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DISCUSSION PAPER SERIES

IZA DP No. 14389

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University of Munich, ifo Institute, CESifo, CReAM and IZA

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ABSTRACT

Population Aging and Migration*

International migration flows largely reflect demographic patterns and economic opportunities. Migration flows increase in expected income and other pull factors in potential destinations, and in push factors in the origin, like high unemployment, low wages, and high population growth. Migration flows decrease in the geographic and cultural distance between the potential origin and destination, and in other migration costs. To the extent that migrants are employed, immigration can alleviate challenges arising from population aging. For origin countries, the effects of migration may go either way, depending on whether increased incentives to invest in education are sufficient to compensate the loss of skilled workers. Throughout the 20th century, Northern America and Australia and New Zealand attracted highest immigration flows. Latin America was consistently a continent of emigration. Europe went through a major reversal from a continent of emigration until 1950s to a continent of immigration. In the 21st century, crucial questions for demographic and migration research are how fertility rate and emigration rate are going to develop in Africa. Even modest increases in emigration from Africa would generate major increases in immigration pressure in the rest of the world, mostly in Europe. Other major questions on the future research agenda are the effects of the climate change and rapid improvements in information technology.

JEL Classification: F22, O15, J11, J13, J61

Keywords: international migration, population aging, demographic trends, fertility, immigrant workers

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1 Introduction

The world's population increased from 1.65 billion in 1900 to 2.54 billion in 1950 and 7.79 billion in 2020 (Klein Goldewijk et al. 2010; United Nations, Department of Economic and Social Affairs, Population Division 2019). At the same time, life expectancy at birth increased from 32.0 years in 1900 to 45.7 years in 1950 and 72.8 years in 2020 (Riley 2005; Zijdeman and Ribeira da Silva 2015; United Nations, Department of Economic and Social Affairs, Population Division 2019). Decreases in mortality were followed by decreases in total fertility rate, defined as the total number of children that would be born to each woman if she were to live to the end of her child-bearing years and give birth to children in alignment with the prevailing age-specific fertility rates. Total global fertility rate decreased from 5.05 in 1950 to 2.45 in 2019 (United Nations, Department of Economic and Social Affairs, Population Division 2019). These interlinked changes constituted a demographic transition from an equilibrium with high fertility and low life expectancy to one with low fertility and high life expectancy. The demographic transition took first place in Europe, followed by North America and parts of East Asia, and subsequently most of the rest of Asia and Latin America. In Africa and the Middle East, the demographic transition has proceeded at a slower pace (Reher 2004; Cervellati and Sunde 2017).

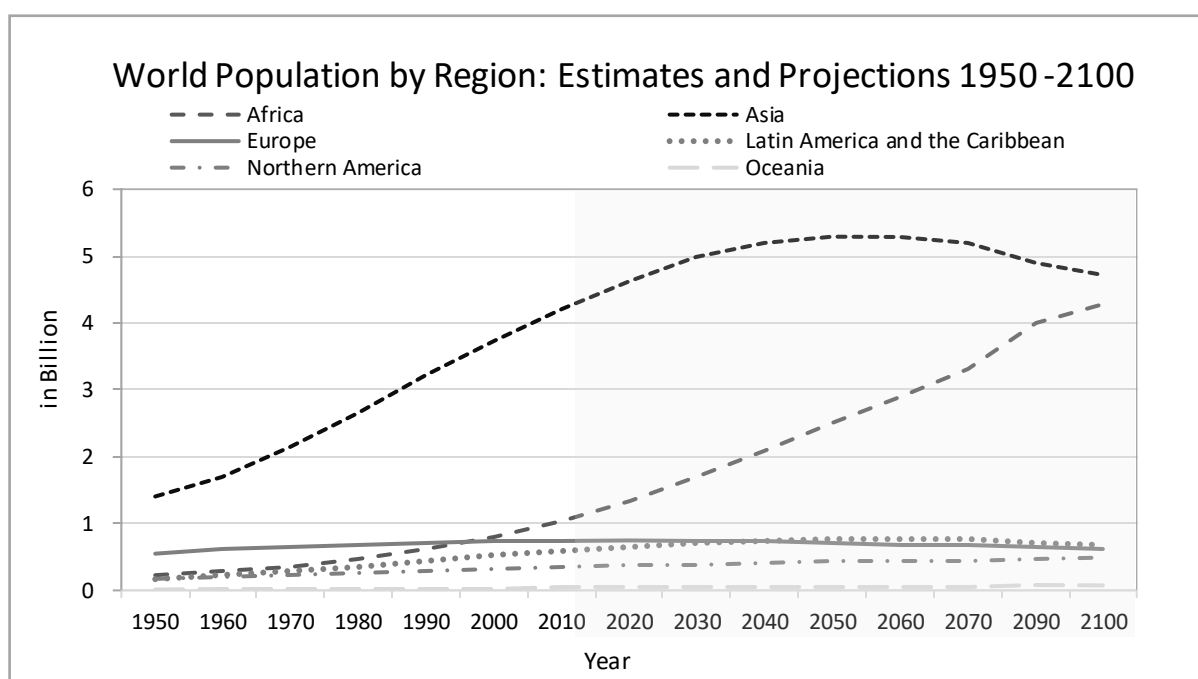


Figure 1 World Population by Region: Estimates and Projections 1950-2100. (Source: United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, Online Edition. Rev. 1)

Taken together, early decreases in age-specific mortality rates and subsequent decreases in fertility rates have not only multiplied the size but also transformed the distribution of the world population, depicted in Figure 1 by continents. Values after 2020 are based on the medium forecast of the United Nations. Most of the population growth since 1950 has taken place in Africa and Asia. From 1950 to 2020, the share of Africa of the world population increased from 9.0 percent to 17.2 percent and that of Asia from 55.4 percent to 59.5 percent. At the same time, the population share of Europe declined from 21.7 percent to 9.6 percent, the North American share decreased from 6.8 percent to 4.7 percent, and the population share

of Latin America increased from 6.7 percent to 8.4 percent (United Nations, Department of Economic and Social Affairs, Population Division 2019). African population is projected to increase from 1.34 billion in 2020 to 4.28 billion in 2100, while the population in Asia is projected to peak in 2055 and then turn to decline, with populations in Europe and Americas expected to remain rather stable.

The demographic transition was followed by major changes in global migration patterns. Until 1950s, Europe was for more than 400 years a major origin of global migration flows, following European colonization of Americas and Australia that resulted in violent replacements of indigenous populations, and establishment of colonial regimes in most of Africa and Asia. Figure 2 shows net migration rate by world regions over five-year periods from 1950 onwards, relative to their populations, with realizations until 2020 and the UN medium forecast from that onwards. In every five-year period, North America and Oceania (including Australia and New Zealand) have had highest net immigration rates. In 1950s, Europe and Latin America had highest emigration rates, but after that their paths diverged. Europe transformed from 1960s onwards from a continent of emigration to a major destination of global migration flows, primarily from Africa and Asia (Haas et al. 2018; 2016; van Mol and de Valk 2016). The transition went together with the decolonization in Africa and Asia. France, the United Kingdom, Belgium, and the Netherlands received significant immigration flows from former colonies. Latin America, instead, continued to experience highest continental emigration rates from 1960s to the present, although the rate decreased considerably in 2010s.

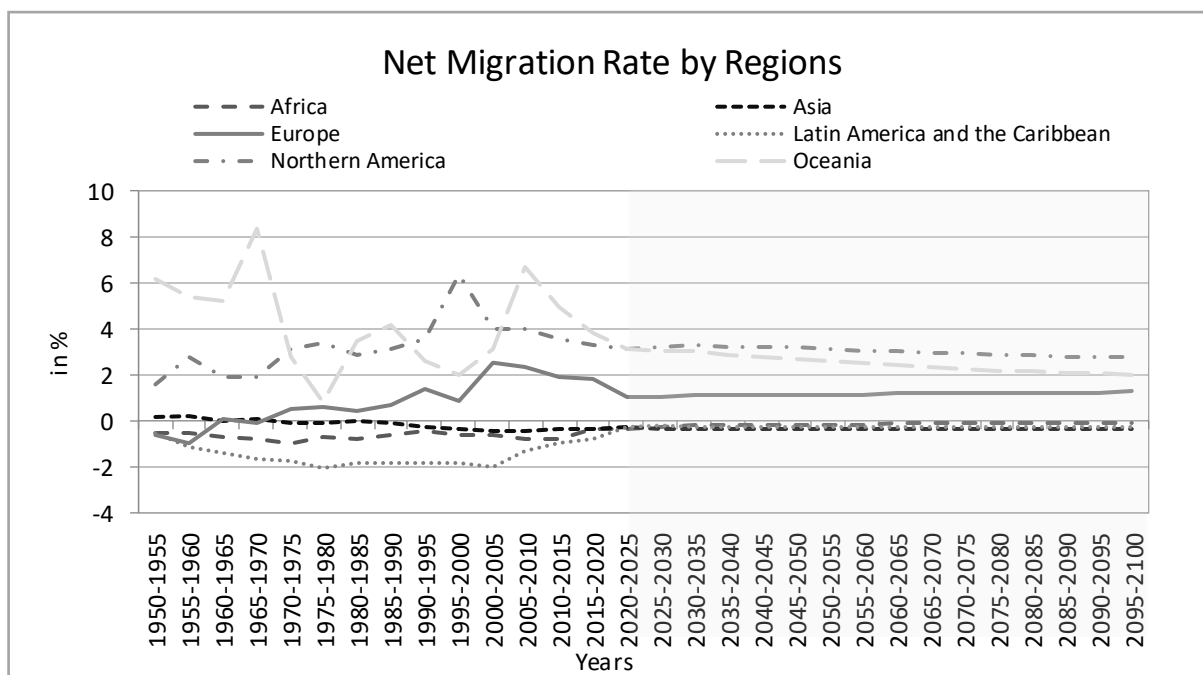


Figure 2 Net Migration Rate by Regions. (Source: United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, Online Edition. Rev. 1)

