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Immigration and economic growth in the OECD countries 1986-2006: A panel data analysis

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Abstract

This paper presents a reappraisal of the impact of migration on economic growth for 22 OECD countries between 1986 and 2006. It is based on a unique dataset that enables to distinguish net migration of the native-born and foreign-born by skill level. Migration is introduced in an augmented Solow-Swan model and the results are obtained using a GMM estimation, in order to deal with the potential endogeneity of the migration variables. In this framework, we identify a positive impact of the human capital brought by migrants on economic growth. The contribution of immigrants to the human capital accumulation tends to dominate the mechanical dilution effect, but the net effect is fairly small, including in countries which have highly selective migration policies.

Keywords: International migration, human capital, economic growth, generalized methods of moments

JEL classification: C23, F22, J24, J61, O41, O47

1. Introduction

International migration to OECD countries, notably labour migration, has increased significantly over the past decades. Between 1997 and 2007, in most southern European countries, in the United Kingdom, in the United States as well as in several Nordic countries, immigrants accounted for, on average more than 40% of net job creations. As of 2007, the share of immigrants in employment reached 12% on average in the OECD (OECD -2009). In many developed countries the first effects of population ageing, can be already seen in working-age population as baby boomers begin to retire in large numbers and youth cohorts are declining. In this context, labour migration will continue to play a significant role in the medium and longer term. For example, international migration is expected to account for all labour force growth between 2005 and 2020 in Canada, Switzerland, Sweden, Spain or the United Kingdom but also in the OECD area as a whole.

At the same time, many countries have recently adapted their migration system to make it more selective vis-à-vis skills and education. Traditional settlement countries (Australia, Canada, New Zealand and the United States) have implemented skilled migration programmes for a long time which now serve as models to other countries. The United Kingdom, Denmark and the Netherlands have recently reformed their migration system to give more priority to highly educated migrants within a points based migration system. Most European countries have also implemented specific migration programmes to attract highly skilled foreign workers (Chaloff and Lemaitre, 2009). This trend is most likely to continue, if not to reinforce, in the future.

These changes in migration trends and policies prompt us to reconsider the economic impact of migration. Empirical analyses have indeed been flourishing in recent years in two key areas susceptible of influencing public opinion's views on migration, namely the labour market impact of immigrants (Borjas -2003, 2009, Angrist and Kugler -2003, Lubotsky -2007, Ottaviano and Peri -2008[1]) and the fiscal impact of immigration (Auerbach and Oreopoulos -1999, Storesletten -2000, 2003, Hansen and Lofstrom -2003[2]). However, the debate is relatively mute on a third major area of interest, which relates to the impact of migration on economic growth. This is precisely the question addressed by this paper.

Is international migration fostering economic growth in OECD countries and to which extent? If there are little doubts about the impact of a labour shock due to migration on aggregate GDP growth, the question is not so trivial with regard to per capita GDP growth. Indeed, in the standard augmented neoclassical growth model developed by Mankiw, Romer and Weil (1992), an increase in migration will have a negative impact on long-term economic growth because of so-called “capital dilution”, which might be compensated by a positive contribution of new migrants to human capital accumulation (Dolado, Goria and Ichino -1994, Barro and Sala-I-

[1] See, for example, Longhi, S., Nijkamp, P. and Poot, J. (2005, 2008) for recent meta-analyses.
[2] See, for example, Rowthorn (2008) or Liebfritz et al. (2003) for a review of the literature on the fiscal impact

Martin -1995). Consequently, in this framework, whether migration affects positively or not per capita GDP growth depends on the scope of migration and its demographic and educational structures.

Few empirical studies have tried to estimate the impact of migration on economic growth, especially due to the lack of harmonized international data on migration. To our knowledge, the only published empirical study is Dolado, Goria and Ichino (1994). This analysis applies to the period 1960-85, which was characterized, until the second oil shock at the end of the 1970s, by large low-skilled migration concentrated in the manufacturing sector. In the past 2 decades the characteristics of international migration has evolved considerably and its impact therefore needs to be reconsidered.

This paper departs from previous studies notably by identifying independently the effect of net migration of the foreign-born and native-born by skill level. A unique data set has been developed for the paper, from various data sources, for 22 OECD countries between 1986 and 2006. A particular effort has been devoted to produce robust estimates for educational attainment of recent immigrants as well as native-born expatriates. Finally, given the current state-of-the-art in the empirical literature on the source of cross-country growth, the estimation was conducted based on system generalised method of moments (system GMM) in order to deal with endogeneity of migration variables.

The results show that, over the period considered, the impacts of migration on productivity growth via the human capital accumulation and capital dilution are significant, with the expected positive and negative signs (ie. respectively positive and negative). In most OECD countries, the former dominates the latter. Therefore, migration tends to have a small positive impact on economic growth, including in countries which have highly selective migration policies. Simulations based on these results show that, everything else being equal, a one percentage point increase in foreign-born net migration would have increased productivity growth by about a tenth of a percentage point on average for the 22 OECD countries considered.

The remainder of this paper is organised as follows. Section 2 provides a short review of the literature and section 3 presents the theoretical model. Econometric specifications are introduced in a forth section before describing the data (section 5) and analysing the empirical results (section 6). Finally, some conclusions are drawn in the last section.

2. Direct and indirect effects of migration on economic growth: an overview of the literature

International migration has potentially direct and indirect effects on economic growth. Firstly, migration flows can be viewed as a demographic shock. In the Solow-Swan textbook growth model, an increase in migration has a negative impact on the transitional path to the long-term steady state where all per capita variables are nonetheless stable. Even in this framework, however, migration affects the age structure of the population of the destination country because migrants tend to be more concentrated in active age groups compared to natives. Consequently, migration contributes to reduce dependency ratios and has potentially a positive impact on aggregate savings[3], which finally could result in higher Total Factor Productivity (TFP) growth[4]. Yet, this transmission channel has not been directly considered in the literature.

Secondly, migrants arrive with their skills and abilities, a human capital that supplements the stock of human capital of the host country. To our knowledge, Dolado, Goria and Ichino (1994) were the first to introduce migration into the Solow-Swan model augmented by human capital. In this framework the contribution of immigrants to human capital accumulation compensates, at least partially, the negative capital dilution effect associated to population growth. The authors estimate their model for 23 OECD countries between 1960 and 1985. They do not include data on migrants' average educational attainments in their estimations, but they infer the impact of the human capital brought by migrants from their econometric results. They conclude that on average migrant education represents 80% of that of the resident population. As a result, migration has a negative effect on output growth per worker by lowering the average level of human capital embodied in workers.

More recently, several authors have included migration in endogenous economic growth models. This literature considers notably the role of immigrants on technological progress and notably their contribution to innovation[5]. Walz (1995), for example, introduces migration in a two countries endogenous growth model based on Lucas (1988). He finds that the sign of the growth rate effect depends on the initial specialization of the two countries and on the fact that migration is selective towards high-skilled individuals. Robertson (2002) also analyses the impact of migration in an Uzawa-Lucas model with unskilled labour and shows that an inflow of relatively unskilled immigrants results in lower transitional growth.

