Does Europe need immigration for demographic reasons?

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Main Text

Introduction

Ever since the publication of an influential 2001 study by the United Nations on "Replacement migration" (1) this notion has prominently entered the public as well as the scientific debate over migration. This terminology has evidently been inspired by the notion of replacement-level fertility, a rather technical term in demography referring to the level of fertility which after adjusting for child mortality would result in two children surviving to reproductive age per woman and thus, in the absence of migration and future changes in mortality, would result to a stationary population size and structure in the long run. Replacement migration in this sense refers to the international migration that a country would need in order to offset population decline and aging resulting from fertility rates that are lower than replacement-level. Although the UN study itself dealt with this in a purely numerical and rather neutral way, the implicit underlying assumption motivating the study was that population decline and increases in the so-called age dependency ratio (persons aged 65+/15-64) would have negative consequences that should be avoided. The study illustrated under which hypothetically assumed future migration patterns these consequences could be avoided.

In our study we also try to stay neutral with respect to specific policy recommendations in demonstrating the implications of alternative migration and labor force participation scenarios on different dependency ratios, but we base our discussion on a much richer multi-dimensional model. While the 2001 study only considered age as a relevant human characteristic, in our micro-simulation model we use 13 such characteristics (including among others labor force participation, duration of stay in the country, region of birth, own education and level of mother's education). We also assess the demographic outcomes of the alternative scenarios in terms of three different dependency ratios that not only cover the changing age structure but also changing patterns of labor force participation and productivity as approximated by level of education. Based on the still widely used conventional old age dependency ratio – which considers everybody aged 15-64 as equally productive and all people above age 65 as unproductive – the presumed aging burden associated with an increase in this ratio is widely seen as a major economic problem leading to higher social security costs, relatively lower economic growth or even stagnation and decline. We consider such a simplistic approach based on age alone as outdated and partly misleading (2–5).

In the following, we will define a set of six alternative scenarios that also reflect different possible policy choices for all 28 member states of the European Union with respect to volume of immigration, selectivity of migrants in terms of education and efforts made in terms of integrating migrants into the labor force. These different migration related scenarios are assessed against the background of different possible future trends in labor force participation of the total population by either assuming a continuation of the recent trend or assuming that all EU member states move towards the pattern of much higher participation that is already observed in Sweden today. Figure 1 illustrates this Swedish pattern and contrasts it against the current pattern in Italy where at all ages people – and in particular women – participate to a lesser degree in the labor force. Also, the age at retirement is much higher in Sweden.

Alternative Scenarios on migration and labor force participation

Here we address the question of how to view aging through a multidimensional demographic approach in which the populations of all 28 EU member states are stratified, not only by the conventional age and gender, but also by labor force participation, immigration status and educational attainment which is also used as a proxy for productivity. Using a multidimensional population projection model by microsimulation called CEPAM-Mic (6–9) which also considers the duration of stay in the destination country and the age at immigration, we built different scenarios of changes in labor force participation rates, in the number of immigrants, in their composition and in their integration into the labor market to measure the impact of different policies on different types of projected dependency ratios for 2015-2060. Here, integration of immigrants into the labor market is modeled as their differential in labor force participation rate by duration of residence when compared to native's rates.

The different migration and labor force participation scenarios are:

i. The Baseline scenario is "business as usual". It thus assumes continuation of past trends in terms of immigration levels (about 10 million immigrants over 5 years combined with constant out-migration rates, resulting in a net migration gain of roughly 4.6 million over 5 years), constant composition and integration process, as well as in terms of the continuation of recent trends in labor force participation rates for native-born.

ii. The Baseline/Swedish_LF scenario, which assumes gradual increases up to 2050 in labor force participation rates, in particular among women and elderly, to the levels already observed in Sweden today. Sweden is the country where participation rates are among the highest in Europe. Thus, this scenario shows the effect of efficient policies seeking to increase the labor force participation.

iii. The Canadian scenario tests the effect of a more selective immigration system combined with a higher immigration rate as observed in Canada. It thus assumes a doubling of the EU immigration volume (20 million over 5 years, which corresponds to the Canadian immigration rate in the last quarter of a century), as well as a selection with respect to educational attainment as currently done by Canada. It assumes, however, the same integration rates into the labor market as the baseline scenario;

iv. The Canadian/Swedish_LF scenario combines both an immigration system similar to Canada and efficient policies to increase labor force participation of the population to today's Swedish level.