The change of Europe from a major source of global migration flows to a major destination is in line with what standard models of labor market supply and demand would predict. A decreasing supply of young workers and high wages in Europe are a major pull factor for potential migrants from Africa and the Middle East which face an oversupply of young workers relative to new job openings and have relatively low wage levels. Corresponding

dynamics take place in Americas, where the United States has been a magnet for Latin American migrants since the 19th century.

Figure 3 depicts the immigrant stock by world region as a share of regional population every five years from 1990 to 2020, including intra-regional migrants. Oceania (including Australia and New Zealand) has had consistently highest immigrant shares, exceeding 20 percent of population from 2015 onwards. In North America, the population share of migrants has increased by more than half, from 9.9 percent in 1990 to 15.9 percent in 2020. The share of migrants of the European population has increased from 6.9 percent to 11.6 percent, reflecting to a large extent increasing migration inside the European Union, but also continuing immigration from the rest of the world. In Africa, Asia, and Latin America, the share of immigrants has remained relatively flat, varying between 1.3 and 2.5 percent during the last three decades.

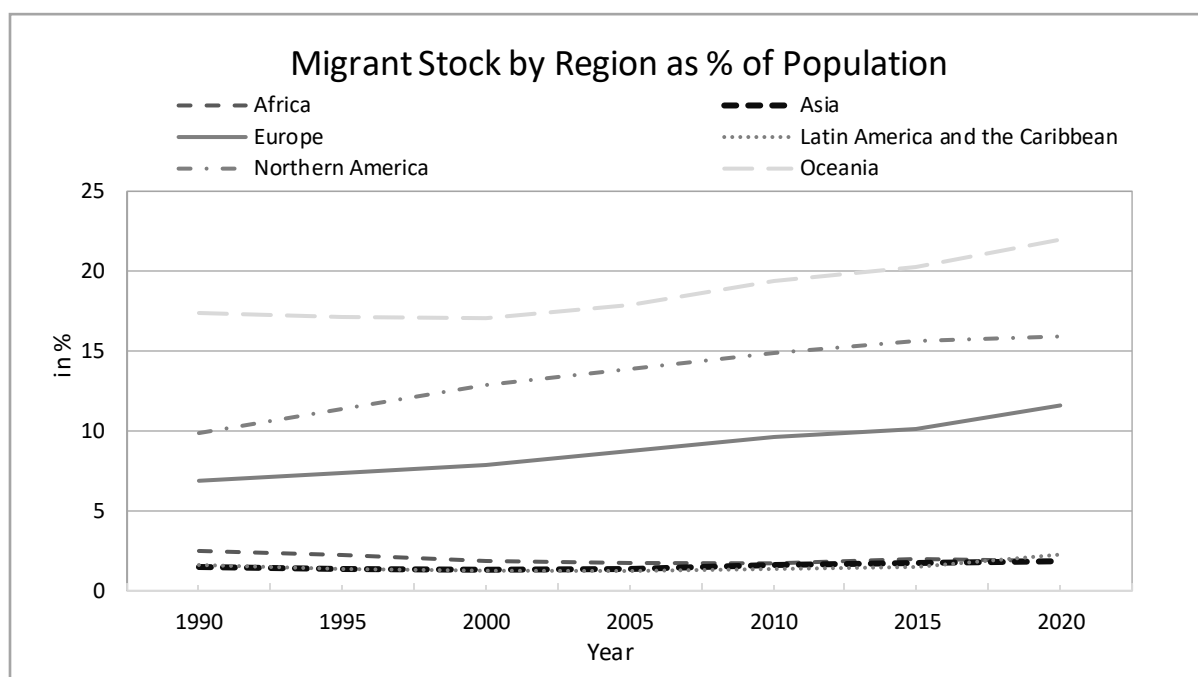


Figure 3 Migrant Stock by Region as % of Population. (Source: United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, Online Edition. Rev. 1)

Abel and Sander (2014) evaluate global between-country migration flows from 1990 to 2010 and conclude that largest movements take place between South and West Asian countries, from Latin America to North America, and within Africa. From 1995 to 2010, migration flows over five-year-periods are about 0.6 percent of world population. Dao et al. (2021) document the centrality of demographic changes for international net migration flows, as well as major heterogeneity in the skill content. From 1960 to 2019, the share of international migrants of world population fluctuated around 3 percent until 2010, increasing then to 3.5 percent in 2019. At the same time, the population share of foreigners in high-income countries increased from 4.5 percent to 12.0 percent, driven mostly by immigration from less developed countries. According to their estimates, the net flow of low-skilled immigrants (with less than college education) was 35.2 million over the 1970–2010 period, with migration from Latin American to North American countries accounting for 28 percent, migration within the South and East Asian region for 13 percent, and migration from the Middle East and North Africa to Europe for 6.8 percent. Intra-European migration

movements accounted for 4.5 percent. The net flow of high-skilled immigrants (with college education or more) was 27.6 million over the 1970–2010 period. Migration flows from South and East Asia to the United States, Canada, Australia, and New Zealand accounted for 19.8 percent of the total, intra-European movements for 10.7 percent, and migration between successor states of the Soviet Union for 10.5 percent. Migration from Latin America to the United States, Canada, Australia, and New Zealand was 9.7 percent, and from Europe to the same destinations 6.5 percent. It should be noted that relatively low shares of intra-European flows among both skill types reflect focus on net flows between countries. In Europe, there are significant cross-border flows going in opposite directions. However, although gross flows are a more relevant measure when it comes to the overall scale of international migration, focus on net flows is appropriate when evaluating the impact of international migration on demographic challenges.

The rest of the paper is organized as follows. Section 2 presents an overview on previous literature on the effects of immigration. Section 3 presents a stylized model to derive predictions on how population aging in coming decades can be expected to affect migration, wage rates in origin and destination regions, and public finances. Section 4 presents empirical evidence on predictors of net immigration into OECD countries and on how immigration has affected age structure and labor markets in receiving countries. The final section concludes with suggestions for future research agenda.

2 Previous Literature

Migration research has a long pedigree within economics, going back all the way to *The Wealth of Nations*. Already Smith (1776[1776]) noted that the wage differences between different locations in the United Kingdom were much larger than price differences, concluding that “a man is of all sorts of luggage the most difficult to be transported.” Sjaastad (1962) pioneered the analysis of migration research from the human capital perspective. In his model, migrants compare net present value of benefits and costs associated with alternative locations, choosing the one maximizing their utility. This implies that labor migrants can be expected to be relatively young. As migration imposes fixed costs, potential gains are more likely to exceed costs if the time horizon during which the costs are amortized is longer. From the perspective of demographic change, this and basic supply and demand mechanisms on the labor market all push in the same direction: migration flows can be expected to go from regions with rapid population growth and low wages to regions with slow growth and high wages, reacting especially to the size of the new cohorts entering the labor market.

International migration affects both origin and destination countries through labor markets, public finances, and cultural aspects. Most of the economic literature has focused on labor market and public finance effects. In general, if migration is based on productivity differences, it tends to increase global production by ensuring efficient allocation of factors of production (Borjas 1995; Clemens 2013). If, instead, migration would be based on other factors, like differences in the welfare state, it need not improve efficiency (Wildasin 1991; Sinn 1997; Borjas 1999). Given major differences in gross domestic product per capita, economists generally expect global migration to result in major productivity gains (Clemens 2011).

This section starts by presenting evidence on self-selection of international migrants, discusses then the effects of immigration in destination countries and in origin countries, and concludes by estimates from previous literature that brings together migration and demographic change.

