The Wage Effects of Immigration and Emigration*

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Abstract

In this paper, we simulate the long-run effects of migrant flows on wages of high-skilled and low-skilled non-migrants in a set of countries using an aggregate model of national economies. New in this literature we calculate the wage effect of *emigration* as well as *immigration*. We focus on Europe and compare the outcomes for large Western European countries with those of other key destination countries both in the OECD and outside the OECD. Our analysis builds on an improved database of bilateral stocks and net migration flows of immigrants and emigrants by education level for the years 1990 through 2000. We find that all European countries experienced a decrease in their average wages and a worsening of their wage inequality because of *emigration*. Whereas, contrary to the popular belief, *immigration* had nearly equal but opposite effects: positive on average wages and reducing wage inequality of non-movers. These patterns hold true using a range of parameters for our simulations, accounting for the estimates of undocumented immigrants, and correcting for the quality of schooling and/or labor-market downgrading of skills. In terms of wage outcomes, it follows that prevalent public fears in European countries are misplaced; immigration has had a positive average wage effect on native workers. Some concerns should be focused on the wage effect of emigration, instead.

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1 Introduction

Fear of immigration is once again manifesting itself strongly in Europe and other developed regions of the world.[1] Spurred by the recent crisis and giving voice to a large portion of the public, many politicians argue that immigration's negative employment and wage effects have become unbearable especially for the less skilled. Do the migration data and economic analysis bear out this pessimistic scenario? Might the populist outcry be ignoring a more important flow of migrants? Does emigration, especially of highly educated workers, affect the wages and employment of non-migrants? The loss of high skilled workers deprives their home countries of the scientists, entrepreneurs, educators and other professionals who drive their economies to higher levels of efficiency and productivity.[2]

Immigrants in Rome or Paris are more visible to the European public eye than the Italian or French engineers in Silicon Valley, but are they more harmful to the Italian and French labor markets? This asymmetric view leads to economic misconceptions of the economic effects of migration. The goal of this paper is to assess the impact of recent global labor movements on the wages of those who do not migrate. We focus on the major European countries since they have experienced both emigration and immigration, especially when compared to the United States, Canada and Australia whose experiences have been primarily shaped by inflows of migrants. In addition, for comparison, we include several non-OECD countries (Argentina, South Africa and Singapore) with significant migration flows as well as Eastern European (Poland, Czech Republic, Hungary) and other developing countries (Mexico, Turkey) that have established important migration corridors with developed OECD countries. We use a newly available dataset to generate measures of migration flows by education levels for all countries in our sample for the period 1990-2000. We analyze the wage effects on the highly educated (college graduates) non-migrants and less educated (high school graduates or less) non-migrants separately to be able to assess the distributional impacts along with overall effects.

In order to calculate these effects at the national level, we adopt an aggregate production model which has been used in the evaluation of the impact of immigration at the national level (e.g. Borjas 2003, Manacorda et al., forthcoming) and in macroeconomic studies analyzing growth, productivity and skill premium in the US and other countries (e.g. Acemoglu and Zilibotti 2001, Caselli and Coleman 2006, Card and Lemieux 2001, Goldin and Katz 2008). We use this model to simulate the wage effects of immigration and emigration, isolating this phenomenon from all other changes that happened in the same period. This simulation approach bypasses the issues of endogeneity and omitted variables encountered in the regression estimates of the wage effects of immigration. The results, however, rely in important ways on the assumptions and on the parameter choice, which are therefore discussed and documented in detail. The model we use has four important components (with

[1]See, for example, the following recent articles from the Economist magazine on immigration to Spain ("Bad new Days", February 24 2010), to Italy ("Southern Misery" January 14th 2010) and to Europe in general ("No Boatloads but still troubles" August, 12th 2010).

[2]Even the academic literature has been mostly concerned with the impact of immigration on European Countries. Vis-a-vis the occasional study on the size of the "Brain drain" from Europe (such as Saint-Paul, 2008) there are scores of studies of the labor market impact of immigrants in Europe (see for instance Longhi et al 2005 for a summary).

associated parameters) that affect the conclusions of our exercise. We start with a preferred (usually average) set of parameter values and we present the results as the benchmark case. Next, we consider for each parameter a range of values deemed reasonable by the literature and we discuss how robust our results are to these variations.

The first component of our model assumes that aggregate labor is combined with physical capital to produce output. While capital may take some time to adjust to changes in the labor supply, we assume that it adjusts in the long run to maintain constant the capital-output ratio (and hence its rate of return). Such property may be derived from a classic or neoclassic growth model (such as Solow 1956, Ramsey 1928) in the case of a closed economy or alternatively from the assumption of an open economy. Most of our simulated wage effects should be understood as long-run effects[3].

In the second building block of the model, we combine labor of highly educated and less educated workers in a function with constant elasticity of substitution. This representation is common in labor markets studies (such as Katz and Murphy, 1992, Card and Lemieux, 2001) and in cross-country analysis of relative productivity (Caselli and Coleman, 2006). Following the literature, we choose college graduates as the highly educated portion of the labor force and we pick a range between 1.3 and 2 for the elasticity of substitution which spans most labor market studies including Angrist (1995), Borjas and Katz (2007) and Katz and Murphy (1992).

The third ingredient of our model is that immigrants and natives within the same skill/education category are allowed to be imperfect substitutes within a CES structure. There is debate in the literature on the estimates of the elasticity of substitution between natives and immigrants. Borjas et al (2008) put it essentially at infinity, Ottaviano and Peri (forthcoming) and Card (2009) put it around 20 and Manacorda et al. (forthcoming) put it around 6. We will analyze the wage impact of immigration and emigration on natives using each one of these parameter values. We describe the sensitivity of simulated average wages and the distributional effects for non-migrant natives with different education levels to different assumptions about this elasticity.

Finally, the fourth ingredient of the model is to allow human capital (skill) intensity to have a productivity externality as immigration and emigration alter the skill composition in an economy (i.e. the ratio of highly educated to the less educated). There is some debate in the literature on this issue as well. Moretti (2004a and 2004b), based on data from the US cities, puts the elasticity of productivity to the share of college educated between 0.75 and 1. On the opposite end of the spectrum, Acemoglu and Angrist (2001) estimate essentially no productivity effect of increased schooling in US states. Iranzo and Peri (2009) estimate an externality around 0.44 using US state level data. Again, we analyze the impact of immigration, emigration and net migration under each of these parameter values.

While the specific quantitative details of the simulations vary with the choice of parameter values, some general results emerge from this exercise. First, in general, over the period 1990-2000 *immigration had zero to small positive long-run effect* on the average wages of non-migrant natives in the rich OECD countries (Western Europe plus the US, Canada,

[3] In section 5.5 by making assumptions on how the total migration flows are distributed over the years, and on the short-run speed of adjustment of capital we can calculate the short-run average wage effects accounting, that is, for the sluggish adjustment of capital.

Australia). Using the estimates for the average values of the parameters, this positive effect ranges from zero in Italy to +1.7% in Australia. Second, over the period 1990-2000, *emigration had a mild to significant negative long-run effect* on the wages of non-migrants. Still focusing on rich OECD countries, the effects range from 0 for the US (due to the near absence of emigration) to -0.8% in the UK and -0.7% in Portugal. Third, over the period 1990-2000, *immigration generally improved the income distribution of European countries while emigration worsened it* by increasing the wage gap between the high and low skilled natives.

All three results go counter to the popular beliefs about migration, but they are a result of the nature of migrant flows from 1990 to 2000. European countries (along with the US, Canada, Australia) have experienced both immigration and emigration that were usually more skill intensive than (or as skill intensive as) their domestic labor forces. Under these conditions, in the long run, immigration is associated with average wage gains and emigration with average wage losses for non-migrant natives unless there is no externality of human capital and migrants are perfectly substitutable with natives. In this latter case, both immigration and emigration have no effect on the average wages of non-migrant natives.

The skill composition of migrants relative to non-migrants is crucial in determining our average wage results. We attempt to correct the "effective" skills of migrants to account for certain important phenomena which might not be fully reflected in our aggregate statistics. First, we use estimates of the extent of illegal immigration into the main Western European countries to correct for the inflows of migrants into Europe. Second, we account for the potential lower quality of schooling for migrants who completed their education in their home countries or for the "downgrading" of their skills in the host countries' labor market. Both corrections reduce the effective percentage of highly skilled immigrants. While the corrections make some difference, the general picture described above remains unchanged.

We consider two other extensions. First, we introduce the possibility of crowding effects of immigrants on productivity due to the presence of a fixed factor or the presence of a positive density externality, such as in Ciccone and Hall (1996), on productivity. While their presence either attenuates or increases slightly the effects but leaves the basic results unchanged. Second, we account for the short-run impact of immigrants by including in the simulations sluggish capital adjustment. We distribute net immigration into yearly flows of immigrants and assume a speed of adjustment of capital that is consistent with estimates from the macro literature. While such sluggish adjustment generates a small negative contribution to average wages in the short run, the overall short-run effects of immigration are still positives in four of the ten considered European countries. When negative, these short-run effects are very small, with the largest negative impact achieved in Spain in the order of -0.35%. Emigration turns out still to exert a negative wage effect on non-movers in the short run and usually larger, in absolute value, than the effect of immigration.

The rest of the paper is organized as follows. Section 2 presents the simple aggregate production framework from which we derive wages as marginal productivity of different types of workers. Section 3 describes the data, their construction and their sources and shows some simple summary statistics about the educational structure of labor force data and migrant data. Section 4 presents the basic results of the simulated wage effects of immigrants using our model and the range of parameters available from the literature. Section 5 considers the wage effect when accounting for undocumented workers, for schooling quality differences, for downgrading of skills, for density effects and adjusting for employment rates and for the short-run capital adjustment. Section 6 concludes the paper.

2 Model

We construct an aggregate model of the economy to examine the long-run wage effects using data from 1990 and 2000 national censuses on migration and native non-migrant labor force by education level. The analysis builds on two different strands of the literature. The first strand aims at identifying the impact of immigration on national labor markets while the second analyzes the external effects of individual schooling on overall productivity. In this context, international migrations have two essential long-run effects. The first is to change the schooling composition of the sending and receiving economy. The second is to introduce in the host countries workers with a different skill sets from natives and, hence, even for given education, not perfect substitutes with them. These two aspects imply that the size and the educational composition of immigrants and emigrants relative to the non-migrants are the crucial factors in determining the long-run domestic wage effects of international migration patterns.

2.1 Aggregate production function

The prevalent model adopted in this literature is based on a production function where the labor aggregate is represented as a nested constant elasticity of substitution (CES) function of different types of workers. In the production function (we omit country subscripts for simplicity), we assume that at time t output (Y_t) is produced in a country according to a constant-returns-to-scale Cobb-Douglas production function with two factors, physical capital (K_t), and labor in efficiency units (Q_t):

$$Y_t = \widetilde{A}_t K_t^{1-\alpha} Q_t^{\alpha} \tag{1}$$

The term $\widetilde{A}_t$ represents the total factor productivity (TFP), and α is the income share of labor.

Assuming that physical capital is internationally mobile and that each single country is too small to affect the global capital markets, the returns to physical capital are equalized across countries. If R^* denotes the international net rate of return to capital, the following arbitrage condition implicitly defines the equilibrium capital-to-labor ratio in the economy:

$$R^* = (1-\alpha)\widetilde{A}_t K_t^{-\alpha} Q_t^{\alpha} \tag{2}$$

The above condition holds in the short and in the long run in a small open economy. However, even in a closed economy as in Ramsey (1926) (or Solow 1951) condition (2) holds in the long-run balanced growth path, with R^* being a function of the inter-temporal discount rate of individuals (or of the savings rate)[4]. Hence in the long-run we can substitute this

[4] As long as immigration does not change the saving rate of an economy the pre- and post- migration R^* are identical.

arbitrage condition into (1) to obtain an expression of aggregate output as linear function of the aggregate labor Q_t:

$$Y_t = A_t Q_t \tag{3}$$

where $A_t \equiv \widetilde{A}_t^{1/\alpha}\left[(1-\alpha)/R^*\right]^{(1-\alpha)/\alpha}$ is an increasing function of TFP and is referred to as modified TFP.

Following the labor (Katz and Murphy 1992, Card and Lemieux 2001) and growth (Caselli and Coleman 2006) literature, we assume that labor in efficiency unit (Q_t) is a nested CES function of highly educated ($Q_{h,t}$) and less educated workers ($Q_{l,t}$):

$$Q_t = \left[\theta_q Q_{h,t}^{\frac{\sigma_q - 1}{\sigma_q}} + (1-\theta_q) Q_{l,t}^{\frac{\sigma_q - 1}{\sigma_q}}\right]^{\frac{\sigma_q}{\sigma_q - 1}} \tag{4}$$

where θ_q is the relative productivity level of highly educated workers (with tertiary education) and is set to 0.6 for the rest of the paper. The second parameter, σ_q, is the elasticity of substitution between the two groups of workers.

We distinguish between natives and immigrants within each labor aggregate $Q_{h,t}$ and $Q_{l,t}$. If native and immigrant workers of education level s were perfectly substitutable, the aggregate $Q_{s,t}$would simply be equal to the sum of natives' and immigrants' labor supplies. However, there are various reasons to believe that native and immigrant workers may differ in several respects which are relevant to the labor market. First, immigrants have skills, motivations and tastes that may set them apart from natives. Second, in manual and intellectual work, they may have culture-specific skills and limitations (e.g., limited knowledge of the language or culture of the host country), which create comparative advantages in some tasks and disadvantages in others. Third, even in the absence of comparative advantage, immigrants tend to concentrate in different occupations than natives due to migration networks or historical accidents. In particular, new immigrants tend to disproportionately cluster in those sectors or occupations where previous migrant cohorts are already over-represented. Finally several studies (such as Card 2009, Ottaviano and Peri, forthcoming, Manacorda et al., forthcoming) find imperfect degrees of substitution between natives and immigrants. Hence, we assume that the quantities of high-educated ($Q_{h,t}$) and low-educated labor ($Q_{l,t}$) are both nested CES functions of native and immigrant labor stocks with he respective education levels. This is given by,

$$Q_{s,t} = \left[\theta_s N_{s,t}^{\frac{\sigma_I - 1}{\sigma_I}} + (1-\theta_s) I_{s,t}^{\frac{\sigma_I - 1}{\sigma_I}}\right]^{\frac{\sigma_I}{\sigma_I - 1}} \quad \text{where } s = h, l \tag{5}$$

where $N_{s,t}$ is the number of type-s native workers and $I_{s,t}$ is the number of type-s immigrant workers who are present in the country. σ_I is the elasticity of substitution between natives and immigrants in group s. The parameter θ_s captures the relative productivity level of natives and is set at 0.6 for the rest of the paper as it was the case with θ_q. This choice provides reasonable skill premia and wage differentials between natives and immigrants. Our results, however, are insensitive to the value of these parameters.