v. The Canadian/Hi_Int scenario is identical to the Canadian scenario, but in addition assumes a best-case scenario for the integration of newcomers (i.e., their country-specific labor force participation rates match that of the native-born with similar characteristics by 2050). Indeed, despite selection of immigrants based on their human capital, Canada's immigrants still face some economic integration issues;

vi. The Canadian/Lo_Ed/Lo_Int scenario assumes a high volume of immigration, their labor force participation deteriorates and reaches in 2050 those observed in Denmark (the EU country with the largest gap between immigrants and natives) and a low education level of future immigrants as recently observed in Italy. This scenario thus shows what could happen if the EU immigration policies fail with the integration and selection processes while the number of immigrants increases.

All scenarios share the same assumptions (in terms of group-specific parameters) for fertility, mortality, migration within the EU, and educational attainment of natives. For the whole EU28, total fertility rate is projected to slightly increase from 1.6 in 2015 to 1.8 in 2060. We also assume a continuous improvement in life expectancy and long-term regional convergence with life expectancy exceeding 90 years in most European countries by 2060. For educational attainment, development in post-secondary education is assumed to continue and for internal EU migration and out-migration from the EU we assume the rates observed over recent years to remain constant.

Population aging and dependency

The mid-to long-term consequences of population aging and migration are manifold. In addition to economic dimensions the impacts include social and cultural changes which often dominate the public discourse, but are more difficult to quantify and capture in scientific models often because of lack of data. For this reason, in our discussions here about trade-offs between possible future trends in migration and population aging we restrict our analysis to labor-related demographic measures. More specifically, we address the issue of dependency at three different levels with increasing complexity.

Population aging leads to a higher proportion of elderly, which generally means more people in a situation of economic dependency, and relatively fewer people in the working-age group to support them. This raises policy concerns about the fiscal burden for future generations and the viability of previously constructed social programs, because a larger share of the elderly leads to increased public expenditures, especially in terms of health care and pension, and to a proportional decrease in potential workers contributing to the system (10). The conventional **age dependency ratio** (ADR) is widely used to measure this dynamic. For a country *c* at time *t*, the ADR is the ratio between the children and the elderly (0-14 + 65 and older) to the traditionally working-age groups (15-64) (equation 1). This indicator strictly reflects the age structure of the population.

Eq. 1 $$\mathrm{ADR}_c^t = \frac{Pop0{-}14_c^t + Pop\ 65over_c^t}{Pop15{-}64_c^t}$$

Although the age and sex structure of a population is a major determinant of its economic burden, recent trends in labor force participation are showing important changes that should also be accounted for when projecting the labor force. First, future cohorts will likely be more educated than older ones, and the more educated – particularly in case of women – tend to work to a higher extent and stay active in the labor market for longer. Consequently, the older workers of the future are more likely to be economically active than current older workers (11–13). Indeed, in many countries, labor force participation rates continue to increase among the population age 55 and over (12). Similarly, women are working more than ever. Thus, considering the labor force participation and its evolution become necessary to have a more accurate measure of the dependency ratio.

For these reasons, we also calculated the **labor-force dependency ratio** (LFDR), which has all economically inactive persons (I) in the numerator and the active ones (A) in the denominator (equation 2), regardless of their age. It thus captures the fact that quite some people aged 15-64 are not in the labor force (students, housewives, early retirement, etc.) and some above age 65 are still in the labor force.

Eq. 2 $$\mathrm{LFDR}_c^t = \frac{I_c^t}{A_c^t}$$

Many argue that the fiscal impact of a decline of the labor force size could be compensated by an increase in overall productivity, which is highly correlated with education (14–17). To take account of the fact that not all members of the labor force equally contribute to the economy, we propose in this paper an innovative dependency indicator, the **productivity-weighted labor force dependency ratio** (PWLFDR). This indicator approximates differences in productivity through wage differentials associated with different levels of educational attainment.