2.1 Self-selection of International Migrants

Building on Roy (1951), Borjas (1987) showed that if skills are sufficiently transferable across countries, theory suggests that migrants from a less egalitarian to a more egalitarian country should come from the lower part of the skill distribution, while migrants from a more egalitarian to a less egalitarian country should come from the upper part of the skill distribution. Grogger and Hanson (2011) concluded that international migrants tend to be positively selected in that the more educated are more likely to emigrate. Furthermore, there is positive sorting in that more educated migrants are more likely to settle in destination countries that offer higher rewards to skill, in line with (Borjas 1987).

A common way to model migration decisions at the macro level builds on gravity model, with migration flows being increasing in pull factors in a potential destination, most notably high wages, and push factors in the origin, like high unemployment and low wages, and decreasing in the geographic and cultural distance between the two (see Mayda 2010; Bertoli and Fernández-Huertas Moraga 2013). An important component of such models is the stock of previous migrants: by helping their compatriots to find employment or housing and simply providing information on their destination, a network of previous migrants reduces costs for subsequent migrants, boosting subsequent migration. Beine et al. (2011) show that larger diasporas are associated with bigger migration flows and new migrants having lower average level of education.

Docquier and Rapoport (2012) show that emigration rates of the college-educated tend to be highest from the lower middle-income countries where potential migrants have substantial potential income gains from migrating to rich countries, but also means to emigrate. Furthermore, migration flows tend to be much higher from small countries. When defining high-skill migrant as a foreign-born individual who is aged 25 or more and is college graduate (independently of where the person has obtained the degree), brain drain as share of college graduates born in a region but living outside it was in year 2000 highest for Pacific islands (not including New Zealand) at 52.3 percent, the Caribbean at 43.0 percent, Central America at 17.1 percent, sub-Saharan Africa at 12.8 percent and South-Eastern Asia at 9.8 percent.

Emigration of the high-skilled is a challenge also for Western European countries. Docquier and Rapoport (2012) show that 8.9 percent of native-born Western European college graduates live abroad while for the United States, the share was only 0.5 percent. Emigration of the highly-skilled from Europe to the United States is even more pronounced when analyzing researchers. The share of native-born researchers in science and technology living and working in the United States was 29.0 percent for the United Kingdom, 18.0 percent for Germany, 17.0 percent for Italy, and 7.6 percent for France.

Borjas et al. (2019) show that the Roy model has more precise predictions about the self-selection of migrants than previously realized. The conditions that have been previously shown to result in positive or negative selection in terms of average expected earnings also imply a stochastic dominance relationship between the earnings distributions of migrants and

non-migrants. Furthermore, Borjas et al. (2019) analyze self-selection from Denmark, one of the richest and most egalitarian countries in the world, using the full population administrative data. They find that the income distribution for the migrants outside other Nordic countries almost stochastically dominates the distribution for the non-migrants, in line with the theory. This relationship holds for education, earnings, and residual earnings. Together with results from Grogger and Hanson (2011), this suggests that the United States is better placed to attract high-skilled immigrants to fill the gaps left by population aging than European countries.

The outlook of global migration is further complicated by environmental risks and conflicts. Cattaneo and Peri (2016) conclude that already in the period 1960 to 2000, higher temperatures increased emigration rates from middle-income countries. In poor countries, instead, liquidity constraints appeared to dominate, and emigration rates decreased. Beine and Parsons (2017) analyze the effects of colonial origins and find that natural disasters foster emigration from middle-income origins to former colonial powers. Although most refugees stay in developing countries, also migration flows to European destinations have increased dramatically since 2015 (Hatton 2020). Aksoy and Poutvaara (forthcoming) extend the Roy model to include risks related to staying in an unsafe country and risks related to unsafe passage and gender-specific returns to human capital. They then analyze how refugee self-selection differs from the self-selection of irregular economic migrants. Their model predicts, and survey data relying on interviews of refugees and irregular migrants arriving in Europe in 2015 and 2016 confirms, that refugees and female irregular migrants are positively self-selected with respect to their education, while male irregular migrants are negatively self-selected.

2.2 Effects of Immigration in Destination Countries

In the presence of worker heterogeneity, even efficiency-improving migration tends to generate winners and losers in the labor market. Most of the literature has focused on the complementarity and substitution effects (Borjas 2003; Ottaviano and Peri 2012). In perfectly competitive labor markets with low-skilled and high-skilled labor, immigration of one skill type tends to reduce wages of natives of the same skill type and increase wages of natives of the other skill type. Chassamboulli and Palivos (2014) were the first to identify a job-creation channel which arises in imperfectly competitive labor markets. An increase in the share of immigrant workers affects the incentives for job creation by firms in the presence of search and matching. If immigrants have inferior outside options (a worse bargaining position) compared to natives, wage bargaining results in immigrants receiving lower wages than natives of the same skill type. This, in turn, encourages firms to create more vacancies for the skill type experiencing immigration. That means that immigration may benefit even natives of the same skill type as immigrants.

Borjas (2001) argues that an additional benefit from immigration is that immigrants grease the wheels of the labor market, by reacting more flexibly to differences in job opportunities than native workers. Immigrants' higher flexibility arises as they are less attached to any specific location than natives often are. On the other hand, with low labor market flexibility, like wages set above market-clearing level in a unionized labor market or heavy restrictions on firing that also deter hiring, especially low-skilled immigration may result in increased unemployment. For example, Angrist and Kugler (2003) conclude that low labor market flexibility in Europe increases the negative effects of immigration.

A separate strand of literature has analyzed whether immigrants are net payers or net recipients when it comes to public finances. Empirical papers have arrived at opposite conclusions. This strand of literature has tended to assume perfectly competitive labor markets and has concluded that native population gains from immigration if immigrants are net contributors to public finances. Storesletten (2000; 2003) calibrated dynamic equilibrium models featuring demographics and fiscal policy for the United States and Sweden and concluded that natives can gain from immigration when immigrants are middle aged and have sufficiently high employment rates. Razin and Sadka (2000) show that with a pay-as-you-go pension system, even low-skilled migration can be beneficial to both high-skilled and low-skilled groups. Poutvaara (2007) showed that the overall effect of migration between countries with earnings-related and flat-rate pay-as-you-go pension systems on human capital investment and fiscal sustainability may go either way, depending on the contribution rates in the different countries. Although one might expect that countries with earnings-related pension systems would gain from international migration due to lower rate of intragenerational redistribution, such systems often redistribute more across generations (Disney 2004; Koethenbueger et al. 2008).

Battisti et al. (2018) were the first to analyze the welfare effects of immigration in the presence of both imperfectly competitive labor market and public sector that taxes and redistributes. They modelled search unemployment and public sector that taxes wages and provides unemployment benefits and other public expenditures. They then calibrated the effects of immigration for 20 OECD countries and concluded that the overall effects of immigration are positive for both low-skilled and high-skilled natives in most countries, if compared with hypothetical situation with no immigrants. However, when analyzing additional immigration, in terms of more recent immigration inflows or hypothetical further inflows, distributional conflict becomes more common. Especially primarily low-skilled migration would create a distributional conflict, with high-skilled natives gaining and low-skilled natives losing. This, in turn, can help to explain why especially low-skilled immigration has become a major political division line in many western countries. Edo et al. (2019) show that especially low-skilled immigration has increased regional support for far-right candidates in French presidential elections over three decades, and review evidence from other countries.

Card et al. (2012) highlight that compositional amenities, reflecting largely cultural concerns, play a major role in negative attitudes toward immigration in Europe. Their term compositional amenities refers to the composition of natives' neighborhoods, schools and workplaces. Card et al. (2012) estimate that worries about compositional amenities are 2–5 times more important in determining eventual concerns about immigration than concerns about wages or taxes. Also Halla et al. (2017) and Edo et al. (2019) find that that the effects of immigration on far-right voting depend on the origin of immigrants. Edo et al. (2019) highlight the interdependency between labor market and cultural concerns as the increase in far-right voting resulting from immigration is driven by low-educated immigrants from non-Western countries.

Labor market, public finance, and compositional amenities effects of immigration depend largely on how well immigrants are integrated. Battisti et al. (2018) document that the average yearly wage paid to immigrants equals 86 percent of that paid to natives for both high-skilled and low-skilled workers across 20 OECD countries, with large cross-country heterogeneity. Among the high-skilled, unemployment rates are higher for immigrants in all countries, and among the low-skilled, in most countries. Brell et al. (2020) find that refugees

have much higher unemployment rates than other migrants. Aksoy et al. (2020) show that both local unemployment and natives' attitudes towards immigrants matter for refugees' labor market and social integration outcomes.