Lundborg and Segerstrom (2000 and 2002) include migration in a quality ladders growth model (Grossman and Helpman -1991). They find that free migration would stimulate growth; notably if it responds to differences in labour force endowments. Similarly, in an expansion-in-variety framework, Bretschger (2001) shows that skilled migration can promote growth through decreasing costs of Research and Development but also by raising market share in certain types of goods.

However, most of the above-cited studies are theoretical and there are indeed very few empirical assessments of the impact of migration on economic growth. When such analyses exist, they are not based on structural models and are often hampered by serious data constraints.

[3] This effect may be partially offset by remittances sent by migrants to their country of origin.

[4] There are increasing evidence of the impact of changes in age structure of the population on productivity (Sarel -1995, Lindh and Malmberg -1999, Kögel -2005, Feyrer -2007)

[5] Hunt and Gauthier-Loiselle (2008) provide recent evidence on the impact of highly skilled migration in the United States on innovation. They find that a one percentage point rise in the share of immigrant college graduates in the population increases patents per capita by 6%.

Morley (2006) analyses the causality between migration and economic growth with and Autoregressive Distributed lag approach on data for Australia, Canada and the United States between 1930 and 2002. He finds evidence of a long-run causality running from per capita GDP to immigration but not the reverse. More recently, Ortega and Peri (2009) analyse the effects of immigration flows on total employment, total hours worked, physical capital accumulation and total factor productivity in 14 OECD countries, between 1980 and 2005. The authors find that migration increases employment and capital stocks, but doesn't have a significant effect on total factor productivity. Since immigration shocks lead to an increase in total employment and a proportional response of the production, output per capita is not affected by the immigration inflows. One of the limitations of the Ortega and Peri (2009) paper lies in the fact that it does not take into account the human capital of migrants[6]. In addition, these estimations are based on gross migration flows and therefore do not control for return migration.

The main contribution of this paper is to provide more robust estimates of the impact of net migration on productivity growth, controlling for endogeneity of migration, based on a clear theoretical framework which is presented in the next section and a better data set.

3. The theoretical model

As in Dolado, Goria and Ichino (1994), migration is introduced in a standard augmented neoclassical Solow-Swan growth model where aggregate output Y is produced from physical capital (K), human capital (H) and labour (L) using a Cobb-Douglas function with constant returns to scale:

$$Y = K^{\alpha} H^{\beta} \left(A\, L \right)^{1-\alpha-\beta} \qquad \alpha + \beta < 1 \tag{1}$$

where A is labour-augmenting (or Harrod-neutral) technological progress that grows at the constant exponential rate g_A.

The first channel through which migration affects the economy of the host country is demographic as new inflows of foreign workers add to labour force growth. This impact can be decomposed between net migration of foreign-born workers (M) and net migration of native-born workers (E). As we shall see in section 4.2, it is necessary to make that distinction because the dynamic and the skill composition of these two migration streams are quite dissimilar[7].

[6] Orefice (2010) also attempts to estimate the impact of migration on economic growth in a gravity model, using OECD data on gross migration flows for 24 countries between 1998 and 2007 and proxy for education based on migrant stocks in 2000. In this context, the author finds that human capital brought by migrants do not compensate for capital dilution and therefore he finds a negative impact of migration on economic growth.

[7] There might be also differences in the educational structure of inflows and outflows of foreign-born workers (resp. native-born workers) that would have justified considering gross migration flows rather that net flows by place of

Labour force growth is therefore given by[8]

$$\dot{L} = \tilde{n}L + M + E$$

$\tilde{n}$ is the growth rate of the labour force due to demographic factors (ie. new entries of young people into the labor force minus retirements and deaths notably), assumed constant.

Let m be the net migration rate of the foreign-born $m = M / L$ and e the net migration rate of the native-born ($e = E / L$). Net migration rates are supposed to be constant. The model therefore follows the Solow model by assuming that the labour force increases at a constant rate ($n = \tilde{n}+m+e$).

Immigrants and native-born returnees bring their skills and abilities, a human capital, that supplements the domestic stock of human capital human capital[9]. Inversely, those who leave the country, take away with them their human capital. This is the second channel through which migration impacts production factors endowments in this basic model.

Let's denote by h^I the average quantity of human capital that each foreign-born migrant brings along, h^E the average human capital of native-born migrants and $\hat{h}$ the average human capital per worker $\left(\hat{h} = H / L\right)$. The accumulation of human capital is given by:

$$\begin{aligned} \dot{H} &= s_H Y - \delta H + M\ h^I + E\ h^E \\ &= s_H Y - \left(\delta - \left(m\kappa^I + e\kappa^E\right)\right) H \end{aligned} \tag{2}$$

s_H is the fraction of resources devoted to human capital accumulation, δ is the rate of depreciation of human capital, $\kappa^I = h^I / \hat{h}$ (resp. $\kappa^E = h^E / \hat{h}$) is the relative human capital of foreign-born (resp. native-born) compared to the average human capital per worker in the host economy.

The dynamics of physical capital are the same as in the Solow model. A fraction s_K of the output is saved, and capital depreciates as an exogenous rate δ [10]:

$$\dot{K} = s_K Y - \delta K \tag{3}$$

Using units of effective labour ($y \equiv Y / AL$, $k \equiv K / AL$, $h \equiv H / AL$), the production function is given by:

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birth. However, in absence of relevant data source to support this hypothesis, and for the sake of simplicity, the model only takes into account net migration flows.

[8] Time subscripts are omitted for convenience.

[9] Migrants are supposed not to bring a significant amount of physical capital to the economy of the host country.

[10] Following Mankiw et *al*. (1992), human capital is assumed to depreciate at the same rate as physical capital.

$$y = k^{\alpha} h^{\beta} \quad (4)$$

The evolution of the economy is therefore determined by:

$$\dot{k} = s_K\, y - \left(\delta + g_A + n\right) k \quad (5)$$

$$\dot{h} = s_H\, y - \left(\delta + g_A + n - \left(m\, \kappa^I + e\kappa^E\right)\right) h \quad (6)$$

The economy converges to a steady state defined by:

$$k^* = \left(\frac{s_K}{\delta + g_A + n}\right)^{\frac{1-\beta}{1-\alpha-\beta}} \left(\frac{s_H}{\delta + g_A + n - \left(m\kappa^I + e\kappa^E\right)}\right)^{\frac{\beta}{1-\alpha-\beta}} \quad (7)$$

$$h^* = \left(\frac{s_K}{\delta + g_A + n}\right)^{\frac{\alpha}{1-\alpha-\beta}} \left(\frac{s_H}{\delta + g_A + n - \left(m\kappa^I + e\kappa^E\right)}\right)^{\frac{1-\alpha}{1-\alpha-\beta}} \quad (8)$$

Substituting (7) and (8) into the production function and taking logarithms, the steady-state income per effective worker is:

$$\begin{aligned} \ln y^* = {} & \frac{\alpha}{1-\alpha-\beta} \ln s_K + \frac{\beta}{1-\alpha-\beta} \ln s_H \\ & - \frac{\alpha}{1-\alpha-\beta} \ln\left(\delta + g_A + n\right) \\ & - \frac{\beta}{1-\alpha-\beta} \ln\left(\delta + g_A + n - \left(m\kappa^I + e\kappa^E\right)\right) \end{aligned} \quad (9)$$

The rate of growth as the economy converges to the steady state is then determined by :

$$\frac{\dot{y}}{y} = \frac{\partial \ln y}{\partial t} \cong -\lambda\left(\ln y(t) - \ln y^*\right) \quad (10)$$

where $\lambda = (1-\eta)(g_A + \delta + n)$ (Cf. Appendix A.1).