To calculate it, we used wages as a proxy of productivity differentials by education level. Although the relationship between wages and labor productivity is a source of controversy in some contexts, it has been shown that it holds in the most economically developed countries (18). In theory, when the labor market is competitive, workers receive a salary equal to their marginal labor productivity.

Using the employee cash or near-cash income (PY010G) of the active population from the European Statistics on income and living conditions 2004 to 2017 (EU-SILC), education-specific weights are calculated using a Poisson regression controlling for age, sex, and country, as expressed by equation 3:

Eq.3 $$\ln(WAGE) = \beta_0 + \beta_1 EDU + \beta_2 AGE\_GR + \beta_3 CNTRY + \beta_4 SEX$$

We estimated productivity weights using the natural exponential of β_1, which are set at 1 for medium education, 1.66 for high education, and 0.62 for low education. This means that someone with a high level of education is on average 66% more productive than someone with a medium level of education, while someone with a low level of education is 34% less productive than the latter. Those weights are then multiplied by the active population of the corresponding education level in the denominator, and the resulting ratio is normalized at the EU level of 2015. The PWLFDR at time *t* for a country *c* can thus be defined by equation 4.

Eq.4 $$\mathrm{PWLFDR}_c^t = \frac{I_c^t}{0.62*L\_A_c^t + 1*M\_A_c^t + 1.66*H\_A_c^t} / \frac{I_{EU}^{2015}}{0.62*L\_A_{EU}^{2015} + 1*M\_A_{EU}^{2015} + 1.66*H\_A_{EU}^{2015}}$$

Where:

I is the inactive population;

L_A is the active population with a low level of education;

M_A is the active population with a medium level of education;

H_A is the active population with a high level of education.

A PWLFDR higher than 1 reveals that, considering the productivity of workers, the burden of dependent people is heavier relative to the average burden in the EU in 2015.

The PWLFDR has some limits in its interpretation. Since weights are constant over time, an implicit assumption is that trends in jobs by skill requirements will follow trends in education (such as what anticipated by the CEPFOP (19)), or in other words, that there will be no major shift in over- or under-qualification. The PWLFDR also takes into account only gain in productivity resulting from changes in education. Increase in productivity resulting from progress in technologies or in institutional organization are not considered here and are assumed to be constant. But this is consistent with the general view that demographic models capture the changes in human capital as the supply side of labor and do not attempt to model the demand for labor and labor market itself which belongs to the real of economic modelling.

Methods

The microsimulation projection model used for this research, named CEPAM-Mic, allows the study of alternative scenarios and their consequences for future population trends in the European Union. Microsimulation is a powerful tool that can replace traditional multistate projections when the number of dimensions becomes large (24, 25). It uses complex statistical models to project life-course transitions and events at the individual level using a large number of characteristics that are determinants of the different transitions. Briefly, the model aims to project the population of all EU28 member countries along several demographic, ethnocultural and socioeconomic dimensions. In addition to age, sex and education, immigration-related variables are also included in the model, such as immigrant status, place of birth, age at immigration and duration of residence in the host country.

Individuals from the base population are simulated one by one and their characteristics are modified through scheduled events whose timing are stochastically (Monte-Carlo) determined using the values of their specific input parameters at any given time during the projection period. The parameters used as inputs are themselves derived through various statistical methods, using available data sources.

Immigration policies can have an impact on the future labor force through three dimensions: the volume of immigration, the socioeconomic composition of migrants, and the extent to which newcomers are well integrated or not. This paper evaluates the effectiveness of these different options using 'what if' scenarios. All scenarios share the same assumptions (in terms of group-specific parameters) for fertility, mortality, domestic migration (internal to EU), education, language and religion shifts. For the whole EU28, total fertility rate is projected to slightly increase from 1.6 in 2015 to 1.8 in 2060. We also assume a continuous improvement in life expectancy and long-term regional convergence with life expectancy exceeding 90 years in most European countries by 2060. For educational attainment, development in post-secondary education is assumed to continue and for domestic migration and emigration, rates from recent years are assumed to remain constant.