2.3 Welfare Effects of Emigration in Origin Countries

Emigration has also major direct and indirect impacts on countries of origin. Traditional literature on brain drain has highlighted the adverse effects of high-skilled emigration on origin countries, following Bhagwati and Hamada (1974). Subsequently, Mountford (1997) and Stark et al. (1997) showed that, under certain conditions, brain drain may benefit poor countries of origin. The reason is that the prospect of emigration increases expected returns to education, thereby stimulating human capital formation in poor countries of origin. A key mechanism for beneficial brain drain is that mobility of the educated must be stochastic, so that only a fraction of the educated can emigrate. A moderately low probability of emigration may then generate brain gain through brain drain, as part of those who invest in education in the hope of being able to migrate are not able to do so, thereby benefiting their country of origin. Docquier and Rapoport (2012) summarize empirical literature on high-skilled emigration and conclude that brain gain through brain drain is most likely if potential wage gains from migration are sufficiently high, but the probability of high-skilled emigration is sufficiently low. Furthermore, origin countries can benefit from international migration directly through remittances (Lucas and Stark 1985; Rapoport and Docquier 2006; Yang 2008) and indirectly through international trade (Gould 1994; Rauch and Trindade 2002; Parsons and Vézina 2018) and knowledge flowing back from emigrants to the country of origin (Kerr 2008; Fackler et al. 2020). Recent research has also shown that emigration to western countries can promote democracy in the country of origin, plausibly through information and cultural diffusion (Spilimbergo 2009; Barsbai et al. 2017).

Poutvaara (2004; 2008) shows that the possibility of migration can also distort the provision of public education, away from internationally applicable towards country-specific skills. Governments that care about their tax revenue and their own citizens' disposable incomes would end up educating too many lawyers (with law being mostly country-specific) and too few engineers and economists (degrees that are internationally applicable), due to the risk that those with internationally applicable education could emigrate. If governments care only about their tax revenue and citizens who stay and cannot tax those who emigrate, they would reduce provision of internationally applicable education when its international applicability increases. At the same time, increasing international applicability increases students' private incentives to invest in study effort in internationally applicable education, and would also encourage a larger fraction to invest in it in case of private educational choices (Poutvaara 2008). The distortions in public provision of education could be alleviated by graduate taxes or income-contingent loans, collected also from emigrants. Poutvaara (2000), Poutvaara and Kanninen (2000), and Wildasin (2000) also show that when the educated become mobile, international tax competition tends to result in tax burden being shifted on immobile factors of production, thereby unravelling public financing of higher education.

2.4 Demographic Change and Global Migration

Hanson and McIntosh (2016) evaluate the effects of demographic trends on immigration to Europe and the United States in previous decades, and what to expect in the coming decades, based on demographic trends. They point out that earlier decrease in fertility in the United States than in Mexico helps to explain both the surge in migration from Mexico to the United

States in 1980s, and its subsequent decline when the growth rate in new cohorts entering the labor force in Mexico converged towards that in the United States. Based on demographic trends, their estimates suggest that immigration from Mexico to the United States is going to decrease in coming decades, while migration from Africa and the Middle East to Europe is going to increase substantially. Given that the African population is expected to increase by about three billion by the end of the century (see Figure 1), even substantial inflows relative to previous population in European countries would absorb only a small fraction of demographic pressure in Africa.

Dao et al. (2021) present a numerical model of migration between countries that differ in their initial populations and productivity. They calibrate the model to observed migration and socio-economic characteristics of 180 countries in 2010 and conclude that past migration is mostly governed by demographic trends. Their model predicts that under constant immigration policies, the average share of immigrants in OECD countries continues to increase from 12 percent in 2010 to 25–28 percent during the 21st century.

3 Theoretical Framework

To analyze the effects of population aging and technological change on migration, assume two countries, P and R. Country P is poorer and has younger population, while country R is richer and has an aging population. In each country, there are two overlapping cohorts, the young and the old. The young are working and the old are retired. The working time in each period is fixed and normalized to unity. The size of the young cohort in period t in country J , $J \in \{P, R\}$, is denoted with $N_{J,t}$. In the absence of migration, the size of the young cohort corresponds to the labor force, implying that $L_{J,t} = N_{J,t}$. Each country has a Cobb-Douglas production technology, combining labor and a fixed factor of production, normalized to unity, with production function $Y_{J,t} = A_{J,t} L_{J,t}^\alpha$, in which $A_{J,t}$ refers to the state of the technology in country J in period t and α is the factor share of labor. The model could be extended to include capital, but it is omitted to keep the model simple. If capital is internationally mobile it would simply be allocated between the two countries to equalize its expected net return, while if capital would not be mobile, its effects could be captured through general productivity parameter $A_{J,t}$. Country J collects taxes at rate $\tau_{J,t}$ on wage income to finance public expenditures.

In the absence of migration, the wage rate in country J , denoted by $w_{J,t}$, is given by $w_{J,t} = \alpha A_{J,t} N_{J,t}^{\alpha-1}$. Population aging can be modelled as a decrease in the size of the younger cohort. In Europe, East Asia, and other regions with fertility rates below replacement rates, young cohorts are smaller, implying that $N_{J,t} < N_{J,t-1}$. If technological progress is not sufficiently strong to compensate the decrease in the labor force, population aging results in decreasing wage sum and tax revenue. Wages per worker, instead, increase even in the absence of technological progress due to its increasing relative scarcity. In a poor country with increasing population, instead, total tax revenue and wage sum increase. However, wages per worker decrease, unless technological progress is sufficient to compensate the reduction in the fixed factor of production per worker.

Assume next that migration is allowed between the two countries. As in Poutvaara (2004; 2008), human capital is only imperfectly applicable abroad in case of migration. This imperfect applicability could reflect differences in the type of education, different languages, or migrants lacking some destination-specific skills. It also captures any time-equivalent costs of migration and integration efforts as in Borjas (1987). Those who migrate have a remaining effective working time γ_t , $0 < \gamma_t < 1$, in their new country of residence. Assuming that in the absence of migration $(1 - \tau_{R,t})\gamma_t w_{R,t} > (1 - \tau_{P,t})w_{P,t}$, there is going to be migration from P to R once migration is allowed. With migration, wage rates in both countries adjust. Denote the equilibrium migration from P to R by M_t . In equilibrium, after-tax wage income of a migrant from P to R would be equal to the after-tax wage income of a person staying in P , accounting for migration costs through $\gamma_t < 1$:

$$(1) (1 - \tau_{R,t})\gamma_t \alpha A_{R,t} (N_{R,t} + \gamma_t M_t)^{\alpha-1} = (1 - \tau_{P,t})\alpha A_{P,t} (N_{P,t} - M_t)^{\alpha-1}.$$

Solving (1) for M_t gives:

$$(2) M_t = \frac{\left(\frac{(1-\tau_{R,t})\gamma_t A_{R,t}}{(1-\tau_{P,t})A_{P,t}}\right)^{\frac{1}{1-\alpha}} N_{P,t} - N_{R,t}}{\left(\frac{(1-\tau_{R,t})\gamma_t A_{R,t}}{(1-\tau_{P,t})A_{P,t}}\right)^{\frac{1}{1-\alpha}} + \gamma_t}.$$

Differentiating (2) gives: $\frac{\partial M_t}{\partial N_{P,t}} > 0$; $\frac{\partial M_t}{\partial N_{R,t}} < 0$; $\frac{\partial M_t}{\partial A_{P,t}} < 0$; $\frac{\partial M_t}{\partial A_{R,t}} > 0$; $\frac{\partial M_t}{\partial \tau_{P,t}} > 0$; $\frac{\partial M_t}{\partial \tau_{R,t}} < 0$; $\frac{\partial M_t}{\partial \gamma_t} > 0$. Therefore, our model predicts that migration from P to R is increasing in the size of the young cohort in P , in the state of the technology in R , in the tax rate in P , and in the international applicability of migrants' human capital (captured by an increase in γ_t). Correspondingly, migration from P to R is decreasing in the size of the young cohort in R , in the state of the technology in P , in the tax rate in R , and in time-equivalent migration costs (captured by a decrease in γ_t).

With balanced government budget, public expenditures equal tax revenues:

$$(3) G_{R,t} = \tau_{R,t} \alpha A_{R,t} (N_{R,t} + \gamma_t M_t)^\alpha$$

$$(4) G_{P,t} = \tau_{P,t} \alpha A_{P,t} (N_{P,t} - M_t)^\alpha.$$

Differentiating (3) and (4) with respect to M_t gives $\frac{\partial G_{R,t}}{\partial M_t} > 0$, $\frac{\partial G_{P,t}}{\partial M_t} < 0$. Therefore, immigration improves public finances in the destination country, provided that public expenditures do not increase correspondingly. This effect would be weakened if a considerable share of tax revenues is spent on redistribution among working-age generation, or on publicly provided private goods that also immigrants consume. The negative effect on the origin country could be alleviated at least partly if migrants would send remittances or invest in their origin country.

