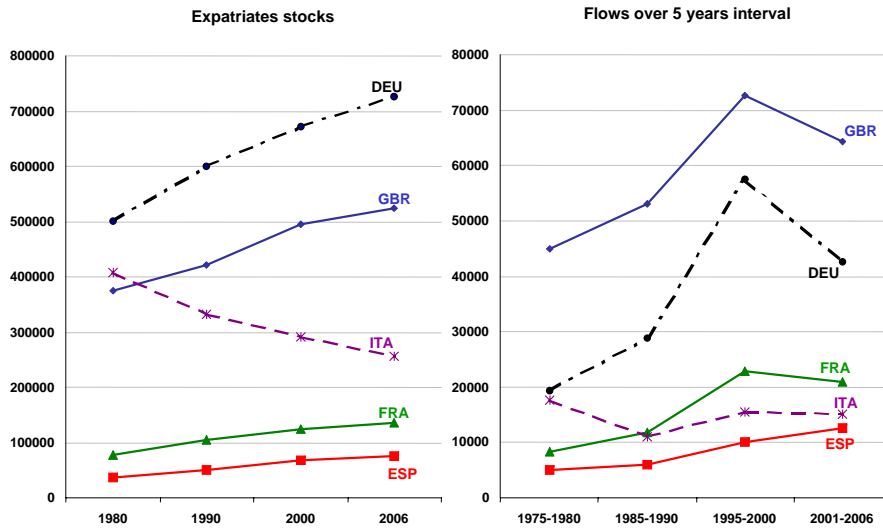
¹⁵I chose (when available) regressions that do not distinguish between male and female. This may cause some discrepancies as there are slightly more female in my expatriates sample than male, while in the source country female labor force participation remains lower than that of male. However, this will only catch productivity differences across gender unrelated to education. I also choose the specification that control for experience and its square. I have also computed the indices with a specification that omits the control for experience and have obtained similar results.

¹⁶Thus, for instance returns to education are decreasing throughout the 1980s and the 1990s in France as confirmed by Marion and Thelot (2003). Other countries for which returns are decreasing are Austria, Sweden and Switzerland. Instead, Denmark, Finland, Italy, Portugal and Germany have upward trend in the returns to education. Other countries have no general trends. Harmon et al. (2001) provide a full treatment of time trends in returns to education in Europe.

has accelerated in the second half of the 1990s. A deceleration is palpable only for the most recent years. However, this deceleration has to be interpreted in the light of the specific context and switch in the US immigration policy and visa procedures following the September 11th events as well as the large economic downturn in the early 2000s. Hence, the deceleration may reflect a transitory episode along the rising pattern of the last three decades. Italy is a peculiar case as the rising inflows are insufficient to balance the flows out of the labor force caused by an aging expatriates labor force. For the other countries, recent trends show that the rising stock of expatriates is fed by increasing inflows and is not an artifact of the initial demographic composition of the expatriates population.

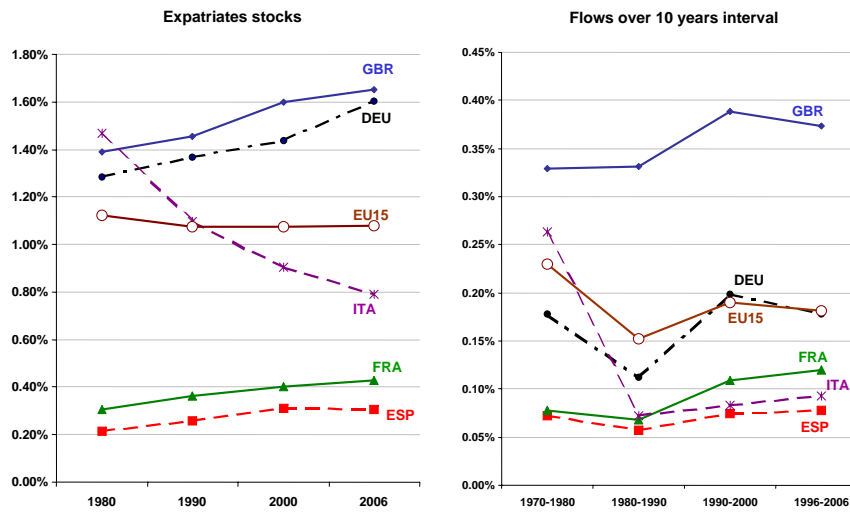
To assess how large these absolute numbers are, the graphs in figure 2 weight the stocks and flows of expatriates by the size of the corresponding home country working age populations. The measure reveals the extent of the drain of raw labor to the US. As expected from the previous graphs on stocks, there are large differences across countries in the share of their working age population in the US. This share is relatively important for Germany and the U.K., where it approaches 2%. The trend rises throughout the 1980s and 1990s for all countries, Italy excepted. Emigration rates measured over a 10 years period have a U shape time pattern. After a fall in the 1980s, the 1990s witnessed a revival of the outflows. Albeit still small, these figures have to be put in the context of an aging population in Europe. For instance, between 1995 and 2005 the working age population in Germany decreased by 3% while it increased by 6% during the first half of the 1990s. The same pattern is observed in all European countries, except for Spain owing to high inflows of foreign workers during the past 10 years. Therefore, in a labor-scarce Europe these small outflows may further depress the contribution of labor to economic performance and exacerbate other imbalances due to an aging population.

I consider now the nature of these flows, focusing on who is leaving in terms of their personal attributes, their level and type of human capital. The age of expatriates is an important determinant of emigrants stocks and shape their future pattern. Human capital theory along the line of Becker (1964) would predict that emigrants are on average younger than their home country workers as they need a long enough attachment to the labor market to recover their initial investments. Furthermore, return migration at later ages should lower the share of old workers among expatriates. Therefore, due to inflow of young workers and return migration of old workers, the expatriates population is expected to be younger than the workforce in the source country. Figure 3, which presents the age distribution of recent expatriates relative to workers in their country of origin, confirms that young workers are much more likely to emigrate than older ones. However, a significant share of emigrants from countries in figure 4 are above 35 years old, and this share increased in the 1990s compared to



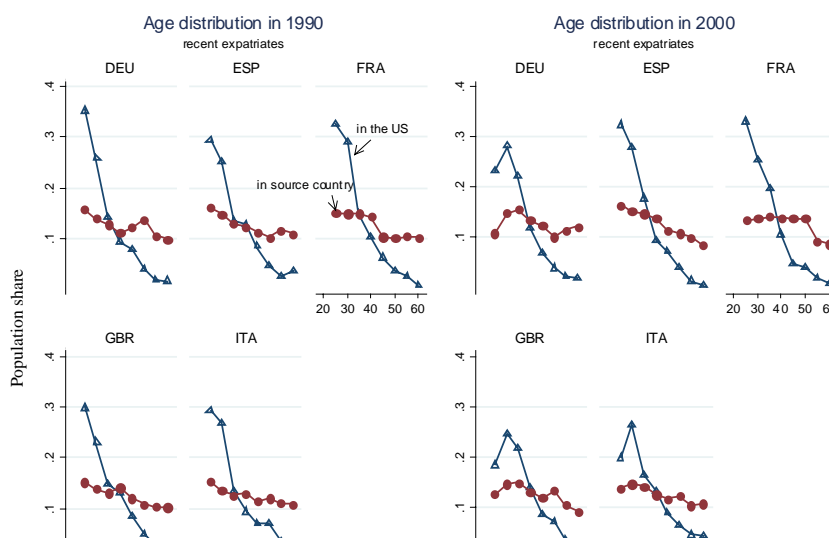
Source: US census

Figure 1: Magnitude of expatriates stocks and flows



Source: US census

Figure 2: Expatriates' share of source country working age population (25-64 years old)