In the baseline scenario, constant entry and exit rates by age, country, and education are used for the future labor force participation, while in the Swedish variant, they converge to Sweden's ones by 2050. This results in increasing participation rate in most countries for women and elderly. Country- and sex-specific differentials for immigrants by duration of stay and age at arrival are then applied, which allow to take into account the economic integration process and to build alternative variants on this dimension. In general, the labor force participation rate for immigrants born outside the EU is lower than for EU-born individuals, although it improves with the number of years spent in the host country. After 10 years, the labor force participation rates of immigrants are close to the rates of EU-born individuals for men, but still lower for women. In the high integration variant, rates for immigrants converge by 2050 to natives' ones with similar characteristics (age, sex, education), while in the low integration one, it converges to the immigration participation rates of immigrants as observed in Denmark.

The number of international immigrants and their composition are direct inputs into the projection model from exogenous parameters. In the baseline assumption, the average number of immigrants admitted in recent years is assumed to remain constant (about 10 million immigrants per 5 years) throughout the projection, while the high variant doubles this number. In the baseline scenario, it is assumed that the educational attainment of immigrants is the same as what is observed in recent years. The alternative assumptions change the composition of immigrants in terms of education by reweighting them so that distributions by level of education correspond to those observed for immigrants admitted in Canada or Denmark.

Results

Figure 2 shows that the three different indicators of dependency have very different future trajectories for the EU even under the same scenario (Baseline) that assumes middle of the road fertility, mortality, migration, education and labor force participation trajectories up to 2060. To better compare the trends over time, the three indicators have been standardized to 1.0 in 2015. Over the coming decades the conventional age dependency ratio shows the most dramatic increase by more than 60 percent to 2060. The increase even accelerates somewhat after 2025 due to the large baby boom generation reaching age 65. When focusing on the labor force dependency ratio, the increase gets already much smaller (only 20 percent), profiting from the already embedded increase by younger cohorts in participation rates of women and older workers in the baseline scenario and an of the increasing share of the more educated who also maintain higher participation rates, thus increasing the overall labor force participation. Finally, factoring in the increases in productivity through the improving educational composition of the population brings further reductions in the projected burden. Thus, despite the widespread fear of huge increases in dependency resulting from population aging, as generally transmitted by studies based solely on the future evolution of the age structure, for the productivity-weighted dependency ratio even under the baseline scenario (continuation of status quo) our results show a quite modest 10 percent increase by 2060.

When assessing the relative impact of various migration and integration scenarios in terms of the resulting changes in economic dependency, the underlying changes in the overall pattern of labor force participation of the total population hold a large influence(20, 21). Figure 3 shows the projected trends in the productivity-weighted labor force dependency ratio for the EU up to 2060 under our different scenarios. A convergence of labor force participation rates to what is currently observed in Sweden would be enough to completely reverse the trend and to expect a decrease in the dependency ratio by 10 percent (baseline/Swedish_LF scenario). Similarly, the Canadian/Hi_Int scenario, which assumes higher immigration rates of better educated migrants and a better integration of them into the labor market, produces results very close to the baseline/Swedish LF scenario even if it maintains the country specific labor force participation rates. The Canadian scenario assuming high immigration of well-educated people combined with intermediate integration into the labor force results essentially in a flat line of no future change in economic dependency. At the opposite, a combination of high migration volumes with low education and unsuccessful integration (Canadian/Lo_Ed/Lo_Int) results in a sizeable increase in the dependency burden of 20 percent, twice the increase of the baseline scenario.

The impact of those different scenarios on the demographic structure of the EU is shown in figure 4, which shows age pyramids decomposing the population by labor force participation and education in 2015 and 2060 for selected scenarios. Compared to the pyramid of 2015, the one for the baseline scenario in 2060 already reveals that for the EU, despite an older age structure, the working-age population will be more educated (darker shades) and will participate more in the labor force (green shades), as a result of current trends of better education among younger cohorts and higher participation rates for older women. The resulting age pyramid for the Canadian/Swedish_LF scenario further increases the working-age population size with high education through more highly educated immigrants, and reduces sharply the percent of inactive women, through improvements in their labor force participation rates. At the opposite, the Canadian/Lo_Ed/Lo_Int scenario increases the size of the working-age population, but mainly among the low educated (lighter shades) and among the inactive population. Despite having the same assumed volume of immigration, the Canadian/Swedish_LF and the Canadian/Lo_Ed/Lo_Int scenarios yield very different outcomes, thus highlighting the importance of a multidimensional approach for population projections.