2.2 Wages

We consider each country as a single labor market since workers are free to move within it to arbitrage away wage differences. Then we derive the wage rates for native workers of both education levels ($w_{h,t}$ and $w_{l,t}$) by substituting (4) and (5) into (3) and taking the derivative with respect to the quantity of labor. This yields the following:

$$w_{h,t} = A_t \theta_q \theta_h \left(\frac{Q_t}{Q_{h,t}}\right)^{\frac{1}{\sigma_q}} \left(\frac{Q_{h,t}}{N_{h,t}}\right)^{\frac{1}{\sigma_I}} \tag{6}$$

$$w_{l,t} = A_t (1-\theta_q) \theta_l \left(\frac{Q_t}{Q_{l,t}}\right)^{\frac{1}{\sigma_q}} \left(\frac{Q_{l,t}}{N_{l,t}}\right)^{\frac{1}{\sigma_I}} \tag{7}$$

These expressions allow us to evaluate the effects of immigration/emigration on non-migrant natives. The change in the average wages of non-migrant natives due to 1990-2000 immigration flows of immigrants (defined as new gross immigration minus return migration of foreigners to their home countries) is defined as

$$\begin{aligned}(\Delta w_{2000})^{IMMI} &= (w_{h,2000} - w_{h,2000}^{IMMI})\frac{N_{h,2000}}{N_{h,2000}+N_{l,2000}} \\ &+ (w_{l,2000} - w_{l,2000}^{IMMI})\frac{N_{l,2000}}{N_{h,2000}+N_{l,2000}}\end{aligned} \tag{8}$$

where $w_{h,2000}$ and $w_{l,2000}$ are the wages of more and less educated natives, respectively, as defined by (6) and (7) and calculated using aggregates $Q_{t+1}, Q_{h,t+1}$ and $Q_{l,t+1}$ inclusive of immigrants observed in 2000. Moreover, $w_{h,2000}^{IMMI}$ and $w_{l,2000}^{IMMI}$ are the wages calculated for year 2000 keeping the stock of immigrants as observed in 1990 (i.e. excluding the 1990-2000 immigration flows).

The change in average wage of non-migrant natives due to 1990-2000 emigration flows of natives (defined as new gross emigration minus return migration of natives) is defined as the following

$$\begin{aligned}(\Delta w_{2000})^{EMI} &= (w_{h,2000} - w_{h,2000}^{EMI})\frac{N_{h,2000}}{N_{h,2000}+N_{l,2000}} \\ &+ (w_{l,2000} - w_{l,2000}^{EMI})\frac{N_{l,2000}}{N_{h,2000}+N_{l,2000}}\end{aligned} \tag{9}$$

where $w_{h,t+1}^{EMI}$ and $w_{l,t+1}^{EMI}$ are the wages of highly and less educated natives calculated for 2000 using the stock of emigrants observed in 1990 (i.e. excluding 1990-2000 emigrant flows), but keeping immigrants constant at their 2000 values. Note that to compute changes in natives' average wage, we keep $N_{h,t}$ and $N_{l,t}$ at their 2000 values. Indeed, the effects on average wage of non-migrants are weighted at the observed composition of natives. This isolates only the wage effects of emigration on non-migrants and not those effects due to changing composition of the domestic labor force. Adding the two effects, we obtain the average wage effect of net international migration.

2.3 Schooling externalities

We also consider the possibility of a positive externality from highly educated workers, in the spirit of the recent literature (Acemoglu and Angrist 2000, Ciccone and Peri 2006, Moretti 2004a, 2004b and Iranzo and Peri 2009). There is a large body of growth literature (beginning with Lucas 1988, and extending to Azariadis and Drazen 1990, Benhabib and Spiegel 2005, Cohen and Soto 2007 and Vandennbussche et al 2009) that emphasizes the role of human capital (schooling) on technological progress, innovation and growth of GDP per capita. More recently, however, the empirical literature has pointed out that while it is sometimes hard to find an effect of human capital on growth of income per capita (Benhabib and Spiegel 2005), there seems to be evidence that human capital contributes to the level of income per person beyond its private returns. This implies that TFP is an increasing function of the schooling intensity in the domestic labor force. Such formulation is particularly appropriate to be included in our model and, based on the expressions used in Moretti (2004a, 2004b), the TFP can be expressed as follows ,

$$A_t = A_0 \left(\exp\left(\frac{Q_{h,t}}{Q_t} \right) \right)^{\lambda} \tag{10}$$

where A_0 captures the part of TFP independent of the human capital externality, and λ is the semi-elasticity of the modified TFP to the share of highly skilled in the economy, $\frac{Q_{h,t}}{Q_t}$[5]. Acemoglu and Angrist (2000) and Iranzo and Peri (2009) use a similar formulation to express schooling externalities and we use their estimates of the parameter λ. Relying on this structure and using migration data from national Censuses, we can simulate the effects of immigration and emigration on wages of non-migrants in a range of countries for a range of values obtained from the literature for the three key parameters σ_q, σ_I and λ.

3 Data description

Assessing the national wage effects of immigration to and emigration from diverse set countries across the globe requires country-level international migration and labor force data by skill level. The detailed description of the migration data is in the Data Appendix. Here we describe briefly the main sources and features of the migration and labor force data used.

3.1 International migration data

The relevant migration flows to be used in our exercise are immigration and emigration flows (namely gross flows of immigrants and emigrants net of returnees and re-migrants). They capture the change in actual supply of migrants in a country.

There are several sources for migration flows by receiving country (e.g. OECD International Migration database, UN migration statistics) but those only include gross inflow of people in a country and they almost never correct for migrants who leave or go back to their country of origin. Moreover they never record undocumented migrants and they often

[5] The externality is expressed in terms of the ratio between labor composite. Such a ratio, however, is almost identical to the share of workers with high schooling in the labor force.

record immigrants when they achieve their resident status rather than when they first enter the country. Finally, definition of migrants - by nationality or birth - vary across countries. Most importantly for our purposes, those data are not available by education level. The flows of immigrants to a country can only be recovered by measuring the stock of foreign born people in a destination country (from a certain origin country) at different points in time and then taking the difference. The other advantage of starting with data on stocks of migrants is that they are usually from national censuses which tend to be more representative and complete than other data sources. Plus censuses often account for (i) undocumented immigrants at least in some countries like the US, (ii) they categorize immigrants by place of birth, rather than nationality which can change over time and across countries due to naturalization laws and (iii) report their education levels.

Our database is described in Docquier et al. (2010) who construct bilateral measures of immigrant and emigrant stocks for 195 countries in 1990 and 2000. The starting point for the new data is Docquier and Marfouk (2005) which collected the stock of foreign-born in OECD destination countries in 1990 and 2000, by country of origin and level of schooling (primary, secondary and tertiary). These data are supplemented with original data from the censuses of a large number of non-OECD countries. Finally, for many destination countries with no data on immigration, bilateral migrant stocks were predicted using a gravity framework as described in greater detail in Docquier et al. (2010). Their own census data would suffice to measure immigration into OECD countries. However, evaluation of emigration also requires data from all the possible destination countries, at least the most relevant ones. In other words, emigrant stocks from a certain origin can only be measured by aggregating all migrants recorded in the censuses of all destination countries. As some important destination countries (such as Russia, South Africa, Brazil, Argentina, and Singapore) are outside the OECD, this new database ensures the coverage of essentially all emigrants from all countries in our sample. Table A2 in the appendix show that the majority of emigrants from Western Europe are in destination countries for which we have actual census data.[6] For most OECD countries, less than 10% of their emigrants are in countries with imputed (rather than actual) migration data. The only European country relying on imputed data for a large fraction of its emigrants is France at about 30%.

We distinguish two skill types s, denoted by $s = h$ for college graduates (referred to as highly educated) and $s = l$ for individuals with secondary education completed and less (referred to as less educated). The database covers the years 1990 and 2000 and the differences in stocks by country of origin and destination provides the measures of the flows. It focuses on individuals aged 25 and over as a proxy of the working-age labor force which is one of the main differences with other migration databases (such as Ozden et al. 2010). This choice maximizes comparability between data on migration and on labor force per education attainment. Furthermore, it excludes a large number of students who emigrate temporarily to complete their education or children who migrate with their families.[7] The data description and some summary statistics follow.

[6] This pattern is also confirmed in Ozden et.al. (2010) which presents global bilateral migration stocks but does not disaggregate by education levels.

[7] The dataset contains 195 source countries: 190 UN member states (after excluding North Korea), the Holy See, Taiwan, Hong Kong, Macao, and the Palestinian Territories. We consider the same set of countries in 1990 and 2000, although some of them had no legal existence in 1990.

3.2 Labor force data per education level

It is relatively easier to identify the number and average education level of workers in each country of the world. Several data sources can be used to assess the size and skill structure of the labor force of each country. The size of the working-age labor force (i.e. population aged 25 and over) is provided by the United Nations. Data is missing for a few countries but can be estimated using the CIA world factbook.[8]

Labor force data is then split across skill groups using international indicators of education attainment. Here, we follow Docquier and Marfouk (2006) and Docquier, Lowell and Marfouk (2009) in combining different data sets documenting the proportion of post-secondary educated workers in the population aged 25 and over. They use De La Fuente and Domenech (2006) for OECD countries and Barro and Lee (2001) for non-OECD countries. For countries where Barro and Lee's measures are missing, they estimate the proportions educated using Cohen and Soto's measures (see Cohen and Soto, 2007). In the remaining countries where both Barro–Lee and Cohen–Soto data are missing (about 70 countries in 2000), they apply the educational proportions of the neighboring country having the closest enrollment rate in secondary/tertiary education, or the closest GDP per capita.

3.3 Description and summary statistics for our sample

Table 1 shows the 1990-2000 flows of immigrants, emigrants and their difference (net migration) for a set of ten large Western European countries and four other groups: (i) three Anglo-Saxon non-European countries (US, Canada and Australia) traditionally attracting large numbers of immigrants, (ii) three large Eastern European countries (Czech Republic, Hungary and Poland) with a range of emigration rates, mostly to Western Europe, (iii) two middle income countries with large emigration rates (Mexico and Turkey) and (iv) three non-OECD countries with large immigration rates (Argentina, South Africa and Singapore). We focus on the 1990-2000 flows for several reasons. First, they are the most recent flows that one can construct for both immigration and emigration (based on censuses) hence their skill composition and size is more relevant and possibly closer to later migration flows during the 2000's.[9] One could also assess with our method the labor market impact of the total stock of immigrants and emigrants across countries (reported for 1990 and 2000 in Table A3 of the Table Appendix). However the stock is accumulated over many decades and reflects migration that took place in the far past. Hence the migrant stock is less relevant to establish recent labor market effects of immigration and emigration.

Several features of migration flows are worth emphasizing. First, the US, Canada and Australia have much larger immigration (between 4.4 and 10.6%) than emigration (between 0.2 and 1.3%) rates among the highly educated portion of the labor force. The US is the only country with a comparable rate of immigration of less educated (5.8%) while both the immigration and emigration of low skilled is small in Canada and Australia. In Western Europe, high skilled immigration rates range from 0.2% (Greece) to 8.5% (the UK) while the emigration rates range between 1.1% (France and Germany) and 8.1% (Portugal). Em-

[8] See http://www.cia.gov/cia/publications/factbook.

[9] Clearly it would be best to have the flow of migrants between 2000 and 2010 but this will be available only in a few years as the Censuses from the 2010 round are collected, processed and made public.

igration rates of the highly educated in Eastern Europe and in middle income countries can be very high while the rate of immigration and emigration of the less educated is comparable. Mexico is the main exception with significant emigration of less educated (7.8%) and minimal immigration. Finally the non-OECD immigration-receiving countries have comparable immigration and emigration rates, except for Singapore that has a very large inflow of highly educated workers.[10]

The picture emerging from a first glance at the data is that both the recent inflow of immigrants and outflow of emigrants has a high-skill concentration greater than those of native non-migrants for Western European countries as well as for the other rich countries included as comparison. This confirms the data-based observation of Grogger and Hanson (forthcoming) and of Docquier and Marfouk (2005) but is in sharp contrast with the anecdotal image of unskilled immigrants flooding Western European labor markets. This conflicting perception is mainly due to the fact that less educated migrants formed a smaller share of the migrant flow than the corresponding group for the native labor force, but they still outnumber the highly skilled migrants in absolute numbers. Hence the large number of less educated immigrants stand out and attract the public attention in most European countries. Germany is a good example to illustrate this point. Looking at the composition of the migrant flow in the 1990s, the highly educated immigrants were 3.1% and the less educated immigrants 2.2% of their respective groups in the domestic labor market. However as 78% of the domestic labor force was less educated (and only 22% highly educated in 1990) there were still twice as many less educated immigrants relative to highly educated ones.

Another important observation is that the recent flows are usually more educated when compared with the stock of immigrants already present as of 1990 (see table A4). Hence, if the impression on immigrants is based on the stock, rather than recent flows, there may be a perception bias towards less educated migrants who possibly migrated long ago. Third, in spite of the fact that census data are better than official immigration data, they may miss some undocumented migrants, especially in Western Europe. If those undocumented migrants that are missing from the census data are mainly less educated, the actual numbers of the less educated are understated by our data. We address this issue in section 5.1 by using estimates on the extent of undocumented migration in different destination countries.