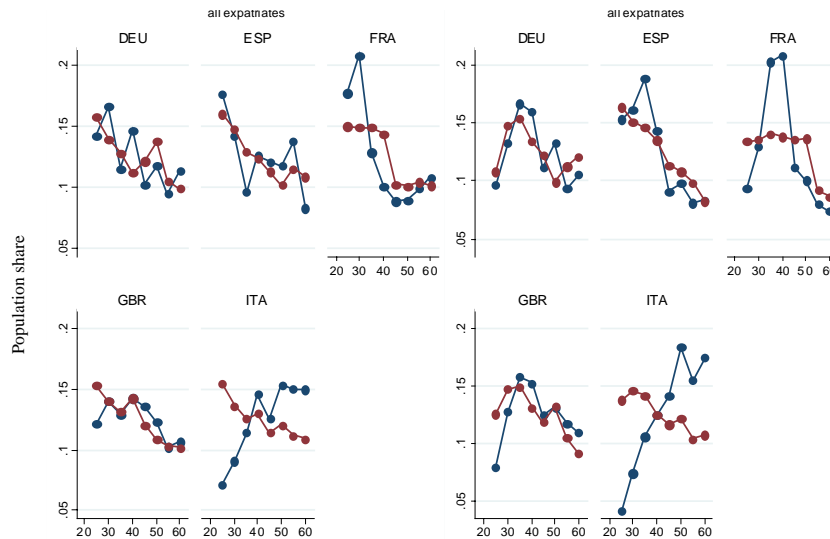


Source: US census

Figure 3: Age distribution of recent expatriates and stayers (aggregate flows over 5-years age group: 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64).

the 1980s. As a consequence, and against conventional wisdom, at the time they enter the US labor market, expatriates have on average substantial years of labor market experience. However, while new expatriates are younger, the expatriates population as a whole is not systematically younger than source country working-age population. This is notably the case for the U.K. and Italy as shown in figure 4. Except for Italy, the 1990 and 2000 censuses (see figure 4) reveal that the expatriates are increasingly concentrated in the middle of the age distribution, between 35-44 years old, which is the mark of an aging expatriates population.

European emigrants may take a lot with them and the previous graphs show that, given their age, they have significant labor market experience. But, by and large, the most important component of their human capital is their education. Hence, schooling is the most basic index of skills to consider, and how much they have compared to stayers determines the degree of selectivity along the educational ladder and thus the strength of the brain-drain. Figure 5 provides a clear evidence that expatriates are more educated than their country peers. Moreover, and not surprisingly, expatriates originating from the most educated European nations are also more educated on average (mainly Scandinavian countries). One may argue that the schooling of successive emigrants cohorts reflects the trends in their source countries. Most European countries narrow their educational gap with respect to the US throughout the 1980s and

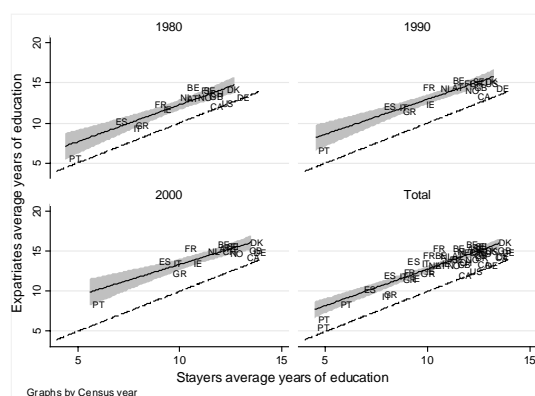


Source: US census

Figure 4: Age distribution of all expatriates (recent and old) and stayers

the 1990s, hence very likely the educational attainment of relatively "young" European expatriates reflects this rising trend. To emphasize this point and the importance of migrant selectivity, figure 6 displays the educational attainment of expatriates and stayers over time. The (vertical) distance between the 45°line and the connected line for each country tells us how large is the migrant schooling selectivity, moving along a country plot to the north-east reveals how this selectivity evolves over time, while the changing slope between two consecutive segments suggests the pace at which it is evolving. The shape of countries' plot reveals that the schooling of expatriates is expanding at a higher pace than that of their home country working age population, as a consequence the migrant selectivity is increasing. This is notably the case for France, Germany, Italy, the Netherlands, Spain and Sweden. Although the 1990s are marked by a slight deceleration in the emigrant selectivity growth for the Netherlands, Spain and Italy, there is a clear stabilization only for the Great Britain. Noticeably, while the German expatriates were almost as educated as the German stayers in the 1970s, the former became steadily and increasingly more educated in the 1980s and 1990s. Migrant selectivity is higher for countries with relatively lower educational attainment (France, Italy, Spain).¹⁷ As a consequence, as schooling differences among countries

¹⁷That is the countries having the highest vertical distance with the 45°line are more likely to be located at the left side of the graph.



Source: US census and Cohen and Soto (2007)

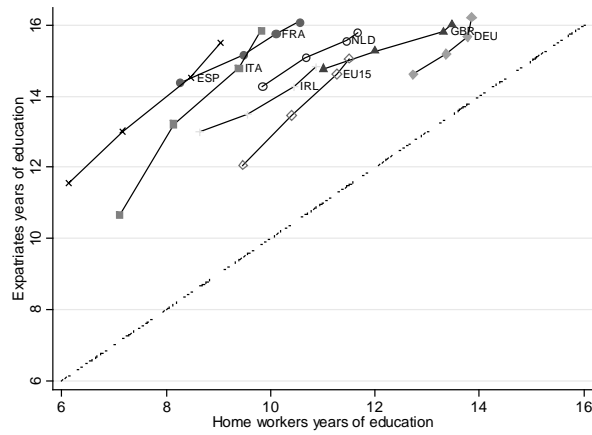
Figure 5: Emigrants stayers schooling disparity (25-64 years old decennial flows). The dashed line corresponds to the 45° line

narrow, disparities among expatriates are shrinking and are much lower than they are between source countries workforce. For instance, in the 1990s the average Swedish worker is a college graduate while the average French worker is still a high school graduate, but both the French and the Swedish expatriates on average hold a bachelor degree. And so, the French and the Swedish expatriates are from the highest rungs of their home country educational distribution.¹⁸ Moreover, during the 1980s traditional exporters of low skilled labor such as Italy and Spain become exporters of college graduates, while their working age population at home remains relatively low skilled (below high school diploma).¹⁹

The time pattern of educational disparities between emigrants and stayers can be interpreted with a model of selective migration as developed by Borjas (1987, 1999). According to Borjas immigrants are positively selected, that is pulled from the upper

¹⁸This is measured by the vertical distance between the upper right point for the France plot and the 45° line.

¹⁹To account for schooling disparities due to age differences between expatriates and stayers, I have computed the average education of expatriates assuming that they have the same age distribution as workers in their countries of origin. I found that a very small part of schooling disparities are due to higher share of young among expatriates. This is an indication that the schooling gap concerns all emigrants irrespective of their age. Results are available from the author upon request.



Source: US census and Cohen and Soto (2007)

Figure 6: Emigrants stayers schooling disparities over time (decennial flows). Each point corresponds to a given emigration cohort (1970s, 1980s, 1990s and 1996-2006 cohorts) and country. The dashed line corresponds to the 45° line.

part of the distribution of skills in their country of origin, if returns to skills are higher in the destination country. More precisely, in this model disparities in return to skills determine a critical threshold above which highly-skilled individuals have monetary incentives to move from the region with lower returns to skills (Europe) to the region with the higher returns (US). The lower are these disparities the higher is this threshold and the more selective is the emigration. Differences in returns to skills between Europe and the US throughout the 1980s and 1990s can then provide an explanation for the patterns of emigrants' selectivity observed in the data. On average differences in returns to education between Europe and the US peaked in the 1980s and narrowed in the 1990s. For instance in the 1980s, for an additional year of education a US worker received about 5% higher wage than a typical European worker, in the 1990s this difference is 3%.²⁰ Since Europe-US disparities in returns to education are lower in the 1990s than in the 1980s, the skill threshold above which a European worker has an incentive to emigrate to the US is higher in 2000 than it is in 1990. As a consequence, the average European emigrant is more skilled in the 1990s than in the 1980s. Therefore, emigrants-stayers schooling disparities (e.g. migrants' selectivity) happened while returns to skills in the US were rising sharply in the 1980s (Autor and Katz, 1999), and kept on rising while returns to skills started to rise in Europe during the 1990s (and decelerate in the US). As for the increase in the outflows it can be explained by the fact that as Europe narrows its educational gap with the US more candidates are above the skill level threshold above which European workers have incentives to work in the US.

