Immigration and host countries income and productivity: A channel accounting approach

Mariya Aleksynska, Ahmed Tritah*

March 2009

Abstract

This paper investigates the economy wide contribution of immigration to income and productivity of host countries. Using a dataset constructed from census data and labour force surveys for 20 OECD countries in the period from 1960 to 2005, we explore the information on age and educational attainment of immigrants to decompose the contribution of heterogeneous migration to income into its contribution to physical output, human capital, including employment and education, as well as total factor productivity. We combine level accounting approach with panel income regressions, and also account for the endogeneity of migration choices. The main findings are that, owing to their complementarity with natives in terms of age and education, immigrants do not have any detrimental impact on income or productivity of host countries. The adjustment process involves employment and capital accumulation, but also changes in the level of human capital and TFP. In particular, in the long run, unskilled immigrants have a positive impact on host country productivity by rising the equilibrium capital output ratio (investment rate) in the economy.

JEL classification: *F22, J24, J31, O31*

Keywords: International migration, productivity, income, employment, instrumental variable

1 Introduction

During the last decade immigration has increased in most of the OECD countries. Yet, some countries have been receiving significant inflows of immigrants

*Corresponding author: ahmed.tritah@cepii.fr. Address: 9 Rue Georges Pitard 75015 Paris. Part of this study has been done while the second author was visiting the Robert Schuman Center for Advanced Studies at the European University Institute which is gratefully acknowledge for its hospitality. We are thankful to Xavier Chojnicki for very helpful advice on migration and demographic data.

starting already from the 1960-es. Immigration has become an important component of the OECD labour force, shaping its structure and dynamics over a relatively long period of time. In this paper, we use this simple observation to investigate whether immigration has been an important source of cross country income and productivity differences over this period.

Despite the fact that immigration is at the forefront of the economic and political arena, the real impact of immigration on the host economy is still hotly debated. There is a strong literature tradition to focus on the immigrants' impact on employment and wages of natives (Borjas, 2003; Card, 2005), however, some authors (Lewis, 2005; Ottaviano and Peri, 2008) have stressed the importance of taking into account general equilibrium effects at the country level. Being "more than a simple labour supply shock" (Peri, 2008), immigration affects relative supply of workers with different characteristics. As such, it has an impact that goes beyond simple augmentation of labour supply, and affects specialization patterns, investment decisions, and choice of technology. The contribution of this paper is to explore these long term economy-wide effects of immigration on aggregate output and productivity.[1] Using development accounting methods and factor-proportions approach (Hall and Jones 1999, Caselli 2005, Freyer 2007), we study the impact of immigration on the decomposed accumulable factors of production: physical capital, human capital, including employment rates, and total factor productivity. By doing so, we identify the most important channels through which economies adjust to immigration.

In addition, we are also interested in exploring the heterogeneity of immigrant labour input with respect to the labor input of natives, the importance of which is highlighted by Friedberg and Hunt (1995), and more recently by Ottaviano and Peri (2006, 2007, 2008). Specifically, we decompose the ratio of immigrants over natives into nine groups, by three age and three education categories, and exploit the variation in these characteristics of immigrants as opposed to natives across countries and over time. Up till now, existing cross-country studies on the economy wide impact of immigrants failed to take into account their skill composition. This weakness clashes with most micro empir-

[1] As compared to the literature on migration, growth and convergence, such as Barro and Sala-i-Martin (1991, 1995).

ical labor studies that stress the importance of complementarities in assessing the impact of immigrants on natives labor market outcome. For example, Ottaviano and Peri (2005) and Peri (2007) consider immigrants as being imperfectly substitutable to native workers, notably due to their different education and experience, and show that to fully account for immigrants impact on wages at national level, one needs to consider physical capital adjustments to migration shocks within detailed education and experience groups of workers. Thus, we are offering a complementary approach to the studies that have essentially focused on local impact of immigration within a single country.[2] Understanding the effect of immigration on income and productivity, and decomposing this effect into its channel of transmissions, is also important for reconciling previous empirical results with theory, such as the finding that immigration does not significantly lower wages or employment of natives.

The investigation on the effect of immigrants on productivity and income using cross-country panel analysis has been hindered by the lack of detailed data on the number of immigrants across countries and over time. An important contribution of this paper is to build the analysis on a new and unique dataset on migrant characteristics by age and education level in 20 OECD countries. Thus, in addition to standard data on output, physical capital and human capital, we undertake a challenging construction of the shares of migrants over natives decomposed by three age and three skilled groups, by five-year intervals, in the period from 1960 to 2005, using individual country-year censuses and complementary labor force surveys. Our data set on migrants by age and schooling show that immigrants have demographics and educational characteristics complementary to those of natives, even in countries that are traditionally non selective. Moreover, the share of immigrants within groups defined by age and education has significant variation over time and across countries.

Another contribution of this paper is the use of data on past population age structure to deal with the endogeneity of factor accumulation which in our context take the form of inflows of immigrants to highly productive countries

[2] Among studies done in a setting of several countries and years are Angrist and Krueger (2003) and Jean and Jiménez (2007), however, they mainly focus on the employment effect of immigration.

(Bils and Klenow, 2000). At the same time we adress the issue of measurement errors in the share of immigrants because of the collection of data from various national agencies.

Unlike many other variables used in cross-country panel setting, current demographic structure is strongly predetermined relatively to current output movements, as it results from fertility decisions made 20 to 60 years earlier (Feyrer, 2007). Moreover, even though the general tendency in the core OECD countries is the labor force ageing, the demographic structure presents substantial variation over time and across countries, providing necessary variance in the panel data setting.[3] Thus, we use lagged demographic structure of the current labor force population as an exogenous immigrants' destination country pull factor. In addition, we explore further our immigration data, and instrument changes in immigration rates with time varying lagged ratio of females to males in the migrant population, as well as with the lag share of immigrants. An imbalanced sex ratio among immigrants should encourage additional immigration of the disadvantage gender. At the same time, the sex ratio can serve as a proxy for the type of migration policy. A more balanced sex-ratio is likely to reflect a family oriented type policy targeted toward permanent residence. Instead, in a guest-worker type of program, the sex-ratio is more likely to be unbalanced.

The findings of this paper suggest that, on average, once the endogeneity of migration choices is controlled for, immigrants have no impact on income and productivity, but that they do positively affect the TFP in host countries.

At the same time, we show that this aggregate result can be explained by complementarities in age and education dimensions of immigrant relative to native population. Decomposition of immigration rate by skill and education reveals local complementarities between natives and immigrants. For example, productivity is affected positively by a higher share of middle-aged immigrants, but negatively by a higher share of young workers. We interpret the latter effect as a short-term impact, because young immigrants, on average, have less

[3] As emphasized by Feyrer (2007) predetemined variables that have time series variations are rare in empirical growth literature. Indeed for most variables that change over time like trade and education reversed causality can not be rejected. Unlike our demographic variables, plausible exogenous variables that could be used as instruments, such as geographic measure tend to lack time series variation.

years of residence in hosts countries. Long term migration, as measured by the share of immigrants among older workers, shows no impact on productivity. We find that this is due to the countries' adjustment to past migration shocks, reflected in the significant impact of higher share of older immigrants on factor accumulations.

As for the relative education of immigrants, a larger share of unskilled immigrants is associated with lower productivity, while a higher share of middle skilled workers has the opposite effect.

Controlling for both age and education, we do not find any impact of immigrants on income and productivity in the short (or medium run), though there is some evidence that immigrants influence various productivity channels. Many of the short- and medium-term channel effects cancel out in the aggregate. In contrast, we find a positive effect on productivity for the oldest group of unskilled immigrants, which reflects the positive long-term effect of past migration shocks. This result also suggests that complementarity of immigrants with natives goes beyond their observable characteristics, such as age and education, and in the long run materializes through changes in factor accumulation, such as a higher equilibrium investment rate. The latter is consistent with the views that immigrants create new opportunities for investment that raises productivity, increase saving capacity of hosts countries, and increase return to capital by increasing the labour input.

The paper is organized as follows. The next section presents the production function channel accounting framework. It is followed by the data description and descriptive statistics in Section 3. The main analysis is carried out in Section 4, which presents the estimates of the effect of immigration on hosts countries income and productivity and its channel decomposition using different measures of migration shares over native population. It also provides a few robustness checks. Section 5 concludes.

2 The Empirical Framework

We work within an income decomposition framework, which allows distinguishing the impact of immigrants on the host country income and productivity

through different components of countries' aggregate production functions. In other words, we seek to assess to what extent immigration explains differences in per capita output and productivity across countries and to identify the most important channels of this process. Following Hall and Jones (1999), Wong (2001), and Freyer (2007), we extend the development accounting decomposition to cross-country panel accounting.