Finally the perception of the skills of immigrants may be based on the occupations and the labor market performance of immigrants (rather than their formal education) as analyzed by Mattoo et.al. (2008) in the US labor market. In many cases, college educated immigrants are less productive and take less skilled occupations than college educated natives since their education quality, mostly obtained at home, might be less easily transferable or lower than those of the natives in the destination. The lower quality/downgrading of education levels for immigrants matter for our exercise as well. We address quality adjustment in the extensions of our simulation exercise in section 5.2.

In terms of the overall picture of migration across countries in the world, the non-European Anglo-Saxon countries (US, Canada, Australia) attract highly educated immigrants, from all over the world and their native-born citizens tend not to emigrate. Western European countries seem to attract highly educated immigrants (from other European and

[10] See our discussion below on undocumented migration, which tends to be less skill intensive, and how we try to account for this in our analysis.

less developed countries) but also lose highly educated emigrants (to other OECD countries and between each other). This is more similar to what happens to countries of intermediate income level that attract immigrants from poorer countries and send migrants to richer countries. With these overall patterns in mind, we turn to the simulation exercise.

4 Simulated wage effects: basic specification

4.1 Parameterization

Our model allows us to calculate the wage effects of migration depending on the values of three fundamental parameters σ_q, σ_I and λ. We take a range of values from the literature. Table 2 summarizes the values of the parameters chosen and the respective sources. We would like to remind the reader that parameters θ_q and θ_s are set to 0.6 in all simulations. This choice generates reasonable skill premia and wage differentials between natives and immigrants when immigrants represent around 10 percent of the skill-specific labor force.[11]

For the parameter σ_q there are several estimates in the literature. A group of influential papers propose specific estimated values for low, intermediate and high levels of substitution. For instance Johnson (1970) and Murphy et al (1998) estimate values for σ_q around 1.30 (respectively 1.34 and 1.36); Ciccone and Peri (2005) and Krusell et al. (2000) estimate values around 1.50 (respectively 1.50 and 1.66) and Ottaviano and Peri (forthcoming) estimate a value close to 2.

The parameter σ_I has been the subject of several recent papers and has generated a certain level of debate. This parameter is particularly relevant to determine the effect of immigrants on wages of natives and, as we will see, the choice of this parameter makes some difference in evaluating the effects of migration in certain countries. Borjas et al (2008) and Ottaviano and Peri (forthcoming) use US data and Manacorda et al (forthcoming) use UK data in their estimation.

Finally the parameter λ, whose magnitude has been estimated using data from US cities (Moretti 2004a, 2004b) or US states (Acemoglu and Angrist 2000 and Iranzo and Peri 2009) is also subject to a certain level of disagreement between those who find substantial schooling externalities and those who do not.

To preview the main features of the dependence of the simulated effects on parameter values, σ_q has very little bearing on the impact of immigration and emigration on average wages, but it is critical for the effects on the wage distribution between more and less educated natives. The parameter σ_I influences the average wage impact of immigration on natives but has no bearings on the impact of emigration. Finally λ matters for the impact of immigration and emigration on average wages with no effect on the wage distribution.

4.2 Simulation with the basic specification

Table 3 and the three panels of Figure 1 show the long-run impact of immigration (dotted line), emigration (dashed line)) and net migration (solid line) between 1990-2000 on average

[11] Those preference parameters play a minor role in our wage simulations. They enter both the numerator and denominator in the expressions for percentage changes in wages and hence they canel out.

wages (Panel 1a) as well as on the wages of highly educated (1b) and of less educated (1c) non-migrants. All figures are presented as percentage of the 2000 value of the respective wage level. We have arranged countries starting with the non-European Anglo-Saxon on the left, followed by the Western European, Eastern European countries and then, the countries of emigration (Turkey and Mexico) and finally the non-OECD countries. The graph provide a clear visual impression that immigration has a positive average wage effect on non-migrants (except for Argentina, the dotted line is always above zero) while emigration has a negative average wage effect (the dashed line is always below zero). The effect of net migration (combining immigrants and emigrants) on average wages is clearly positive for Canada, Australia and Singapore, clearly negative for Portugal and Poland and usually negative but not too large for the other Western European countries. Figure 1b shows that immigration has usually a negative effect on wages of highly educated (except for the US), while emigration has a positive effect on those wages. Finally Figure 1c shows the positive and sometimes very large (in the case of Singapore and Australia) effect of immigration on wage of less educated and the negative and also sometimes large (e.g. for Portugal, Greece and Poland) effect of emigration on the wage of less educated workers.

Focusing on European countries, some patterns emerge clearly. First immigration has either a null (Italy and Greece) or a positive effect on the average wage of natives, particularly sizeable for Sweden (+0.5%), the Netherlands (+0.5%) and the UK (+1.0%). At the same time emigration has negative average wage effects for all European countries and those are particularly large for Greece (-0.4%), the UK (-0.8%) and Portugal (-0.7%). As a consequence, in countries where emigration is greater than immigration (such as Portugal and Greece, but also in Italy during the considered period), non-migrants suffer net wage losses. On the other hand, in countries of larger immigration (UK and France) non-migrants benefit of the positive wage externalities from the arrival of highly educated immigrants.

Very interesting is also the effect of emigration on wage inequality. Emigration from European countries has a much stronger effect on the less educated non-migrants whose wages, for example, decline by 2.5%, 2.3% and 1.3% in the UK, Portugal and Greece, respectively. As far as immigration is concerned, Table 3 shows that recent immigration flows are usually more education-intensive in many countries. Hence, immigration substantially helps the wages of low-educated British workers (+2.8%), so that in net, they gain from international mobility. Low-skilled workers in Sweden and Netherlands also experience significant gains from immigration. However, the gains from immigration in Portugal and Greece do not compensate the losses from emigration and the low-skilled workers suffer considerable net losses of -2.1 and -1.3%, respectively.

We report the effects of immigration, emigration and net migration also for the aggregate EU15, considered as one country, in Table 1 and Figure 1. These figures ignore intra-EU15 mobility and only consider the overall effect of immigration from and emigration to the rest of the world on the aggregate EU15 economy. As a whole, EU15 is much less open to labor movements than some of its countries. Immigration levels for both the high-skilled (2.6%) and the low-skilled (1.4%) are higher when compared to the emigration levels (0.9 and -0.4% respectively) but the net migration levels are almost identical across the education levels. Emigration, which exhibits strong positive selection, has a negative effect of 0.2% on average wages while immigration, also positively selected relative to non-migrants, has a positive effect of equal magnitude. Even more remarkably, less educated European workers experience a 0.5% wage increase due to immigration into EU15 and a 0.6% wage decrease due to emigration out of EU15 to the rest of the world.

What is the channel through which less educated natives lose as a result of emigration? The emigration of engineers, teachers and scientists (highly educated) implies that fewer high-tech companies, schools and research laboratories operate, leading to lower demand for construction workers, assistants and lab technicians (less educated). The supply of highly educated creates demand for the complementary less educated workers and loss of the first group decrease the demand and, in the long-run, the wages of the latter group. Interestingly, the pattern in European countries is similar to what happens in Poland, Mexico and South Africa. The reverse takes place in Canada and Australia where immigration strongly helps the wages of less educated (+3.3 and +4.5% respectively). In the US, we see very small effects on wages of less educated (-0.4%) and highly educated (+0.3%).

4.3 Robustness checks

Figure 2, 3 and 4 show various sensitivity analyses for a range of parameter values. Following the specific values presented in Table 2, Figures 2, 3 and 4 show the variation in our results when we vary the values of σ_q, σ_I and λ, respectively. For purposes of clarity, we only represent the wage effect of immigration and emigration leaving aside the net effect (which is approximately the sum of the two).

Figure 2a shows that the sensitivity of the average wage effect to changes in σ_q is quite minimal. The simulated lines are almost completely overlapping, indicating that the average wage effects of immigration and emigration do not critically depend on the elasticity of substitution between more and less educated workers in the labor force. What depends on this parameter, however, as shown by figure 2b and 2c are the distributional effects - wage effects for non-migrants with different education levels. Higher values of σ_q imply closer substitutability between more and less educated workers and this reduces the negative (positive) effect of immigration (emigration) on the wages of highly educated. At $\sigma_q = 2$, the positive effect of emigration on highly educated wages is almost eliminated and the negative effect of immigration is turned into a small positive effect due to the imperfect substitution and positive externality of immigrants. For the wages of less educated non-migrants, on the other hand, higher substitutability of more and less educated workers reduces both the positive effect of immigration and (in absolute value) the negative effect of emigration. However, even at $\sigma_q = 2$, there are clear wage gains from immigration and clear wage losses from emigration for less educated non-migrants. This is due to the fact that for less educated workers, the wage effects (operating through skill-complementarities, schooling externalities and imperfect substitution with immigrants) go in the same direction - they are positive for immigration and negative for emigration. Hence even when we reduce the strength of the skill-complementarity channel via increasing σ_q, the other two channels remain strong and of opposite direction for immigration and emigration on less educated wages. For the more educated workers, on the other hand, reducing the schooling-complementarity channel increases the relative importance of schooling externalities and of the imperfect substitutability between native and immigrants. These last two effects are positive and, for high values of σ_q, may prevail generating null or positive overall effects of immigration on highly educated.

With these mechanisms in mind, we can also easily understand and interpret the sensitivity analysis of the parameter σ_I performed in Figure 3. First, we should note that this parameter, as expected, has no impact on how emigration affects average or skill-specific wages. All of the lines in all three panels for emigration are perfectly overlapping. As the substitutability between natives and immigrants decreases, on the other hand, the average wage effects of immigration become stronger and more positive for every country in the sample. Intuitively this occurs because the inflow of immigrants is more beneficial to natives' wages when the two groups are more complementary with each other. Interestingly when $\sigma_I = 6$ (based on Manacorda et al., forthcoming) immigration implies wage benefits for both more and less educated in most of the countries. In some countries, such as Canada, Australia, the UK and even more Singapore, the positive average wage impact of immigrants is quite large, in the order of 2, 3 and even 5%.[12]

Finally, Figure 4 shows the sensitivity to the schooling externality and reveals some interesting effects. First, when we completely eliminate this channel ($\lambda = 0$), the average wage effects of emigration become essentially zero while the effects of immigration on non-migrant wages stay positive, driven by imperfect substitution as discussed above. If we increase the value and effect of λ, the average wage effect of immigration also increases with significant positive effect on the less-educated and lower negative effect on the highly educated workers, off-setting the negative impact on highly educated due to the skill-complementarity channel.

The robustness checks show that essentially for the whole parameter range, immigration has a positive effect on average wages of non-migrants for most considered countries. For most European countries, it is positive or, in some cases, zero for the extreme parameter values. On the other hand, emigration has an effect that ranges from 0 to negative depending on parameter values. For all the Western European countries considered the effect of emigration are always negative. The winners from immigration are, for Europe, the less educated native workers while the losers from immigration are the more educated. For this group, however, the wage losses are significantly reduced and also turned into gain if (i) the elasticity between more and less educated is at the high end of the spectrum, (ii) the elasticity between natives and immigrants is at the low end or (iii) if the schooling externality is at the high end of the spectrum. Average wages and wages of he less educated seem to benefit from immigration and suffer from emigration in all simulations for all European countries.

4.4 Best-case and worst-case scenarios

Previous sections presented the wage effect of immigration and emigration for a wide range of critical parameter values ($\sigma_q, \sigma_I, \lambda$) as identified in the literature (see Table 2). Figure 5 shows the estimated average wage effect of immigration (panel 5a) and emigration (panel 5b) for non-migrants considering the configurations of the parameters that produce the most and the least beneficial wage effect on natives. In particular, the combination of parameters producing the most beneficial wage effects of immigration on non-migrants is: $\sigma_q = 1.3, \sigma_I = 6, \lambda = 0.75$, while the configuration producing the least beneficial effect is $\sigma_q = 2, \sigma_I = \infty, \lambda = 0$. For emigration, the worst case scenario is reached when $\sigma_q = 1.3, \lambda = 0.75$ and the best case scenario when $\sigma_q = 2$, $\lambda = 0$ independently from the value of σ_I.

[12] With imperfect substitution between natives and immigrants, new immigrants benefit native workers in the host country. They compete, however, more directly with previous immigrants. However their wages are not included in the simulated effects for national non-migrants.

As far as immigration is concerned, the 'Worst-case' effect is essentially equal to zero for all countries whereas the 'Best-case' effect is positive everywhere. The largest gains are obtained for Singapore (+3.7%), Australia (+2.6%), Canada (+1.9%) and the UK (+1.7%). The opposite picture emerges with regard to emigration. The 'Best-case' effect is essentially equal to zero for all countries whereas the 'Worst-case' effect is negative everywhere. The largest losses are obtained for the UK (-1.3%), Portugal (-1.1%), Poland (-0.9%), Singapore and South Africa (-0.8%), Greece and Canada (-0.7%). For EU15 as a whole the best case scenario for immigration implies a gain around 0.5% of non movers' wages. On the other hand the worst-case scenario implies a loss from emigration also around -0.5% of non movers' wage.

5 Simulated wage effects: extensions

The parametrization of our model reflects different results on the impact of immigration, schooling externalities, and the substitutability between highly educated and less educated workers. However our analysis of the wage effects of immigration can be seen as somewhat optimistic. First, our database may not capture illegal immigration to the OECD countries, which is widely believed to be low-skill intensive. Second, it assumes that highly educated immigrants are homogeneous across origin countries and contribute the same skills as native highly educated workers to the destination labor markets. Finally, we did not include yet the potential congestion effects of immigration on the labor market of receiving countries, nor did we examine the short-run effects accounting for sluggish adjustment of physical capital to immigrants. This section deals with those issues and extends our robustness analysis.