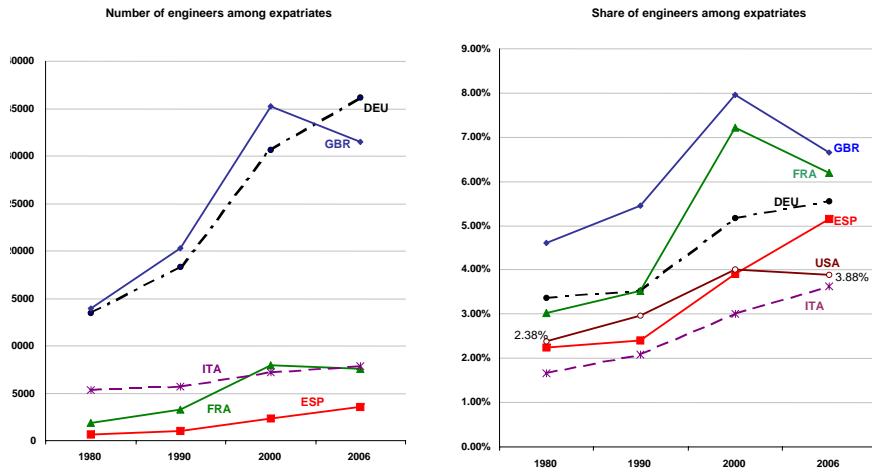
Above schooling, the production of knowledge requires people involved in such activities. Specifically, the brain drain between knowledge-based economies entails the emigration of those who not only use knowledge, but also create it and transmit it. Not surprisingly then, brain drain fears in Europe center on these specific occupations which are scarce and highly demanded. For these reasons it is important to assess the importance of these workers among expatriates. Engineers are involved in the adoption of new technologies and in innovations. Scientists and university teachers are more critical from a longer term perspective. Scientists create knowledge that will find some applications in a more or less nearby future. University teachers determine the quality of higher education and are responsible for the transmission of knowledge to future generations. Figures 7, 8 and 9 present the estimated number and the share in the expatriates population of engineers, research scientists and university instructors. Throughout the 1980s and 1990s the number of expatriates in these three occupations increased dramatically. Since the 1990s the number of French and Spanish expatriates engineers has quadrupled and has more than doubled for Germany and

²⁰Returns to education were 9.5% in the US (my own calculation from the US census) in 2000 and 6.5% in the EU15 (de la Fuente and Ciccone, 2003).

the U.K., and it has increased by half for Italy. Most of the rise happened in the 1990s and is partly due to the dot-com bubble during the second half of the 1990s. Indeed, the early 2000s witnessed a slowdown and even a decrease in emigration of engineers from the U.K. and France, this slowdown shows up also in the share of engineers in the overall US population suggesting that it is indeed related to the bursting of the bubble in the early 2000s. The emigration of researchers and university instructors that are less sensitive to business cycles, grew at a more sustained and rapid pace throughout the last three decades. Again, the rise is impressive for Spain and France. The number of researchers has been multiplied by more than 4 for Spain and has more than doubled for France, and that of university instructors has more than tripled. As a consequence, since the 1990s the share of human resources involved in the building of long term growth potential has increased much more than that of other type of skills. This empirical evidence on the expatriates' occupations makes a convincing argument that not only are Europeans increasingly selected along the educational ladder but also along the ladder of knowledge occupations related to scientific and technological fields. To grasp the issue at stake it is important to emphasize that engineers, researchers and university instructors are highly complementary occupations. These complementarities generate agglomeration externalities and explain their geographic concentration around "knowledge-clusters", of which the Silicon-Valley is the most acclaimed achievement, whose major functions are to generate, transfer and apply knowledge, and to transmit it through education and training.

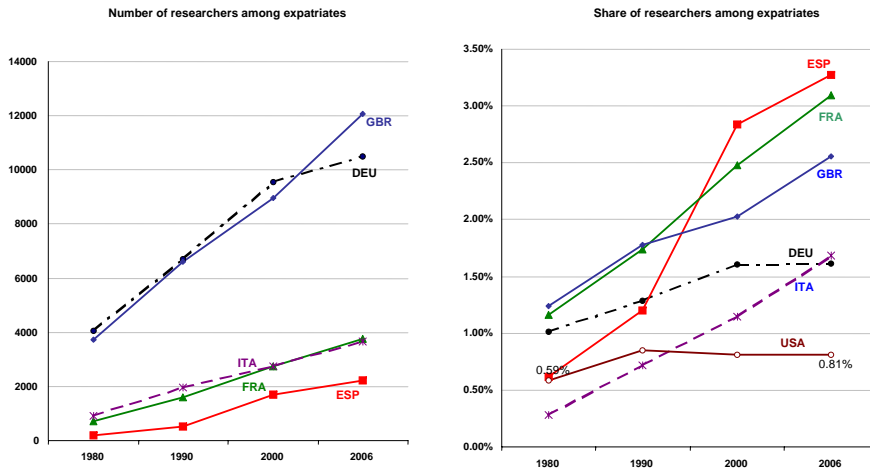
3.3. Brain-drain or Brain-circulation: how important is return-migration?

An important issue in any assessment of the brain-drain is whether migration turns to be permanent or only temporary. In the latter case emigrants acquire valuable skills which may dampen the human capital loss for their countries and may even be seen as a gain for their countries of origin. The difficulty here is that return migrants are not observed. Yet, by tracking a given cohort of recent expatriates and changes in its size and characteristic across censuses, one can form a rough idea about the significance and nature of return migration. An important limit of this exercise is that we have no guarantee that "missing" expatriates actually return back home as they can move to another country or die. Hence, such estimations have to be considered as an upper bound from the point of view of the sending country and should be interpreted with caution. Despite its shortcoming, the cohort analysis is still a useful tool to detect some time pattern and for this reason it is common in migration studies (Smith, 2006). To gather information about returnees in the 1980s and the 1990s, I keep track of two cohorts of recent expatriates (less than 5 years after their arrival).