Assume that Y_{it}, the output in country i at period t, is produced with physical capital K_{it} and human capital H_{it} according to:

$$Y_{it} = K_{it}^{\alpha}(A_{it}H_{it})^{1-\alpha} \tag{1}$$

where A_{it} is a labor-augmenting total factor productivity. The aggregate human capital input H_{it} can be further decomposed into the product of raw labor, L_{it} and human capital per worker h_{it}:

$$H_{it} = h_{it} * L_{it} = h_{it} * emp_{it} * P_{it}$$

where the raw labor L_{it} is the product of emp_{it}, the share of the total population which is employed, and the total population P_{it}. Following Bils and Klenow (2000), human capital per worker embeds the exponential structure of years of schooling, S_{it}, of a representative worker:

$$h_{it} = e^{\beta_{it}S_{it}} \tag{2}$$

and β_{it} represents Mincerian return to a year of schooling (Mincer, 1974). An additional year of schooling increases effective labor by 100*β% and therefore increases labor productivity by the same amount. The exponential structure assumed in this production function is traditional in labor economics, and is also consistent with the literature on growth empirics that estimates log output as a linear function of years of education (Cohen and Soto, 2007). It has also been followed by most of studies on development accounting such as Hall and Jones (1999) and Caselli (2005).

Noting that output per capita, y_{it}, is the product of output per worker and employment rate we have:

$$y_{it} = A_{it}\kappa_{it}^{\frac{\alpha}{1-\alpha}} * h_{it} * emp_{it} \tag{3}$$

where κ_{it} is the capital output ratio. The capital output ratio is used instead of capital per worker because the former captures variations in capital accumulation that are not induced by differences in A. For instance, in the steady state of the Solow model, the ratio depends only on the saving rates and population growth rate, while capital per worker is also a function of A.

Taking logs on both side yields the following output decomposition:

$$\log(y_{it}) = \log(A_{it}) + \frac{\alpha}{1-\alpha}\log(\kappa_{it}) + \log(h_{it}) + \log(emp_{it}) \tag{4}$$

Within this channel accounting exercise, we regress each of the components of output per capita on various measures of immigration. At the onset assume that the log of output per capita, or any of its components, in country i at period t, is a function of a time invariant fixed-effect f_i, a time trend common to all countries μ_t and a vector of explanatory variables x_{it}, measuring the share of immigrants over natives in various demographic and skill sub-groups:

$$\log(y_{i,t}) = f_i + \mu_t + \beta x_{i,t} + u_{i,t}. \tag{5}$$

All variables are measured at five-year time intervals, which partially mitigates the problem of serial correlation in the error term. Serial correlation, while not affecting the consistency of the parameter estimated, can lead to misstated standard errors. To deal with this issue, we exploit the panel structure of the data and cluster standard errors by country. This approach allows for an arbitrary covariance structure within countries and produces consistent estimates of the standard errors.

Equation (4) is an identity. Therefore, any impact of immigrants on output should go through any of the four determinants of income identified in Eq. (4), the first three components amounting to worker productivity. In particular, given any linear conditional expectation function E, the conditional expectation of $\log(y_{it})$, given the explanatory random variable x_{it} can be decomposed as:[4]

[4]For the sake of presentation the expectation of country and time fixed effects has been omitted.

$$
\begin{aligned}
E\left[\log(y_{it})|x_{it}\right] &= E\left[\log(A_{it})|x_{it}\right] + \frac{\alpha}{1-\alpha} E\left[\log(\kappa_{it})|x_{it}\right] \\
&\quad + E\left[\log(h_{it})|x_{it}\right] + E\left[\log(emp_{it})|x_{it}\right] \\
&= (\hat{\beta}_A + \hat{\beta}_\kappa + \hat{\beta}_h + \hat{\beta}_{emp}) * x_{it} \\
&= \hat{\beta} * x_{it} + E(u_{it}/x_{it})
\end{aligned} \tag{6}
$$

where $\hat{\beta}_j$ is the coefficient estimate obtained from the regression of the variable j on any explanatory variable x_{it}. We refer to $\hat{\beta}_j$ as the contribution of x_{it} to income, or productivity, that goes through factor j. This decomposition allows comparing the magnitude of coefficients, since by design they sum to one, and identify the main channels through which immigrants impact host countries' income and productivity. Moreover, even if one does not find any impact on overall income and productivity, (6) can still provide explanation to whether economies adapt to specific migration through changes in factors' efficiency, A_{it}, or accumulable inputs κ_{it}, h_{it}, emp_{it}.

There are two important concerns with the estimation of (5). Providing that $E(u_{it}/x_{it}) = 0$, Eq. (5) can be consistently estimated via OLS. However, we should seriously consider the simultaneity between immigration and productivity which results in a positive correlation between the disturbance in the productivity regressions and differences in immigration rates, that is $E(u_{it}/x_{it}) \neq 0$. The simultaneity issue is relevant for each determinant of output. For instance, a shock to productivity will raise labor demand and exert a pull effect on immigrants. Similarly, immigrants are more likely to settle in countries with good and growing employment opportunities, which means that the coefficient on employment is biased upwards in least square estimations.

Second, measurement errors in immigrant shares can bias the estimated impact toward zero, a possibility mooted by Card and Dinardo (2000). In our case, this concern is especially severe, as migration stocks are gathered from different national agencies over a long time period.

To address both concerns we will be using Intrumental Variables on within groups. We take advantage of an interesting feature of demographics: native population structure depends on past fertility decisions. These decisions are

highly predetermined and are orthogonal to unobserved factors that influence current productivity and its components. However, they shape the size and age distribution of future native population and, as a consequence, the current weight of immigrants in the working age population. Thus, we use lagged demographic structure of the current population in the labor force to instrument the current share of immigrants in the population. For instance, a small cohort of young individuals entering the labor market and a large cohort of old individuals leaving it due to past negative and positive demographic shocks, means that the economy is affected by a pre-determined negative labor supply shock, and that this shock is unevenly distributed across various demographic segments of the working age population. An economy short of young labor supply should be more open to young immigrants.[5] In contrast, a large cohort of young workers entering and a small cohort of old workers leaving the labor market should produce an opposite effect. In all IV regressions, the results are systematically completed by specifications tests.

3 Data and descriptive statistics

Macroeconomic data

Our panel database consists of 20 OECD countries observed every 5 years over the period from 1950 to 2005. Data sources and definitions are in the Appendix. The macroeconomic aggregates are from the Penn World Table version 6.2 (PW6.2). Specifically, output per worker y_{it}, is the real GDP per worker measured in international dollars. Physical capital, K_{it}, is generated using the perpetual inventory method (Barro and Sala-i-Martin, 1995):

$$K_{it} = I_{it} + (1 - \delta) * K_{it-1},$$

where I_{it} is the PPP real aggregate investment and δ is the depreciation rate. The initial capital stock K_0 is computed as $I_{i0}/(g + \delta)$, where I_{i0} is the value of

[5]This should also reinforce a positive attitude toward migration policy on the part of employers (capital owners) and middle-age native workers, i.e. those that could presumably benefit from migration (see Ortega, 2003, for a description of the political economy of migration policy with capital and labor complementarity).

the investment series in the first year available, and g is the average geometric growth rate for the investment series between the first year of available data and 1970. Following the literature, δ is set equal to 0.06.[6] The number of workers is obtained by dividing real GDP per capita by real GDP per worker and multiplying by the total population. The capital output ratio is obtained by dividing the capital labor ratio by the real GDP per worker.

Human capital is constructed according to (2). The data on the average years of education of the population aged 15 to 64 come from the new Cohen and Soto (2007) database, and returns to education are from the database on Mincerian returns assembled by Hendricks (2004). We work with the estimates obtained for the total population, missing values are imputed by interpolations between two successive returns. For a few countries Mincerian returns are missing, and we impute the values from a regression of returns to years of education and their square.[7]

Demographic and immigration data

Host countries population shares by age groups are from the United Nations (UN) demographic data.

Immigration data are gathered from a combination of sources. First, the total number of immigrants comes from the UN: we work with the estimated number of international migrants at midyear (both sexes) net of estimated number of refugees. The total number of natives is the total population minus migrants. We create our reference variable "share of immigrants" as a ratio of immigrants to natives aged 15-64.

Compilation of a dataset on the number of immigrants and natives in different age, education and age/education categories has been a more challenging task. We rely on host country data, using censuses and labor force surveys. Census data are particularly attractive to measure population shares by charac-

[6] Sensitivity tests performed by Caselli (2005) show that the sources of differences of income across countries are not very responsive to the assumptions made to compute K_0.