The aggregate picture for the European Union covers some remarkable differences among individual countries as shown in Table 1 for the productivity-weighted labor force dependency ratio. In 2015 Italy had the highest dependency burden with 1.44 (i.e. 44 percent above the EU average), followed by Malta with 1.19 and Belgium with 1.17. At the low end there are Lithuania with 0.77, Estonia with 0.79, Sweden and Cyprus with 0.80. Under the baseline scenarios these ratios will increase in most countries, but much more so for some than for others. In 2060 under the baseline scenario the dependency burden for the EU, as a whole, increases by 11 percent, with the highest increase projected for Greece to 1.59 followed by Croatia (1.38) Slovenia (1.37) and Spain (1.32). For the baseline scenario combined with Swedish labor force participation rates, the dependency burden for the EU-28 would actually be about 10 percent lower than in 2015. About the same is the case for Canadian migration policies combined with best case integration. Again, there are significant country-specific differences. Italy and Belgium would have particularly strong declines in dependency under the Canadian/Hi_Int scenario by 2060, but also the biggest EU country, Germany, would see a favorable dependency ratio under this scenario which would be 18 percent lower than the EU's 2015 average and 25 percent lower than Germany in 2060 under the baseline scenario. These highlight the importance of integration policies and are actually rather optimistic range of futures for the country that together with Japan is the oldest country in the world today.

Discussion

There can be no doubt that Europe's population is getting older, at least if age is defined in the conventional way as time since birth, which does not factor in the trend of increasing life expectancy and better health and increasing education. In many respects today "70 is the new 60" (22, 23). Despite this, the proportion of the population that is above the age of 65 is still widely considered a critical indicator. At the level of the EU-28, it is projected to increase from currently 18.2 percent to around 30 percent by 2050, which has given rise to widespread fears about negative economic and fiscal consequences of this demographic trend. As a consequence, either increased immigration or alternatively efforts to increase fertility have been suggested – by different sides of the political spectrum – as possible policies to counteract population aging. But neither of these two strategies pursued within realistic bounds will have as much impact as possible future changes in labor force participation, improving educational attainment and of better economic integration of immigrants.

In this analysis we show that the policy conclusion drawn with respect to a possible "demographic need" for migrants in Europe changes markedly when different sources of population heterogeneity and associated dependency burdens are considered. The conventional way of only considering the changing age composition of the population had been applied by the widely discussed UN study on "Replacement Migration" (1) which concluded that migration can help avoid population decline but that a stop in the increase of the total age-dependency ratio would require implausibly high volumes of immigrants and would therefore be unrealistic. Here we show that already when adding labor force participation and education as additional demographic characteristics to the analysis, the projected dependency ratios will increase much less under baseline trend assumptions. When the model also covers the effect of education on productivity and not only on labor force participation – an innovation introduced here – the projected increase in burden under the baseline scenario is only a low 10 percent by 2060. This means that much of the fears of population aging seem exaggerated. As this increase is modest, either moderate migration levels, if migrants are well-educated and integrated, or an increase in labor force participation among the general population can fully compensate for it.

Under a Canadian migration scenario – high volume of well-educated immigrants, but with intermediate integration – the European Union would experience virtually no increase in this dependency ratio accounting for labor force participation and productivity. If labor force integration of migrants deteriorates though, the EU's dependency ratio would worsen by a significant 20 percent increase. This shows the high stakes involved with integration outcomes under high migration volumes. But if special efforts for economic integration of migrants into the labor force were made to have them reach the same participation rates as natives (Canadian/Hi_Int scenario), it would actually lead to a decline in this dependency ratio similar to the projected decline under the assumption of higher labor force participation rates in all EU country to the level observed in Sweden today. If migration in Europe would be simultaneously associated with policies leading to increasing labor force participation of the native population (assuming that today's Swedish participation rates will be reached by all countries by 2050) this (Canadian/Swedish_LF) scenario would actually result in a substantial decline in the dependency burden by around 20 percent.