This leads to (11)

$$\ln y(t) - \ln y(0) \cong \left(1 - e^{-\lambda t}\right)\left(\ln y^* - \ln y(0)\right) \quad (11)$$

Where *y(0)* is income per effective labour at some initial date.

Noting that $\ln y(t) = \ln \hat{y}(t) - \ln A(0) - g_A t$ ($\hat{y}$, average income per worker) and using (9), we finally obtain the productivity growth rate:

$$\ln \hat{y}(t) - \ln \hat{y}(0) = g_A\, t + \left(1 - e^{-\lambda t}\right) \ln A(0) - \left(1 - e^{-\lambda t}\right) \ln \hat{y}(0)$$
$$+ \left(1 - e^{-\lambda t}\right) \frac{\alpha}{1 - \alpha - \beta} \left(\ln s_K - \ln\left(\delta + g_A + n\right)\right)$$
$$+ \left(1 - e^{-\lambda t}\right) \frac{\beta}{1 - \alpha - \beta} \ln s_H$$
$$- \left(1 - e^{-\lambda t}\right) \frac{\beta}{1 - \alpha - \beta} \ln\left(g_A + \delta + n - \left(m\kappa^I + e\kappa^E\right)\right) \tag{12}$$

Equation (12) indicates that for given α, β, λ and g_A, the rate of growth of productivity is negatively related to the net migration rate because of the capital dilution effect associated to population growth ($-\ln(\delta + g_A + n)$). This effect is, however, counterbalanced by a positive impact of human capital accumulation $\left(m\kappa^I + e\kappa^E\right)$. The net effect of migration on productivity growth is therefore theoretically ambiguous and depends on the relative human capital contributions of native-born and foreign-born migrants (κ^I, κ^E), on the scope of net migration (m, e) and on the parameters of the production function (α, β).

In this framework, *ceteris paribus*, an increase in the inflow of foreign workers will have a positive impact on productivity growth only if new migrants are, on average, more qualified than the resident population ($\kappa^I > 1$). That is not a sufficient condition, however, as the human capital brought by migrants should also offset the capital dilution effect. Indeed, Appendix A.2.1 shows that, provided there is not a net outflow of human capital associated to total net migration (ie. $m\kappa^I + e\kappa^E \geq 0$), $\kappa^I \geq (\alpha + \beta)/\beta$ is a sufficient condition for migration to have a positive impact on productivity growth. Below that threshold the impact will however depend on other parameters of the model.[11]

4. Empirical analysis

4.1. Econometric model

Equation (12) presents a specification that can be used to evaluate the impact of immigration on economic growth in receiving countries. Note that:

[11] The fact that migration has a positive impact on productivity growth if and only if its contribution to human capital accumulation more than compensates for the effect on capital dilution is a direct consequence of the augmented Solow-Swan theoretical framework. In this context, recent migrants need to be more qualified than the resident population to generate a positive impact on productivity growth. This would not have been necessarily the case in an endogenous growth framework.

$$\ln\left(g_A+\delta+n-\left(m\kappa^I-e\kappa^E\right)\right)=\ln\left(g_A+\delta+n\left(1-\frac{m\kappa^I+e\kappa^E}{g_A+\delta+n}\right)\right)$$
$$=\ln\left(g_A+\delta+n\right)+\ln\left(1-\frac{m\kappa^I+e\kappa^E}{g_A+\delta+n}\right) \quad (13)$$

One can expect that $\frac{m\kappa^I+e\kappa^E}{g_A+\delta+n}$ is small[12] and consequently (13) can be approximated to obtain:

$$\begin{aligned}\ln\widehat{y}_{it}-\ln\widehat{y}_{i0}=g_A\,t+\left(1-e^{-\lambda t}\right)\ln A(0)\\ -\left(1-e^{-\lambda t}\right)\ln\widehat{y}_{i0}\\ +\left(1-e^{-\lambda t}\right)\frac{\alpha}{1-\alpha-\beta}\ln s_{Kit}\\ +\left(1-e^{-\lambda t}\right)\frac{\beta}{1-\alpha-\beta}\ln s_{Hit}\\ -\left(1-e^{-\lambda t}\right)\frac{\alpha+\beta}{1-\alpha-\beta}\ln\left(g_A+\delta+n_{it}\right)\\ +\left(1-e^{-\lambda t}\right)\frac{\beta}{1-\alpha-\beta}\frac{m_{it}\kappa_{it}^I+e_{it}\kappa_{it}^E}{g_A+\delta+n_{it}}\end{aligned} \quad (14)$$

Following the standard practice in the literature[13], we assume that the convergence parameter λ is constant over time and across countries. The term *A(0)* represents all the unobserved elements (the initial level of technology, resource endowments, climate, institutions and so on). It suggests the presence of a country-specific effect, which may be correlated with the other explanatory variables considered in the model.

The model used to estimate the effect of immigration on productivity growth to be estimated for a given country *i* is a more general form of equation (14):

$$\begin{aligned}ln\hat{y}_{it}=\beta_1+\beta_2 ln\hat{y}_{i0}+\beta_3 lns_{K_{it}}+\beta_4 lns_{H_{it}}+\beta_5 ln(g_A+\delta+n_{it})+\beta_6\frac{m_{it}\kappa_{it}^I}{g_A+\delta+n_{it}}\\ +\beta_7\frac{e_{it}\kappa_{it}^E}{g_A+\delta+n_{it}}+\mu_t+\gamma_i+\nu_{it}\end{aligned} \quad (15)$$

[12] The data set, presented in the next section, indicates a mean value equals to 0.095 and a standard error of 0.14 for $\frac{m\kappa^I+e\kappa^E}{g_A+\delta+n}$.

[13] See Benhabib and Spiegel (1994), Islam (1995), and Cohen and Soto (2007).

where μ_i and γ_t represent country-specific and time-specific effects and where β_1, ..., β_7 are parameter to be estimated.

To estimate the parameters of a dynamic panel like (15), we may think about estimating first a fixed-effects model using the within transformation. The transformed model is obtained by subtracting out the time-series means for each country. It is then estimated by ordinary least squares (OLS). However, this estimator is inconsistent when the number of time period available is small (Nickell -1981). The inconsistency comes from the fact that the transformed error term obtained after removing the country means is correlated with lagged output. Kiviet (1995) proposed a corrected Within estimator that subtracts a consistent estimator of this bias from the original Within estimator[14]. However, this method is valid only if all variables are exogenous. The possible presence of endogeneity can produce biased estimates of the parameters.

An alternative estimation technique, which takes account of unobserved country-specific effects and addresses the potential endogeneity of some regressors, is the Generalized Method of Moments estimator (GMM) (Hansen -1982). This method provides a more convenient framework for obtaining asymptotically efficient estimators in the context of empirical growth models.