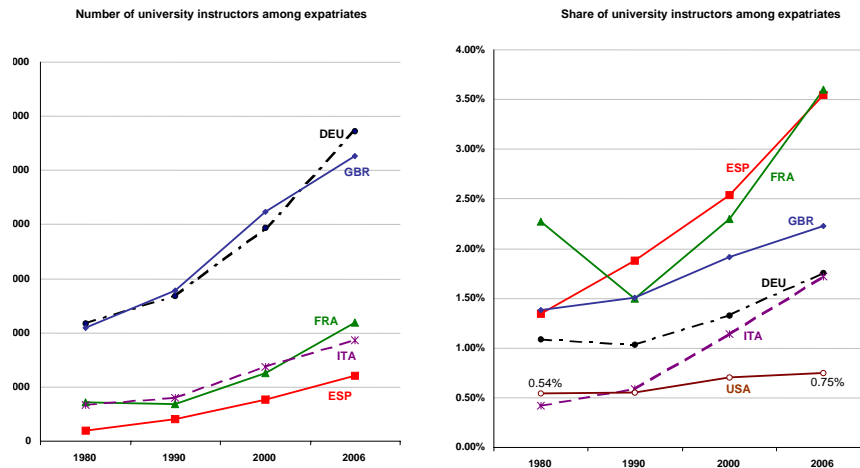
Source: US census

Figure 7: The engineers in the expatriates population



Source: US census

Figure 8: Researchers in the expatriates population



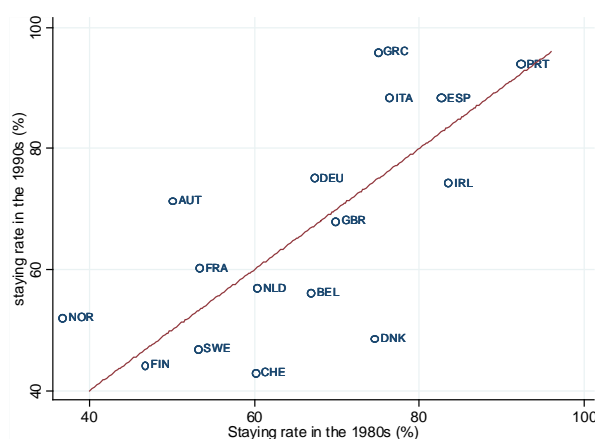
Source: US census

Figure 9: University instructors in the expatriates population

The first is between 25 and 54 years old in 1980 and the second in the same age range in 1990. Thus, the remaining expatriates (the non-returnees) in the 1990 and 2000 censuses are those between 35 and 64 years old that emigrated respectively in the second half of the 1970s and the 1980s.

Figure 10 presents a scatter plot of the share of expatriates aged 25-54 that emigrated between 1975-1980 and that are still working in the US by the year 1990 against the shares for the 1985-1990 cohort of expatriates still in the US by the year 2000. This graph reveals how large could be the size of return migration of Europeans and how it has changed across the 1980s and the 1990s. Return migration is more frequent among Scandinavian as up to 50 % of an expatriate cohort returns back home by the year 2000, while it is comparatively much lower among Southern European countries for which less than 20% of a cohort returns back during the 1990s. Returns rate in all large European countries decrease across the two decades, except for the U.K. where it remains stable, and are below 40% in the 1990s. Namely, the more recent cohorts are less likely to return back home than the previous ones.

The benefits from return migration to the source country depend on the age of returnees. If return migrants are older, the gains for their country of origin are likely to be lower as those are about to retire and older cohorts are on average less educated. Instead, if returnees are relatively younger, they profit their home country from the experience acquired abroad for a longer period of time. Given the initial age of a co-



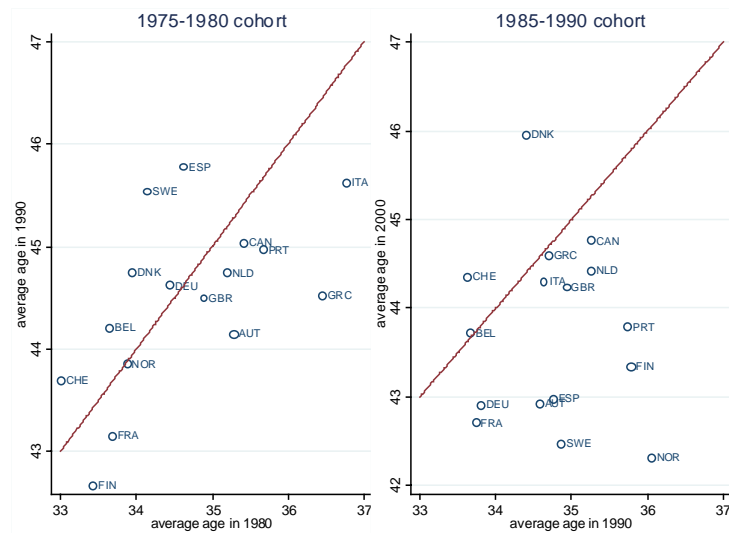
Source: US census

Figure 10: Staying rates of two successive cohorts of emigrants. The dashed line corresponds to the 45° line

hort, if returnees were equally distributed across all ages, then the same cohort should be on average 10 years older in the next census, if they happen to be younger then this may be an indication that older emigrants are more likely to return home.²¹ Figure 11 shows clearly that for most countries returnees are more likely to be older and more so in the 1990s compared to the 1980s. Hence, if anything, expatriates in the 1990s are less likely to return back home than in the 1980s, and returnees are more likely to be older. A life cycle human capital interpretation of this pattern may suggest that young expatriates invest more heavily in US specific human capital (housing, language, social ties) whose returns are recovered over a longer period of stay.

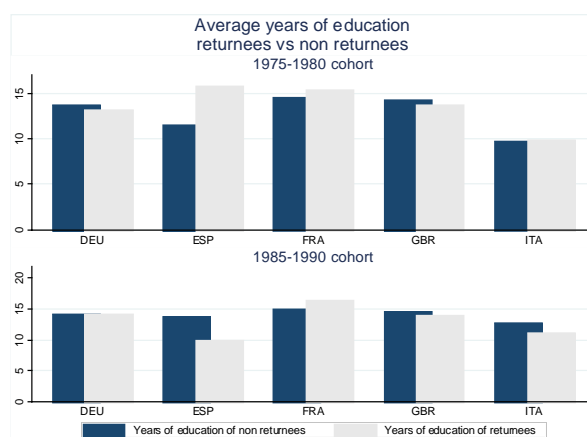
Lastly, in figure 12 I consider the schooling disparities of returnees and non-returnees. Among the large European countries, only the French returnees are slightly more educated than the non returnees. There is no time pattern in schooling disparity for Great-Britain and Germany. Spain is a striking case. During the 1980s' Spanish returnees were more educated while in the 1990s we observe the converse. The finding is entirely consistent with data in figure 11 showing that Spanish returnees in the 1980s were the youth, while in the 1990s returnees are older, and the fact that

²¹The 10 years is an upper bound since older expatriates have lower life expectancy. Hence, the computation of the age of returnees may be biased toward old age and should be interpreted with caution.



Source: US census

Figure 11: Age of returnees: the line is the locus representing the hypothetical age of expatriates if the full cohort of expatriates is still in the US by the next census year. Points below this line indicate that older expatriates are more likely to return back home.



Source: US census

Figure 12: Schooling disparity among returnees and the non-returnees. Note: equality of means is rejected for Spain for the 1975-1980 cohort and for France, Spain and the UK for the 1985-1990 cohort.

young expatriates are on average more educated.

In short, the size of European expatriates in the US is rising, and relatively rapidly for Spain and France. Expatriates are young but they still have significant years of labor market experience at the time they enter the US. Migrants are positively selected along the educational distribution and ladder of occupations that matter the most in the knowledge economy, and more so nowadays than in the 1980s. For all large European countries, return-migration represents no more than 40% of recent inflows and return rates have declined in the 1990s compared to the 1980s. The returnees are also more likely to be older and there is no compelling evidence that they are more educated (except for France). Overall the empirical evidence, across the 1980s and the 1990s, shows that despite a rise in average education, migrant selectivity is more important and it increases more rapidly for the large and relatively human capital scarce nations in Western Europe such as France, Italy and Spain.²² Yet, these movements are probably to be expected given the unprecedented period of economic expansion experienced by the US throughout the 1990s, one that boosted salaries (Acemoglu, 2002), and pushed up the Europe-US wage gap especially for the most qualified jobs and the so-called knowledge workers. Consequently, the US employers turn elsewhere to meet their needs. Europe which is catching up with the US in terms of educational attainment offers a potential pool of well qualified and drainable labor force easily able to step in the US jobs. Hence, *pull* factors are probably a major determinant of the observed pattern in the magnitude and nature of flows (see figure 2). However, one can hardly ignore European's *push* factors. The magnitude and nature of emigration results from the comparative rewards to skills (Borjas, 1987, 1999) and economic performance in the destination and source country. The US have exhibited better growth performance than Europe from the early 1980s. In 2000 the per capita GDP was 30% lower in Europe than in the US, which was a larger gap than in the 1970s. Most of the gap happened over the 1990s and has not narrowed still. The annual average GDP growth rate of the E.U. in the 1990s was 1.91% against 3.25% for the US.²³ The largest European countries, e.g. France, Germany and Italy were significantly below this average. While it is not the place in this paper to review the possible causes for the observed pattern of flows, spending and public policy probably matters a lot for workers in some specific occupations such as university instructors and researchers who, unlike in the US, work mostly in the public sector. In 2000, the US spent 2.3% of their GDP in tertiary education against 1.1% in the

²²The Portuguese and the Greek have also relatively high emigration rates, respectively the third and the fourth highest in 2000. For the EU15 emigration rates decrease in the 1990s only for the Irish and the Portuguese. The Irish emigration decline can be related to the exceptional performance of this economy in the 1990s.