[7] This regression shows that there are a U shape relationship between years of education and Mincerian returns with a minimum at around 10 years of education. The $R2$ of this regression with country and time dummies is 0.77. A similar pattern has been found in a sample of 28 countries by Walker and Woolley (1999).

teristics. Most of the OECD countries have run censuses since 1960 on a regular basis (for most countries, by decade), and, most importantly, around the same years. For some countries, we can go back as early as 1960 (France, USA, The Netherlands) or 1970 (Canada, Greece, Austria). Starting from 1985, and for countries-years where censuses are not available, we use the data from representative European Labor Force surveys and the US June Current Population Surveys. Thus, for the year 2005, for all countries except Canada, we use Labor Force Surveys.[8]

For most countries, immigrant status is defined according to an individual country of birth. Appendix A provides migration data sources for each country and the period covered, and the adopted definition of immigrants. Overall, we obtained an unbalanced panel data for a maximum of 20 countries starting from 1960 and with a minimum of three observations per country, which allows to control for country fixed effects in the channel accounting exercise.[9]

Immigration trends

Graph 1 shows the evolution of the share of immigrants in the total population in a selection of countries. From 7% in 1960, the share of immigrants in the total OECD population rose to 12% in 2005. Strating from the mid-1980s, immigrants weight in total population has been accelerating. Despite this general trend, the graph highlights different migration stories on a country per country basis: while in Canada this proportion stayed relatively constant throughout the decades and even had periods of decline, other countries, such as Spain, Portugal, or the USA, witnessed a drastic increase.

Immigrants and Natives demographic and skill composition

While being important in its own right, the aggregate data on the share of immigrants in the population hides many characteristics of migrants that

[8] For Canada, the 2006 Canadian census is used. We are currently working on adding Swiss and Australian Censuses (1970-2000) to our dataset.

[9] The sample comprises Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

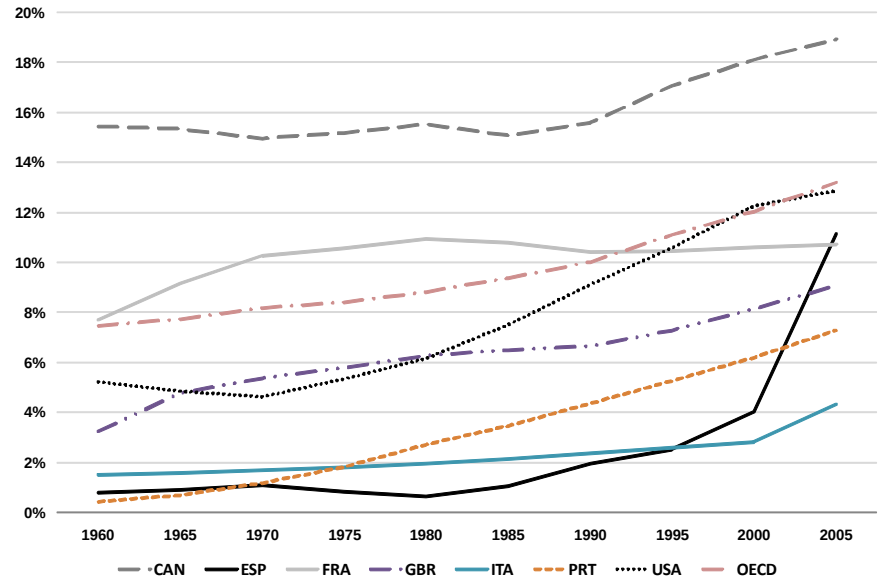

Figure 1: Immigration Rates (Immigrants/Total Population) in Selected Countries (1960-2005).

may matter for their impact on hosts countries. For instance, for the very reason that immigration is a result of an investment choice, immigrants tend to be overrepresented in the working age population. Moreover, the fact that migrants differ from natives in education and age, and that there are higher proportions of migrants in specific age and education groups, may mean that migrants and natives are not perfectly substitutable, and need to be considered as a differentiated input in production (Ottaviano and Peri, 2005).

Hence, Figure 2 shows the evolution of the ratio of the share of migrants in specific age groups over the share of natives in the same age groups, by five-year age categories, in the first and last available census for a selection of countries. When the share of immigrants in a specific age group in the total number of immigrants is equal to the share of natives in a specific age, their ratio is equal to one. Thus, values above one suggest that immigrants are over represented relatively to natives in this age group. Immigrants have clearly different age distribution than natives and these relative distributions

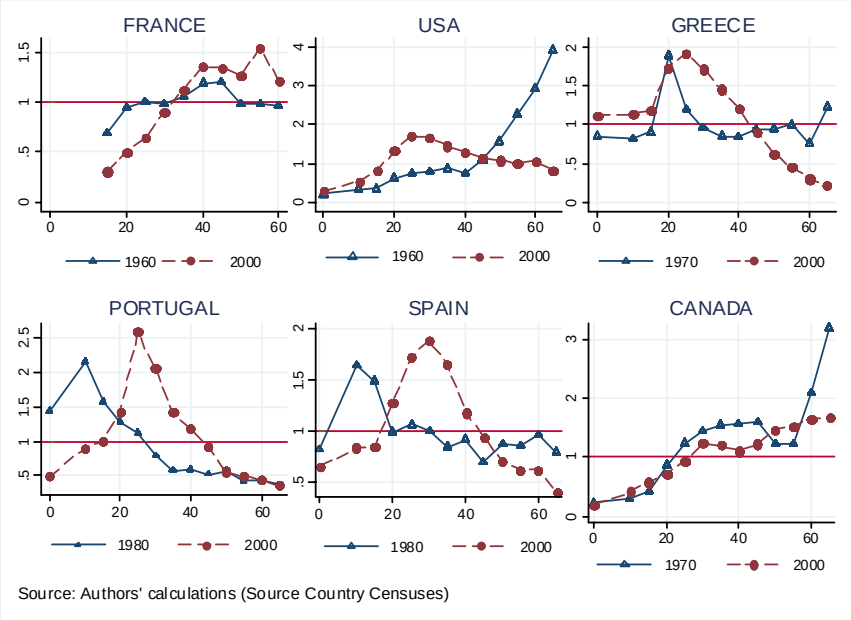

Figure 2: Distribution of Immigrants by Age Categories. Note: Reported years correspond to census periods. Age groups are on the X-axis, and the ratio of immigrants in an age group over the corresponding ratio of natives is on the Y-axis.

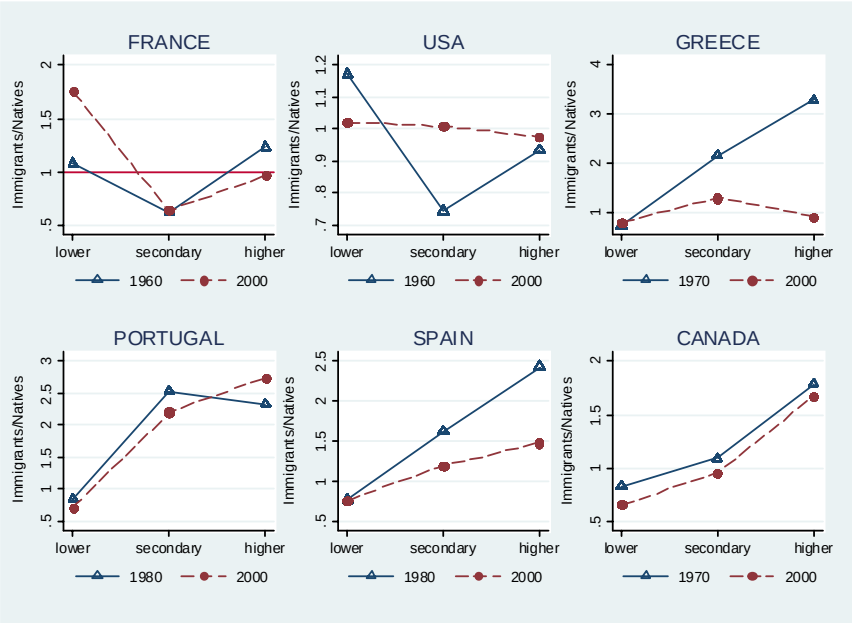

Figure 3: Distribution of Immigrants by Education Categories

changed over time. For instance, in France, the proportion of prime-age and old immigrants has increased significantly between the 1960 and 2000, while the proportion of young immigrants has decreased, implying a right shift in the relative distribution (or the relative ageing) of migrants. In Portugal, while the old-migrant population stayed at relatively low levels in both decades, the number of medium-age immigrants has increased dramatically in the past twenty years. Similar patterns are observed in Spain and Greece, while in the USA and Canada the share of old-age immigrants has gone down.