Although demographic ageing is unavoidable in Europe, the fears associated with the coming economic burden have been unduly exaggerated through the use of the simplistic and inappropriate conventional age-dependency ratio. There are plausible scenarios where feasible public policies could be effective in coping with the consequences of population ageing. Depending on the policy options preferred and available – encouraging higher labor force participation among the native population and/or education selective migration together with high integration efforts – Europe could largely avoid the widely assumed negative impacts of aging and maintain a dynamic labor force based on high human capital.

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References

1. UN, *Replacement migration: is it a solution to declining and ageing populations?* (United Nations, Dept. of Economic and Social Affairs, Population Division, 2001).

2. W. Lutz, *et al.*, *Demographic Scenarios for the EU - Migration, Population and Education* (Publications Office of the European Union, 2019).

3. W. Lutz, S. KC, Global human capital: Integrating education and population. *Science* **333**, 587–592 (2011).

4. F. Willekens, "The demography of labor force participation" (International Institute for Applied Systems Analysis, 1978).

5. N. Keyfitz, "Multidimensionality in population analysis" in *Sociological Methodology*, K. F. Schuessler, Ed. (Jossey-Bass, 1979), pp. 191–217.

6. A. Bélanger, P. Sabourin, G. Marois, J. Van Hook, S. Vézina, A framework for the prospective analysis of ethno-cultural super-diversity. *Demographic Research* **41**, 293–330 (2019).

7. G. Marois, P. Sabourin, A. Bélanger, Implementing Dynamics of Immigration Integration in Labor Force Participation Projection in EU28. *Population Research and Policy Review* (2019) https:/doi.org/10.1007/s11113-019-09537-y.

8. G. Marois, P. Sabourin, A. Bélanger, Forecasting Human Capital of EU Member Countries Accounting for Sociocultural Determinants. *Journal of Demographic Economics* **85**, 231–269 (2019).

9. M. Potančoková, G. Marois, Projecting the future births in the EU28 with fertility differentials reflecting women's educational and migrant characteristics. *Vienna Yearbook of Population Research* (Forthcoming).

10. United Nations, "World Population Ageing 2015" (Population Division, Department of Economic and Social Affairs, United Nations Secretariat, 2015).

11. B. F. Barakat, R. E. Durham, "Future education trends" in *World Population and Human Capital in the 21st Century*, W. Lutz, W. P. Butz, S. KC, Eds. (Oxford University Press, 2014), pp. 397–433.

12. E. Loichinger, Labor force projections up to 2053 for 26 EU countries, by age, sex, and highest level of educational attainment. *Demographic Research* **32**, 443–486 (2015).

13. H. M. Hasselhorn, W. Apt, "Understanding Employment Participation of Older Workers : Creating a Knowledge Base for Future Labour Market Challenges" (Federal Ministry of Labour and Social Affairs, 2015).

14. Börsch-Supan Axel, Labor Market Effects of Population Aging. *LABOUR* **17**, 5–44 (2003).

15. R. Lee, A. Mason, Some macroeconomic aspects of global population aging. *Demography* **47**, S151–S172 (2010).

16. A. Ludwig, T. Schelkle, E. Vogel, Demographic change, human capital and welfare. *Review of Economic Dynamics* **15**, 94–107 (2012).

17. A. Prskawetz, B. Hammer, "Does education matter? – economic dependency ratios by education" in *Vienna Yearbook of Population Research*, (Verlag der Österreichischen Akademie der Wissenschaften, 2019), pp. 1–24.

18. P. Carneiro, J. J. Heckman, E. J. Vytlacil, “Estimating marginal returns to education” (National Bureau of Economic Research, 2010).

19. CEDEFOP, “Future skill needs in Europe: critical labour force trends.” (2016).

20. P. Rees, N. van der Gaag, J. de Beer, F. Heins, European Regional Populations: Current Trends, Future Pathways, and Policy Options. *European Journal of Population / Revue européenne de Démographie* **28**, 385–416 (2012).

21. J. Bijak, D. Kupiszewska, M. Kupiszewski, Replacement Migration Revisited: Simulations of the Effects of Selected Population and Labor Market Strategies for the Aging Europe, 2002–2052. *Popul Res Policy Rev* **27**, 321–342 (2008).

