



Population aging, migration, and productivity in Europe

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This paper provides a systematic, multidimensional demographic analysis of the degree to which negative economic consequences of population aging can be mitigated by changes in migration and labor-force participation. Using a microsimulation population projection model accounting for 13 individual characteristics including education and immigration-related variables, we built scenarios of future changes in labor-force participation, migration volumes, and their educational composition and speed of integration for the 28 European Union (EU) member states. We study the consequences in terms of the conventional age-dependency ratio, the labor-force dependency ratio, and the productivity-weighted labor-force dependency ratio using education as a proxy of productivity, which accounts for the fact that not all individuals are equality productive in society. The results show that in terms of the more sophisticated ratios, population aging looks less daunting than when only considering age structure. In terms of policy options, lifting labor-force participation among the general population as in Sweden, and education-selective migration if accompanied by high integration, could even improve economic dependency. On the other hand, high immigration volumes combined with both low education and integration leads to increasing economic dependency. This shows the high stakes involved with integration outcomes under high migration volumes.

population aging | immigration | projection | labor-force participation | microsimulation

Ever since the publication of an influential 2001 study by the United Nations (UN) 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 in 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) have negative consequences that should be avoided. The study illustrated under which hypothetical future migration patterns these consequences could be avoided.

The scenarios are conditional on immigration and labor-force participation policies, but we 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 study on a much richer multidimensional model. While the 2001 study only considered age as a relevant human characteristic, in our microsimulation

model we use 13 such characteristics (including among others labor-force participation, duration of stay in the country, region of birth, education, and level of mother’s education). We also assess 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 sections of the paper, we will define a set of six alternative scenarios that also reflect different possible policy directions for all 28 member states of the European Union (EU) with respect to volume of immigration, selectivity of migrants in terms of education, and efforts made to integrate migrants into the labor force. These different migration-related scenarios are assessed against the background of possible future trends in

Significance

Migration is one of the most controversial political topics in industrialized countries. One important aspect is population aging and the prospects of a shrinking labor force in case of low or no immigration. We address this aspect systematically through multidimensional microsimulations for all European Union (EU) member states. The outcome variables considered go beyond the conventional old-age dependency ratios by also studying labor-force dependency ratios and the introduced productivity-weighted labor-force dependency ratio. We consider a wide range of future migration scenarios differing by volume, educational selectivity of migrants, and labor market integration efforts. Combined with alternative scenarios of labor-force participation for the EU-born population, the findings provide scientific insights for future migration and labor policies in Europe.

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labor-force participation of the general population by either assuming a continuation of the recent trend or assuming that all EU member states move toward the pattern of much higher participation that is already observed in Sweden today. Fig. 1 illustrates this Swedish pattern and contrasts it against the current pattern in Italy where at all ages people—in particular women—participate less in the labor force. Also, in comparison the age at retirement is much higher in Sweden.

Alternative Scenarios for 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 a 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, the number of immigrants, their composition, and their integration into the labor market in an effort to measure the impact of different policies on projected dependency ratios for 2015–2060. Here, integration of immigrants into the labor market is modeled as the differential in labor-force participation rate by duration of residence compared to native’s rates. A comprehensive description of the model as well as comprehensive tables of the country-specific results can be found in [SI Appendix](#).

The migration and labor-force participation scenarios are as follows:

- 1) 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 y combined with constant outmigration rates, resulting in a net migration gain of roughly 4.6 million over 5 y). The scenario assumes constant migrant compositions and integration, as well as the continuation of recent trends – labor-force participation rates for native born.
- 2) 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.
- 3) 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 y, which corresponds to the Canadian immigration rate in the last quarter of a century), as well as selection for educational attainment as currently done by Canada. It assumes, however, the same integration rates into the labor market as the baseline scenario;

- 4) 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.
- 5) The Canadian/Hi_Int scenario is identical to the Canadian scenario, with the exception of assuming 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;
- 6) 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.
- 7) The Japanese scenario assumes low volume of immigration (about 1.2 million immigrants over 5 y), but highly qualified, such as what is observed today in Japan. This scenario shows the effect of very selective migration policies reducing the overall volume of flows. The labor-force integration assumptions are the same as in the baseline scenario.

All scenarios share the same assumptions (in terms of group-specific parameters) for fertility, mortality, migration within the EU, and educational attainment of natives. Detailed assumptions can be found in [SI Appendix](#), Fig. S1 in the section *Definition of scenarios*. 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 y in most European countries by 2060. For educational attainment, development in postsecondary education is assumed to continue and we assume the rates observed over recent years for internal EU migration and outmigration from the EU remain constant.