A second important dimension of immigrant characteristics considered here is their schooling. This characteristic is at the heart of the current debate on migration policy. We construct ratios of immigrants over natives in three education categories: unskilled (individuals whose maximum education attainment is completed high school), middle-skilled (individuals with vocational training and intermediate degrees) and skilled (individuals with a university degree), over natives in the same education groups. Figure 3 presents the relative distri-

bution of immigrants by education categories. Each point of the graphs reflects the share of immigrants in a given education category relative to natives, and points along the unit horizontal line indicate the same distribution of education. Again, immigrants have clearly different schooling distribution than natives. This distribution has not changed between the first and the last available censuses in Canada, reflecting its selective migration policy. In contrast, most of the European countries witnessed a decline in the share of immigrants among highly educated. In the USA, the share of middle-skilled immigrants has gone up compared to forty years before, while the share of unskilled migrants went down; and overall skill distribution of migrants very much resembles that of natives.[10]

Finally, we also consider the relative distribution of migrants within cells defined by age and education. We present here a three age and two education grouping (unskilled and middle-skilled bundled together, and skilled), creating six categories. From Table 1, which contains ratios of immigrants over natives in these six categories, for a selection of countries, in the year 2005, one can observe a significant variability between countries. For example, while in Belgium the group of young skilled immigrants represents only 3 percent of young skilled natives, this indicator is as high as 27 percent in Germany. Within countries variation is also large. For instance, in the USA, the share of skilled immigrants in young and old age groups is the same and equals 12 percent of skilled natives in the same age groups. At the same time, unskilled migrants of the main working age group represent as much as 30 percent of the similar native population. In what follows, we explore this important variability in the relative age and skill distribution to assess the contribution of immigrants to hosts countries average income and productivity.

[10]However, a more detailed classification of education shows that in the US immigrants are over-represented at the highest rungs of the educational ladder: masters, professionals and PhDs graduates.

Table 1: Ratios of immigrants over natives within age and education group, 2005, Selected Countries

	BEL	DNK	ESP	FRA	GBR	GER	GRC	IRL	ITA	NLD	PRT	USA
Unskilled 15-24	0.08	0.09	0.10	0.06	0.13	0.20	0.10	0.07	0.04	0.12	0.07	0.15
Skilled 15-24	0.03	0.06	0.04	0.05	0.14	0.27	0.05	0.11	0.03	0.08	0.11	0.12
Unskilled 25-54	0.18	0.09	0.13	0.16	0.14	0.26	0.10	0.09	0.07	0.18	0.08	0.30
Skilled 25-54	0.16	0.11	0.13	0.13	0.14	0.18	0.08	0.20	0.06	0.13	0.16	0.17
Unskilled 55-64	0.14	0.03	0.03	0.18	0.09	0.24	0.03	0.04	0.02	0.10	0.02	0.19
Skilled 55-64	0.09	0.08	0.08	0.16	0.11	0.22	0.10	0.12	0.04	0.11	0.09	0.12

4 Results

4.1 Immigration and output: the homogenous case

We start with the specification that first explores the overall impact of immigration on productivity and its channels. We use the full dataset for 20 OECD countries between years 1960 and 2005, at 5 years intervals. Table 2 contains results of estimating a set of regressions, in which dependant variables are the log of output per capita (y), log of output per worker (Y/P), as well as their decomposition into residual productivity (A), capital–output ratio (K/Y), human capital per worker (h) and employment rate (e). The independent variable of interest is the ratio of immigrant to native population. The chosen method of estimation is panel data within-group (fixed-effect), which allows distinguishing the effect of immigration on economic outcomes from changes over time in the pattern of cross-sectional variation, and to eliminate the country fixed effect. By construction, the coefficients of each component of output sum to one, provided that the coefficient on $\log(K/Y)$ is multiplied by $(\alpha/(1-\alpha))$.

Point estimates in Table 2 indicate that differences across countries in the relative share of immigrants are positively significantly correlated with differences in both productivity (column 1) and income (column 2). In particular, the main channel through which the effect of immigration is propagated is total factor productivity.[11]

Our results show that, on average, doubling the share of immigrants in the

[11] Cross country differences in TFP have also been identified as the main source of cross country income differences (Hall and Jones, 1999).

Table 2: -Effect of immigrants on productivity and per capita output: channel decomposition

	(1)	(2)	(3)	(4)	(5)	(6)
	log(y)	log(Y/P)	log(A)	log(K/Y)	log(h)	log(e)
Log(m)	0.130**	0.130***	0.143**	0.0498	-0.0385	0.000754
	(0.0525)	(0.0444)	(0.0592)	(0.0333)	(0.0250)	(0.0292)
Constant	10.38***	9.497***	9.633***	0.838***	0.325***	-0.880***
	(0.207)	(0.166)	(0.246)	(0.113)	(0.101)	(0.104)
Observations	194	194	194	194	194	194
Number of country	20	20	20	20	20	20
R-squared	0.874	0.935	0.411	0.631	0.689	0.700

*** p<0.01, ** p<0.05, * p<0.1
All regressions are estimated with a full set of year dummies. Robust Standard errors clustered at the country level are in parenthesis

population relative to natives is associated with 13% higher output per worker. Such shifts were not rare in recent years, even over a relatively short period of time. In Spain, for instance, the share of migrants over natives changed from 4.2% in year 2000 to 12.5% in year 2005. The magnitude of the estimated impact is the same whether we consider output per worker or per capita, suggesting that differences in migration share do not correlate with differences in employment rate. The latter is confirmed by the last column that shows no significant relationship between migration share and employment rate, implying no crowd-out effect of immigration on employment of natives. Coefficient estimates for other output components suggest no significant correlation between other output channels and immigration.

These basic results should be interpreted with caution, however, since measurement errors and endogeneity of migration variable are both present in these estimations. We thus turn to the IV within groups estimation. As main instruments, we use the logarithm of the ratio of male to female immigrants, with the idea that countries with more imbalanced ratios should attract more immigrants of the disadvantaged gender in the next period, and the logarithm of the ratio of immigrants over natives lagged twice, as a measure of networks and previous

migration history of a country. The choice of lagging twice is the result of an arbitrage between having a sufficiently distant variable to eliminate as much endogeneity as possible and not going too far back in time to preserve sufficient number of observations.

Table 3 presents the results of these regressions. Instrumentation has rendered coefficients on the immigration ratio insignificant for all dependent variables, except the TFP, and eliminated a large part of the positive bias on income and productivity.[12] The instruments fare well according to test statistics. In all cases, F-test of excluded instruments shows that instruments are rather strong, and the Sargan (Hansen) test of over-identifying restrictions suggests that the excluded instruments are uncorrelated with the error term and correctly excluded from the estimated equations. Given this, the positive relationship between immigration and income and productivity observed in Table 2 has been mainly driven by the fact that immigrants tend to settle in countries with higher income and productivity.

The positive impact of the share of immigrants on the TFP is consistent with Lazear (1998), who argues that one of the economic benefits of migration goes through its effect on productivity, because diversity contributes to creativity and enhances the environment in which individuals trade.[13] This is also in line with Niebuhr (2006), who shows that differences in knowledge and capabilities of workers from diverse cultural backgrounds enhance performance of German regional R&D sectors (a component of TFP). More generally, labor market efficiency requires that the value of the marginal product of workers be equalized across labor markets. This is the argument first raised by Borjas (2001), suggesting that immigrants grease the wheels of hosts countries labor market. Indeed since immigrants are more mobile than natives, they are more likely to be "marginal" workers whose location decisions arbitrage wage differences across regions or industries within countries. In this context, a higher share of immigrants raises the overall labour market input allocation, contributing to

[12] It should be appreciated, though, that in these regressRestricting the OLS estimation of Table 2 to the same sample used in Table 3 provides similar results. Thus differences in coefficient estimates are not driven by differences in sample composition.

[13] Similar argument is explored by Ottaviano and Peri (2004), who show that cultural diversity at the US city level increases productivity of natives.

Table 3: -Effect of Immigrants on Productivity and per Capita Output: Channel Decomposition - IV estimates

	(1) log(y)	(2) log(Y/P)	(3) log(A)	(4) log(K/Y)	(5) log(h)	(6) log(e)
Log(m)	0.0963	0.0987	0.153*	0.00871	-0.0608	0.00236
	(0.0637)	(0.0630)	(0.0853)	(0.0675)	(0.0457)	(0.0292)
Sample size	154	154	154	154	154	154
Number of Country	20	20	20	20	20	20
OverID test (p-value)	0.994	0.888	0.728	0.356	0.808	0.672
F-test of exclusion	17.24	17.24	17.24	17.24	17.24	17.24
R-squared	0.822	0.901	0.224	0.409	0.604	0.780

*** p<0.01, ** p<0.05, * p<0.1
All regressions are estimated with a full set of year dummies. Instruments are the lagged twice immigrants' sex ratio and ratio of immigrants over natives. The OverID test is the Hansen test of over identification restriction distributed as a Chi2. Robust standard errors are in parentheses

higher TFP (Borjas, 2001).