²³Within Europe there are some exceptions like Ireland and Luxembourg.

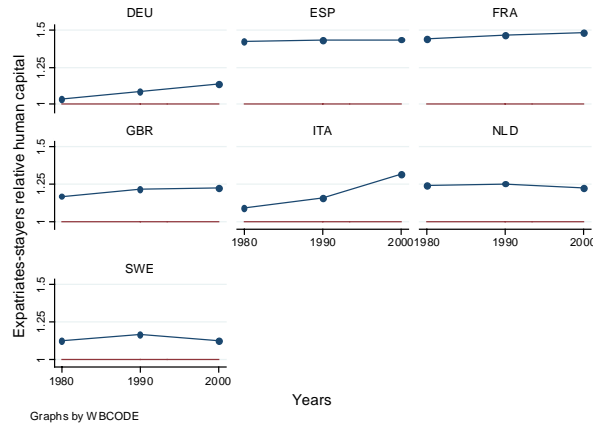
EU15, and the 5 large European countries considered are significantly below this average. Such spending disparities are largely reflected in international university rankings. Hence, as it is already the case for the "students' market", in an ongoing globalized labor market for skills, the mobility of human resources is increasingly sensitive to the quality of education and research environment offered worldwide.

4. TRENDS IN HUMAN CAPITAL INDICES

4.1. Productivity based indices

The schooling of expatriates does not provide a readily measure of productivity drained. The productivity of years of education - embodied human capital - is country specific and depends on the overall quantity of input used and the technology adopted by firms in a country at the time it is measured. The synthetic index (5) which is a productivity weighted relative measure of years of education for each country and time period is more suitable for making cross country and longitudinal comparisons. Figure 13 presents this index for some European countries computed over decennial flows of expatriates. Not surprisingly, countries have an index of relative human capital above one. Hence, according to the criterion defined in (5), absent emigration the average human capital and workers productivity (e.g. output per worker) in source countries would have been higher. As one may have anticipated from figure 6, by the year 2000, the French and the Spanish expatriates embodied the highest quantity of human capital as their index $\Phi_{c,t}$ is around 1.50%, meaning that expatriates' productivity exceed stayers' by 50%. The German and the Swedish index is the lowest, in 2000 a Swedish and a German expatriates' productivity exceed stayers' by 10%. Considering countries in figure 6, with the exception of Italy and Germany, the index has a flat time profile, despite the documented expanding disparities in movers and stayers schooling throughout the 1980s and the 1990s. The rational for this apparent discrepancy has to be related to the contrasted changes of returns to schooling across European countries in the 1980s and 1990s. Indeed, the index evolves over time (and across countries) due to two components: first variations in relative years of education and second changes in the returns to skills ($\beta_{c,t}$). During the 1980s returns to education remain stable or decline in Europe (while they increase in the US), and start to rise (or to stabilize) again in the 1990s for some countries. The rise is more pronounced for Italy and Germany in the 1990s (Autor and Katz, 1999), and so, the relative human capital of Italian and German expatriates increases in the 1980s and the 1990s.²⁴ Instead, returns to education follow a downward trend in France,

²⁴Returns to one year of education was 0.04% in Italy in the 1980s and rises to 0.07% by the end of the century. For a high school graduate (12 years of education) this represents a wage gain equal to



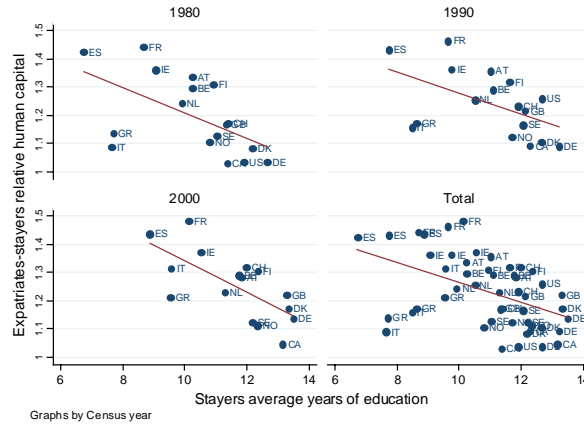
Source: US census, Cohen and Soto (2007), Hendricks (2006)

Figure 13: Relative productivity of expatriates: $\Phi_{c,t}$. An expatriates is $\Phi_{c,t}$ time more productive than a non expatriates.

Netherland (throughout the 1980s and the 1990s, see Marion and Thelot (2003) for France), Sweden (in the 1990s, Palme and Wright (1998)) and Spain. For instance, an additional year of education rises a French worker productivity by 10% in the late 1970s, by the end of the century the same additional year rises productivity (wages) by 7.1%. Hence, despite a rising educational gap between French expatriates and stayers, their productivity gap, measured by the differences in returns to skills on the French labor market, increases more slightly. Conversely, Italy despite a flatter educational gap than France, experiences a steeper expatriates-stayers productivity gap due to the rising returns to skills observed throughout the 1980s and the 1990s.

Consistent with the result of figure 6 that schooling disparities are higher for countries with lower level of education, figure 14 shows that the relative productivity of an expatriate is lower for countries with higher level of schooling. Overall, expatriates' relative productivity is higher in European countries combining higher returns to education and lower educational attainment (with the lead held by France, Spain and recently Italy) and is comparatively lower for countries with either low returns to education (Scandinavian countries) and/or higher average schooling (Germany, UK).

36% ($\exp(12 * 0.03)$). In Germany returns were 0.07% in the 1980s and rise to 0.09% in the 1990s, that is a wage gain equal to 24%.



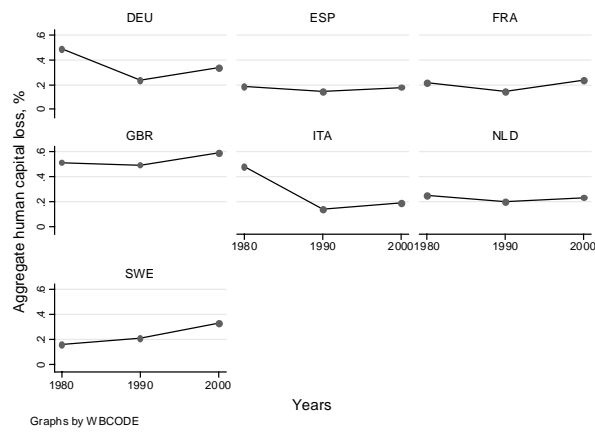
Source: US census, Cohen and Soto (2007), Hendricks (2006)

Figure 14: Home workers educational attainment and relative expatriates productivity. The linear fit is significant at 95% for the three years.

Lastly, I combine both the drain (quantity) and the brain (quality) dimensions of emigration within the synthetic index $\Omega_{c,t}$. The index measures the aggregate human capital of expatriates: that is the share of a country's total human capital that emigrants convey to the US. The U shape pattern of the index $\Omega_{c,t}$ in figure 15 follows that of the emigration rate. After a fall or a flattening in the 1980s, the drain of European stock of human capital rises (or stabilizes) in the 1990s. In 2000 the drain of human capital varies from 0.2% up to 0.6%. The Great Britain has the larger drain of human capital, it is followed by Germany, Sweden and France. Overall the quantity effect ($em_{c,t}$) tends to overcome the quality effect ($\Phi_{c,t}$). Sweden for instance, whose expatriates' relative productivity declines in the 1990s, experiences a rising drain of its aggregate human capital driven by the sharp increase of its emigration rate in the 1990s. Instead, the Italian shrinking emigration rate explains its declining drain of human capital in the 1980s and the revival in the 1990s explains the slight increase, despite an ever increasing quality of emigrants.