The analysis is based on the system GMM estimator proposed by Arellano and Bover (1995) and Blundell and Bond (1998). System GMM procedure consists of a joint estimation of the equation in first-differences and in levels. For the equations in first-differences the lagged levels of the regressors are used as instruments. For the equations in levels the lagged first-differences of the explanatory variables are used as instruments[15].

System GMM estimator is more efficient than the first-differenced, GMM estimator in dynamic panel data (Blundell and Bond, 1998, 2000; Blundell, Bond and Windmeijer, 2000). When the time series are persistent and the number of time series observations is small, Blundell and Bond (1998, pp.133) show that there is “a serious problem of weak instruments for the first-differenced GMM estimator”. They find “both a much smaller bias and much improved precision” for the system GMM.

Additionally, system GMM estimator provides consistent parameter estimates even in the presence of measurement error and endogenous regressors. It has the particular virtue that, it can be used in the absence of any strictly exogenous explanatory variables or instruments. Moreover, it is highly recommended for empirical growth models (cf. Bond et *al*. -2001).

The consistency of the GMM estimator depends on the validity of the moment conditions being

[14] This approach works only for balanced panels. Bruno (2005) develops it for the case of unbalanced panels.
[15] See table 2 below for more detailed information on the different lags that have been used for each variable.

exploited. We will therefore check the correct specification of the instruments by conducting specification tests (see Arellano and Bond -1991 for details). The overall validity of the moment conditions is checked by the conventional Sargan (1958) / Hansen (1982) test of over-identifying restrictions. Furthermore, we perform difference Sargan/Hansen test based on the difference between the two standard Sargan/Hansen statistics to test the validity of additional instruments used by the system GMM estimator. In addition, Arellano and Bond (1991) propose two tests for first-order and second-order serial correlation for the disturbances of the first-differenced equation (m_1 and m_2, respectively).

4.2. Data

The estimation was made possible due to the compilation of a unique dataset on net migration and educational attainment of migrants by place of birth for 22 OECD countries. Data refer to the period between 1986 and 2006, split in 5 sub-periods of four years[16].

If data on total net migration is relatively easily accessible, even for long time periods, no international database provides information on net migration by place of birth. In addition, statistics available on migration flows are usually not broken-down by educational level. An important part of the background work for this study has consequently consisted in gathering and estimating these data[17]. Data on net migration by place of birth were directly available from statistical offices only for a limited number of countries, including Australia (1986-2006), Germany (1986-2006), New Zealand (1986-2006), Netherlands (1990-2006), Switzerland (1998-2006) and the United Kingdom (1990-06). For the 16 other countries, net migration of the native-born (*E*) is estimated using the population stocks from population censuses, population register or labour force surveys, births and deaths data (see Appendix A.3 for more details on the estimation procedure). The OECD database[18] provides data for total net migration from which net migration of the native-born is subtracted to estimate net migration of the foreign-born (*M*). Data are presented in table A.2. in the Appendix.

Availability of data on the average educational attainments of migrant flows is even more problematic and indeed was one of the weak points of previous studies. The share of tertiary educated among recent foreign-born migrants (ie. who arrived in the destination country in the past 4 years) has been computed based on labour force survey data for European countries[19] and

[16] The dataset is a slightly unbalanced panel with 105 observations as data are missing for some periods for some countries. The list of countries, of periods covered and of main data sources are presented in Table A.1. in the Appendix.
[17] The dataset is available from the authors upon request.
[18] http://stats.oecd.org/index.aspx
[19] Because LFS data are not available before 1994, data on education for recent immigrants in 1986-90 are approximated by considering people aged 20-64 with 5 to 9 years of residence in 1994.

the United States and from population censuses for other OECD countries[20]. This share is then compared to the corresponding figure for the total resident population at the beginning of the period to estimate κ^I. Implicitly, we assume that the educational structure observed for recent foreign-born migrants applies also to total net migration of the foreign-born, which means that return migrants are supposed to have comparable educational characteristics to new migrants. This hypothesis may be problematic as we know that return migration is more likely at both ends of the skill spectrum (Dumont and Spielvogel, 2008). This may be partly compensated, however, by the fact that newly arrived migrants may be more qualified on average than those who are leaving the country at the same time and have arrived with previous migration waves.

To calculate κ^E, we take advantage of a database on immigrants in OECD countries, recently published by the OECD[21] which provides information on people born in the OECD and living in another country circa 2000 by educational attainment, age and duration of stay.

The educational attainment of native-born expatriates is directly observed from this data source for those who emigrated between 1998 and 2002 and those who emigrated between 1990 and 1994[22]. Data are then linearly extrapolated for other periods (1986-1990, 1994-1998 and 2002-2006)[23]. Implicitly again we assume that the average educational attainments observed for the native-born emigrants also apply to total net migration of the native-born (and thus to native-born return migrants). Data are presented in table A.3. in the Appendix.

Results clearly show that net migration of the native-born tends to be negative in most OECD countries over the period considered while the reverse is true for foreign-born net migration. Furthermore, net migration of the native-born is not negligible and OECD expatriates are on average significantly more qualified than both foreign-born migrants and the resident population. The capacity to distinguishing between net migration of the foreign-born and that of the native-born is therefore essential to estimate the full impact of migration on host countries.

Data on GDP and the working-age population (foreign-born and natives) are from the OECD database. Real GDP in PPP (constant prices 2000) is used to measure output Y. Labour force, L, is measured by the population aged 15-64 at the beginning of each period. So n is the growth rate of the working-age population during the period.

The saving rate is approximated by the share of investment in real GDP, taken as an average over each period. Data come from Penn World Table version 6.2 (Heston et *al.* -2006). We use a

[20] Data do not make a distinction according to where the tertiary diploma was obtained, nor does it take into account difference in skills, including language proficiency, by country of origin. Implicitly, it is assumed that all tertiary educated migrant contribute the same to the stock of human capital in the destination country.

[21] OECD (2008)

[22] The former is approximated by considering OECD expatriates with less than 5 years of residence in 2000 and the later OECD expatriates with 5 to 10 years of residence in 2000.

[23] Data on the educational attainments of the resident population are from Lutz et al. (2007).

proxy for the rate of investment in human capital (s_H) that measures approximately the percentage of the working-age population that is in tertiary school. Most previous studies have used secondary enrolment rate as the measure of educational input. However, tertiary education is identified as important for the development of innovative research and the ability to acquire and adopt it. Gemmell (1996) finds that, other things equal, tertiary education seems to be more important for economic growth in OECD countries. The data are from World Development Indicators (World Bank -2006).

Sample statistics are shown in Table 1.

Table 1 : Sample statistics

Variables	Mean	Standard deviation	Min	Max
$\frac{y_t}{y_0}$	1.09	(0.066)	0.872	1.330
y_0	36575	(9.826)	15972	83280
s_K	0.233	(0.033)	0.166	0.351
s_H	0.501	(0.185)	0.076	0.931
n	0.031	(0.031)	-0.008	0.255
$m\,\kappa^J$	0.036	(0.031)	-0.016	0.168
$e\,\kappa^E$	-0.011	(0.028)	-0.152	0.074

4.3 Results

We estimate the growth equation on data for 22 OECD countries over the period 1986-2006. The results for system GMM estimates are reported in Table 2 [24]. Two types of specifications are considered. The first is the standard augmented Solow model, which serves as a benchmark. Results for this specification are presented in column 1. The second includes migration variables in the augmented Solow model as specified in equation (15) above.