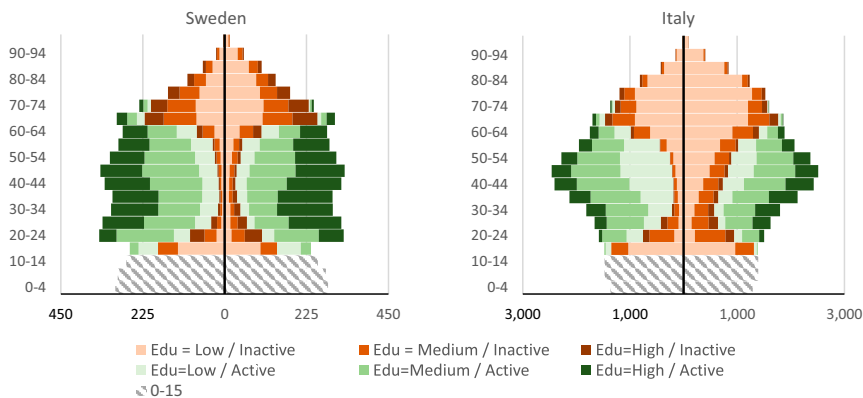


Fig. 1. Age pyramids by labor-force participation and education for Sweden and Italy, 2015 (thousands).

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 social scientific models often due to 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 of 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 population to support them. This raises policy concerns about the fiscal burden on future generations and the viability of social programs, because a larger share of the elderly leads to increased public expenditures, especially in terms of health care and pension, as well as 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) (Eq. 1). This indicator strictly reflects the age structure of the population.

$$ADR_c^t = \frac{Pop0 - 14_c^t + Pop\ 65over_c^t}{Pop15 - 64_c^t} \quad [1]$$

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 greater 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 labor-force participation and its evolution become necessary to have a more accurate measure of dependency.

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 (Eq. 2), regardless of their age. It thus captures the fact that an important share of people aged 15–64 are not in the labor force (students, housewives, early retirement) and some above age 65 are still active in the labor force.

$$LFDR_c^t = \frac{I_c^t}{A_c^t} \quad [2]$$

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 (PWLFR). This indicator approximates differences in productivity through wage differentials associated with various levels of educational attainment. Although the relationship between wages and labor productivity is a source of controversy in some contexts, it has been shown to hold 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 2004–2017, education-specific weights are calculated using a Poisson regression controlling for age, sex, and country, as expressed by Eq. 3:

$$\ln(WAGE) = \beta_0 + \beta_1 EDU + \beta_2 AGE_GR + \beta_3 CNTRY + \beta_4 SEX \quad [3]$$

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 PWLFR at time t for a country c can thus be defined by Eq. 4:

$$PWLFR_c^t = \frac{I_c^t}{0.62 * L_A_c^t + 1 * M_A_c^t + 1.66 * H_A_c^t} \Bigg/ \frac{I_{EU}^{2015}}{0.62 * L_A_{EU}^{2015} + 1 * M_A_{EU}^{2015} + 1.66 * H_A_{EU}^{2015}} \quad [4]$$

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

A PWLFR 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 PWLFR 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 [as anticipated by the European Centre for the Development of Vocational Training (CEPFOP) (19)], or in other words, that there will be no major shift in over- or underqualification. The PWLFR also takes into account only gains 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

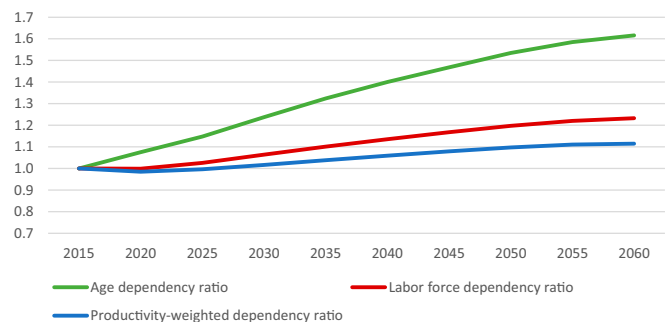


Fig. 2. Projections of the three different dependency ratios for the EU-28, baseline scenario, 2015–2060.

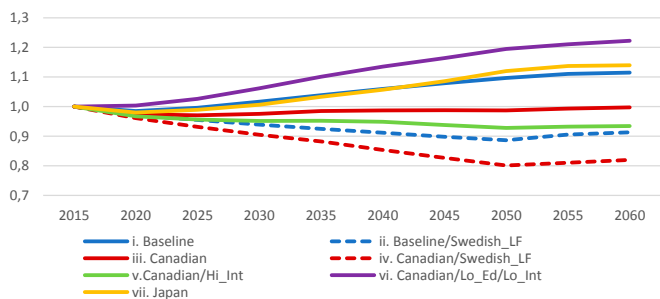


Fig. 3. Projection of the productivity-weighted labor-force dependency ratio for the EU-28 under different scenarios, 2015–2060.

and labor market itself, which belongs to the realm of economic modeling.