5.1 Accounting for undocumented immigrants

By focusing on census data, our database fails to record undocumented immigrants in most countries, for whom systematic statistics by education level and country of birth are not available. An exception is the United States where demographic evidence indicates that most residents, regardless of legal status, are identified in the census. However, other host countries provide no accurate data about the size and educational status of undocumented migrants. In their recent report, Kovacheva and Vogel (2009) estimate the size of irregular migrant populations in the European Union and in selected member states. Annex 1 of their paper provides lower and upper bounds for the proportion of undocumented in the immigrant population in 2002.[13] Data are available the for the 10 European countries in our sample - Belgium (11-18%), France (9-15%), Germany (14-20%), Greece (42-63%), Italy (53-75%), Netherlands (11-26%), Portugal (18-89%), Spain (8-29%), Sweden (1.7-2.5%), and the U.K. (11-21%).

Figure 6 gives the effect of immigration on average wages when illegal immigration is taken into account where the 'Lower Bound' and 'Upper Bound' scenarios use the proportions listed above. Although there may be some instances of highly skilled undocumented migrants (such as those overstaying their H-1B visas in the United States), the majority of undocumented migrants are believed to be low-skilled. Hence, we make the two extreme assumptions that

[13] See http://irregular-migration.hwwi.net/Stock_estimates.6170.0.html.

(i) all undocumented immigrants as measured in the early 2000's are less educated and that (ii) they migrated to the destination country between 1990 and 2000. Our simulation uses the baseline set of elasticities of Table 3. Hence the solid line in Figure 6 corresponds to our baseline simulation depicted on Figure 1 Panel 1a. In the original scenario, the effect of immigration is positive or nil in all EU countries. Adding illegal immigration (see dashed and dotted lines) slightly modifies our conclusions only in countries where the proportion of illegal immigrants is very large (above 50 percent). Hence, Greece and Italy now suffer small immigration costs (0.2 and 0.1%, respectively), while the effect for the Netherlands turns to zero in the 'Upper Bound' scenario. The change is obviously driven by the adverse effect on less educated non-migrants. Most of the countries however (such as UK, Belgium, France, Netherlands, Portugal, Spain and Sweden) maintain a positive wage effect of immigration even under the most pessimistic scenario which is likely to largely overestimate the undocumented. In summary, only Italy and Greece suffered a (small) negative wage effect from immigration even after adding the highest estimates of undocumented immigrants and counting all of them as less educated.

5.2 Accounting for the quality of education and skill downgrading

Simulations presented in Section 4 account for potential complementarity between natives and foreign workers in each skill category. Such imperfect substitutability emerge because immigrants have different motivations, culture-specific skills and limits compared to natives. Another source of heterogeneity between immigrants and natives arises from the absence of equivalence between national and foreign degrees both in terms of quality and subject coverage (such as the case in law degrees). In particular, highly educated immigrants trained in developing countries could be less productive in high-skill jobs than natives with similar educational degrees.

Evidence of such heterogeneity in the quality of education is provided by Coulombe and Tremblay (2009), who compare the skill intensity and schooling levels of Canadian immigrants and natives who were both submitted to standardized tests in literacy, math, and problem solving. These tests provide measures of proficiency that are comparable across countries and over time. On this basis, Coulombe and Tremblay estimate a 'skill-schooling gap' for each origin country, defined as the difference between the mean years of schooling of the immigrant subgroup and the typical native with the same proficiency level. A positive skill-schooling gap of n years means that Canadian nationals with y years of schooling are as productive as immigrants with $y+n$ years of schooling. The larger the skill-schooling gap, the lower is the quality of education in the country of origin. Simple bivariate OLS regressions show that the skill-schooling gap is a decreasing function of per capita income of the origin country. Their -0.10 point estimate of the slope coefficient indicates that the skill-schooling gap is one year smaller when per capita income increases by US$10 000 in the origin country. Using this estimate and cross-country data on per capita income, we construct an indicator of skill-schooling gap for each origin country. Then, assuming that one year of schooling generates a productivity gain of 8 percent, we estimate the relative productivity of educated immigrants and natives in each country, with a benchmark value of one for workers trained in Canada (as well as workers trained in richer origin countries, i.e. the upper bound of this index is one). For example, college graduate immigrants from Angola and Portugal are equivalent to 0.73 and 0.85 Canadian college graduates, respectively.

We revisit the wage effect of immigration on average wages when the skill levels of immigrants and nationals are quality-adjusted. Differences in the quality of education is likely to be a source of 'brain waste' (see Matoo et al, 2008). Hence, our adjustment consists in multiplying the number of college graduates originating from a given country by the relative productivity index computed for that country, and consider the remaining fraction as less educated workers. In the previous example a college graduate from Angola is considered as a combination of 0.73 college graduates and 0.27 non-college graduates in the rich country. This method has two main limitations. First, as our adjustment factor is based on Canadian data, it suffers from a selection bias. Indeed, Moroccan migrants to Canada are more than likely to have higher skills than Moroccan migrants to France. For this reason, we also provide a second simulation with a correction based on the squared of the Canadian index. Coming back to our example above, one college graduate immigrant from Angola or Portugal accounts for 0.51 or 0.72 units of highly skilled workers, respectively. Second, while our benchmark non-adjusted measure implies that immigrants' human capital is equivalent to that of natives (as if all migrants were trained in the host country), our adjusted measure implies that all immigrants were trained in their birth country. Reality is obviously somewhere in between. However our only objective here is to explore whether a correction for education quality can modify our predictions, hence an extremely negative assumption implies simply that our estimate is a lower bound of the wage effect.

Our third correction in the accounting of foreign-born highly educated is based on the US wage of immigrants from each country of origin (in year 2000). We calculate the weekly wage of college educated immigrants from country j as a linear combination of the wages of US-born college educated and non college educated workers. We then use those weights to distribute a highly educated foreign-born between more and less educated US equivalents. With this method, for instance, a highly educated Vietnamese is considered as equivalent to 0.73 units of US college graduate and 0.27 units of US less educated. If foreign-born college educated migrants from a certain country are paid more than US born they are considered pure college equivalent.

Our fourth and final correction is based on Mattoo et.al (2008) who calculate the probability that an immigrant from country j with tertiary education (completed at home prior to migration) obtains a skilled job in the US labor market. Using the data from 1990 and 2000 censuses and controlling for individual factors (such as age, experience and years since migration), they calculate these probabilities for hypothetical individuals identical in every respect except their origin country. They find that migrants from South Asia perform very well while those from Eastern Europe and Latin America are placed in relatively unskilled jobs.

The results from all of the four corrections are reported in Figure 7. Some corrections imply smaller gains for host countries (especially for the US, Canada, Australia and Singapore) The largest change, relative to the baseline, is for the US where we now observe a loss of around 0.2% in average wages due to ten year of immigration, which is still a small percentage. The corrections do not change the overall picture and the a positive impact of immigration in most European countries is maintained. The limit of all corrections is that, for data limitations, they are all based on schooling quality and labor market assessment of immigrants in Canada or the US and not in European countries.

5.3 Accounting for density/crowding externalities

An additional aggregate effect of immigration may stem from its impact on the aggregate scale of production. On one hand, the existence of a fixed factor in production (such as land) would cause aggregate decreasing returns. On the other hand, the efficiency of production may be increased by an increase in employment density due to "agglomeration externalities" as in Ciccone and Hall (1986). In general agglomeration externalities/crowding effects can be modeled by assuming that the TFP is also as function of the aggregate scale of production (Q_t). An extension of expression 10 above can be stated as follows:

$$A_t' = A_0 \left(\exp \left(\frac{Q_{h,t}}{Q_t} \right) \right)^{\lambda} (Q_t)^{\phi} \tag{11}$$

In this expression, the crowding effect of labor force size on land, assuming a share of land in production of 0.03 in rich countries (see Ciccone and Hall 1986) would give $\phi = -0.03$. On the other hand, incorporation of the positive density externalities estimated by Ciccone and Hall (1986) would lead to a positive value of $\phi = 0.06$.[14] We explore the implication of such effects for the impact of immigration, keeping the values of the other parameters at the basic specification.

Figure 8 illustrates the estimates in the benchmark case and compares with either type of externality. Since the values of the estimates for the parameter ϕ and the effect of emigration in changing total employment (and its density) are small, the effects of introducing this externality (either positive or negative) are also minimal. The presence of an agglomeration externality would marginally increase the positive average wage effects of immigrants, while the crowding externality would marginally reduce it but the differences are on the order of a small fraction of a percentage point.

5.4 Accounting for employment rates

While the model is based on employment the empirical analysis is based on working-age population data. As reduced labor market participation of immigrants and/or natives may alter the wage effect of immigration (see Angrist and Kugler 2003, or D'Amuri et al 2010) it is important to check whether excluding from the analysis non-employed natives and immigrants affects our predictions.

Using the European Labor Force Survey, we correct the size of each skill group (highly and less educated natives and immigrants) for their employment/population ratio as of year 2000. If these employment rates are identical across the four groups, the results would not change at all. If they are very different between natives and immigrants, they may imply differences in relative employment effects for given population sizes. While employment/population ratios may differ across countries what matters for our wage effects is their within country difference across the four skill groups described above. Figure 9 shows the simulated wage

[14] Notice that we simply model the density effect as depending on average density: total population divided by area. The fact that immigrants move mainly into cities that are already dense should increase even further the effect, if one uses the exact Ciccone and Hall (1996) index that counts density in cities (where most population lives) as more relevant.

effects using employment data (obtained applying group-specific employment-population ratios) relative to the baseline case calculated with population data. The new estimates are hardly distinguishable from the baseline case. This is because while the employment rate is somewhat different between highly and less educated, they are very similar for native and immigrants for the same education levels in most countries. In some countries immigrants have in fact slightly higher employment rates than natives. In most countries less educated immigrants have a somewhat smaller employment rate than corresponding natives. This is true in particular for Spain and Sweden where the low employment rate of highly skilled immigrants (relative to natives) reduces the positive wage effects of immigration but only slightly.

5.5 Accounting for physical capital sluggishness (short-run effects)

While the model has, so far, evaluated the long-run effects of immigrants and emigrants, by assuming full capital adjustment, we can also calculate the short-run effects by accounting for imperfect capital adjustment. From the production function in (3) we can obtain the compensation to the composite factor Q, w_t^Q,which corresponds to the average wage, as:

$$w_t^Q = \frac{\partial Y_t}{\partial Q_t} = \alpha \widetilde{A}_t \left(\kappa_t\right)^{1-\alpha} \tag{12}$$

where $\kappa_t = K_t/Q_t$ approximates the capital-labor ratio. In balanced growth path (or in an open economy) the capital-labor ratio is given by the following expression $\kappa_t^* = \left(\frac{1-\alpha}{R^*}\right)^{\frac{1}{\alpha}} \widetilde{A}_t^{\frac{1}{\alpha}}$. Hence the average wage in the balanced growth path (aggregating immigrants and natives) depends only on total factor productivity, $\widetilde{A}$ and on the rate of return of capital and not on the total labor supply Q_t. In the short run, however, the percentage change in average wages may depend on the percentage response of κ_t to immigration. Taking the differential of the logarithm of (12) relative to immigration, and approximating logarithmic with percentage changes, we have:

$$\frac{\Delta w_t^Q}{w_t^Q} = (1-\alpha)\left(\frac{\Delta \kappa_t}{\kappa_t}\right)_{immigration} + \left(\frac{\Delta \widetilde{A}_t}{\widetilde{A}_t}\right)_{immigration} \tag{13}$$

where $(\Delta\kappa_t/\kappa_t)_{immigration}$ is the percentage deviation of the capital-labor ratio from κ_t^* due to immigration, while $\left(\Delta\widetilde{A}_t/\widetilde{A}_t\right)_{immigration}$ is the productivity effect (if any) from immigrants. With full capital adjustment and the economy on the balanced growth path, $(\Delta\kappa_t/\kappa_t)_{immigration}$ equals 0 and the only average wage effect of immigrants is through $\widetilde{A}_t$[15]. At the opposite extreme, with fixed total capital, $K_t = \overline{K}$, then $(\Delta\kappa_t/\kappa_t)_{immigration}$ equals the negative percentage change of labor supply due to immigration: $-\frac{\Delta I_t}{Q_t}$, where ΔI_t is the net change in foreign-born workers and Q_t is, approximately, the aggregate labor supply at the beginning of the period. While for short periods or for sudden shocks the short run

[15] Obviously immigration has also an effect on relative wages of native-immigrants and highly-less educated as shown above. Physical capital, however, only affects the average wage and hence we can simply add this effect to the group-specific wage effect.

effect may be evaluated considering capital as fixed in the case of ten years of immigration, which is a slow and continued phenomenon, we need to account explicitly for the dynamics of capital.

A popular way to analyze the deviation of $\ln(\kappa_t)$ from its balanced growth path trend, used in the growth and business cycle literature, is to represent its time-dynamics in the following way:

$$\ln(\kappa_t) = \beta_0 + \beta_1 \ln(\kappa_{t-1}) + \beta_2(trend) + \gamma \frac{\Delta I_t}{Q_t} + \varepsilon_t \tag{14}$$

where the term $\beta_2(trend)$ captures the balanced growth path trajectory of $\ln(\kappa_t)$, equal to $\frac{1}{\alpha} \ln\left(\frac{1-\alpha}{R^*}\widetilde{A}_t\right)$, and the term $\beta_1 \ln(\kappa_{t-1})$ captures the sluggishness of yearly capital adjustment. The parameter $(1 - \beta_1)$ is commonly called the "speed of adjustment " since it is the share of the deviation from the balanced growth path (trend) eliminated each year. Finally, $\frac{\Delta I_t}{Q_t}$ represents the yearly immigration flows as share of the labor force and ε_t are other mean-zero uncorrelated shocks. Once we know β_1, γ and the sequence of yearly immigration flows, $\frac{\Delta I_t}{Q_t}$, we can use (14) to obtain an impulse response of $\ln(\kappa_t)$ as of 2000 in deviation from its trend (short run). This in turn allows us to correct the average wage effect (currently determined only by the productivity effect of immigration and emigration) for this sluggish capital adjustment and to obtain the short-run effect on the average wage of non-migrants. The empirical growth literature (Islam, 1995; Caselli et al., 1996) and the business cycle literature (Romer, 2006, Chapter 4), provide model-based and empirical estimates of β_1. The recent growth literature usually estimates a 10% speed of convergence of capital to the own balanced growth path for advanced (OECD) economies (Islam, 1995; Caselli et al., 1996), implying $\beta_1 = 0.9$. Similarly, the business cycle literature calculates the speed of convergence of capital to be between 10% and 20% in each year (Romer, 2006, Chapter 4) for closed economies, and even faster rates for open economies. Hence $\beta_1 = 0.9$ seems a reasonable estimate (if anything on the sluggish side).