All estimated standard errors are corrected for heteroskedasticity. We report the heteroskedasticity-robust two-step parameter estimates for the GMM estimations. As expected, there is evidence of first-order serial correlation in the first-differenced residuals, while the hypothesis of no second-order serial correlation cannot be rejected. We suspect that the error term is heteroskedastic, so the Sargan statistic is inconsistent and therefore we report only results of tests based on the Hansen statistic. The Hansen test of over-identifying restrictions and the Difference Hansen test indicate that our instruments are valid[25].

Note that initial output per worker is supposed to be predetermined. Physical capital investment rate is also treated as a predetermined variable. We assume that the rate of investment in human

[24] System GMM results are computed using the xtabond2 command for STATA.

[25] Following Roodman (2009) recommendations, we use only certain lags instead of all available lags for instruments, and we collapse the instrument set.

capital and the population growth rate, partly driven by immigration, are endogenous. Immigrants would tend to go where the economic conditions are the best. Thus migration flows, such as labour force growth, may be correlated with past and current GDP shocks. According the specification tests reported Table 2, our instruments are valid.

The results from Table 2 show that most coefficient signs are in line with expectations for all specifications. Only the estimated coefficients of the rate of human capital accumulation are statistically insignificant[26].

Tableau 2 : Productivity growth Dependent variable : $\Delta \ln y_t$

	(1)	(2)
$\ln y_{it-1}$	-0.040***	-0.123***
	(0.062)	(0.097)
$\ln(s_{Kit})$	0.241***	0.286***
	(0.080)	(0.125)
$\ln(s_{Hit})$	0.011	-0.019
	(0.040)	(0.028)
$\ln(g_A+\delta+n_{it})$	-0.446**	-0.604***
	(0.209)	(0.209)
$m_{it}\ \kappa_{it}^{I}/(g_A+\delta+n_{it})$	-	0.437**
		(0.167)
$e_{it}\ \kappa_{it}^{E}/(g_A+\delta+n_{it})$	-	0.336*
		(0.186)
λ	0.010	0.032
	(0.016)	(0.027)
m_1	0.014	0.003
m_2	0.936	0.233
Hansen Test *p-value*	0.117	0.858
Difference Hansen Test *p-value*	0.319	0.458
Test $\beta_6-\beta_7=0$ *p-value*	-	0.449
Observations	110	105
Instruments	13	17

Note : Heteroskedasticity-consistent standard errors are in parentheses.
***, ** and * indicate that the coefficient is significant at 1, 5, and 10 percent respectively
The *p*-values relating to first and second order correlation tests are given by m_1 and m_2 respectively.
Instruments used for first-differenced equations are: Model (1) and(2): $ln(y_{it-2})$, $ln(y_{it-3})$ $ln(s_{kit-1})$, $ln(s_{kit-2})$ $ln(s_{Hit-2})$ $ln(s_{Hit-3})$ $ln(n_{it-2}+\delta+g_A)$ $ln(n_{it-3}+\delta+g_A)$. Model (2): $\frac{m_{it-2}\kappa_{it-2}^{I}}{n_{it-2}+\delta+g_A}$, $\frac{e_{it-2}\kappa_{it-2}^{E}}{n_{it-2}+\delta+g_A}$
Additional instruments for levels equations: Model (1) and (2): $\Delta ln(y_{it-1})$, $\Delta ln(y_{it-2})$, $\Delta ln(s_{Kit})$, $\Delta ln(s_{Kit-1})$, $\Delta ln(s_{Hit-1})$, $\Delta ln(s_{Hit-2})$, $\Delta ln(n_{it-2}+\delta+g_A)$, $\Delta ln(n_{it-3}+\delta+g_A)$. Model (2): $\Delta\left(\frac{m_{it-1}\kappa_{it-1}^{I}}{n_{it-1}+\delta+g_A}\right)$, $\Delta\left(\frac{e_{it-1}\kappa_{it-1}^{E}}{n_{it-1}+\delta+g_A}\right)$

[26] Similar results are reported by many authors (Benhabib and Spiegel -1994, Islam -1995, Bond *et al*. -2002).

Estimation of the benchmark model shows a highly significant negative coefficient for initial per capita income, but yields an implicit convergence rate, λ, of 1% per year (table 3) which is significantly lower than the value usually found in the literature (about 2%). The working-age population growth has a significantly negative effect on the growth of the productivity. The coefficient of the physical capital investment rate is positive and significant.

The estimated coefficient for human capital investment is insignificant. This is a common result in the empirical literature on the growth effects of human capital investment.[27]

The second column of Table 2 presents estimates for the augmented Solow model with migration. The human capital brought (or taken away) by foreign-born and native-born migrants are treated as endogenous. Faster growing economies are more likely to attract highly-skilled migrants, and then both the scope of migration flows and their skill composition may be correlated with past and current shocks to GDP. According to the specification tests reported Table 2, our instruments are valid.

The results reported in column 2 of Table 3 show that the coefficient on initial income has the expected negative sign and is strongly significant. It implies a conditional convergence speed of about 3% per year. The estimated coefficient for human capital investment remains insignificant. The coefficient for the growth rate of the labour force has the expected negative sign and is strongly significant.

The human capital contribution of foreign-born migrants has a positive and significant effect on productivity growth. A similar impact is found for native-born migration, although it is slightly less significant (only at the 10% level).

Equation (14) predicts that the coefficients on the foreign-born and native-born human capital should be equal. This restriction $\beta_6 - \beta_7 = 0$ is not rejected by the data, and imposing it has little effect on the coefficients' estimates.

Overall, the model seems to perform well and all coefficients have the expected signs and are significant, except the human capital investment variables.

5. The impact of immigration on productivity growth

The theoretical model described in section 2 suggests that the impact of migration on the

[27] Benhabib and Spiegel (1994: 149-150) also find that the investment in human capital between 1965 and 1985 has an insignificant effect on per capita output growth.

productivity growth is ambiguous and depends (i) on foreign-born and native-born migrants' relative human capital endowment; (ii) the scope of migration; and (iii) production parameters.

For each country included in our sample, based on the estimation results for (15) (Cf. Appendix A.2.2) and applying the average values of the variables for the period 1986-2006, we estimate the impact of an increase in the net migration rate of the foreign-born and of the impact of an increase in the skill composition of net migration flows. Results are reported in the Table 4.