At the same time, we take the "absence" of a significant impact of immigration on output as a result in itself, the idea being that the aggregate measure of migration hinders other mutually balancing effects that can be revealed once its decomposition is considered. Indeed, this estimation assumed that migrants and natives are homogenous inputs into the production function, constraining the impact of immigrants to be the same across their age and education distribution. Next sections explore the variation in the share of immigrants over natives across education and age, looking for "local" complementarities between natives and immigrants specific to age and education groups.

4.2 Accounting for immigrants heterogeneity

4.2.1 The age of immigrants

From Figure 2, immigrants' age distribution is very different from that of the natives, and this difference has a remarkable variability both across countries and over time. Thus, controlling for age of immigrants should result in a better account of the importance of immigrants' labor shocks in host countries, as

well as of the time pattern of its cross sectional variability. Moreover, it can also capture both positive and negative production complementarities that are "local" in a sense that they are specific to an age group. For instance, if young immigrants perform jobs complementary to those of young natives, then having more young immigrants can rise the overall productivity, as the productivity of the abundant factor (the natives) increases, shifting upward the labor demand curve. However, if immigrants and natives are, after controlling for their age, mainly substitute to each other, we should not observe any impact on productivity. In addition to this, age decomposition is also informative of immigrants duration of residence in a host economy, as older immigrants have been present for a longer period of time in a given host country than younger ones. Variation in the duration of stay has at least two implications. First, those with longer residence have a larger local specific experience, the importance of which has been highlighed, among others, by Friedberg (1996). Second, older immigrants also reflect the long-term effect of immigration, pointing out to the gradual adjustment of countries to immigration shocks, such as, for example, long-term and usually delayed adjustments in capital.[14]

Thus, we further work with a sub-sample of country-years, for which finer information on age distribution of immigrants is available. Table 4 summarizes the results of these estimations in which we decompose the overall immigrants share over natives in three age categories: aged between 15 and 24; 25 and 54; and 55 and 64. We continue exploring the panel structure of the data, accounting for country fixed effects. Lagged population structure (ratios of the population in age groups 10-20, 20-30, etc, and 50 to 60, over the population aged 10 to 60) is used as instruments, in addition to the instruments employed in the previous estimation.

In comparison with Table 3, the decomposed results reveal several channels of immigration impact on income and productivity. In particular, the share of the youngest migration group contributes negatively to productivity through

[14]For instance, Eckstein and Weiss (2001) show that during the periods of mass migration, such as in Israel in 1990-1997, a constant capital quality-adjusted labor ratio can be preserved, provided that immigrants gradually adapt to the labour market and move across occupations and industries.

Table 4: Effect of Immigrants Age Distribution on Productivity and per Capita Output: Channel Decomposition - IV estimates

	(1) log(y)	(2) log(Y/P)	(3) log(A)	(4) log(K/Y)	(5) log(h)	(6) log(e)
Log(m1524)	-0.161*	-0.123	-0.245**	-0.00489	0.0872	0.0375
	(0.0670)	(0.102)	(0.112)	(0.0661)	(0.0753)	(0.0380)
Log(m2554)	0.246**	0.299**	0.252*	-0.0806	0.0344	0.0535
	(0.0189)	(0.121)	(0.133)	(0.0787)	(0.0898)	(0.0454)
Log(m5564)	-0.170	-0.311**	-0.0507	0.170**	-0.205**	-0.140***
	(0.109)	(0.123)	(0.135)	(0.0801)	(0.0913)	(0.0461)
Sample size	90	90	90	90	90	90
Number of Country	17	17	17	17	17	17
OverID test (p-value)	0.403	0.364	0.229	0.178	0.183	0.145

Robust standard errors in parentheses
All regressions are estimated with a full set of year dummies. The instruments are the lagged demographic structure of the population aged 10-59 in period t-1, the migrant's sex ratio in t-2 and the ratio of migrants to native in t-2. The OverID test is the Hansen test of over identification restriction distributed as a Chi2. The F test rejects strongly, at any conventional level the null hypothesis of irrelevance of excluded instruments for all three endogenous variables.
*** p<0.01, ** p<0.05, * p<0.1

their negative impact on TFP. Various explanations can be given to this. First, upon their arrival, young immigrants may be systematically employed in low-TFP sectors, such as construction or services, thus contributing to higher size of these sectors in host countries. Second, the TFP is a measure of residual productivity. This means that, given the observed level of human capital h, if young immigrants lack country specific skills, their lower, unobserved, human capital should be reflected in the residual productivity term even though they have the same observable characteristics as natives.[15] Thus, the negative impact on productivity is most likely to reflect the short term impact of immigration.

In contrast, the share of immigrants in the main working age group (between 25 and 54), has a positive impact on both productivity and income, and this

[15]This argument is related to the fact that the Solow residual (TFP) is as labeled by Abramovitz, (1956) "the measure of our ignorance". The level of TFP converges to the true underlying technological level only if all the variety of inputs is accurately identified and measured.

effect also goes through the positive contribution to TFP.

The oldest group is the only group that affects factor inputs rather than TFP. Higher share of immigrants in this age group reflects past migration shocks, as well as long-term impact of immigration, because immigrants in this age group are most probably long-term stayers. An increase in their share is associated with the gradual capital adjustment, which is consistent with the fact that the presence of more workers stimulate investment (Ottaviano and Peri, 2005). The positive effect on capital is partly offset by the negative contribution of this age group to overall human capital. Human capital and employment adjust more slowly to changes in labor supply driven by migration than TFP does. While we do not have a clear-cut explanation for these effects, we reserve it for the next section, where age is also decomposed by education. Finally, an increase in the share of foreign born in this age group has a negative effect on income, but not on productivity, differences being due to the effect of such an increase on employment.

4.2.2 Accounting for the education of immigrants

Another important dimension of immigrants' heterogeneity is their relative education. Immigrants have different levels and quality of education as compared to natives, and thus potentially should work in different sectors and occupations. If immigrants within a specific education group substitute natives irrespective of their age, we should observe no effect of the relative share of immigrants within a particular education group on productivity. Instead, if immigrants, given their education, perform tasks complementary to natives, we should observe a potentially positive effect of higher share of immigrants within an education group on the productivity, and hence on income.

Thus, in Table 5, we also present estimations results where the ratio of immigrants over natives is decomposed into three education groups: unskilled, middle-skilled, and high-skilled. We continue using fixed effects and exploring the panel structure of the data. Our identification strategy is as in the previous section, it relies on past demographics structure of the population. At the same time, we employ a more suitable set of instruments: the past demographics

of each type of skill, the idea being that not only fertility, but also education choices are made well in advance by natives. Thus, for each type of skill, we compute the share of young, middle and old age individuals. For this, we use a recent data set of the education distribution by age provided by Lutz et *al.* (2007), which covers the period from 1970 to 2000 in five years interval. The use of demographic structure by education lagged twice results in a loss of all observations before 1980, and a significant reduction of the sample.

The results show that there is a negative impact of a higher share of unskilled migrants on overall productivity and income. Yet, the impact on income is half of that on productivity, owing to the positive contribution of unskilled immigrants to employment. The latter is probably reflecting the higher employment rate of immigrants compared to natives within this group of skills. The effect of higher share of middle-skilled migrants on productivity is of the same magnitude but of the opposite sign than that of low skilled immigrants, which explains why in aggregate estimation we do not find any effect.

As before, our result highlights the importance of TFP as a channel of transmission, with a direction of the effect that depends on the type of immigrants skill. Higher share of immigrants in both low and high skill groups affect negatively the residual productivity. This either suggests that immigrants in these groups are more likely to work in low TFP sectors as compared to their native counterparts, thus increasing the share of low TFP sectors in the economy, or that, despite having similar education, they have lower unobserved human capital, notably due to cross-country differences in the quality of schooling or the lack of country-specific skills.