We use the immigration and emigration rates over 1990-2000 for the considered countries, and assume a uniform distribution of migration flows over the ten years. We adopt as parameters of capital adjustment $\beta_1 = 0.9$ and $\gamma = -0.9$ (assuming that capital adjustment begins the same year as immigrants are received or emigrant lost). Hence the recursive equation (14) allows us to calculate $(\Delta\kappa_{1990-2000}/\kappa_{1990})_{migration}$ as of year 2000. Using formula (13) we can calculate the effect of $\Delta\kappa$ on the average wage and by adding this to the baseline average wage estimate for non-movers we obtain the short-run effects of immigration and emigration. We report the simulated short-run effect (together with the long-run effects from the baseline case) in Figure 10. Such a short-run correction, driven by sluggish capital adjustment, is usually negative for immigrants and positive for emigrants. The largest value of the short-run correction for immigration is -0.9% for the US average wage, as this country has by far the largest immigration rate over the period. Several other countries (such as Mexico, Hungary and Czech Republic) have a correction term for immigrants close to 0[16]. For Europe the largest short-run adjustments in average wages due to capital sluggishness are for Sweden (-0.48%) and for Spain (-0.55%). The smallest are for France (-0.14%) and for

[16] In terms of net flows of immigrants, during the 90's the largest yearly inflows were in Spain, at 0.2% of the labor force in each year and the smallest were in Greece at 0.02% of the labor force per year.

Greece (-0.04%). For emigration, except for Mexico that has a very large and positive short-run correction, due to a very large emigration rate (1.2% per year in the period considered), the other corrections are very small. Figure 10 shows the simulation of short-run effects vis-a-vis the long run effects of immigration and emigration on average wages for the baseline scenario. Combining imperfect capital adjustment with the long-run effects, we still have positive short-run average wage effects of immigration on non-migrants in four European countries. In the UK, France, Netherlands and Sweden immigration had a positive effects on average native wages *already in the short-run.* For Greece, Italy, Portugal and Belgium *the short-run effects on average wages are negative and very small* (less than -0.2% in absolute value). For Germany and Spain they are negative and between -0.27 and -0 35%. The same countries experienced a long-run increase in their average wage due to immigrants equal to 0.20%. Hence, even in the short run, accounting for sluggish capital adjustment we do not find much of a negative average wage effect of immigration. As for emigration the short-run effects are smaller in absolute value but still negative for seven European countries and for the EU15 as a whole. Even in the short run in most European countries the effect of emigration is negative and larger in absolute value than the effect of immigration. Both of them, however, are rather small in the order of few tenths of a percentage points. Even in the short run and accounting for the slow adjustment of capital immigration has a very moderate effect, usually close to zero and, if negative, smaller (for seven countries out of ten) than the effect of emigration. Not even in a short-run perspective did immigration have a significant negative impact on native wages for European countries. To the contrary emigration did not produce any short-run gains for native wages that may reduce the welfare cost of the long-run losses.

6 Conclusions

Immigrants are highly visible to the governments and public in destination countries especially in times of economic anxiety and high unemployment levels. They are also relatively easy to measure by statistical agencies of the host countries through censuses, population and labor force surveys. On the other hand emigrants are much less visible to governments of their birth countries and less known to the general public. There is no mandatory registration for those who leave a country, they are dispersed in many receiving countries and no statistical agency keeps detailed records of all its emigrants and returnees. There is rarely a policy instrument that can affect emigration since freedom of movement allows people to leave any democratic country.

During the last decades emigration has been considered mostly in connection with poor countries and usually in the context of brain drain. There have been studies on the labor market impact of immigration in the destination since the 1970s. However, only very recently and only in connection with the debate on brain drain and brain gain, some economists have began to measure empirically the aggregate income effects of emigration (Beine et.al. 2008). This paper uses a recently constructed database on emigration flows by schooling level between 1990 and 2000, constructed using data across all countries in the world. Using a range of parameters and an aggregate representation of labor markets of receiving countries, we show that residents of Western European countries experienced wage gains, on average, from immigration while they experienced wage losses due to emigration. The magnitude of the wage losses due to emigration is roughly equal to or larger than the gains from immigration. This is due to the fact that both immigrants and emigrants in European countries are, on average, more educated relative to non-migrants. Moreover immigrants are generally imperfect substitutes for non-migrants bringing skills that only partially compensate the losses due to emigration. Our analysis also finds that immigration in Europe was somewhat more beneficial to the less educated natives, reducing their wage gap with highly educated, while the opposite is true of emigration. These surprising results imply that several European countries should begin to discuss more seriously the causes and effects of their significant emigration rates, especially of their highly educated professionals, rather than obsessing with immigration that has mostly been beneficial in economic terms.

A Data appendix

Migration data presented in Section 3 follow Docquier et al. (2010) who construct comprehensive 195x195 matrices of bilateral migration stocks. These matrices cover the two skill groups (college graduates and less educated individuals), and two years (1990 and 2000). Migration is defined on the basis of country of birth which is time invariant (contrary to the concept of citizenship, which changes with naturalization) and independent of the changes in policies regarding naturalization. However, this definition does not account for whether education has been acquired in the home or in the host country. This induces a potential over-estimation of the intensity of the brain drain migration of children and students can represent an important fraction of total immigration for certain countries.[17]

The methodology is described in detail in Docquier et al. (2010) and it consists of three main steps. The starting point (step 1) is the database described in Docquier, Lowell and Marfouk (2009) documenting bilateral migration stocks in OECD host countries. It is based on a collection of census and register immigration data by country of birth and educational level in the 30 OECD countries in 1990 and 2000. This OECD set of destinations does not include the three member states which joined the OECD in 2010 (Chile, Israel and Slovenia) and future members (Estonia and Russia). This database characterizes the education level, origin and destination of about 57.4 million migrants in 2000 and 40.8 million migrants in 1990. High-skill migration represents 35.4 percent of the total in 2000 (30.1 percent in 1990). The second step consists of a collection of similar immigration data from 46 non-OECD destinations in 2000 and 31 destinations in 1990. In the third step, data collected in steps 1 and 2 are used to estimate the determinants of the size of bilateral migration (M^s_{ijt}) from country i to country j in the education group s at year t. Then, based on these estimations, the size of the migrant stock from each origin country to the remaining 119 non-OECD host countries in 2000 (and 134 in 1990) for each education level is predicted. The final 195x195 database combines recorded migration stocks (when census and register data are available) and out-of-sample predictions (when official statistics are missing).

Table A1 provides summary statistics for migration stocks which are comparable with labor force data. The database characterizes the origin, destination and education level of about 100.5 million adult migrants in 2000, and 80.2 million in 1990. Table A2 distinguishes observed and imputed values for immigrants to countries included in our sample. Table A3 shows stock of immigrants and emigrants in 1990 and 2000 as percentage of the skill-specific labor force. Table A4 describes the distribution of the labor force between college graduates and less educated as percentage of total.

[17] Beine et al (2007) have estimated the age-of-entry structure of high-skill immigration and proposed alternative measures of the brain drain excluding those who left their home country before age 12, 18 or 22. The corrected rates are obviously lower than those calculated without age-of-entry restrictions. However, the correlation between corrected and uncorrected rates is extremely high and the country rankings by brain drain intensities are basically unaffected by the correction. This should mitigate concerns about children migration possibly leading to cross-sectional biases in the brain drain estimates.

References

[1] Acemoglu, Daron, and Joshua Angrist (2000). How large are human capital externalities? Evidence from compulsory schooling laws.

NBER Macroeconomic Annual 15.

[2] Acemoglu, Daron, and Fabrizio Zilibotti (2001). Productivity Differences. *Quarterly Journal of Economics* 116 (2): 563-606.

[3] Angrist, Joshua D. (1995). The Economic Returns to Schooling in the West Bank and Gaza Strip. *American Economic Review* 85 (5): 1065-1087.

[4] Angrist, Joshua, and Adriana D. Kugler (2003). Protective or counter-productive? Labour market institutions and the effect of immigration on EU natives. *Economic Journal* 113, F302-F331.

[5] Azariadis, Costas, and Allan Drazen (1990). Threshold externalities in economic development. *Quarterly Journal of Economics* 105 (2): 501-526.

[6] Barro, Robert J., and Jong-Wha Lee (2001). International data on educational attainment: Updates and implications. *Oxford Economic Papers* 53: 541–563.

[7] Beine, M., F. Docquier and C. Ozden (forthcoming), "Diasporas," *Journal of Development Economics*

[8] Beine, M., F. Docquier and H. Rapoport (2001), Brain Drain and Economic Growth: Theory and Evidence, *Journal of Development Economics* 64 (1), 275-289.

[9] Beine M., Docquier, F. and H. Rapoport (2008), Brain Drain and Human Capital Formation in Developing Countries: Winners and Losers, *Economic Journal*, 118, 631-652.

[10] Benhabib, Jess, and Mark M. Spiegel (2005). Human Capital and Technology Diffusion. In Ph. Aghion and S. Durlauf (eds.), Handbook of Economic Growth, Elsevier: Vol. 1, Chapter 13, 935-966.

[11] Borjas, George. 2003. The Labor Demand Curve is Downward Sloping: Reexamining the Impact of Immigration on the Labor Market. *Quarterly Journal of Economics* 118, no. 4: 1335-1374.

[12] Borjas, George (2009). The Analytics of the Wage Effect of Immigration. NBER Working Papers 14796.

[13] Borjas, George, and Lawrence Katz. 2007. The Evolution of the Mexican-Born Workforce in the United States. In: Borjas, George (Ed), Mexican Immigration to the United States National Bureau of Economic Research Conference Report, Cambridge, MA.

[14] Borjas, George, Jeffrey Grogger, and Gordon Hanson (2008). Imperfect Substitution between Immigrants and Natives: A Reappraisal. National Bureau of Economic Research, Working Paper # 13887, Cambridge, MA.

[15] Card, David (2005). Is the new immigration really so bad?. *Economic Journal* 115 (4): 300-323.

[16] Card, David (2009). Immigration and inequality. *American Economic Review* 99 (2): 1-21.

[17] Card, David, and Thomas Lemieux (2001). Can Falling Supply Explain the Rising Returns to College for Younger Men? A Cohort Based Analysis. *Quarterly Journal of Economics* 116 (2): 705-746.

[18] Caselli, Francesco, Gerardo Esquivel, and Fernando Lefort. 1996. Reopening the Convergence Debate; A New Look at Cross-Country Growth Empirics. *Journal of Economic Growth* 1, no.3: 363-389.

[19] Caselli, Francesco, and Wilbur Coleman (2006). The World Technology Frontier. *American Economic Review* 96 (3): 499-522.

[20] Ciccone Antonio, and Robert E. Hall (1996). Productivity and the Density of Economic Activity. *American Economic Review* 86 (1): 54-70.

[21] Ciccone Antonio and Giovanni Peri (2005) "Long-Run Substitutability between More and Less Educated Workers: Evidence from U.S. States 1950-1990" (with Antonio Ciccone) *Review of Economics and Statistics*, Vol. 87, Issue 4, pages 652-663.

[22] Ciccone Antonio and Giovanni Peri (2006) "Identifying Human Capital Externalities: Theory with Applications" *Review of Economic Studies*, Vol. 73, pp. 381-412.

[23] Coe, David T., Elhanan Helpman, and Alexander W. Hoffmaister (1997). North-South R&D spillovers. *Economic Journal* 107 (440): 134-149.

[24] Cohen, Daniel, and Marcelo Soto (2007). Growth and human capital: Good data, good results. *Journal of Economic Growth* 12 (1): 51-76.

[25] Coulombe, Serge, and Jean-François Tremblay (2009). Migration and skills disparities across the Canadian provinces. *Regional Studies* 43 (1): 5-18.

[26] D'Amuri, Francesco, Gianmarco I.P. Ottaviano, and Giovanni Peri (2010). The labor market impact of immigration in Western Germany in the 1990s. *European Economic Review* 54, 550-570.

[27] Docquier, Frédéric, B. Lindsay Lowell, and Abdeslam Marfouk (2009). A gendered assessment of highly skilled emigration. *Population and Development Review* 35 (2): 297-321.

[28] Docquier, Frédéric, Abdeslam Marfouk, Caglar Ozden, and Christopher R. Parsons (2010). Geographic, gender and skill structure of international migration. Report written for the Economic Research Forum.

[29] Easterly, William, and Ross Levine (2001). What have we learned from a decade of empirical research on growth? It's Not Factor Accumulation: Stylized Facts and Growth Models. *World Bank Economic Review* 15 (2): 177-219.

[30] Iranzo, Susana, and Giovanni Peri (2009). Migration and Trade: Theory with an Application to the Eastern-Western European Integration. CReAM Discussion Paper Series 0905.

[31] Johnson, George E. (1970). The Demand for Labor by Educational Category. *Southern Economic Journal*, 37: 190-203.

[32] Katz, Larry, and Kevin Murphy (1992). Changes in Relative Wages 1963-1987: Supply and Demand Factors. *Quarterly Journal of Economics* 107 (1): 35-78.

[33] Krusell Per, Lee E. Ohanian, José-Victor Rios-Rull and Giovanni L. Violante (2000). Capital-Skill Complementarity and inequality: A Macroeconomic Analysis. *Econometrica* 68: 1029-53.

[34] Goldin, Claudia and Larry Katz (2008). The Race Between Education and Technology. Harvard University Press, Cambridge, MA, 2008.

[35] Grogger, Jeffrey and Gordon Hanson (forthcoming) "Income Maximization and the Selection and Sorting of International Migrants," Journal of Development Economics, forthcoming.