The model's predictions help to explain major recent changes along the dominant migration corridors from Africa and the Middle East to Europe and from the Latin America to the North America, in line with econometric estimates in Hanson and McIntosh (2016) and numerical predictions from Dao et al. (2021). Youth bulge in Africa and the Middle East, corresponding to ever larger young cohorts $N_{P,t}$, are a major push factor that goes together with the pull factor of population aging in Europe, corresponding to decreasing $N_{R,t}$. In Latin America, instead, population growth rate has levelled off which reduces push factors to North America,

while birth rates in North America have remained at higher level than in Europe. Increasing migration from countries like India, in turn, reflects both steady increases in the number of graduates and increasing international applicability of their human capital. The model can also be applied to migration within Europe: even though population growth rates in Eastern Europe have plummeted, much higher standards of living in Western Europe have exerted a powerful gravitational pull, together with free mobility of labor that can be interpreted as a reduction in time-equivalent migration costs. Finally, if the model would be extended to migration between different destinations, it could capture the effects of shared language (Adserà and Pytliková 2015) or network effects of previous migrants, which could be modelled as an increase in γ_t .

4 Empirical Evidence

Figures 4, 5, and 6 show the divergence between different continents when analyzing separately different age groups, and Table 1 shows how the share of global population living on different regions has developed. While Asia's share of share of world population aged 0 to 19 has remained relatively stable, Africa's share has increased from 10.6 percent in 1950 to 26.2 percent in 2020, and Europe's share has declined from 17.2 percent in 1950 to 6.1 percent in 2020. Europe's share has decreased, and Africa's increased sharply also in the in the age group 20 to 64. Europe's share of the elderly has declined less, and Africa's increased only marginally. Taken together, especially Europe and East Asian economies face, in the absence of migration, decreasing labor force and challenges in taking care of their aging populations. In Africa and the Middle East, instead, the challenge is the lack of jobs for the youth bulge. Together with vast gaps in the standard of living, these demographic forces exert major pull and push factors on migration.

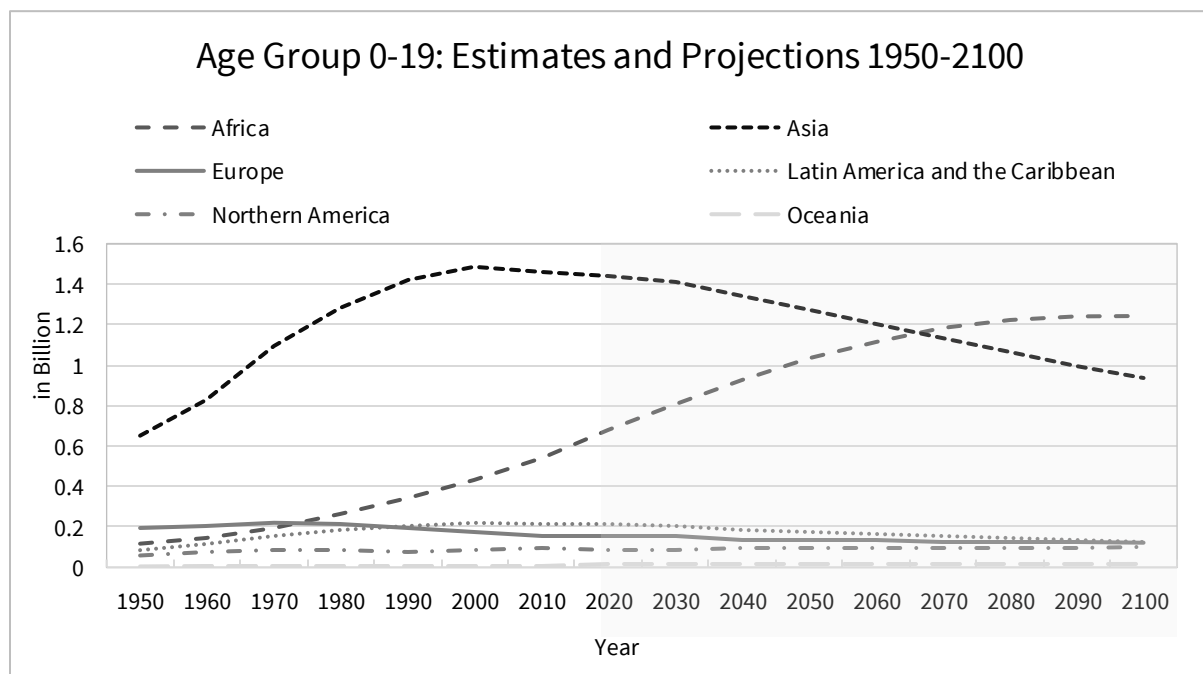


Figure 4 Population by Age Group: Estimates and Projections 1950-2100. (Source: United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, Online Edition. Rev. 1.)

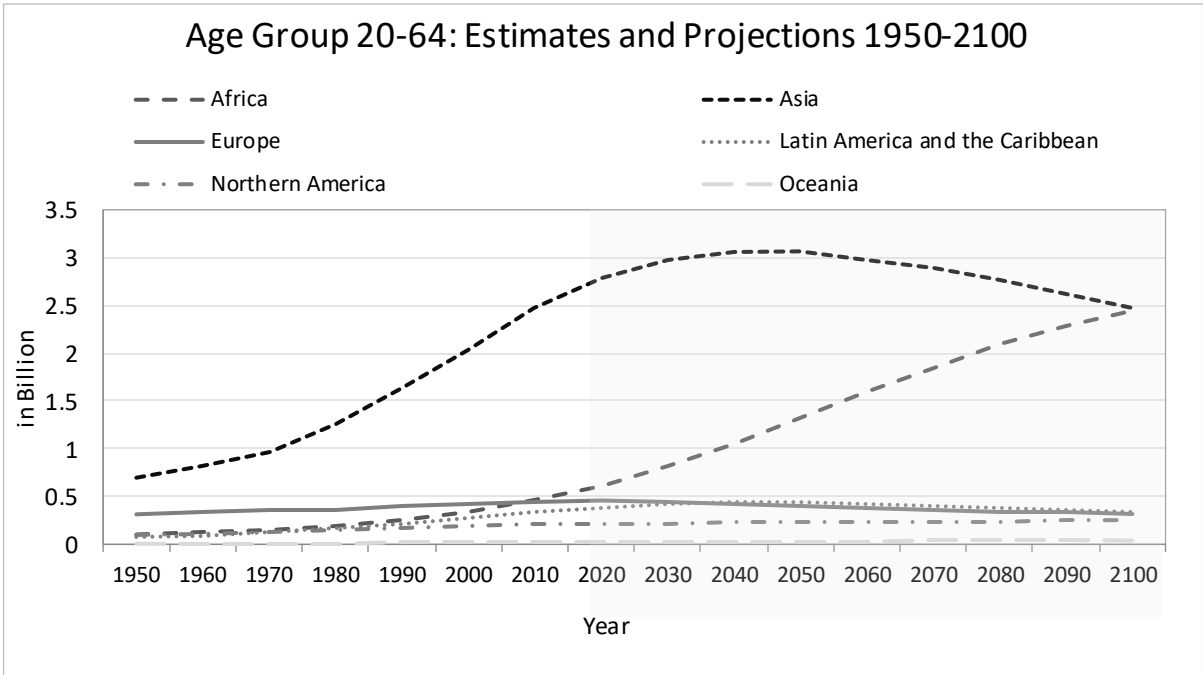


Figure 5 Population by Age Group: Estimates and Projections 1950-2100. (Source: United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, Online Edition. Rev. 1.)

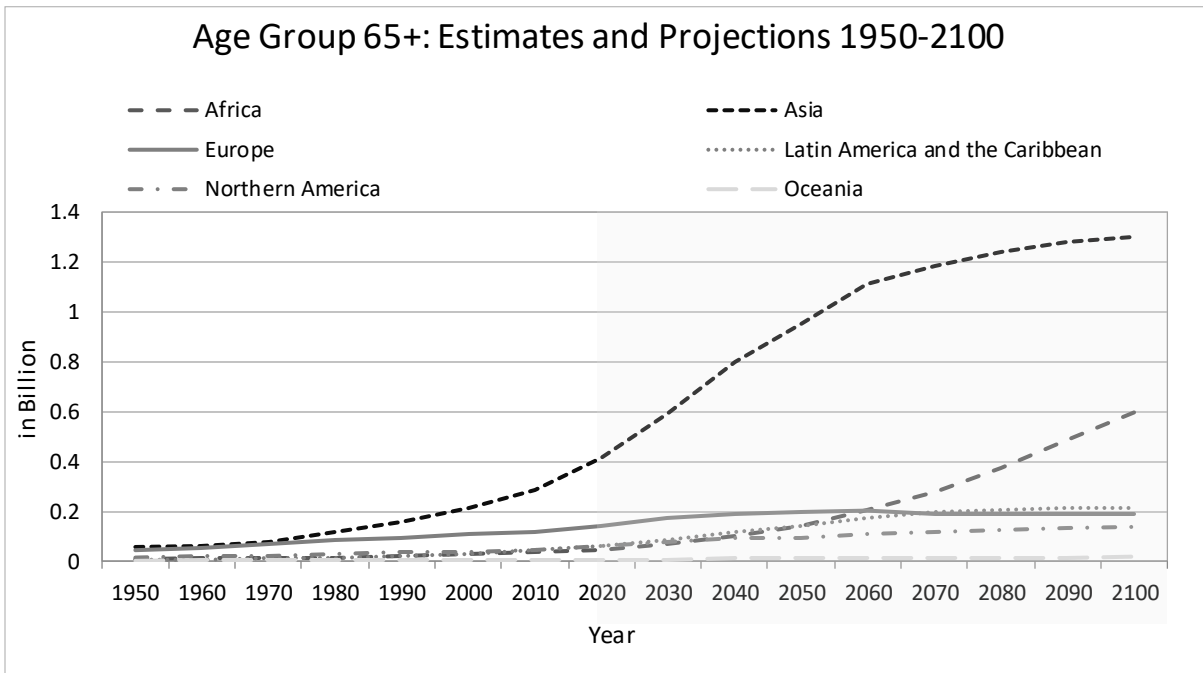


Figure 6 Population by Age Group: Estimates and Projections 1950-2100. (Source: United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, Online Edition. Rev. 1.)