4.2. Indices based on higher education and knowledge levels

Figures 16 and 17 put an emphasis on the importance of college graduates flows. As already stressed, while human capital outflows are harmful for workers productivity,



Source: Source: US census, Cohen and Soto (2007), Hendricks (2006)

Figure 15: small Emigrants relative aggregate human capital $\Omega_{c,t}$: aggregate productivity will rise by $\Omega_{c,t}\%$ if the decennial cohort of expatriates return back home at period t .

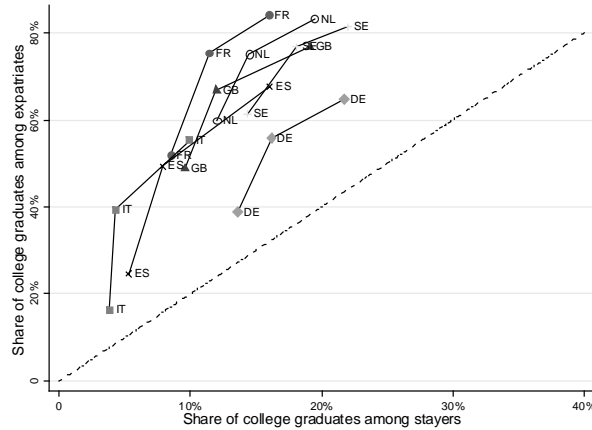
human capital composition matters as well. For advanced countries the relevant educational margin is likely to be that of college educated workers, as they are more likely to be the ones who are better able to create and make effective use of new technologies and to embrace changes.²⁵

Figure 16 makes clear that an expatriate is several times more likely to be a college graduate than a stayer, by a factor ranging from 3 (Germany) up to 5 (France), corresponding to the index $\eta_{c,t}$ in Eq. (7). The gap widens mainly throughout the 1980s, but due to the rising share of college graduates in Europe in the 1990s, the share of college graduates working in the US declines somewhat in the 1990s (see figure 17).

Figure 17 may suggest that the drain of highly skilled workers is decelerating. However, figure 6 warns that it is unlikely to be the case given that the average years of schooling of expatriates increases. More likely figures 7, 8 and 9 suggest that within the group of college graduates, expatriates are increasingly drained from upper tail of the educational distribution. Using data on the number of researchers in 1999 and their growth rate in the 1990s that are obtained from the third European Report on Science and Technology 2003, I express in figure 18 the size of expatriate researchers as a share of total researchers in origin countries. The results confirm that throughout the 1990s, despite a slowdown in college graduates emigration, the US based European researchers represent a growing share of total European researchers. The growth is higher for Southern European countries. To the extent that return migration may have decreased over the period, this is a further evidence that the brain-drain is accelerating as one moves along occupations that matter the most in the knowledge economy. This is the all worrisome particularly since, according to a large body of theoretical and empirical research, that sort of human capital is necessary to stand-up in the world competition and has been the main source of divergence in the growth performance among advanced countries during the last three decades (Vandenbussche et al., 2006).²⁶

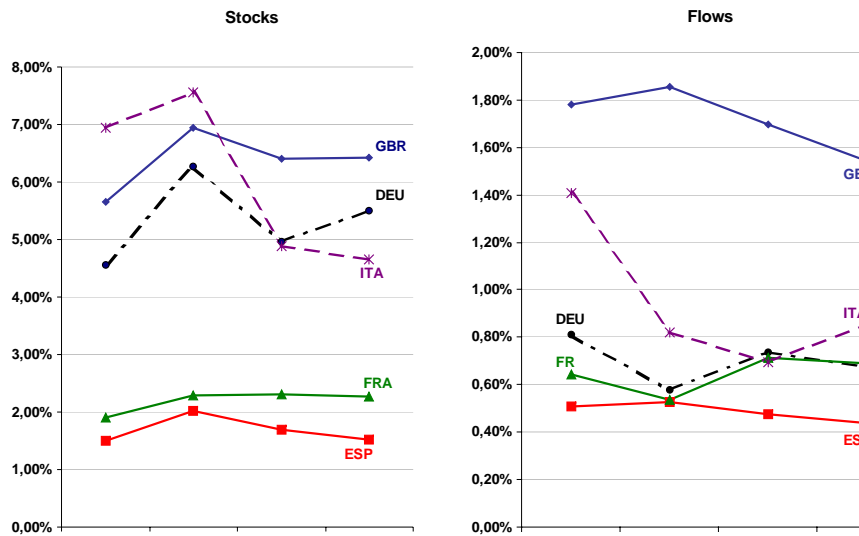
²⁵In our sample, 5% of 1980s European college graduate expatriates hold a PhD. Assuming that most of them are involved in R&D activities, the outflow corresponds to a permanent decrease in resources devoted to R&D. As a consequence, the number of discoveries being made each year is lower, and so is the pace at which productivity grows. This generates a permanent negative shock in the corresponding growth rate of the economy. This negative growth effect is much longer lived than the simple loss in human capital underlying the emigration of college graduates.

²⁶I further emphasize that accounting for return migration is unlikely to reverse this conclusion. As shown previously, return migration is more than balanced by new emigrants which are both more numerous (inflows have increased) and more educated (new emigrants are more qualified) such that the stock and the quality of expatriates' human capital is rising.



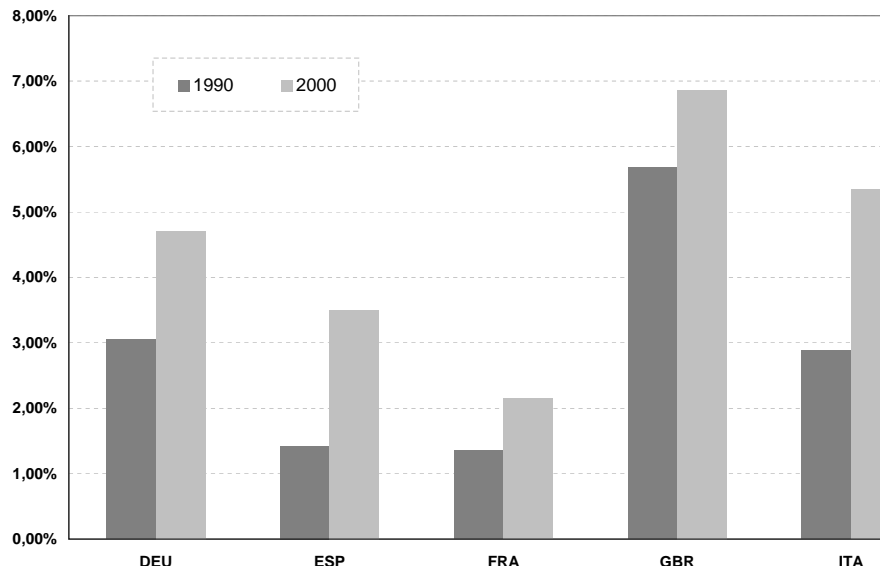
Source: US census, Cohen and Soto (2007)

Figure 16: Index $\eta_{c,t}$: the dashed line corresponds to the locus along which an expatriate is twice more likely to be a college graduate than a stayer ($\eta_{c,t} = 2$).