Table 4. estimated impact of increases in net migration of the foreign-born and selectivity of migration on productivity growth

	Key structural variables			Impact on productivity growth, percentage points		
Country	Average annual net foreign-born migration rate, % (m)	Share of tertiary educated foreign-born migrants,% (hi)	κ^I	+1 percentage point in net migration	50% increase in net migration	10% increase in κ^I the relative share of highly skilled migrants
AT	0.47	18.9	2.0	0.25	0.060	0.18
AU	0.56	36.6	1.8	0.10	0.029	0.16
BE	0.44	33.6	1.7	0.11	0.024	0.14
CA	0.76	49.5	1.7	0.05	0.017	0.21
CH	0.97	34.2	1.9	0.14	0.070	0.33
DE	0.58	20.3	1.1	-0.14	-0.040	0.11
DK	0.33	28.4	1.4	-0.02	-0.004	0.09
ES	0.56	24.1	1.4	-0.06	-0.017	0.14
FI	0.17	24.0	1.2	-0.08	-0.007	0.04
FR	0.32	27.8	1.8	0.16	0.026	0.11
GR	0.32	13.5	1.0	-0.27	-0.044	0.06
IE	0.81	43.6	2.7	0.46	0.184	0.35
IS	0.55	34.7	2.3	0.33	0.090	0.21
IT	0.29	10.9	1.6	0.11	0.016	0.10
LU	1.24	35.5	2.1	0.13	0.083	0.43
NL	0.35	22.8	1.3	-0.04	-0.008	0.09
NO	0.36	29.4	1.3	-0.08	-0.015	0.08
NZ	0.79	35.2	1.8	0.12	0.048	0.23
PT	0.09	18.3	2.6	0.54	0.025	0.04
SE	0.50	36.6	1.6	0.06	0.016	0.15
UK	0.37	39.6	2.0	0.25	0.046	0.14
US	0.51	26.7	1.0	-0.21	-0.053	0.08
EU15	0.46	26.5	1.7	0.10	0.02	0.14

Note: κ^I is the relative human capital of foreign-born (resp. native-born) migrants compared to the average human capital per worker in the host economy. On average over the period considered κ^I is slightly below 1 only for two countries, the United States and Greece.

Results show that in most OECD countries, taking into account the skill composition of foreign-born migrants, increasing the net migration rate of foreign-born workers by 1 percentage point would generate a positive increase in productivity growth comprise between one and five tenth of a percentage point (column 4, Table 4). Small negative impacts are observed for about a third of the countries in our sample because in these countries immigrants are not sufficiently skilled compared with the native-born to positively affect productivity growth.

A one percentage point increase in net migration is, however, not necessarily comparable across countries as it represents quite distinct shocks on migration. If we consider a 50% increase in net migration of the foreign-born, everything else being equal, we find in all countries, except may be in Ireland, Iceland and Luxembourg, that the change in productivity growth is negligible (column 5, Table 4).

In this framework, adopting more selective migration policies has a more direct impact. If we assume a 10% increase in the relative share of tertiary educated immigrants compared with the resident population (column 6, Table 4), we find a systematically positive and often sizeable impact on productivity growth. Raising the average education level of new immigrants will have a particularly large impact in countries such as Switzerland, Ireland or Luxemburg where net migration is more important.

6. Conclusion

This paper provided a new look at the impact of migration on economic growth, which is based on an effort to collect and estimate recent data on net migration of the foreign-born and the native-born by skill levels for 22 OECD countries between 1986 and 2006.

The theoretical model takes into account two contrasting impacts of migration on capital dilution and on human capital accumulation in a standard augmented Solow-Swan framework. Depending on the relative skill endowment of migrants compared with the resident population, the impact of migration may be able to positively impact productivity growth.

Estimations were conducted based on system GMM, in order to deal with the potential endogeneity of the migration variables. They support the theoretical model and demonstrate a positive impact of the human capital brought by migrants on economic growth. The contribution of immigrants to the human capital accumulation tends to dominate the mechanical dilution effect, but the net effect is fairly small, including in countries which have highly selective migration policies. An increase of 50% in net migration of the foreign-born generates less than one tenth of a percentage-point variation in productivity growth in all the countries but one. Increasing selectivity of migration logically yields to more positive effects on productivity growth.

Obviously one could argue that our model only partially captures the effects of migration on economic growth. For example, migration also contributes to reshape the age pyramid of receiving countries as migrants tend to be more concentrated in active age groups compared with natives and therefore contribute to reduce dependency ratios. Moreover, skilled immigrants may contribute to research and could boost innovation and technological progress. Further research is needed to take into account these effects before one can definitively state the full impact of migration on economic growth, although our results suggest that one should not expect large gains, nor significant looses, in terms of productivity from migration.

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Appendix :

A.1. The speed of convergence :

Using the production function in intensive form (equation 4):

$$y = k^{\alpha} h^{\beta}$$

$$\frac{\dot{y}}{y} = \alpha \frac{\dot{k}}{k} + \beta \frac{\dot{h}}{h}$$

$$\frac{\dot{y}}{y} = \alpha \left[s_K \ \frac{y}{k} - (\delta + g_A + n) \right] + \beta \left[s_H \ \frac{y}{h} - \left(\delta + g_A + n - \left(m\ \kappa^I + e\ \kappa^E \right) \right) \right]$$

Noted that at the steady state (from 7 and 8) :

$$s_K \ \frac{y*}{k*} = (\delta + g_A + n)$$
$$s_H \ \frac{y*}{h*} = \delta + g_A + n - \left(m\ \kappa^I + e\ \kappa^E \right) \tag{A.1}$$

Then :

$$\frac{\dot{y}}{y} = \alpha \left[s_K \ \frac{y}{k} - s_K \ \frac{y*}{k*} \right] + \beta \left[s_H \ \frac{y}{h} - s_H \ \frac{y*}{h*} \right]$$

$$\frac{\dot{y}}{y} = \alpha s_K \ \frac{y*}{k*} \left[\left(\frac{k}{k*} \right)^{\alpha-1} \left(\frac{h}{h*} \right)^{\beta} - 1 \right] + \beta s_H \ \frac{y*}{h*} \left[\left(\frac{k}{k*} \right)^{\alpha} \left(\frac{h}{h*} \right)^{\beta-1} - 1 \right] \tag{A.2}$$

Noted that :

$$\left(\frac{k}{k*} \right)^{\alpha-1} \left(\frac{h}{h*} \right)^{\beta} - 1 = \exp\left[(\alpha - 1) \ln\left(\frac{k}{k*} \right) + \beta \ln\left(\frac{h}{h*} \right) \right] - 1$$

Around the steady state $(\alpha - 1)\ln\left(\frac{k}{k*}\right) + \beta \ln\left(\frac{h}{h*}\right)$ is small, so we can use exponential approximation : $e^x = 1 + x$:

$$\left(\frac{k}{k*} \right)^{\alpha-1} \left(\frac{h}{h*} \right)^{\beta} - 1 = (\alpha - 1) \ln\left(\frac{k}{k*} \right) + \beta \ln\left(\frac{h}{h*} \right)$$
$$\left(\frac{k}{k*} \right)^{\alpha} \left(\frac{h}{h*} \right)^{\beta-1} - 1 = \alpha \ln\left(\frac{k}{k*} \right) + (\beta - 1) \ln\left(\frac{h}{h*} \right) \tag{A.3}$$