[36] Islam, Nasrul. 1995. Growth Empirics: A Panel Data Approach. *Quarterly Journal of Economics* 110, no.4: 1127-1170.

[37] Kovacheva, Vesela, and Dita Kogel (2009). The size of the irregular foreign resident population in the European Union in 2002, 2005 and 2008: aggregate estimates. HWWI Working paper n. 4/2009 (Hamburg Institute of International Economics).

[38] Longhi, Simonetta, Peter Nijkamp, and Jacques Poot (2005). A Meta-Analytic Assessment of the Effect of Immigration on Wages. *Journal of Economic Surveys* 86 (3): 451-477.

[39] Lucas, Robert E.J. (1988). On the mechanics of economic development. Journal of Monetary Economics 22 (1), 3-42.

[40] Manacorda Marco, Alan Manning, and Jonathan Wadsworth (2008). The labour market effects of immigration. CEP discussion paper CEPCP245, London.

[41] Mattoo, Aaditya, Ileana Cristina Neagu and Caglar Ozden (2008). Brain waste? Educated immigrants in the US labor market. *Journal of Development Economics* 87 (2): 255-69.

[42] Moretti, Enrico (2004a). Estimating the Social Return to Higher Education: Evidence from Longitudinal and Repeated Cross-Sectional Data. *Journal of Econometrics* 121 (1), 175-212.

[43] Moretti, Enrico (2004b). Workers' Education, Spillovers and Productivity: Evidence from Plant-Level Production Functions. *American Economic Review* 94 (3), 656-690.

[44] Murphy Kevin M., W. Craig Riddle, and Paul M. Romer (1998). Wages, Skills and Technology in the United States and Canada. In: E. Helpman (Ed), General Purpose Technology and Economic Growth, Cambridge, MA, MIT Press.

[45] Ottaviano, Gianmarco L.P., and Giovanni Peri (2010). Rethinking the effects of immigration on wages. *Journal of the European Economic Association* (forthcoming).

[46] Ozden, Caglar, Christopher R. Parsons, Maurice Schiff and Terry Walmsley (2010). The evolution of global bilateral migration 1960-2000. Paper presented at the second Migration and Development Conference. September 2009: Washington DC.

[47] Ramsey, Frank. 1928. A Mathematical Theory of Saving. *Economic Journal* 38 (152): 543-559.

[48] Romer, David. 2006. Advanced Macroeconomics. McGraw-Hill, Third Edition. New York, NY.

[49] Saint-Paul, Gilles (2008). "Brain Drain: Some Evidence from European Expatriates in the United States, Introduction by Gilles Saint-Paul," CESifo Forum, Ifo Institute for Economic Research at the University of Munich, vol. 9(3), pages 19-27, October.

[50] Solow, Robert. 1956. A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics* 70 (1): 65-94.

[51] Santos Silva, Joao M.C., and Silvana Tenreyro (2006). The log of gravity. *Review of Economics and Statistics* 88 (4): 641-658.

[52] Vandenbussche, Jérôme, Philippe Aghion, and Costas Meghir (2006). Growth, Distance to Frontier and Composition of Human Capital. *Journal of Economic Growth* 11 (2): 97-127.

Tables and Figures

Table 1
Recent immigration and emigration flows (1990-2000) as percentages of the skill-specific labor force

	Immigration		Emigration		Net Migration	
	Low Education	High education	Low Education	High education	Low Education	High Education
U.S.	5.8	4.4	0.0	0.2	5.8	4.2
Canada	0.8	8.0	-1.0	1.2	1.9	6.7
Australia	-0.6	10.6	0.3	1.3	-0.9	9.2
U.K.	0.4	8.5	-0.8	4.8	1.1	3.7
Belgium	1.7	4.4	-0.3	2.2	2.0	2.1
France	0.1	2.8	0.1	1.1	0.0	1.7
Germany	2.2	3.1	-0.1	1.1	2.4	2.0
Greece	0.2	0.2	-0.3	2.8	0.5	-2.6
Italy	0.9	0.8	-0.6	1.2	1.5	-0.4
Netherlands	1.3	5.1	-0.1	2.3	1.3	2.8
Portugal	1.3	1.9	2.0	8.1	-0.7	-6.1
Spain	2.7	3.8	-0.3	1.9	3.0	1.9
Sweden	1.5	5.1	0.3	1.8	1.2	3.3
EU15	1.4	2.6	-0.4	0.9	1.8	1.7
Czech R.	-0.1	3.9	0.6	1.1	-0.7	2.9
Hungary	-0.2	0.1	0.0	0.3	-0.2	-0.2
Poland	-1.1	-0.7	-0.3	6.3	-0.8	-6.9
Argentina	3.5	1.5	0.5	1.6	3.0	-0.1
Turkey	0.3	3.1	1.7	2.4	-1.4	0.7
Mexico	0.0	0.6	7.8	11.4	-7.8	-10.8
Singapore	0.4	18.8	1.2	4.6	-0.9	14.2
South Africa	0.5	3.4	0.2	4.7	0.3	-1.4

Note: Flows of emigrants and immigrants are calculated as difference between stocks in 1990 and 2000. They are measured as the share of the labor force of relative schooling level in 2000.

Table 2
Parameterization of the model

Parameter Estimates (source of estimates)	Low value	Intermediate Value	High value
σ_q (source)	1.3 (Borjas 2003)	1.5 (Katz and Murphy 1992)	2.0 (Angrist 1995)
σ_I (source)	6.0 (Manacorda et al. forthcoming)	20.0 (Ottaviano and Peri forthcoming, Card 2009)	Infinity (Borjas et al. 2008)
λ (source)	0.0 (Acemoglu and Angrist 2000)	0.44 (Iranzo and Peri 2009)	0.75 (Moretti 2004a, 2004b)

Note: The table summarizes the values of the parameters taken from the previous literature and used in our simulation of wage effects of immigrants and emigrants.

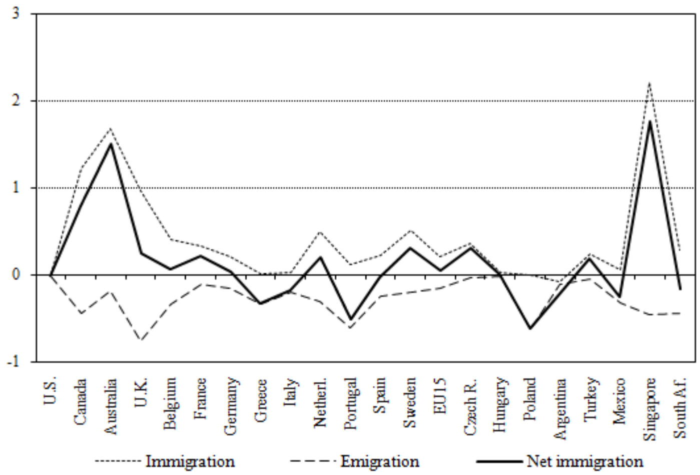
Table 3
Wage effect of immigration, emigration, and net migration: Baseline case

	Average wage			High-skill wage			Low-skill wage		
	Immigration	Emigration	Net migration	Immigration	Emigration	Net migration	Immigration	Emigration	Net migration
U.S.	0.0	0.0	0.0	0.3	0.0	0.3	-0.4	-0.1	-0.5
Canada	1.2	-0.5	0.8	-0.2	0.2	0.0	3.3	-1.4	1.8
Australia	1.7	-0.2	1.5	-1.1	0.2	-0.8	4.5	-0.6	3.9
U.K.	1.0	-0.8	0.2	-1.2	1.3	0.2	2.8	-2.5	0.2
Belgium	0.4	-0.3	0.1	-0.2	0.5	0.3	1.1	-1.3	-0.2
France	0.3	-0.1	0.2	-0.3	0.2	-0.1	1.0	-0.4	0.6
Germany	0.2	-0.2	0.0	0.0	0.2	0.2	0.4	-0.6	-0.2
Greece	0.0	-0.3	-0.3	0.0	0.8	0.8	0.0	-1.3	-1.3
Italy	0.0	-0.2	-0.2	0.1	0.4	0.5	0.0	-0.8	-0.8
Netherlands	0.5	-0.3	0.2	-0.4	0.5	0.1	1.4	-1.1	0.3
Portugal	0.1	-0.6	-0.5	-0.1	1.6	1.5	0.2	-2.3	-2.1
Spain	0.2	-0.2	0.0	-0.1	0.6	0.5	0.5	-0.9	-0.5
Sweden	0.5	-0.2	0.3	-0.3	0.3	0.0	1.4	-0.7	0.7
EU15	0.2	-0.2	0.0	-0.1	0.3	0.2	0.5	-0.6	-0.1
Czech R.	0.3	0.0	0.3	-0.8	0.1	-0.6	1.2	-0.2	1.0
Hungary	0.0	0.0	0.0	-0.1	0.1	0.0	0.1	-0.1	0.0
Poland	0.0	-0.6	-0.6	-0.1	1.8	1.7	0.1	-2.5	-2.3
Argentina	-0.1	-0.1	-0.2	0.4	0.2	0.7	-0.6	-0.5	-1.0
Turkey	0.2	-0.1	0.2	-0.6	0.2	-0.3	0.8	-0.3	0.5
Mexico	0.1	-0.3	-0.3	-0.1	1.0	0.8	0.2	-1.3	-1.1
Singapore	2.2	-0.5	1.8	-2.8	0.8	-1.7	6.8	-1.6	5.0
South Africa	0.3	-0.4	-0.2	-0.6	1.3	0.8	0.9	-1.7	-0.9

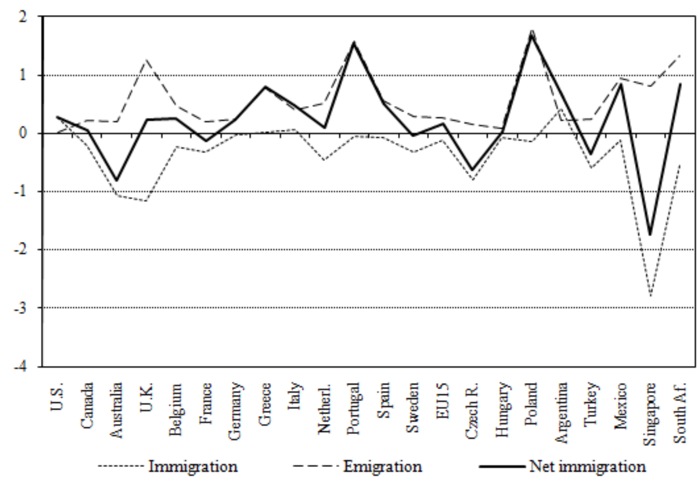
Note: The results above are obtained using the formulas in the Model Section of the text and the following parameter values: σ_q=1.5, σ_l=20.0, λ=0.44.

Figure 1
Wage effects of immigration, emigration, and net migration: Baseline estimation

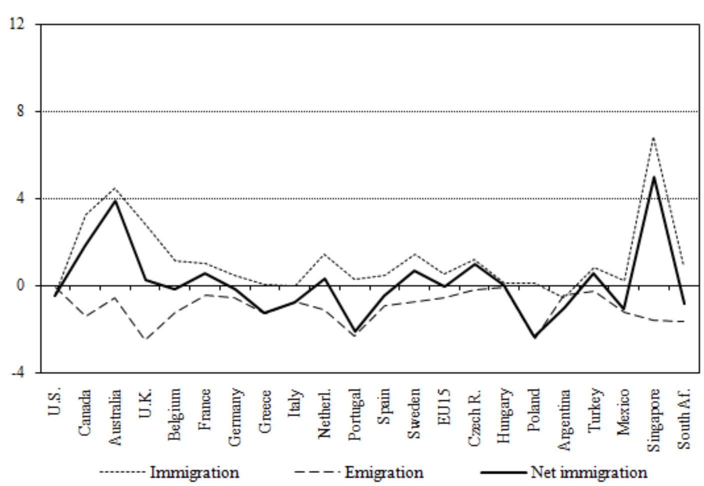
1a. Impact on average wages of non-movers (as %)



1b. Impact on wages of highly educated non movers (as %)



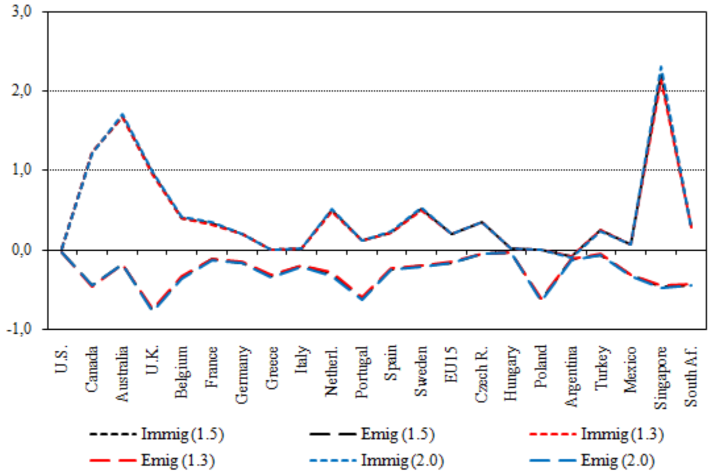
1c. Impact on wages of less educated non-movers (as %)



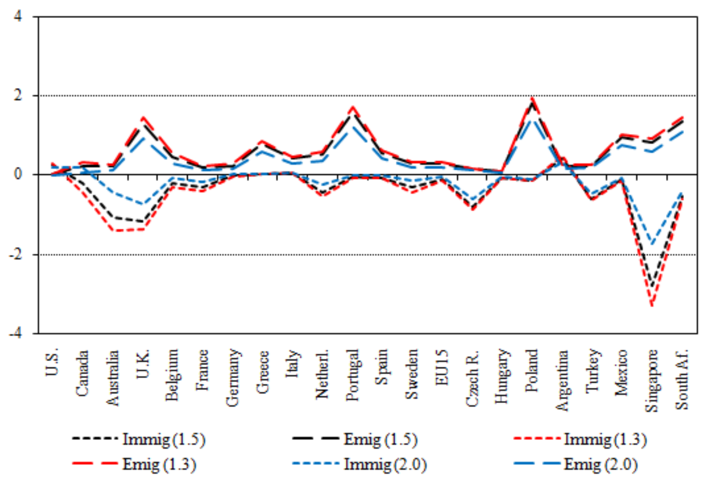
Note: The simulations show the impact of immigration (dotted lines) and emigration (dashed lines) on average wages (2a) wages of more educated workers (2b) and wages of less educated workers (2c). In each panel we use the following parameter configuration: σ_q =1.5, σ_I=*20 and* λ*=0.44.*