Source: US census, Cohen and Soto (2007)

Figure 17: College graduate expatriates stocks and flows as share of source country college graduate



Source: US census and European Commission (2003)

Figure 18: Expatriate researchers in % share of origin country researchers

5. BEYOND EDUCATION: THE DRAIN OF TALENTS

Previous sections have shown that emigrants are more represented in the highest rungs of the educational, occupational and productivity ladder of their home countries. However, observing the labor market performance of successive cohorts in the US should provide additional insights on the changes in the quality of European emigration in the US and its nature. Emigrants are observed in a common labor market such that I can compare their skills for a given institutional environment and endowment of complementary factors.

A direct assessment of emigrants quality comes from their relative wages with respect to the US born workers. Labor market outcomes of emigrants depend on their skills and the price for these skills. I have shown that recent expatriates are younger than stayers and by the same token they are also younger than the US natives. While we could argue that age is simply another dimension of skills, age-based differences in emigrants wages is not what we should mean by differences in skills. Unlike age, other forms of skills such as years of education are relatively constant over time and provide a more accurate measure of human capital investments conveyed by emigrants. To age-adjust the time series of wage gaps between recent European expatriates and US natives, I estimate separately for the US natives and recent expatriates

a series of year-specific standard Mincerian log hourly wage equations with years of schooling, an age quadratic and a gender dummy.²⁷ My sample is composed of US wage workers (e.g. US natives and expatriates) aged 25 to 64 years and working in the private for profit sector. To track changes in emigrants' quality across successive cohorts, I restrict the sample of European expatriates to those that emigrate during the second half of the 1970s, 1980s, 1990s and 2000s and that are still in the US by the corresponding census years (e.g. 1980, 1990, 2000 and 2006). I exclude from the sample those working less than 40 weeks a year and less than 20 hours a week, from the US natives sample I exclude non-white workers. The hourly wage rate is before tax and is expressed in 2000 dollar using the CPI provided by the US bureau of labor statistics. I further exclude individuals earning more than 100 dollars per hour. Using the estimated quadratic age profiles, the log hourly wage rate of both native-born and recent European migrants is then adjusted in each year, so that the log hourly wage of each group is evaluated at the same age. I choose 41 years old, as it corresponds to the age of the current average native-born worker. The age adjusted wage premia are displayed in figure 19. Shapes of countries plot show an increasing trend in the quality of European migrants in the US labor market. This result is to be expected given the increase in the educational attainment of European emigrants. There are also remarkable differences across countries. By and large, the British are the most qualified.²⁸ Interestingly, cross country differences in wage premia do not necessarily reflect cross country differences in expatriates' schooling. For instance in 2000 the German emigrants are almost as educated as the French and much more than the Spanish or Italian emigrants (see figure 6), while the wage premia are much higher for Italians, Spanish and the French. This could be an indication that emigrants self select along other unobservable dimensions of skills. Thus, Italians, Spanish and French are more positively selected along these characteristics than are the Germans. To further investigate this issue, I use data on wages and personal characteristics of expatriates to give an idea of the change and differences across country in unobservable characteristics of recent European expatriates. For that purpose, I estimate a series of year-specific Mincerian log wage hourly wage rate with country-specific dummies and I choose the US born workers as a reference group. In the migration literature the estimated coefficient of country dummies are interpreted as the "unobservable quality of immigrants". A natural interpretation for say a French expatriate, if the coefficient is positive, is that it measures the average unobserved productivity-enhancing quality of a French expatriate relative to a US born worker. The sample

²⁷The hourly wage rate is obtained by dividing the yearly wage income by the number of hours work in the year. The latter is obtained by multiplying the usual hours worked per week by the number of weeks worked during the year.

²⁸An other interpretation is that they are more concentrated in high wage sectors.

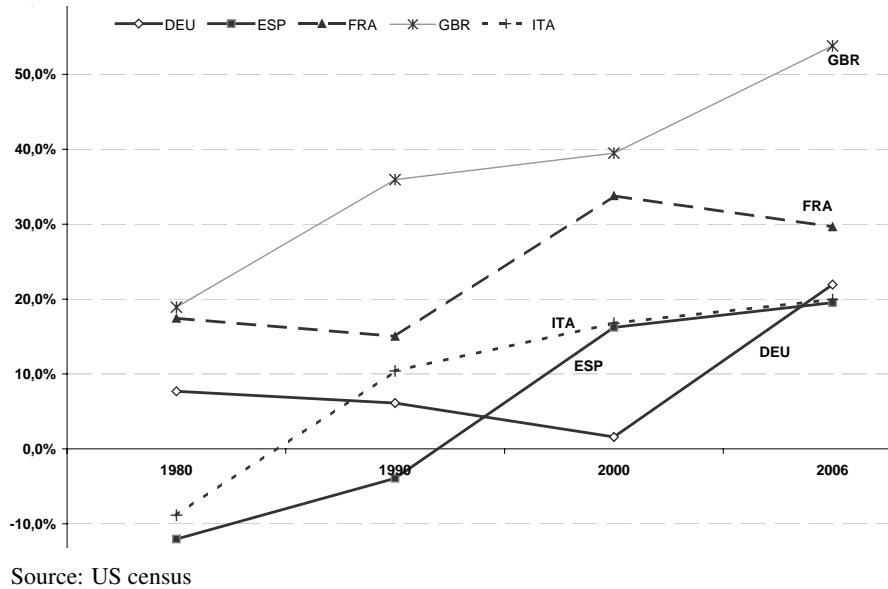


Figure 19: "Age-adjusted" wage premium of recent European immigrants in the US labor market.

used in the estimations is the same as the one used to obtain the age-adjusted wage premia of figure 19. For each census year, I run the following standard earning regression (due to Chiswick (1978)):

$$\ln w_{ijt} = \beta' x_{it} + \sum_j \lambda_{jt} D_{ij} + \varepsilon_{it}$$

where w_{ijt} is the before-tax hourly wage rate, expressed in 2000 dollar using the CPI provided by the US bureau of labor statistics, of a worker i born in country j and observed in year t ; x is a vector of socioeconomic characteristics. Specifically x includes the potential experience, measured as age minus years of education minus 6, and its square, years of education, and marital status and gender dummies; ε_{it} is an individual specific error term which is assumed to be uncorrelated with the other regressors. The indicator variable D_j is set to unity if the immigrant is born in the European country j . The set of indicators coefficients λ_{jt} measures the value that the US labor market places on the unobservable characteristics of workers born in a particular country j at time period t . Whenever the estimated coefficients on these indicators dummies are positive and significantly different from zero it indicates that workers from country j are "exceptional performers", which is my definition of talent. Coefficients in percentage terms together with their standard deviations are shown in

	1980	1990	2000	2006
France	2.8%	-6.2%	10.9%	14.1%
	<i>0.01</i>	<i>0.01</i>	<i>0.01</i>	<i>0.01</i>
Germany	-2.6%	-4.0%	-4.3%	2.2%
	<i>0.00</i>	<i>0.01</i>	<i>0.00</i>	<i>0.00</i>
Great-Britain	6.2%	13.4%	14.8%	24.9%
	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>	<i>0.00</i>
Italy	6.4%	7.0%	2.5%	5.5%
	<i>0.00</i>	<i>0.01</i>	<i>0.01</i>	<i>0.01</i>
Spain	-3.3%	0.2%	2.5%	14.5%
	<i>0.01</i>	<i>0.01</i>	<i>0.01</i>	<i>0.01</i>

Note: Standard deviations are in italic. All the estimated coefficient are significant at 1% level, except for Spain in 1990.