Table 1 Continental Population Shares by Age Groups

Panel A: Continental population shares in age group 0-19			
	1950	2020	2100 (projection)
Africa	10.6	26.2	48.7
Asia	58.7	55.7	36.9
Europe	17.2	6.1	4.8
Latin America and the Caribbean	7.7	8.1	5.0
North America	5.3	3.5	4.0
Oceania	0.4	0.5	0.7
Panel B: Continental population shares in age group 20-64			
	1950	2020	2100 (projection)
Africa	7.9	13.7	41.6
Asia	53.7	62.3	42.2
Europe	24.2	10.0	5.4
Latin America and the Caribbean	6.0	8.6	5.8
North America	7.7	4.9	4.3
Oceania	0.6	0.5	0.7
Panel C: Continental population shares in age group 65+			
	1950	2020	2100 (projection)
Africa	5.7	6.5	24.3
Asia	44.0	56.6	52.9
Europe	34.0	19.6	7.8
Latin America and the Caribbean	4.6	8.1	8.7
North America	11.0	8.5	5.6
Oceania	0.7	0.7	0.7
Source: United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, Online Edition. Rev. 1.			

How well or badly the theoretical framework in the previous section predicts recent immigration flows? To evaluate this, we focus on net immigration into OECD countries, as emigration from many poor countries is strongly affected by immigration restrictions in destination countries that were not part of the model. Figure 7 shows how net immigration into OECD countries from 2015 to 2020 is related to their GDP per capita from 2015 to 2019. Countries with higher GDP per capita attract higher net immigration, in line with the theory.

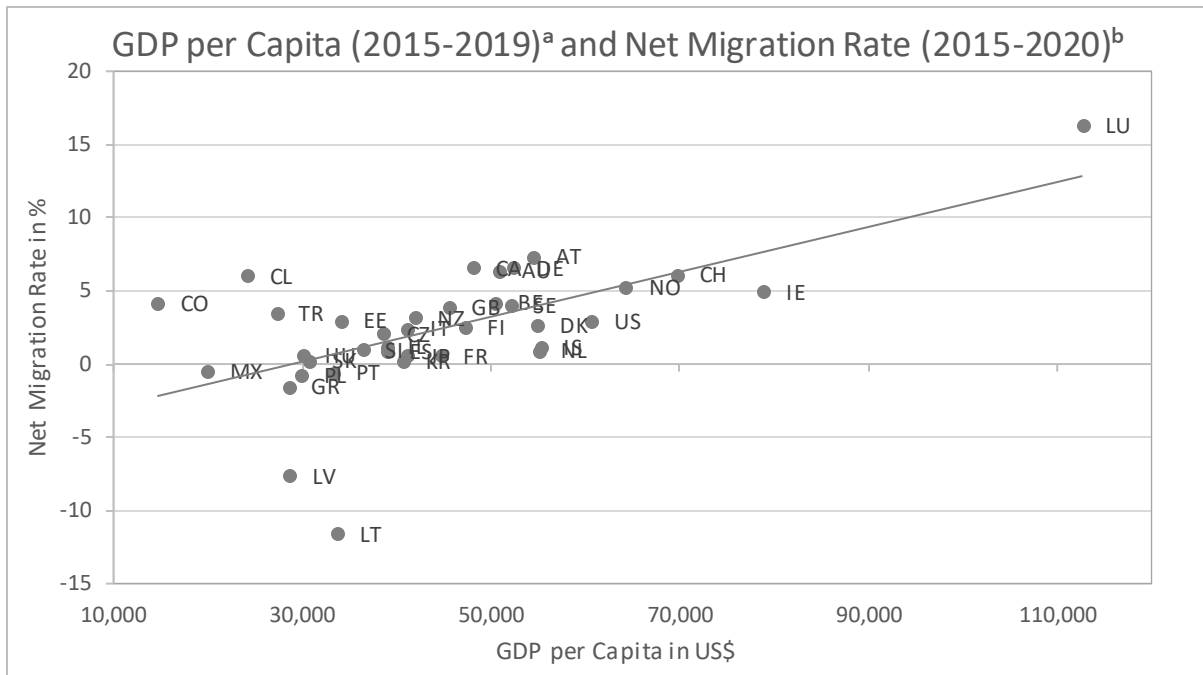


Figure 7 GDP per Capita (2015-2019)^a and Net Migration Rate (2015-2020)^b. (Source: ^a United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019 - Special Aggregates, Online Edition. Rev. 1.; ^b OECD (2021), Gross domestic product (GDP): GDP per head, US \$, current prices, current PPPs, <https://stats.oecd.org/index.aspx?queryid=60706>, accessed on 29/04/2021)

Figure 8 shows how net immigration to OECD countries from 2015 to 2020 responds to demographic development, corresponding to the size of the young cohort $N_{R,t}$ in the model. We instrument the size of young cohort entering the labor force from 2015 to 2020 by the population of those aged 0 to 9 in 1995, as they would be aged 20 to 29 in 2015. We instrument the size of the older cohort gradually leaving the labor force by the population of those aged 35 to 44 in 1995, and 55 to 64 in 2015, aging to 60 to 69 by 2020. If the ratio is larger (smaller) than one, then the underlying demographic structure would be expected to increase (decrease) labor supply from 2015 to 2020. Figure 8 shows that most OECD countries experience underlying demographics that push for decreasing working-age population, and net immigration. However, also OECD countries experiencing increasing labor force have received net immigration, with the exception of Mexico. Although increases in Turkey could be driven by refugees from Syria and increases in Chile and Columbia by refugees from Venezuela, the overall conclusion from Figure 8 is that cross-country correlation between net immigration and cohort sizes for OECD countries is close to zero in the studied period. The link between demographic fundamentals and immigration appears in global analysis over longer time periods (Hanson and McIntosh 2016; Dao et al. 2021).

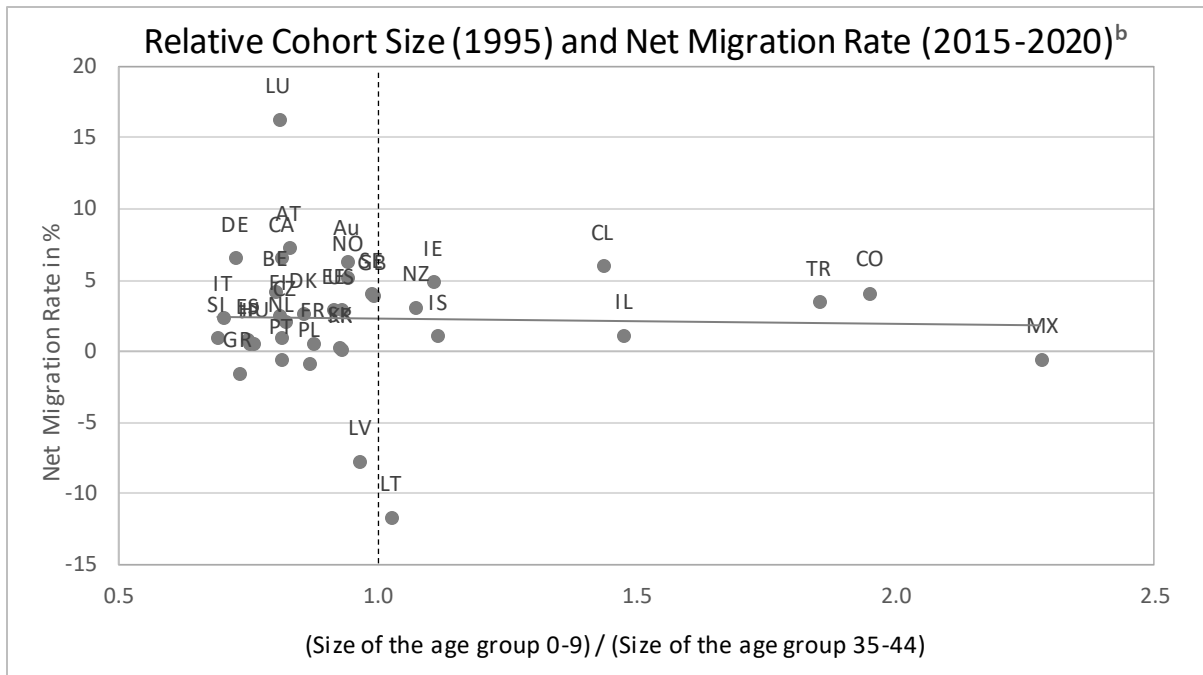


Figure 8 Relative Cohort Size (1995) and Net Migration Rate (2015-2020). (Source: United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019 - Special Aggregates, Online Edition. Rev. 1.)