Substituting (A.1.) and (A.3) into (A.2)

$$\frac{\dot{y}}{y}=\alpha(\delta+g_A+n)\left[(\alpha-1)\ln\left(\frac{k}{k*}\right)+\beta\ln\left(\frac{h}{h*}\right)\right]$$
$$+\beta\left(\delta+g_A+n-\left(m\,\kappa^I-e\,\kappa^E\right)\right)\left[\alpha\ln\left(\frac{k}{k*}\right)+(\beta-1)\ln\left(\frac{h}{h*}\right)\right]$$

$$\frac{\dot{y}}{y}=\alpha(\delta+g_A+n)\left[\ln\left(\frac{y}{y*}\right)-\ln\left(\frac{k}{k*}\right)\right]+\beta(\delta+g_A+n)\left[\ln\left(\frac{y}{y*}\right)-\ln\left(\frac{h}{h*}\right)\right]$$
$$-\beta\left(m\,\kappa^I+e\,\kappa^E\right)\left[\ln\left(\frac{y}{y*}\right)-\ln\left(\frac{h}{h*}\right)\right]$$

$$\frac{\dot{y}}{y}=-(\delta+g_A+n)\left[(1-\alpha-\beta)\ln\left(\frac{y}{y*}\right)+\beta\frac{m\,\kappa^I+e\,\kappa^E}{\delta+g_A+n}\left[\ln\left(\frac{y}{y*}\right)-\ln\left(\frac{h}{h*}\right)\right]\right]$$

For $\frac{m\,\kappa^I+e\,\kappa^E}{\delta+g_A+n}$ small, $\beta\frac{m\,\kappa^I+e\,\kappa^E}{\delta+g_A+n}\left[\ln\left(\frac{y}{y*}\right)-\ln\left(\frac{h}{h*}\right)\right]$ may be neglected. So, the rate of growth as the economy converges to the steady state is :

$$\frac{\dot{y}}{y}=-(\delta+g_A+n)(1-\alpha-\beta)\ln\left(\frac{y}{y*}\right)$$

The rate of convergence is given by :

$$\lambda=(1-\alpha-\beta)(\delta+g_A+n)$$

A.2. The growth effect of migration :

A.2.1 The theoretical model

The annual growth rate of output per worker $g_{\hat{y}}$ is given by equation (13) :

$$\ln\widehat{y}(t)-\ln\widehat{y}(0)=tg_{\hat{y}}$$
$$=g_A\,t+\left(1-e^{-\lambda t}\right)\ln A(0)-\left(1-e^{-\lambda t}\right)\ln\widehat{y}(0)$$
$$+\left(1-e^{-\lambda t}\right)\frac{\alpha}{1-\alpha-\beta}\left(\ln s_K-\ln(\delta+g_A+n)\right)$$
$$+\left(1-e^{-\lambda t}\right)\frac{\beta}{1-\alpha-\beta}\ln s_H$$
$$-\left(1-e^{-\lambda t}\right)\frac{\beta}{1-\alpha-\beta}\ln\left(g_A+\delta+n-\left(m\kappa^I+e\kappa^E\right)\right)$$

$$tg_{\hat{y}} = \ln \widehat{y}(t) - \ln \widehat{y}(0) = g_A t + \left(1-e^{-\lambda t}\right)\left(\ln A(0) - \ln \widehat{y}(0) - \ln y^*\right)$$

The growth impact of the immigrants flow is given by

$$t\frac{\partial g_{\hat{y}}}{\partial m} = \frac{\partial\left(\ln \widehat{y}(t) - \ln \widehat{y}(0)\right)}{\partial m} = \frac{\partial\left(1-e^{-\lambda t}\right)}{\partial m}\left(\ln A(0) - \ln \widehat{y}(0) - \ln y^*\right) + \left(1-e^{-\lambda t}\right)\frac{\partial \ln y^*}{\partial m}$$

Given the rate of convergence

$$\begin{aligned}\frac{\partial\left(1-e^{-\lambda t}\right)}{\partial m}\left(\ln A(0) - \ln \widehat{y}(0) - \ln y^*\right) &= \frac{\partial \lambda}{\partial m} te^{-\lambda t}\left(\ln A(0) - \ln \widehat{y}(0) - \ln y^*\right) \\ &= \frac{(1-\alpha-\beta)te^{-\lambda t}t\left(g_{\hat{y}} - g_A\right)}{\left(1-e^{-\lambda t}\right)}\end{aligned}$$

Countries are supposed growing near their steady state, so $g_{\hat{y}} - g_A \approx 0$ and the growth impact of the immigrants flow is determined by the partial derivation of $ln\ y^*$ given by equation (9) with respect to immigration rate m :

$$\begin{aligned} t\frac{\partial g_{\hat{y}}}{\partial m} &= \left(1-e^{-\lambda t}\right)\frac{\partial \ln y^*}{\partial m} \\ &= \left(1-e^{-\lambda t}\right)\underbrace{\frac{\left(-(\alpha+\beta)+\beta\,\kappa^I\right)\left(g_A+\delta+n\right)+\alpha\left(m\,\kappa^I + e\,\kappa^E\right)}{(1-\alpha-\beta)\left(g_A+\delta+n\right)\left(g_A+\delta+n-\left(m\,\kappa^I+e\,\kappa^E\right)\right)}}_{\geq 0} \end{aligned} \quad (A.4)$$

The growth impact of the relative human capital endowment of immigrants κ^I is given by

$$\begin{aligned} t\frac{\partial g_{\hat{y}}}{\partial \kappa^I} &= \frac{\partial\left(\ln y(t) - \ln y(0)\right)}{\partial \kappa^I} = \left(1-e^{-\lambda t}\right)\frac{\partial \ln y^*}{\partial \kappa^I} \\ &= \frac{\left(1-e^{-\lambda t}\right)\beta\, m}{(1-\alpha-\beta)\left(g_A+\delta+n-\left(m\,\kappa^I+e\,\kappa^E\right)\right)} \end{aligned} \quad (A.5)$$

A.2.1 Empirical analysis

The growth impact of the foreign-born migrants (m) in Table 4 is evaluated from the estimation of the econometric model, given by equation (15) :

$$\begin{aligned}\ln\widehat{y}_{it} - \ln\widehat{y}_{i0} &= \hat{\beta}_1 + \left(\hat{\beta}_2 - 1\right)\ln\widehat{y}_{i0} + \hat{\beta}_3 \ln s_{K_{it}} + \hat{\beta}_4 \ln s_{H_{it}} \\ &+ \hat{\beta}_5 \ln(\delta + g_A + n_{it}) + \hat{\beta}_6\,\frac{m_{it}\kappa^I_{it}}{\delta + g_A + n_{it}} + \hat{\beta}_7\,\frac{e_{it}\kappa^E_{it}}{\delta + g_A + n_{it}}\end{aligned}$$

Where n=n+m+e.

$$t\frac{\partial g_{\hat{y}}}{\partial m} = \hat{\beta}_5 \frac{\partial \ln(\delta + g_A + n)}{\partial m} + \hat{\beta}_6 \frac{\partial (m\kappa^I/\delta + g_A + n)}{\partial m} + \hat{\beta}_7 \frac{\partial (e\kappa^E/\delta + g_A + n)}{\partial m}$$
$$= \frac{\left(\hat{\beta}_5 + \hat{\beta}_6\kappa^I\right)(\delta + g_A + n) - \hat{\beta}_6 m\kappa^I - \hat{\beta}_7 e\kappa^E}{(\delta + g_A + n)^2}$$

Time and country subscripts are omitted for convenience.
The growth impact of the immigrants' skill composition (κ^I) can be appreciated by:

$$t\frac{\partial g_{\hat{y}}}{\partial \kappa^I} = \hat{\beta}_6 \frac{m}{\delta + g_A + n}$$

A.3. Estimation of the net migration by country of birth

This section presents the methodology used to estimate net migration by country of birth when these are not directly available from national statistics. Data sources are mainly national population censuses held between 1980 and 2006, Population registers and European Labour force survey (LFS). Table A.1 summarizes data sources for each country. Data on deaths, births and net migration are from the OECD database. Deaths by age group are from the World Health Organization Mortality Data Base (WHO).