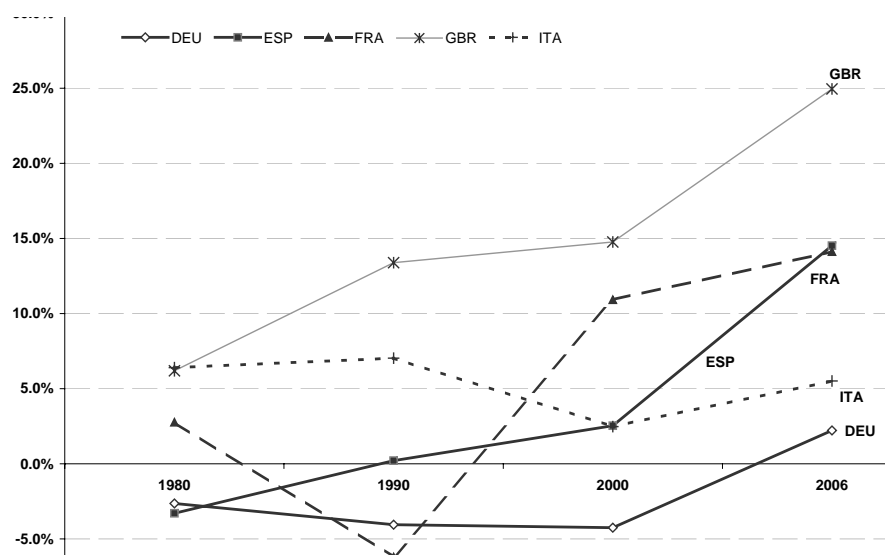
Source: US census

Table 1: Estimated wage premia

Table 1 and plotted in figure 20.

For most years and countries, excepted for Germany the premium is positive and significantly different from zero. Spain and Germany have positive premia only for the most recent cohorts of emigrants. The wage premium is the highest for the British. The rise has been impressive since the 1990s and the 2000s for the French and the Spanish. Overall, throughout the 1980s, the 1990s and the 2000s the wage premium received by European workers has increased except for the Italian. Hence the quality of European workers has increased along observable characteristics, such as years of education and occupations, but also along unobservable dimensions of skills. Moreover, the share of the age-adjusted wage premium of figure 19 explained by unobservable characteristics has increased for the most recent emigrants cohorts. For instance in 2000, these characteristics contribute negatively to the German expatriates' wage performance and for the Spanish, French, British and Italians they account respectively for 15%, 32%, 37% and 14% of the wage premia. By the year 2006 these characteristics explain respectively 10%, 74%, 47%, 46% and 28% of the German, Spanish, French, British and Italian wage premia.²⁹ It turns out that since the 1990s most of the rise in the quality of European expatriates in the US labor mar-

²⁹The figures are obtained by dividing the premium in table 1, which is the share of wage premium not explained by differences in years of education or ages by the wage premia in figure 19 which gives the share not explained by age differences between US natives and expatriates.



Source: US census

Figure 20: Estimated wage premia

ket happens along unobservable dimensions of skills. Although these results are still tentative, since the premium is not measured with respect to the quality distribution in the source country but in the US, they provide a further indication that European expatriates are pulled from the high end of the labor quality distribution.

I should stress two different types of source country labor quality distribution. A first possible unobservable quality of European expatriates may be their unobservable talents. Indeed, recent research shows that the rise in wage inequality among group of well educated workers is a specificity of the new-economy which values intangible assets.³⁰ From a worker point of view, this means that wage differences reflect not only differences in observable characteristics, but also and increasingly those characteristics that help to cope with a fast and changing environment within industries located at the technological frontier.³¹ In a knowledge-based economy the few that are endowed with these highly sought-after characteristics matter a lot and could in principle give much more than a slight edge in the technological race. Accordingly, these individuals should receive a substantial wage premium in the labor market. This extra-rewards were documented for instance during the birth of the semi-conductor

³⁰For instance, according to Acemoglu (2002) this explains that not only inequality has increased between well defined groups of education but also within that groups since the 1980s.

³¹On the importance of talents in a fast evolving economic environment see Hassler and Mora (2000) and Acemoglu et al. (2006).

and biotechnology sectors in the US by Zucker et al. (1998). The fact that Europeans' premium is positive and increasing could then be a preliminary indication that US is pulling more than education from Europe, namely the best and the brightest possibly employed in sectors located at the technological frontier.

A second type of labor quality from which European could be pulled is the quality of education in their country of origin. In that case wage premia could reflect the fact that expatriates are the few that graduate from the top engineering schools or PhD programs and from the most productive and rewarding fields. This interpretation is more convincing than the one arguing that the premium is catching the higher average quality of education in Europe since, at least for the large continental European countries, it does not fit the evidence from international ranking which put most European universities behind the US ones. This explanation would also imply a large increase in the quality of education in Europe over a relatively short period of time.

6. CONCLUSION

This paper provides a quantitative assessment of the brain-drain above anecdotal evidence that frequently fuel the public debate in Europe. As far as the overall magnitude is concerned, European emigrants represent a relatively small share of the corresponding European working age population. However, this share is increasing as one moves along the educational ladder. Depending on the country, our brain drain index shows that on a medium term basis (once capital output ratio has adjusted) the decennial outflow of human capital represents 0.2% up to 0.6% of total human capital.³² Taking the perspective of a non homogenous labor, I have provided some evidence that the emigration rate is accelerating as one moves along the ladder of occupations that matter the most in the knowledge economy (researchers and university instructors), and that expatriates may constitute a significant share of European talents. Arguably, from a long term perspective the latter could constitute the fierce nature of the European human capital outflows to the United States.

Taking an optimistic stance, the observed flows may be the mutual and beneficial outcome of a globalized labor market for highly-educated highly-skilled workers, from which Europe benefits as well by importing skilled labor. However, existing empirical studies suggest that Europe is much less competitive in attracting worldwide "brains". A number of brain-drain studies from the developing to the developed world suggest that while Europe is importing some skilled labor from developing countries it does so in much less intense way than the US does (Docquier et al., 2007), while

³²Or equivalently, given the linearity of output per worker with human capital per worker, the decennial outflow represents 0.2% up to 0.6% of GDP.

the reverse flows of US workers in Europe are very small (OECD, 2007). Often skills and talents are lured into countries as students. Here also the evidence is that Europe despite having lower out-of-pocket payment for higher education is still attracting less international students than the US does (OECD, 2007). Hence if anything, Europe could do much better to benefit from the global labor market for skilled workers and talents in order to overcome its knowledge gap with the US.

A possible reading of our results is that they are the symptomatic expression of European structural features, such as ill functioning labor markets and confiscatory tax systems, which do not allow high quality workers to reap the benefits of their higher productivity (EEAG, 2003). In this paper, I show that the outflows have accelerated for some specific occupations. It is important to identify the most affected groups as it allows to design targeted policies which very often are more efficient than non discriminated ones, such as a general tax-cut. Unlike top executives, knowledge workers do not belong to the higher end of the earning income distribution. Hence, although tax arguments should not be dismissed the issue could be better tackled by considering the specificity of the occupations involved. At first place, the brain drain could result from the lower productivity and profitability of high skilled jobs and research activities in Europe. Indeed, Europe is producing slightly more researchers than the US does but it fails in translating it into more citations and patents.³³ Hence, instead of being lured by attractive tax system, Europeans may be leaving in quest of better opportunities to raise their productivity and reap the associated benefits. As for why is it the case that the productivity of knowledge occupations are lower in Europe, one can hardly rule out spending disparities. Europe has not achieved the objective planed in the Lisbon agenda of reaching 3% of its GDP in R&D. Yet money will not go their way in rising productivity without complementary reforms. The latter will require voluntary and challenging industrial and educational policies. The creation of knowledge-clusters that would allow complementary workers in thin labor markets for their skills to take advantage of the agglomeration externalities generated by putting altogether the activities of creating, transmitting and transforming knowledge into innovative products and know-how will probably go a long way toward retaining and getting the best of Europe's "brainpower". European Nations have at hand an important public policy leverage in that matter since, unlike in the US or Japan, the public sector is employing a large share of knowledge workers.

³³Between 1997 and 2001 the EU share of scientific publication was 34% against 31% for the US. The EU15 share of cited publications was 39% against 49% for the US, within the top 1% highly cited publications the US share was 63% against 37% for the EU15 (see King (2004)).

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