22. W. C. Sanderson, S. Scherbov, Remeasuring aging. *Science* **329**, 1287–1288 (2010).

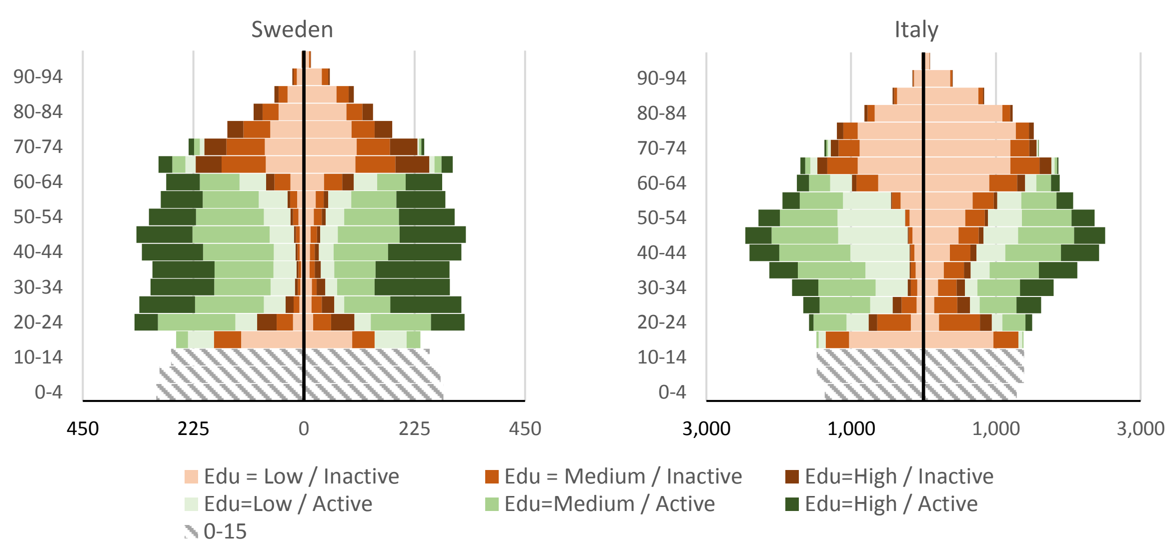
23. W. C. Sanderson, S. Scherbov, Average remaining lifetimes can increase as human populations age. *Nature* **435**, 811–813 (2005).

24. E. Van Imhoff, W. Post, Microsimulation methods for population projection. *Popul* **10**, 97–138 (1998).

25. M. Spielauer, What is Social Science Microsimulation? *Social Science Computer Review* **29**, 9–20 (2010).

Figures and Tables

Figure 1. Age pyramids by labor force participation and education for Sweden and Italy, 2015 (‘000)



Source: Authors’ calculations from the European Labor Force Survey 2015

Figure 2. Projections of the three different dependency ratios for the EU-28, baseline scenario, 2015-2060