Figure 9 shows more detailed age distribution among world population and world migrant population in 2020. While people tend to migrate as young adults, global migrant population, defined based on being born outside the country of current residence, is older than the world population on average. 41.0 percent of world population but only 21.4 percent of world migrant population was younger than 25 in 2020, and 9.3 percent of world population but 12.2 percent of migrant population was 65 years or older.

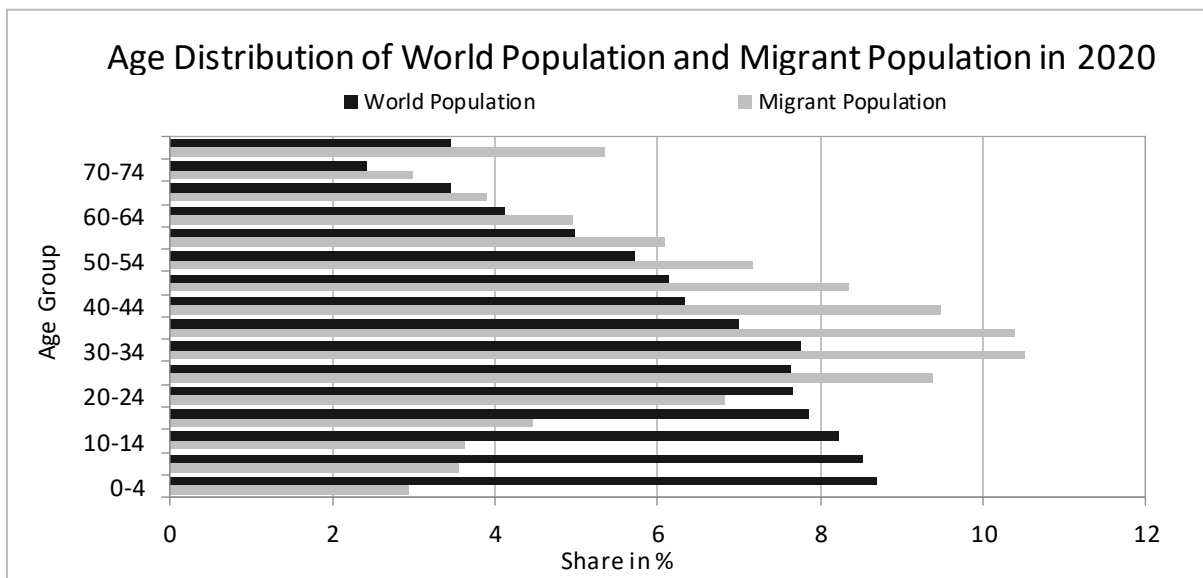


Figure 9 Population Distribution by Age Groups: World Population vs. Migrant Population 2020. (Source: United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, Online Edition. Rev. 1.)

Figure 10 presents corresponding comparison for Europe where natural population growth rates are low or even negative, and immigrants a large share of total population. Even in Europe, at the stock level immigrants are a smaller fraction of children and teenagers than natives, if looking only own migration experience.

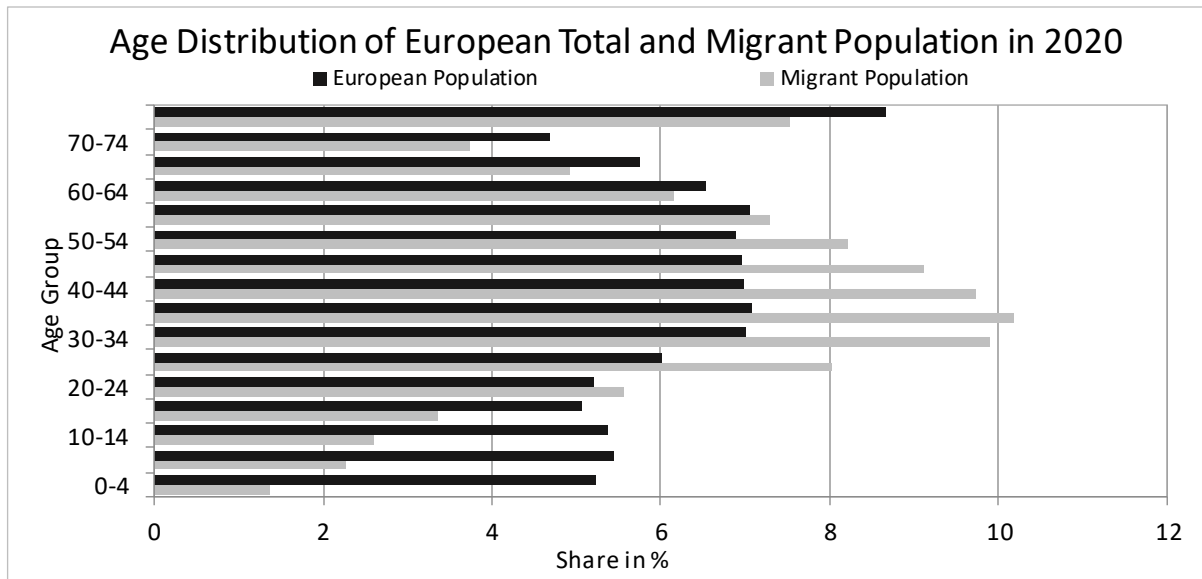


Figure 10 Population Distribution by Age Groups in Europe: Total Population vs. Migrant Population 2020. (Source: United Nations, Department of Economic and Social Affairs, Population Division (2019). World Population Prospects 2019, Online Edition. Rev. 1.)

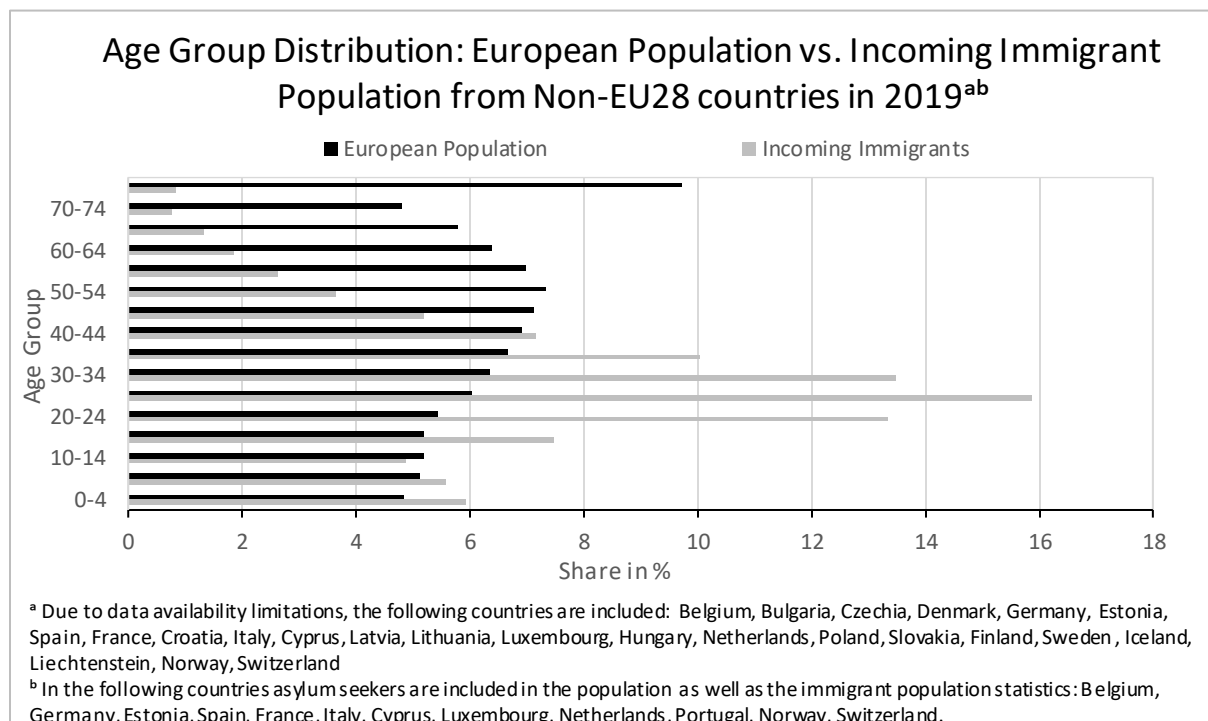


Figure 11 Age Group Distribution: European Population vs. Incoming Immigrant Population from Non-EU28 countries in 2019^{ab}. (Source: Eurostat, Population on 1 January by age group and sex (DEMO_PJANGROUP) and Immigration by age group, sex, and country of previous residence (MIGR_IMM5PRV).)