According to the classic demographic equation the native born population at any point in the time is equal to the native population at the previous point in time plus natural increase (the number of births *B* in the country minus deaths of the native born *NBD*[28]) and net migration of the native-born (*NBM*):

$$NBP_{t+1} = NBP_t + B_{t-t+1} - NBD_{t-t+1} + NBM_{t-t+1}$$

The native-born net migration is then given by:

$$NBM_{t-(t+1)} = NBP_{t+1} - NBP_t - (B_{t-t+1} - NBD_{t-t+1})$$

The foreign-born net migration is given by the difference between total net migration and net migration of the native-born as estimated above[29].

[28] Note that all births are by definition natives, but deaths included also the foreign born deaths. In order to evaluate the deaths of the native-born, we applied the share of native-born in the total population, corrected by their age structure from DIOC and mortality rates by age from the WHO, to the totals of deaths.
[29] When census data are used, the statistical adjustment was added to net migration of the foreign born, except for France between 1990 and 1999 (to the native-born), and for Italy (not included).

Table A.1 Main data sources for net migration data and the educational attainment of recent foreign-born migrants

Country	Period	Foreign-born and native-born net migration	Education of recent foreign-born migrants
AT	1994-2006	LFS	LFS
AU	1986-2006	Department of Immigration and Citizenship	Census
BE	1986-1990	Census	LFS
	1990-2006	Register	LFS
CA	1986-2006	Census	Census
CH	1986-1998	Census	LFS
	1998-2006	Federal Statistical Office (FSO).	LFS
DE	1986-2006	Federal Statistical Office (Destatis)	LFS
DK	1986-1990	Census	LFS
	1990-2006	Register	LFS
ES	1986-2002	Census	LFS
	2002-2006	Register	LFS
FI	1986-1990	Census	LFS
	1990-2006	Register	LFS
FR	1986-2006	Census	LFS
GR	1994-2006	LFS	LFS
IE	1986-2006	Census	LFS
IS	1986-2006	Register	LFS
IT	1986-2002	Census	LFS
LU	1986-2002	Census	LFS
LU	2002-2006	LFS	LFS
NL	1986-2006	CBS	LFS
NO	1986-2006	Register	LFS
NZ	1986-2006	Statistics New Zealand	Census
PT	1986-2002	Census	LFS
	2002-2006	LFS	LFS
SE	1986-1990	Census	LFS
	1990-2002	Register	LFS
	2002-2006	Statistics Sweden	LFS
UK	1986-1990	Census	DIOC
	1990-2006	Office for National Statistics	LFS
USA	1986-2006	Census	LFS

LFS : Labour Force Survey Eurostat for European countries and Current population survey for the United States.
DIOC: Database on immigrants in OECD countries

Table A2. **Net migration rates of native-born and foreign-born in seleceted OECD countries, 1986-2006, thousands**

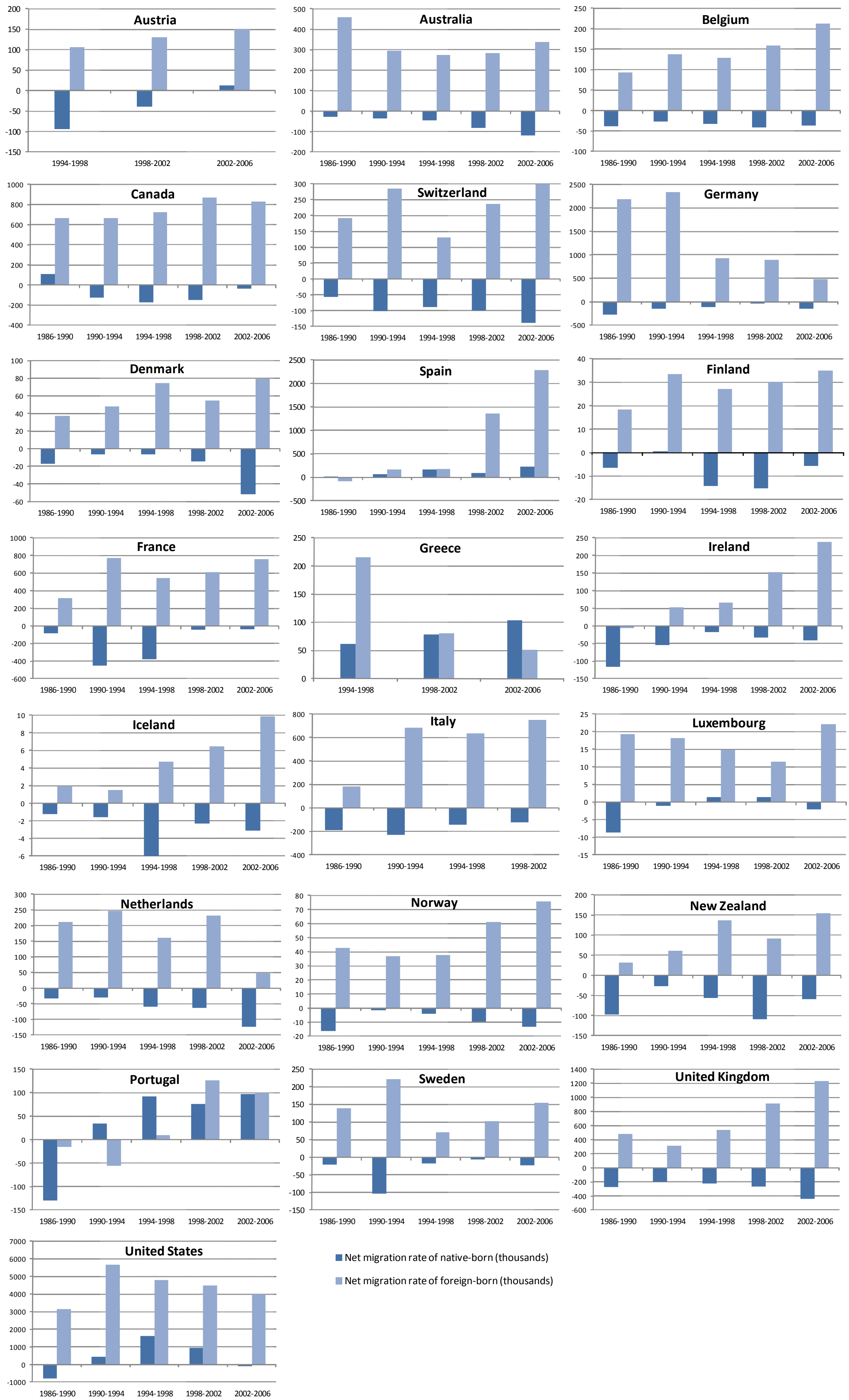

Table A3. **Share of tertiary educated among native-born emigrants and immigrants in selected OECD countries, 1986-2006, percentage**