Figure 2
Robustness-Check: Sensitivity to σ_q

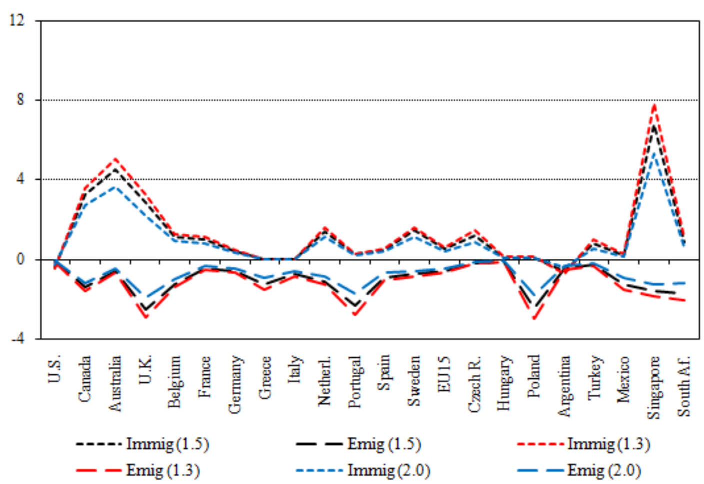
2a. Impact on average wages of non-movers (as %)



2b. Impact on wages of highly educated non movers (as %)



2c Impact on wages of less educated non movers (as %)

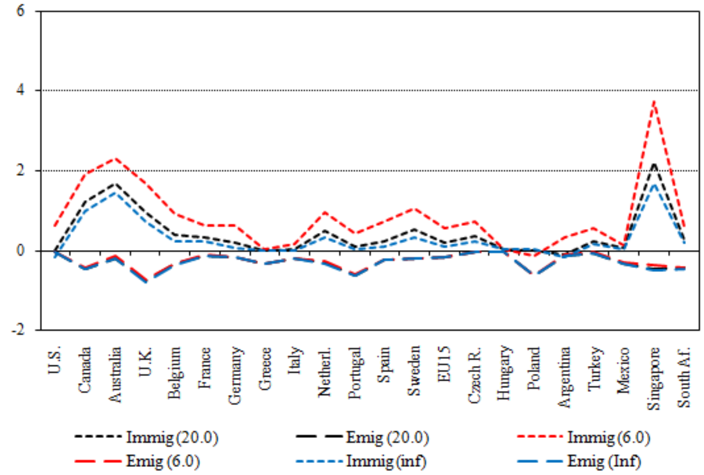


Note : The simulations show the impact on average wages (2a) wages of more educated (2b) and wages for less educated (2c) of immigration (dotted lines) and emigration (dashed lines). In each panel we use 3 values of the parameter σ_q equal to 1.3, 1.5 and 2.0. The other two parameters are set to $\sigma_l=20$, $\lambda=0.44$.

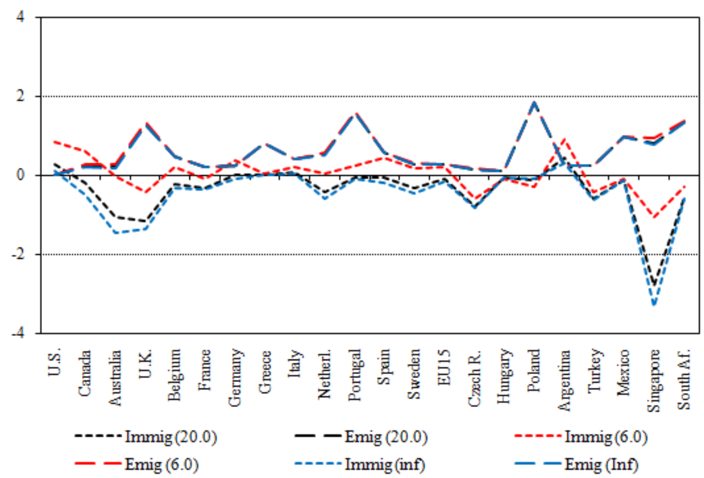
Figure 3

Robustness-Check: Sensitivity to σ_I

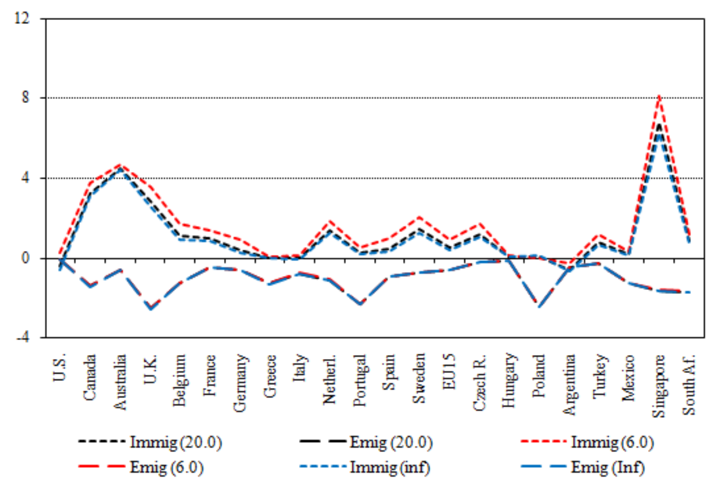
3a. Impact on average wages of non-movers (as %)



3b. Impact on wages of highly educated non-movers (as %)



3c. Impact on wages of less educated non-movers (as %)

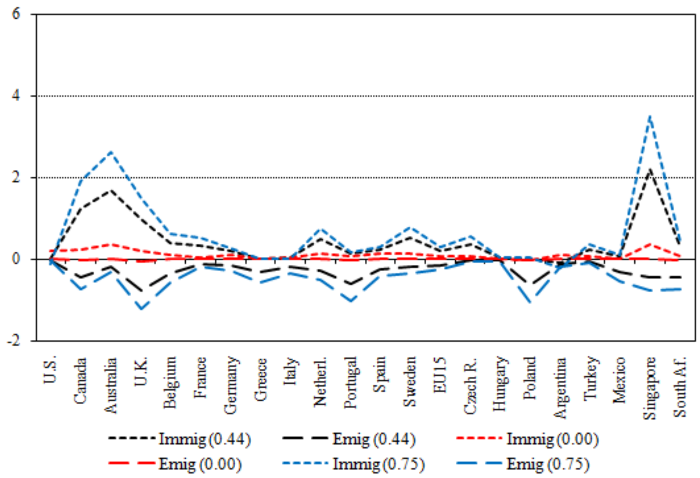


Note : The simulations show the impact on average wages (2a) wages of more educated (2b) and wages for less educated (2c) of immigration (dotted lines) and emigration (dashed lines). In each panel we use 3 values of the parameter σ_I equal to 6, 20 and infinity. The other two parameters are set to $\sigma_q=1.5$, $\lambda=0.44$.

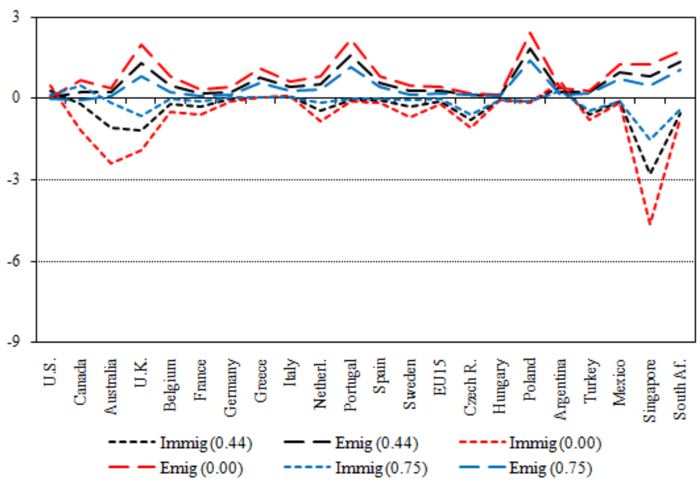
Figure 4

Robustness-Check: Sensitivity to λ

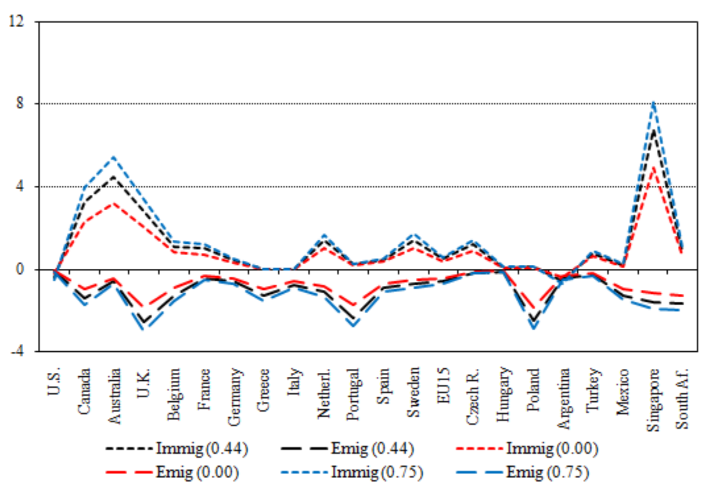
4a. Impact on average wages of non-movers (as %)



4b. Impact on wages of highly educated non-movers (as %)



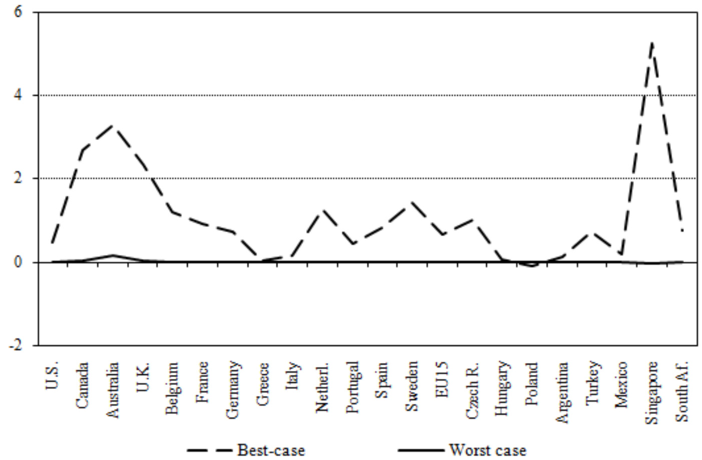
4c Impact on wages of less educated non-movers (as %)



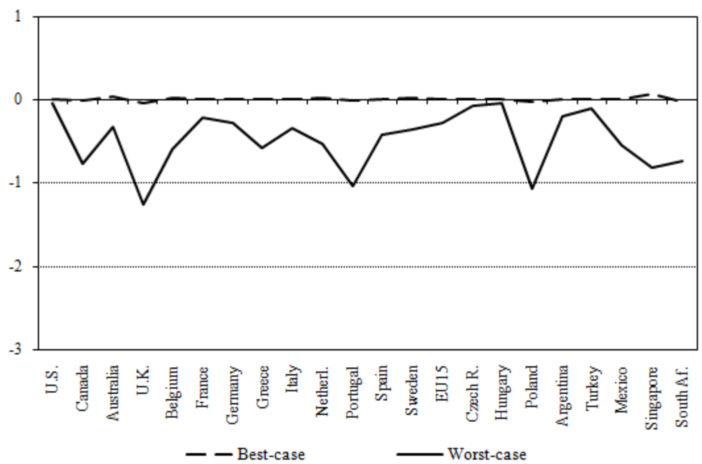
Note : The simulations show the impact on average wages (2a) wages of more educated (2b) and wages for less educated (2c) of immigration (dotted lines) and emigration (dashed lines). In each panel we use 3 values of the parameter **λ** equal to 0, 0.44 and 0.75. The other two parameters are set to $\sigma_q=1.5$, $\sigma_I=20$.

Figure 5
Average wage effects of migration
Best-case and worst-case scenarios

5a. Immigration impact on average wages of non-movers (as %)

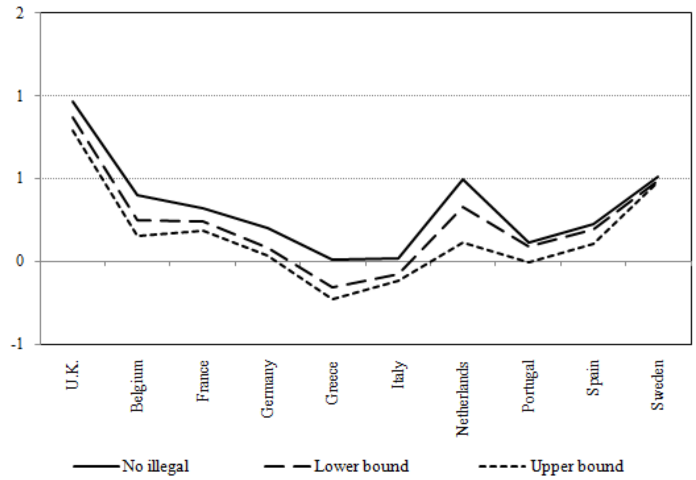


5b. Emigration impact on average wages of non-movers (as %)



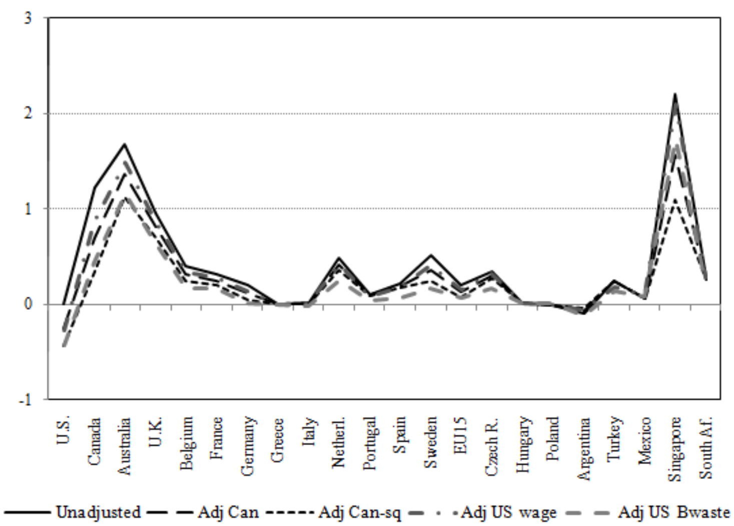
Note: The figures show the estimate average wage effect of immigration for non-migrants considering the two configurations of parameters that produce the most and the least beneficial wage effect.