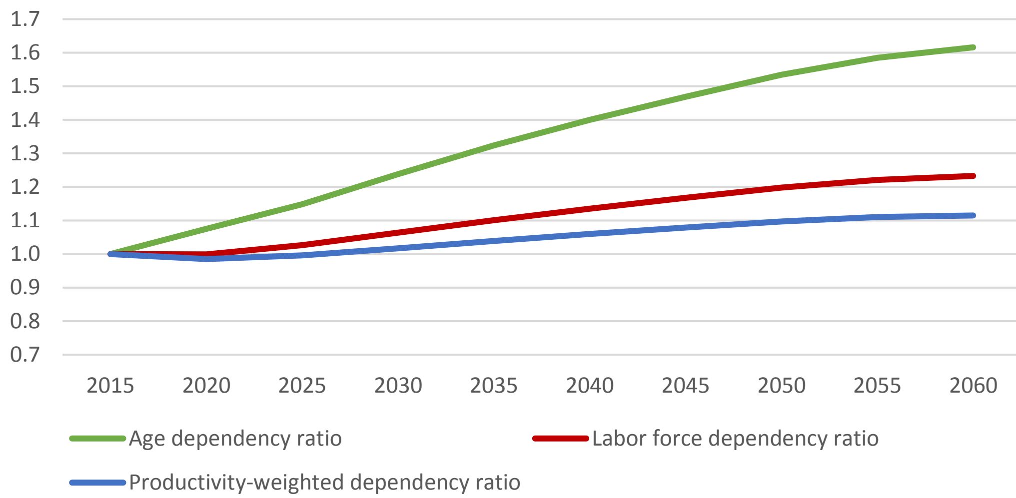


Figure 3. Projection of the productivity-weighted labor force dependency ratio for the EU-28 under different scenarios, 2015-2060

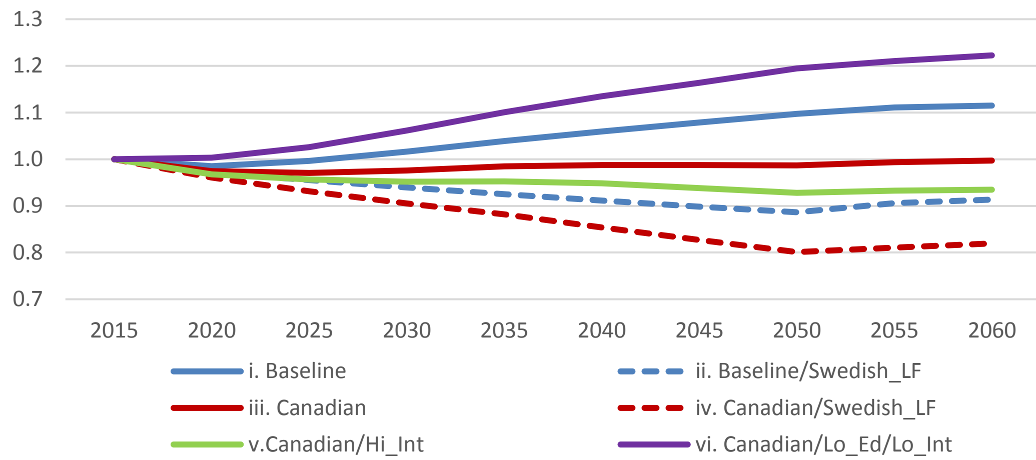


Figure 4. Age pyramids by labor force participation and education for the EU-28 in 2015 and 2060 under different scenarios ('000)

Table 1. Productivity-weighted labor force dependency ratio under different scenarios.

Country	2015	2060		
		Baseline	**Baseline/ Swedish_LF**	**Canadian/ Hi_Int**
Austria	0.90	1.14	0.91	0.90
Belgium	1.17	1.26	0.88	1.03
Bulgaria	1.07	1.31	0.91	1.19
Cyprus	0.80	1.15	0.90	0.89
Czech Rep.	0.93	1.27	1.05	1.13
Germany	0.84	1.11	0.94	0.86
Denmark	0.87	1.08	0.95	0.82
Estonia	0.79	0.96	0.86	0.85
Spain	0.97	1.32	1.03	1.08
Finland	0.89	1.08	0.89	0.94

France	1.10	1.10	0.84	0.98
Greece	1.12	1.59	1.03	1.44
Croatia	1.20	1.38	0.96	1.21
Hungary	1.07	1.19	0.86	1.06
Ireland	0.94	1.14	0.86	0.96
Italy	1.44	1.18	0.97	0.98
Lithuania	0.77	1.07	0.91	0.97
Luxemburg	0.94	1.02	0.84	0.93
Latvia	0.90	1.05	0.90	0.92
Malta	1.19	0.82	0.81	0.59
Netherlands	0.84	0.94	0.90	0.73
Poland	0.98	1.17	0.93	1.03
Portugal	1.11	1.15	1.02	1.08
Romania	1.14	1.22	0.91	1.08
Sweden	0.80	0.83	0.89	0.67
Slovenia	1.02	1.37	1.06	1.12
Slovakia	0.92	1.22	0.96	1.21
U.K.	0.89	0.96	0.83	0.83
European Union	**1.00**	**1.11**	**0.91**	**0.93**