Results

Fig. 2 shows that the three different indicators of dependency have very different trajectories in the EU under the same scenario (baseline) that assumes middle of the road fertility, mortality, migration, education, and labor-force participation 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 of 62% by 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 much smaller (only 20%), profiting from the already embedded increase among 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% 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 labor-force participation of the total population hold a large influence (20, 21). Fig. 3 shows the projected trends in the PWLFDR 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% (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. Conversely, a combination of high migration volumes with low education and unsuccessful integration (Canadian/Lo_Ed/Lo_Int) results in a sizable increase in the dependency burden of 20%, twice the increase of the baseline scenario. Lower levels of immigration with high human capital (Japanese scenario) yields about the same PWLFDR as the baseline scenario, because the expected negative effect of lower level of immigrants is totally compensated by the higher level of education.

The impact of those different scenarios on the demographic structure of the EU is demonstrated in Fig. 4, which shows age pyramids disaggregating the population by both labor-force



Fig. 4. Age pyramids disaggregated by labor-force participation and education for the EU-28 in 2015 and 2060 under different scenarios (thousands).

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

Country	2060			
	2015	Baseline	Baseline/Swedish_LF	Canadian/ Hi_Int
Lithuania	0.77	1.07	0.91	0.97
Estonia	0.79	0.96	0.86	0.85
Cyprus	0.80	1.15	0.90	0.89
Sweden	0.80	0.83	0.89	0.67
Germany	0.84	1.11	0.94	0.86
Netherlands	0.84	0.94	0.90	0.73
Denmark	0.87	1.08	0.95	0.82
Finland	0.89	1.08	0.89	0.94
United Kingdom	0.89	0.96	0.83	0.83
Austria	0.90	1.14	0.91	0.9
Latvia	0.90	1.05	0.90	0.92
Slovakia	0.92	1.22	0.96	1.21
Czech Republic	0.93	1.27	1.05	1.13
Ireland	0.94	1.14	0.86	0.96
Luxembourg	0.94	1.02	0.84	0.93
Spain	0.97	1.32	1.03	1.08
Poland	0.98	1.17	0.93	1.03
European Union	1.00	1.11	0.91	0.93
Slovenia	1.02	1.37	1.06	1.12
Bulgaria	1.07	1.31	0.91	1.19
Hungary	1.07	1.19	0.86	1.06
France	1.10	1.10	0.84	0.98
Portugal	1.11	1.15	1.02	1.08
Greece	1.12	1.59	1.03	1.44
Romania	1.14	1.22	0.91	1.08
Belgium	1.17	1.26	0.88	1.03
Malta	1.19	0.82	0.81	0.59
Croatia	1.20	1.38	0.96	1.21
Italy	1.44	1.18	0.97	0.98

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 among the general population, through improvements in their labor-force participation rates. At the other end, 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 to population projections.

The aggregate picture for the EU covers some remarkable differences among individual countries as shown in Table 1 for the productivity-weighted labor-force dependency ratio. Detailed results by country for all scenarios can be found in *SI Appendix, Fig. S2*. In 2015 Italy had the highest dependency burden with 1.44 (i.e., 44% 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, and 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%, 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% 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, and the biggest EU country, Germany, would see a favorable dependency ratio under this scenario which would be 18% lower than the EU's 2015 average and 25% lower than Germany would have in 2060 under the baseline scenario. These scenarios highlight the importance of integration policies and offer a rather optimistic range of options 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, this proportion is projected to increase from currently 18.2% to around 30% 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 changes in labor-force participation, improving educational attainment and 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 has served as the foundation for 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 when adding labor-force participation and education as additional demographic characteristics to the analysis, the projected dependency ratios will increase much less than previously expected 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% 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 EU would experience virtually no increase in this dependency ratio accounting for labor-force participation and productivity. However, since many developed countries seek to attract highly qualified migrants, the international supply might not be sufficient for high levels of skilled migrants in the EU. In addition,

a larger number of immigrants might deteriorate their economic integration, because resources from the government are limited and the competition among workers with similar profile would be more intense (24). In this case of a scenario of a high number of immigrants, but poorly qualified and economically integrated, the EU's dependency ratio would worsen by a significant 20% increase. 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 countries to the level observed in Sweden today. This shows the high stakes involved with integration outcomes under high migration volumes. 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%. Conversely, if the EU decides to follow the Japanese model by drastically reducing the number of immigrants, its population size would naturally be much lower, but since those migrants are highly qualified, such scenario would result in the same ratio of workers to nonworkers once weighted for productivity compared to the baseline scenario. In addition to their integration into the labor

force, the human capital of migrants is thus also a major determinant of their economic impact.

Although demographic aging 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 aging. 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.

Data and Materials Availability. Model codes and parameters are available on request. The base population of the microsimulation is based on the EU Labour Force Survey, for which access requires Eurostat authorization.

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