Figure 6
Extension: Including undocumented immigrants, Western European Countries



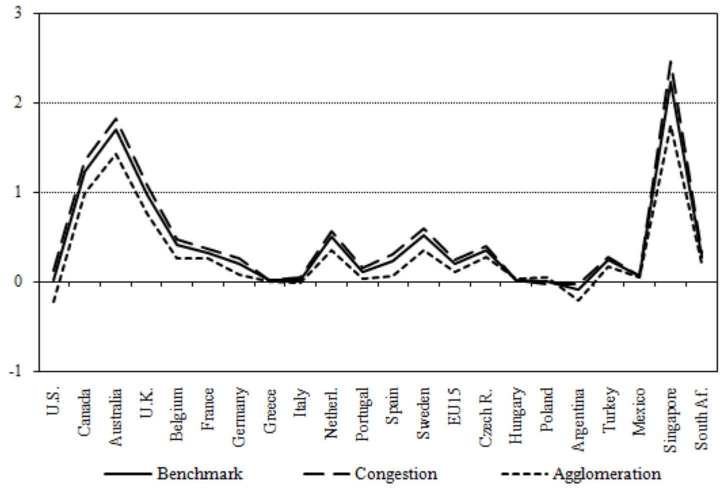
Note : The figures show the estimate average wage effect of immigration for non-migrants including the estimated flow of undocumented among less educated.

Figure 7
Extension: Effects of Immigration Adjusting for Education Quality and skill downgrading



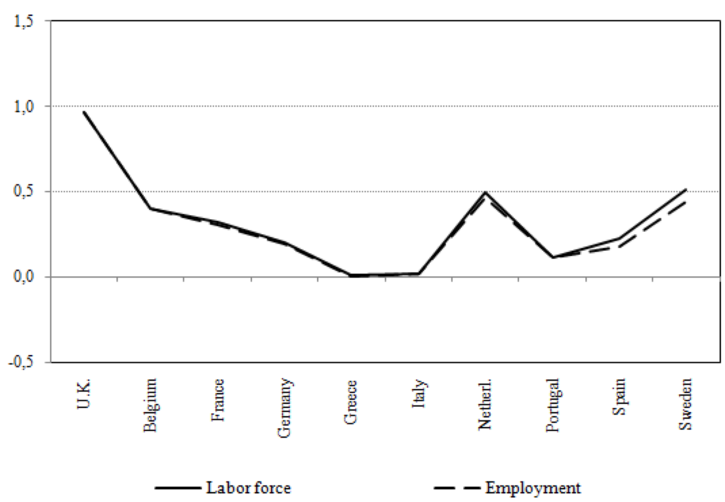
Note : The figures show the estimate average wage effect of immigration for non-migrants correcting for a country-specific quality of education of immigrants (as recorded for Canadian Immigrants) and for the labor-market performance of highly educated immigrants (as calculated for US immigrants)

Figure 8
Extension: Effects of Immigration including density/crowding externalities



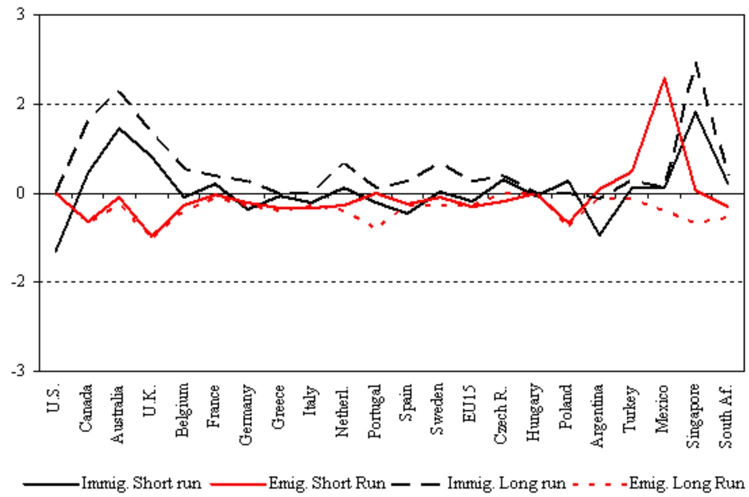
Note : The figures show the estimate average wage effect of immigration for non-migrants considering a crowding or density externality as described in the Section "Extensions" of the paper.

Figure 9
Extension: Accounting for employment rates (by skill and origin) Western European Countries



Note : The figures show the estimate average wage effect of immigration for non-migrants accounting for employment rates. We use the following rates for national low-skilled and high-skilled, and for foreign low-skilled and high-skill workers, respectively: (0.633, 0.872, 0.467, 0.749) for Belgium, (0.574, 0.803, 0.603, 0.709) for Spain, (0.675, 0.844, 0.556, 0.731) for France, Germany and Italy, (0.603, 0.825, 0.651, 0.712) for Greece, (0.718, 0.877, 0.583, 0.749) for the Netherlands, (0.738, 0.908, 0.783, 0.902) for Portugal, (0.786, 0.876, 0.598, 0.702) for Sweden, and (0.744, 0.884, 0.598, 0.828) for the UK.

Figure 10
Extension: Short-run effects of Immigration and Emigration
Accounting for sluggish Capital Adjustment



Note: The short-run effects of immigration and emigration have been calculated accounting for the sluggish capital adjustment. We assumed that the inflow of immigrants and emigrants was distributed equally over the decade 1990-2000 and that Physical capital had a yearly speed of adjustment of 0.10 (10%) each year, starting from the Balanced growth path level in 1990. The Figure reports the Long and short run effects of immigration and emigration, for the Baseline configuration of parameters.

Table and Figure Appendix

Table A1
Immigration stocks aged 25+ in 1990 and 2000 (x 1,000,000)

	1990			2000		
	Low schooling	High schooling	Total	Low schooling	High schooling	Total
OECD destinations (30/30)	28.5	12.3	40.8	37.1	20.3	57.4
Observed non-OECD destinations (31/46)	12.5	1.5	14.0	17.1	3.1	20.2
Imputed non OECD destinations (134/119)	22.9	2.5	25.4	20.1	2.8	22.9
Total (195/195)	63.9	16.3	80.2	74.3	26.2	100.5

Table A2
Stock of emigrants in 1990 and 2000 (x 1,000): Observed and imputed values

	1990				2000			
	Total	Observed	Imputed	*Imputed/tot (%)*	Total	Observed	Imputed	*Imputed/tot (%)*
U.S.	757.2	676.4	80.8	*10.7*	900.6	838.3	62.3	*6.9*
Canada	856.7	846.6	10.1	*1.2*	880.9	874.7	6.3	*0.7*
Australia	163.9	147.1	16.7	*10.2*	242.7	227.4	15.3	*6.3*
U.K.	3302.9	3070.0	232.9	*7.1*	3442.6	3260.4	182.2	*5.3*
Belgium	337.4	293.8	43.7	*12.9*	368.2	328.0	40.1	*10.9*
France	1001.7	697.4	304.2	*30.4*	1148.6	917.4	231.2	*20.1*
Germany	2448.6	2359.0	89.6	*3.7*	2554.5	2451.8	102.7	*4.0*
Greece	861.1	756.8	104.3	*12.1*	876.4	757.1	119.2	*13.6*
Italy	2714.3	2660.0	54.3	*2.0*	2604.9	2548.6	56.3	*2.2*
Netherlands	589.1	574.7	14.3	*2.4*	639.7	625.5	14.2	*2.2*
Portugal	1256.4	1160.8	95.6	*7.6*	1450.4	1315.4	135.0	*9.3*
Spain	959.4	897.6	61.9	*6.4*	973.3	924.7	48.6	*5.0*
Sweden	138.9	135.5	3.4	*2.5*	182.2	174.7	7.4	*4.1*
EU15	9693.7	8648.7	1044.9	*10.8*	9405.9	8420.6	985.3	*10.5*
Czech R.	171.6	169.3	2.3	*1.4*	217.2	215.4	1.8	*0.8*
Hungary	339.1	332.3	6.8	*2.0*	342.0	325.6	16.4	*4.8*
Poland	1309.8	1194.4	115.4	*8.8*	1419.2	1269.2	150.0	*10.6*
Argentina	208.4	183.1	25.3	*12.1*	355.9	338.3	17.6	*4.9*
Turkey	1517.9	1488.0	29.9	*2.0*	2117.5	2082.2	35.3	*1.7*
Mexico	2725.2	2693.8	31.4	*1.2*	6502.1	6457.5	44.6	*0.7*
Singapore	84.9	57.1	27.8	*32.8*	136.8	132.0	4.8	*3.5*
South Africa	224.1	132.3	91.8	*41.0*	360.0	274.0	86.0	*23.9*

Note: The observed emigrants are in one of the 30 OECD countries or one of the 46 (in 2000) or 31 (in1990) non-OECD countries for which we have data. The procedure to impute data is described in detail in the Data Appendix of the paper.

Table A3
Stock of immigrants and emigrants in 1990 and 2000 as percentage of the skill-specific labor force

	1990				2000			
	Immigrants		Emigrants		Immigrants		Emigrants	
	Low schooling	High schooling	Low schooling	High schooling	Low schooling	High schooling	Low schooling	High schooling
U.S.	8.9	9.7	0.4	0.6	15.5	11.0	0.4	0.6
Canada	18.2	23.9	4.5	5.2	19.0	25.6	3.4	5.0
Australia	27.1	34.7	1.2	2.5	23.2	37.3	1.3	3.2
U.K.	6.8	9.2	6.5	20.2	7.1	15.4	5.7	20.1
Belgium	12.3	6.1	4.9	5.3	14.0	9.1	4.6	6.4
France	10.7	4.2	2.5	3.4	10.1	6.3	2.5	3.9
Germany	6.1	4.5	3.7	7.0	8.2	6.6	3.4	6.6
Greece	6.0	8.6	12.0	20.2	5.6	5.5	10.6	15.3
Italy	1.4	1.5	7.1	6.1	2.2	1.9	6.2	5.6
Netherlands	16.1	14.2	4.6	11.6	16.1	16.2	4.2	11.3
Portugal	0.7	1.7	20.4	14.7	2.0	3.0	20.9	17.5
Spain	2.8	4.2	3.9	3.4	5.2	6.6	3.2	4.2
Sweden	10.8	7.9	1.9	4.1	12.4	11.2	2.2	4.9
EU15	3.8	3.6	3.3	7.0	5.0	5.3	2.8	6.3
Czech R.	6.0	3.0	1.7	12.1	5.7	6.1	2.3	10.0
Hungary	0.8	0.8	3.4	19.1	0.7	0.7	3.4	15.9
Poland	4.1	5.7	4.5	17.6	2.8	3.6	4.0	19.6
Argentina	0.4	0.1	0.8	3.5	3.9	1.5	1.3	3.7
Turkey	1.9	4.6	5.8	10.2	1.8	5.1	6.2	6.9
Mexico	0.3	1.6	7.9	12.4	0.2	1.6	13.5	18.5
Singapore	24.3	10.2	3.5	10.8	18.1	24.1	3.8	10.2
South Africa	3.7	13.5	1.0	10.7	3.3	8.0	0.9	8.4

Note: The data on the stock of immigrants and emigrants were obtained by the authors extending the Docquier and Marfouk (2005) database.

TableA4

Distribution of the labor force between highly educated and less educated as percentage of total (1990-2000)

	1990			2000		
	Low schooling	High schooling	Total	Low schooling	High schooling	Total
U.S.	60.8	39.2	100.0	48.7	51.3	100.0
Canada	56.2	43.8	100.0	48.5	51.5	100.0
Australia	68.9	31.1	100.0	66.0	34.0	100.0
U.K.	84.1	15.9	100.0	80.2	19.8	100.0
Belgium	77.2	22.8	100.0	72.6	27.5	100.0
Portugal	78.1	21.9	100.0	76.1	23.9	100.0
Germany	78.2	21.8	100.0	74.5	25.5	100.0
Greece	89.1	10.9	100.0	84.8	15.2	100.0
Italy	85.7	14.3	100.0	82.0	18.0	100.0
Netherlands	80.8	19.2	100.0	78.0	22.0	100.0
Portugal	90.8	9.2	100.0	87.2	12.8	100.0
Spain	88.5	11.5	100.0	84.8	15.2	100.0
Sweden	77.5	22.5	100.0	72.5	27.5	100.0
EU15	82.2	17.8	100.0	78.8	21.2	100.0
Czech R.	91.5	8.5	100.0	89.2	10.8	100.0
Hungary	89.9	10.1	100.0	88.0	12.0	100.0
Poland	91.1	8.9	100.0	88.9	11.1	100.0
Argentina	86.0	14.0	100.0	80.3	19.7	100.0
Turkey	95.0	5.0	100.0	91.5	8.5	100.0
Mexico	90.9	9.1	100.0	88.8	11.2	100.0
Singapore	83.6	16.4	100.0	78.4	21.6	100.0
South Africa	95.0	5.0	100.0	89.7	10.3	100.0

Note: The labor force of a country is defined as people older than 25. The data are from a collection of sources as described in the text.