The contribution of high skill immigrants to human capital accumulation neutralizes their negative contribution to TFP. The positive impact on human capital is likely to be the result of a composition effect, if tertiary educated immigrants are more likely to hold highest degrees than their natives peers for instance. By the same token, the negative effect of middle skilled workers on human capital can reflect a larger proportion of high school drop outs among immigrants, and thus a lower number of years of schooling, as opposed to natives. For instance in the US, while the share of immigrants which are secondary

Table 5: Effect of Immigrants on Productivity and per Capita Output: Channel Decomposition - IV estimates

	(1) log(y)	(2) log(Y/P)	(3) log(A)	(4) log(K/Y)	(5) log(h)	(6) log(e)
Log(m_uk)	-0.202***	-0.129*	-0.228**	-0.130	0.0908	0.0729**
	(0.000773)	(0.0688)	(0.112)	(0.0957)	(0.100)	(0.0323)
Log(m_mk)	0.189*	0.219	0.531***	0.121	-0.402***	0.0299
	(0.0613)	(0.154)	(0.153)	(0.124)	(0.139)	(0.0996)
Log(m_sk)	-0.107	-0.249	-0.538**	-0.106	0.484***	-0.143
	(0.521)	(0.222)	(0.257)	(0.151)	(0.173)	(0.129)
Observations	64	64	64	64	64	64
OverIDtest	0.158	0.311	0.316	0.356	0.922	0.528
Number of Country	15	15	15	15	15	15

Robust standard errors in parentheses
All regressions are estimated with a full set of year dummies. Instrumental variables are the share of old and middle age group among unskilled, middle skilled and skilled in period t-1 and the ratio of migrants to natives and migrants sex ratio in t-2. The OverID test is the Hansen test of over identification restriction distributed as Chi2. The F test rejects strongly, at any conventional level the null hypothesis of irrelevance of excluded instruments for all three endogenous variables.
*** p<0.01, ** p<0.05, * p<0.1

and tertiary educated is close to that of natives, masters, professionals or Phds graduated are more likely among immigrants than natives while among secondary educated foreign born represent a disproportionate share of high school drop-out (Peri, 2006; Card, 2005). This difference among secondary educated workers means that by performing unskilled versus skilled blue collar tasks, semi-skilled immigrants could complement semi-skilled natives in production raising the overall labor efficiency. For instance, Peri and Sarber (2008) show that among workers with low educational attainment, foreign-born specialize in occupations requiring manual and physical labor skills, while natives pursue jobs more intensive in communication and language skills.

4.2.3 Accounting for all observable characteristics of immigrants

Even after controlling for one of the dimensions of differences between immigrants and natives, such as age or education, important differences still remain within each dimension. For instance, Table 1 shows that within the group of young immigrants, there are large differences in terms of schooling distribution,

which are also different across countries and time. Thus, if among the young, migrants are more likely to be unskilled than natives, then the point estimate of Table 5 is reflecting complementarities due to the fact that immigrants have different schooling, rather than due to the fact that natives have some other genuine characteristics (as, for instance, is advocated by Lazear, 1998). If this is the case, then even after controlling for their differences with natives in terms of age and education, immigrants can have an impact (positive or negative) on hosts countries. Thus, we further decompose the overall ratio of migrants over natives into nine categories: each of the three age groups (young, middle, and old) is decomposed into three groups of education (unskilled, semi-skilled, and skilled).

Table 6 contains the results of this decomposition. We use the full, lagged twice, demographic structure of the native population, as well lagged twice demographic structure by group of education as instruments. As we have nine potentially endogenous independent variables, to save on instruments, we assume that the share of old-age group immigrants is exogenous to the current levels of output. This is not unreasonable, as most immigrants aged 55-64 arrived more than 15 years ago, thus, the current level of output cannot be considered as a determinant of their migration decision. We also ensure that Hausmann test does not reject the join null hypothesis of weak exogeneity and no measurement error in these variables. Hence, we instrument only six variables: shares of migrants over natives in young and middle-age groups, decomposed by skill level.

There are two dimensions along which the results of Table 6 can be interpreted: the age and the education.

Starting from the age dimension, we note that the negative contribution of young immigrants to productivity documented in Table 4 was fully due to differences in the educational distribution within this specific age group (mostly new immigrants). Once we control for these differences, we do not find any impact of young immigrants on this indicator. Moreover, the negative effect of young immigrants on input efficiency, i.e. TFP, is all due to the share of low educated immigrants in this group, consistently with the view that immigrants

lack important productive country specific skills because of their short duration of stay. This intuition is further reinforced by the fact that we do not find any effect on TFP of unskilled immigrants among older demographic groups. There is also human capital adjustment in countries that receive a relatively higher share of young unskilled migrants, suggesting a possible upgrading of skills among young natives following an inflow of immigrants. The latter effect neutralizes the negative contribution of this group to TFP.

As for the positive effect of the main age group found in Table 4, results of Table 6 show that this is fully due to differences in the distribution of schooling between natives and migrants. The adjustment fully works through changes in factor inputs, rather than the residual productivity. We find a negative effect on capital output ratio of the unskilled middle-aged group, and a negative impact on overall human capital, both of which are compensated by a small and positive effect on employment. The latter effect can be due either to the complementarities of middle-aged unskilled migrants with their native counterparts, or due to a higher employment rate of immigrants in this group. In addition, an increase in the middle-aged skilled immigrants ratio has a positive association with the level of human capital, which again could reflect the fact that immigrants within this group are more likely to be found in the highest rungs of educational attainment. Comparing the latter result to that of Table 5, we note that half of the reported positive effect of the increase in the share of highly skilled immigrants on human capital is due to the differences in age distribution between natives and migrants. The other half results from a human capital adjustment process of natives.

Finally, we find an overall positive effect on productivity for the group of unskilled old immigrants, which works through higher capital accumulation. As this group reflects the long-term impact of immigration, estimates of Table 4 that do not control for the schooling differences between immigrants and natives underestimate the contribution of long term migration to productivity.

One can also look at the age differences within education groups. This allows understanding whether the results of Table 5 are driven by complementarities between immigrants and natives within skill groups that are due to differences

in age or to other unobserved characteristics. For example, according to Table 5, a higher share of immigrants among unskilled exerts a negative impact on productivity by lowering inputs' efficiency. However, once we control for the age distribution of immigrants, this negative effect disappears, suggesting that, relatively to native workers, immigrants in this education group are more likely to be in the age group that contributes the least to productivity. A look at the channel decomposition further reveals that the negative effect on TFP stems from the negative complementarity between immigrants and natives within the group of young unskilled workers. However, this negative effect on TFP is compensated by human capital adjustment.

In contrast with the result of Table 5, once differences in age distribution are controlled for, the share of unskilled immigrants in the long term, as measured by the share of unskilled in the old age group, is positively correlated with income and productivity. The negative contribution of unskilled immigrants to productivity (Table 4) is a short term phenomenon. In the long term, doubling the ratio of unskilled immigrants increases productivity by 12%. This complementarity works through a higher equilibrium investment rate in countries that received large inflows of unskilled immigrants in the past, either because immigrants create new opportunities for investments that raises productivity, or because immigrants increases saving capacity of hosts countries. For instance, in the standard Solow growth model, the steady state capital output ratio in country i is equal to $s_i/(ni + \delta)$, where s_i and n_i are respectively the saving rate and population growth rate. If immigrants affect the average saving rate either trough a composition effect (because they are older) or because they have genuine different preferences, they can contribute to higher equilibrium capital output ratio by rising s_i.

The positive effect of immigrants on productivity works through the complementarity with natives in the group of unskilled workers. This is usually the type of immigrants who are "greasing" developed countries labor markets, and who possess the type of skills that are in short supply among natives in better educated developed countries.[16]

[16]In Spain, between 1995 and 2005, the share of unskilled immigrants in the age group of 15 to 24 has increased by a factor of five. Taken at face value, our estimates suggest that in 40

Lastly, the positive contribution of unskilled workers to average employment rate found in Table 5 is mainly driven by immigrants-natives complementarities or higher employment rate of immigrants relative to natives within the group of middle aged workers.

4.2.4 Robustness

Alternative skill grouping

One of the main concerns of this type of analysis is the appropriate decomposition of migrant characteristics, especially of their education level. As schooling of immigrants is self-reported, there is a strong concern about the comparability of degrees, their compatibility with the host market, and about the quality of education obtained in host versus origin countries (Friedberg, 1996). Unfortunately, we do not have the information neither on where the schooling was obtained, nor on how much time was spent in the host country. If anything, we are most probably overestimating the number of immigrants in the group of semi-skilled and of skilled workers: due to potentially lower quality of education at home, as well as to the adjustment period needed to obtain a job that fully corresponds to the possessed degree, many immigrants with professional degrees can find themselves in lower occupational attainment (see, for example, Barrett and Duffy, 2007, for the case of Ireland, or Fernández and Ortega, 2008, for the case of Spain). While we are not able to fully deal with the potential discrepancy between self-reported education and the performed job, in this section we consider a different grouping of educational characteristics. We create only two education groups, skilled and unskilled, the latter being composed of all individuals without a tertiary degree. The results (presented in Appendix) are very similar to those with three skill-types grouping. Among other results, we continue finding a positive impact of the group of old unskilled immigrants on productivity.

Robustness to omitted variables

years, this immigration wave can translate into 50 percent higher productivity gain for Spain compared to the case without migration.