However, Figure 11 for those European Union member states and associated countries for which age information is available shows that the flow of new immigrants is considerably younger than existing populations.

Even more important for long-term demographics in destination countries than immigrants' age when they arrive is their fertility pattern after arrival. Figure 12 shows age distribution of Germans without immigrant background, first-generation immigrants, and second-generation immigrants. It highlights that the picture in Figure 10 underestimates the contribution of immigration to alleviating demographic change, as in Figure 10 second-generation immigrants are counted together with natives.

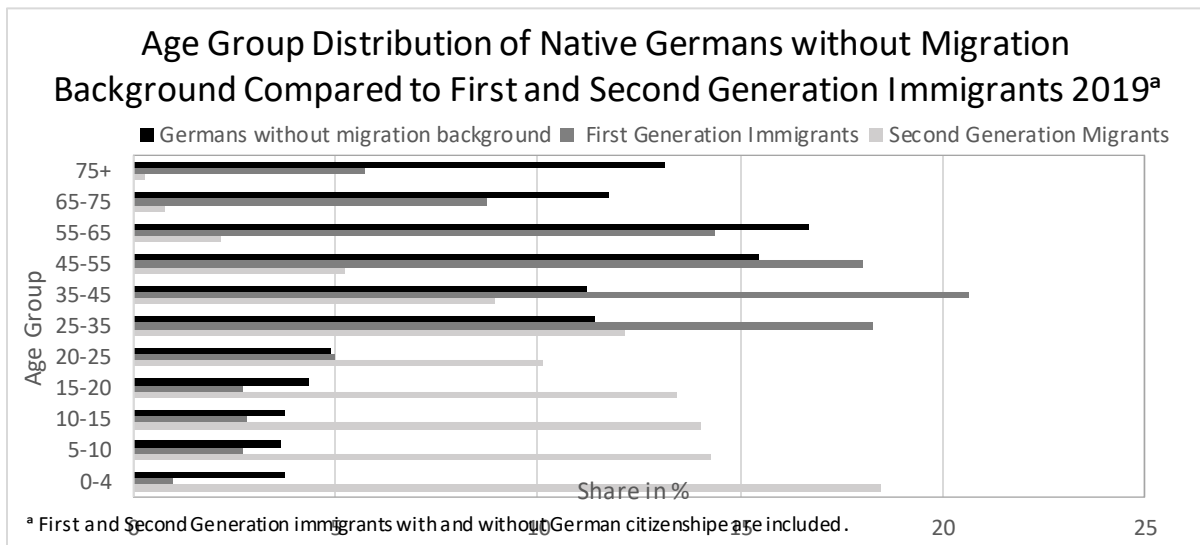


Figure 12 Age Group Distribution of Native Germans without Migration Background Compared to First and Second Generation Immigrants 2019^a. (Source: Mikrozensus, <https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Migration-Integration/Tabellen/migrationshintergrund-alter.html>, accessed 29/04/2021.)

Immigrants being younger than natives is a necessary but not a sufficient condition for immigration to alleviate demographic challenges. An additional condition is that immigrants must be employed. The first column of Table 2 shows the share of foreign-born population of the working age population aged 25 to 54 in Australia, Canada, France, Germany, Italy, the United Kingdom, and the United States. The lower limit is set at 25 to account for a high share of students in younger age groups and the upper limit of 54 reflects the gradual onset of early retirement in older age groups. The share of foreign-born population ranges from 15 percent in France to more than 30 percent in Australia and Canada, with Germany, the United Kingdom, and the United States in between with 22-24 percent shares. The other columns show how employment shares differ between native-born and foreign-born males and females. Employment shares of foreign-born males are almost the same as employment shares of native-born males in Canada, Italy, the United Kingdom, and the United States, and about 7 percentage points lower in France and Germany. Employment shares of foreign-born women are considerably lower than the employment shares of native-born women in all countries, ranging from a 4-percentage-point gap in the United States to a 23-percentage-point gap in France. When it comes to addressing challenges arising from population aging, most countries have considerable potential in increasing female labor force participation rates, especially among immigrants.

Table 2 Foreign-born Population in Selected Countries

		Foreign-Born Population Working-Age (25-54)	Employment-to-Population Ratio (Age Group 25-54)			
			Native-Born Males %	Foreign-Born Males %	Native-Born Females %	Foreign-Born Females %
Country	Year	Share in %				
Australia	2017	35.6				
Canada	2018	30.7	86.4	86.0	82.5	71.8
France	2019	14.8	86.2	78.8	80.4	57.0
Germany	2019	23.9	91.2	84.4	85.7	66.6
Italy	2019	16.9	80.6	82.1	61.8	52.6
United Kingdom	2019	21.8	90.0	91.0	81.7	72.4
United States	2020	21.6	93.2	92.8	93.4	89.6
Source: International Labour Organization, (2021), ILOSTAT database [database], available from https://ilostat.ilo.org/data/ .						

5 Research Agenda for the Future

Most of the world has undergone a demographic transition from an equilibrium with high fertility and low life expectancy to one with low fertility and high life expectancy. This has transformed also migration patterns, with Europe changing from a primary source of global migration flows to an important destination. One of the most important questions for demographic and migration research in the 21st century is how fertility rate is going to develop in Africa. With current trends, African population is predicted to increase from 1.3 billion in 2020 to 4.3 billion in 2100, and the number of those aged 0 to 19 is predicted to exceed one billion by year 2050. So far, Africa's share of global migration flows has been way below its population share. Even modest increases in emigration from Africa would generate major increases in immigration pressure in the rest of the world, mostly in Europe. The other crucial question is how climate change affects migration flows. Berlemann and Steinhardt (2017) summarize recent research on climate change and migration, concluding that rising temperatures tend to induce outmigration, especially in countries dependent on agriculture. The projected population increase of 3 billion by the end of the century in Africa alone coincides with potentially devastating effects of climate change on agricultural productivity, and a specter of environmental disasters from the joint pressure of climate change and rapid population increase. Climate change and rising oceans also threaten the viability of densely populated coastal areas and whole Pacific nations, creating an increasing population of climate refugees.

Previous research has shown that education, development, and population growth are closely related. Educated women tend to have fewer children (Currie and Moretti 2003; Osili and Long 2008), meaning that changes in educational trajectories could also change population forecasts and migration pressure. Would increases in emigration rates discourage governments from providing internationally applicable education (Poutvaara 2004; Poutvaara 2008)? Or would the possibility of migration encourage brain gain through brain drain (Docquier and Rapoport 2012)? The answer may well vary across developing countries. One possibility for achieving mutual gains from high-skilled migration would be education finance partnerships, in which destination countries participate in financing higher education in countries from which they recruit skilled labor.

Drastic improvements in communication technology, especially mobile internet access, make migration much easier and allow migrants to remain in contact with family members left behind. Recent research has extended gravity models of migration decisions by modelling the decision whether to acquire costly information (Bertoli et al. 2020). Migrants rationally invest less in acquiring information concerning countries that they expect to be unlikely to be optimal destinations, or that have high costs of information. Could improvements in information technology result in tipping points in which international migration patterns, say, between Africa and Europe, could rapidly change from a high-information-cost and low-migration equilibrium to a low-information-cost and high-migration equilibrium?

Another important research frontier concerns the interaction of demographic change, migration, and health care. With increasing life expectancy, health care and personal services targeting the elderly are going to gain in importance. An increasing fraction of elderly households in rich countries could afford hiring immigrants from low-wage countries to provide care at home, as an alternative to a nursing home. With sufficiently flexible regulations and keeping employer costs moderate, governments in aging countries could co-opt such services as a way of reducing pressure on nursing homes. However, strict regulations that make legal hiring prohibitively expensive could force such services to remain in the shadow economy, to the detriment of migrants and public finances. This illustrates a more general choice facing governments in destination countries. They can try to stem migration flows or manage the flows with an aim of realizing potential mutual gains arising from labor shortages in Europe, East Asia, and other destinations, and youth bulge in Africa and the Middle East.

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