Table 6: -Effect of Immigrants on Productivity and per Capita Output (9 education*age groups): Channel Decomposition - IV estimates -

	(1) log(y)	(2) log(Y/P)	(3) log(A)	(4) log(K/Y)	(5) log(h)	(6) log(e)
Log(m_uk15)	0.0242	0.0511	-0.317*	0.0431	0.394***	0.0269
	(0.762)	(0.0759)	(0.183)	(0.0717)	(0.131)	(0.0243)
Log(m_mk15)	-0.187	-0.152	-0.0324	-0.151	-0.212	0.0349
	(0.213)	(0.146)	(0.311)	(0.139)	(0.205)	(0.0376)
Log(m_sk15)	-0.0437	-0.0600	-0.00761	0.00709	0.0359	-0.0163
	(0.632)	(0.0933)	(0.195)	(0.0584)	(0.146)	(0.0249)
Log(m_uk25)	-0.0965	-0.0391	0.144	-0.150*	-0.245*	0.0574***
	(0.242)	(0.0806)	(0.217)	(0.0781)	(0.147)	(0.0198)
Log(m_mk25)	0.0912	0.0248	0.194	0.174	-0.0727	-0.0664
	(0.520)	(0.149)	(0.375)	(0.145)	(0.264)	(0.0413)
Log(m_sk25)	0.160	0.111	-0.184	0.110	0.294*	-0.0490
	(0.211)	(0.128)	(0.229)	(0.0944)	(0.173)	(0.0474)
Log(m_uk55)	0.118**	0.0489	0.0552	0.102**	0.0366	-0.0688***
	(0.0244)	(0.0569)	(0.0982)	(0.0474)	(0.0716)	(0.0147)
Log(m_mk55)	-0.00910	0.0358	0.0690	-0.0149	-0.0588	0.0449**
	(0.910)	(0.0777)	(0.178)	(0.0665)	(0.130)	(0.0179)
Log(m_sk55)	-0.0328	-0.0304	-0.00397	-0.0789*	-0.0504	0.00245
	(0.617)	(0.0737)	(0.145)	(0.0466)	(0.121)	(0.0222)
Sample size	62	62	59	62	59	62
OverID test (p-value)	0.256	0.307	0.141	0.108	0.348	0.118
Number of country	15	15	14	15	14	15

Robust standard errors in parentheses
All regressions are estimated with a full set of year dummies. Independent endogenous variables are the share of immigrants over natives by skill type among young and prime-aged individuals. The instruments are the share of old and prime age individuals among unskilled, middle-skilled and skilled in period t-1, the migrant sex ratio in t-2 and the ratio of migrants to native in t-2. The OverID test is the Hansen test of over identification restriction distributed as a Chi2. The F test rejects strongly, at any conventional level the null hypothesis of irrelevance of excluded instruments for all three endogenous variables.
*** p<0.01, ** p<0.05, * p<0.1

As main independent variables, we have been using the share of immigrants in various demographic and education groups. To control for endogeneity and measurement errors, we have used the past demographic structure of the population. For our identification to be valid, past demographic structure should affect income and productivity only through its effect on the share of immigrants. However, as emphasized in the literature on growth and demographics, one obvious variable through which past demographics can affect productivity and income is the dependancy ratio. For example, Bloom, Canning and Sevilla (2001) find that an increase in the size of the working-age population can produce a "demographic dividend" to economic growth. Kögel (2005) finds a negative relationship between total factor productivity and the youth dependency ratio. Given that immigrants are more likely to go to countries that are short of labor and, as a consequence, have higher dependency ratio, omitting the dependency ratio can bias downwards the estimated impact of immigration on productivity.

This intuition is verified in Table 7, where we repeat estimation as in Table 6, and add the logarithm of the dependency ratio (*dependency*) as an additional control variable. The later is computed from the UN population data as the share of the population aged 15 and below or 65 and above over the population aged 16 to 64. We only report results for productivity and income, as well as coefficient estimates that are significantly different from zero. As excepted, countries with higher dependency ratio have lower productivity and income. The estimated impact of unskilled old immigrants on productivity is now twice higher than previously estimated, confirming that immigrants choose countries with higher dependency ratio. We also obtain a positive effect for the group of skilled middle-aged workers, which is even larger than that for the old unskilled immigrants. There is also a weak but negative effect on productivity and income for the group of old skilled immigrants. The differences in signs within the group of old workers are not inconsistent, as immigrants with different type of skills may choose different locations. What Table 7 suggests is that skilled immigrants are more likely to go to countries with lower dependency ratio. This makes sense if, as argued by Beaudry and Collard (2002), countries with

Table 7: Effect of Immigrants on Productivity and per Capita Output controlling for the dependency ratio - IV estimates

	(1) log(y)	(2) log(Y/P)
Log(m_sk25)	0.311**	0.297**
	(0.0296)	(0.151)
Log(m_uk55)	0.215***	0.167**
	(0.000673)	(0.0663)
Log(m_sk55)	-0.0905*	-0.111**
	(0.0938)	(0.0556)
Log(dependency)	-1.063**	-1.233**
	(0.0261)	(0.501)
Observations	62	62
Number of Country	15	15
OverID test	0.222	0.117

Robust standard errors are in parentheses.
All regressions are estimated with a full set of year dummies. Independent variables are shares of immigrants within the 9 education*age groups. Only significant coefficients are reported. Independent endogenous variables are the share of immigrants over natives by skill type among old and prime-aged individuals. The instruments are the share of old and middle age group among the unskilled, the middle-skilled and skilled individuals in period t-1, the migrant's sex ratio in period t-2 and the ratio of migrants to natives in period t-2. The OverID test is the Hansen test of over identification restriction distributed as Chi2. The F test rejects strongly, at any conventional level, the null hypothesis of irrelevance of excluded instruments for all three endogenous variables.
*** p<0.01, ** p<0.05, * p<0.1

lower dependency ratio adopt new available technologies at higher rate, thus increasing their demand for high skilled workers.

Alternative human capital measures

[in progress]

In his review of determinants of income differences across countries, Caselli (2005) highlights the importance of measuring properly the variety of inputs. While better measurement of inputs will not change the estimated impact of immigrants on productivity, it could affect our conclusion in the channels of transmission.[17]

[17] For instance if countries with high average years of education have also lower experience we underestimate the contribution of TFP and over estimate that of factor accumulation.

Thus Bills and Klenow (2000) suggest to introduce on top of schooling the experience of the workforce; indeed another consistent finding in labor economics is the positive and quadratic returns to experience: older workers up to certain age level are more productive than younger workers. A recent contribution by Freyer (2007) shows that an increase in the share of the 40-49 years age group is associated with higher aggregate productivity. To introduce accumulation of experience into the picture we will stick to the Mincerian specification and adopt a quadratic specification for returns to experience, this alternative measure of human capital denoted $\tilde{H}_{it}$ is then:

$$\tilde{H}_{it} = e^{\beta_{it} S_{it} * \beta_{i2} \exp_{it} + \beta_{i3} \exp_{it}^2} * emp_{it} * P_{it} = h_{it}^s * h_{it}^{ex} * emp_{it} * P_{it}$$

where β_{i2} and β_{i3} are the Mincerian returns to experience and its square, and h_{it}^s is the human capital accumulated in school and h_{it}^{ex} is the human capital accumulated in the labor market.[18] We assume that returns to experience is country specific but invariant across time.[19]

Alternative instruments

5 Conclusion

Do countries that attract different number and quality of immigrants differ in income and productivity as a result? What are the channels through which immigration can affect the host country outcomes? This paper is trying to answer these questions within channel accounting approach, focusing on the economy-wide impact of immigration.

The results show that, on aggregate, immigrants have no impact on productivity and income in host countries. At the same time, a closer look at the type of immigrants, and at the components of income and productivity, suggest that the impact of immigration works through finer, local, complementarities

[18] That sort of human capital accumulated via "learning by doing" in the labor market.

[19] We lack sufficient data on returns to experience across time and countries. However, differences in return to experience are much lower than differences in returns to education across countries.

between immigrants and natives. Wherever negative effects are found on some channels of productivity, they are compensated by positive effects on others.

For example, when considering the impact of immigrants of different ages, we find opposing effects on productivity of shares of middle-aged and young workers. In addition to the direct age-effect explanation, we interpret these results as short-term versus medium-term impact of immigration. Considering the education decomposition of immigrants, we find opposing effects on productivity for unskilled and middle-skilled workers. Finally, once controlled for both age and education characteristics, immigration in the oldest group of unskilled workers is found to have a positive effect on productivity. Since the latter reflects past migration shocks, we conclude that unskilled immigrants contribute positively to productivity in the long run, and that this effect works primarily through capital attraction and investment response.

The finding of no overall, but significant and varying decomposed effects of immigration on income and productivity is impressing. It reinforces the notion that immigration is a complex phenomenon, and that more research is needed in the direction of accounting for complementarity and substitability effects between immigrants and natives on different levels.

Data Appendix

Table 8: -List of countries, sources, and migration status definition-

Country	Years	Source	Immigrants Definition	Status
Australia*	1985-2005	Australian Census	Nativity	
Austria	1970-2005	Census and Labor Force Survey	Citizenship	
Belgium	1985-2005	Labor Force Surveys	Nativity	
Denmark	1985-2005	Labor Force Surveys	Nativity	
Finland	1995-2005	Labor Force Surveys	Nativity	
France	1960-2005	Census and Labor Force Surveys	Nativity	
Germany	1995-2005	Labor Force Surveys	Citizenship	
Greece	1980-2005	Census and Labor Force Surveys	Nativity	
Ireland	1986-2005	Labor Force Surveys	Nativity	
Italy	1995-2005	Labor Force Surveys	Nativity	
Luxembourg	1985-2005	Labor Force Surveys	Nativity	
Netherlands	1970-2005	Census and Labor Force Surveys	Citizenship	
New-Zealand	1960-2005	UN data	Nativity	
Norway	1995-2005	Labor Force Surveys	Nativity	
Portugal	1980-2005	Census and Labor Force Surveys	Nativity	
Spain	1980-2005	Census and Labor Force Surveys	Nativity	
Sweden	1995-2005	Labor Force Surveys	Nativity	
Switzerland*	1970-2005	Census and Labor Force Surveys	Nativity	
United Kingdom	1990-2005	Census and Labor Force Surveys	Nativity	
USA	1960-2005	Census and June Current Population Survey	Nativity	

*Data on immigration share by age and education for Australia and Switzerland have not yet been introduced in the analysis presented in the presented in table 4 to 7.

Measurement issues [..to be completed]

Table 9: Summary Statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
Dependent variables					
Output per capita (Y/P)	208	18113	7468	3677	52568
Output per worker (y)	208	39499	14877	9543	122246
Capital output ratio (K/Y)	208	2.515021	0.5176878	1.279114	4.280596
Human Capital (h)	200	2.007648	0.4479724	1.379578	3.868109
TFP (A)	200	2.01	0.45	1.38	3.87
Employment rate (e)	198	12086	2934	5213	20494
Independent variables					
Ratio of migrants over natives (m)	204	0.10	0.10	0.00	0.60
Ratio of migrants over natives in age group j (m_j):					
m1524	103	0.10	0.13	0.00	0.73
m2554	103	0.11	0.13	0.00	0.72
m5564	103	0.07	0.09	0.00	0.49
Ratio of migrants over natives among unskilled (m_uk), middle-skilled (m_mk), and skilled ($m\ sk$) individuals:					
m_uk	90	0.13	0.19	0.00	1.33
m_mk	90	0.11	0.10	0.00	0.67
m_sk	90	0.15	0.17	0.00	1.08
Dependancy ratio	210	0.35	0.03	0.30	0.42
Ratio of migrants over natives in age group i and skill type j:					
m_uk1524	90	0.11	0.10	0.00	0.52
m_mk1524	90	0.08	0.07	0.00	0.35
m_sk1524	90	0.10	0.10	0.00	0.68
m_uk2554	90	0.25	0.43	0.00	2.60
m_mk2554	90	0.11	0.12	0.00	0.82
m_sk2554	90	0.16	0.18	0.01	1.15
m_uk5564	90	0.14	0.18	0.00	0.92
m_mk5564	90	0.11	0.12	0.00	0.62
m_sk5564	90	0.14	0.16	0.00	1.03

Note: summary statistics refer to the period 1960-2005. Variables are measured at 5 years interval and all statistics refer to the pool sample of the 20 OECD countries mentioned in the text.

References

[1] Asplund, Rita (Eds.), "Education and Earnings. Further Evidence from Europe". ETLA, 2001

[2] Barrett, Alan, and David Duffy, "Are Ireland's Immigrants Integrating into its Labour Market?", IZA DP No. 2838, June 2007

[3] Barro, Robert J., "Notes on Growth Accounting". Journal of Economic Growth, 4: 119-137, June 1999.

[4] Barro, Robert J., and Xavier Sala-i-Martin, "Convergence across States and Regions", Brookings Papers Econ.Activity, no. 1 (1991), pp.107-82

[5] Benhabib, Jess, and Spiegel, Mark, "Human Capital and Technology Diffusion", Handbook of Economic growth, in: Philippe Aghion and Steven Durlauf (eds.), Edition 1, Vol. 1, Ch. 13, pahes 935-966, 2005.

[6] Bils, Mark, and P. J. Klenow, "Does Schooling Cause Growth?" American Economic Review, 90, 1160-1183, 2000.

[7] Bloom, David, Canning, D., and Sevilla J., "Technological Diffusion, Conditional Convergence, and Economic Growth", WP No 8713, NBER, Cambridge, MA, January 2002.

[8] Bloom, David, Canning, D., and Sevilla J., "The Effect of health on Economic Growth: A Production Function Approach", World Development, Vol. 32, No. 1, pp. 1-13, 2004.

[9] Bloom, David, Canning, D., Fink, G., and J. E. Finlay, "Does Age Structure Forecast Economic Growth ?" WP No 13221, NBER, Cambridge, MA, July 2007.

[10] George J. Borjas, 2001."Does Immigration Grease the Wheels of the Labor Market?," Brookings Papers on Economic Activity, Economic Studies Program, The Brookings Institution, vol. 32(2001-1), pages 69-134.

[11] Borjas, George J., "The Labor Demand Curve Is Downward Sloping: Reexamining The Impact Of Immigration On The Labor Market," The Quarterly Journal of Economics, MIT Press, vol. 118(4), pages 1335-1374, November 2003.

[12] Card, David, "Is the New Immigration Really so Bad?," Economic Journal, Royal Economic Society, vol. 115(507), pages F300-F323, November 2005.

[13] Cohen, Daniel, and Marcelo Soto, "Growth and Human Capital : Good Data, Good Results", Journal of Economic Growth, 12 :51-76, 2007.

[14] Dougherty Chrys, and D. W. Jorgenson, "International Comparisons of the Sources of Economic Growth", The American Economic Review, Vol. 86, No. 2, pp. 25-29, May 1996.

[15] Education at a Glance. OECD. 1997.

[16] Fernández Cristina and Carolina Ortega. "Labor market assimilation of immigrants in Spain: employment at the expense of bad job-matches?," Spanish Economic Review, Springer, vol. 10(2), pages 83-107, June 2008

[17] Feyrer, James, 2007. "Demographics and Productivity."The Review of Economics and Statistics, MIT Press, vol. 89(1), pages 100-109, 01.

[18] Hall Robert E. & Charles I. Jones, 1999. "Why Do Some Countries Produce So Much More Output Per Worker Than Others?," The Quarterly Journal of Economics, MIT Press, vol. 114(1), pages 83-116, February.

[19] Harmon, Walker & Westergaard-Nielsen (eds.), Education and Earnings in Europe: A Cross Country Analysis of the Returns to Education. Edward Elgar, March 2001.

[20] Hendricks, Lutz, "A Database of Mincerian Earnings Regressions" 2004. www.lhendricks.org/Mincer.htm

[21] Lewis, E. (May 2005). Immigration, skill mix, and the choice of technique. Federal Reserve Bank of Philadelphia Working Paper 05-08.

[22] Lindh, Thomas, "AgeStructure and Economic Policy: The Case of Saving and Growth", Population Research and Policy Review 18: 261–277, 1999.

[23] Ottaviano, Gianmarco, G. Peri, "Rethinking the Gains from Immigration: Theory and Evidence from the U.S." CEPR DP 5226, 2005.

[24] Ottaviano, Gianmarco I P & Peri, Giovanni, 2008. "Immigration and National Wages: Clarifying the Theory and the Empirics," CEPR Discussion Papers 6916, C.E.P.R. Discussion Papers.

[25] Peri, Giovanni, "Immigrants' Complementarities and Native Wages: Evidence from California", NBER WP 12956, March 2007.

[26] Peri, G. and Ortega, F. 2009. "The Causes and Effects of International Migrations: Evidence from OECD Countries 1980-2005", mimeo March 2009.

[27] Poncet, Sandra, "The Long Term Growth Prospects of the World Economy: Horizon 2050". CEPII WP No 2006-16, October 2006.

[28] Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, Trends in Total Migrant Stock: The 2005 Revision http://esa.un.org/migration, Thursday, August 14, 2008.

[29] Vandenbussche J.erome, P. Aghion, and C. Meghir, "Growth, Distance to Frontier, and Composition of Human Capital", Journal of Economic Growth, 11: 97-127, 2006.

[30] Walker & Woolley, Returns to Education: Evidence from 28 countries, Keele Working Paper, forthcoming Labour Economics, 1999.

[31] Wong, Wei-Kang, "Economic Growth: A Channel Accounting Excercise", mimeo, 2003.