REPORT

Migration, ageing and resilience - setting up policy scenarios (Technical report)

January 2026

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Document History		
Version	Date	Comments
1.0	31/01/2026	First version submitted as official deliverable to the EC

Funded by
the European Union

Grant Agreement n° 101094741

The FutuRes project has received funding from the European Union's Horizon 2022 Research and Innovation Programme under Grant Agreement No 101094741.

Can the fiscal challenges of ageing be mitigated by labour market changes? A CGE approach with job automation and migration FutuRes Deliverable 4.3*

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January 27, 2026

Abstract

In an ageing population, a voter-winning strategy will not start from the premise 'let's make people work longer', nor will increase in the pension age likely feature at all in political manifestos of mainstream parties. Yet, the costs associated with population ageing are rising across the economy, with people living longer and pensions being withdrawn at a rate that will make the public pension systems across Europe struggle to maintain a balance. Current generations are being told to increase savings to prepare for retirement which takes away from private consumption and (indirectly) from the public purse through taxation.

Based on a suite of macroeconomic models calibrated to empirical data for a range of European countries, in this report we present a range of migration and macroeconomic scenarios driven by different possible labour market and social policy options, to explore the resilience of specific indicators and parts of the economic systems to structural changes. The scenarios focus on the interrelations and trade-offs between ageing, migration and labour market outcomes, and present implications of various policy options for pension systems.

JEL Classification: E32, E62, F22
Keywords: Ageing, Migration, Pension systems, Savings

*This research is part of the FutuRes project, funded by the European Union's Horizon Programme, grant 101094741. This work package is financed by UK Research and Innovation through Horizon Europe Guarantee, grant 10066259. We are grateful to Miguel Romero-Sánchez and Alexia Fürnkranz-Prskawetz for their very helpful feedback and technical advice on our work. All the errors and inaccuracies remain exclusively ours. This document reflects the authors' view and the Research Executive Agency of the European Commission are not responsible for any use that may be made of the information it contains.

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1 Introduction

The challenges of population ageing are multi-fold and have spillover effects throughout the economy and society. Policy responses to address these challenges, however, can be controversial even though the necessity is clear – increase of retirement age being the prime example. The arguments that future generations should not fare worse than current generations is understandable, but as the populations age the financial viability decreases. In this context, several recent reports such as the EU's ageing report (European Commission, 2024) and the debates surrounding policy changes such as increasing the retirement age and pension contributions have raised the question over how to prepare today for the challenges of tomorrow.

The effects of population ageing are relevant for all age groups, both for the current and future generations. One key driver of the pension system challenges, for example, is that people are likely to live significantly longer beyond the retirement age: the time spend on pension increases, but the contributory period does nor. Hence, the challenge of affordability of social security services is a concern, especially related to public pensions and the cost of health and social care. Existing research that presents a cross-country analysis on a long-horizon with direct comparison between countries is largely to approaches heavily based on population projections (e.g. Bijak et al., 2008). We add to the literature by using extensively calibrated macroeconomic models for a selection of European countries, treated here as small open economies.

The challenges of population ageing are very heterogenous. For older generations, the main concerns are about healthcare, social care and financial security in old-age, with the middle-aged generations bearing the brunt financially and also having 'sandwich' caring responsibilities of both old and young generations, while the younger generations being told to save for retirement already while entering jobs and careers. What was unthinkable 30 years ago, becomes a reality: nowadays, financial products exist for new parents to save for their child's retirement, whereas young workers are suggested to save close to 20% of their earnings in pension funds, which exceeds the average saving rate in Europe[1]

[1]For a detailed figure showing how the savings developed across Europe since the beginning of the 21st century, see Figure A.5a in Appendix A1.

The root 'cause' of the challenge of financing the ageing population is that people are living significantly beyond the full retirement age, while currently the most numerous age groups are those aged 50–54 and 55–59.[2] As of 2024, there are more people aged 60–64 than aged 35–39 in the EU27 – 30.1 million vs 29.3 million – with only 22.3 million children between five and nine years of age.

In this context, the main concerns related to affordability can be attributed to two aspects: provision of public pensions and the cost of care. With respect to pensions, most European countries still run some form of a pay-as-you-go pension system, whereby the existing workforce are paying the pensions of the current retirees through means of taxes and contributions. The pension that retirees receive generally takes a form of a *defined benefit* (for example based on a proportion of final earnings), although with an increasing shift towards a system based on *defined contributions* (Whitehouse et al., 2009), which more accurately reflects the career earnings and reduces the final amount paid.

There is limited research that presents a cross-country analysis on a long-horizon with direct comparison between countries, so in this report we add to the literature by using an extensively calibrated model that is pan-European with the individual countries treated as small open economies. The breadth of this research therefore complements the results of applying a thorough demographic-economic model in a deep-dive study, presented for a selection of countries in Sánchez-Romero et al. (2025), by presenting a Europe-wide picture and recommendation.

Two of the options that have been considered as solutions to the labour market challenges related to ageing include the use of job-automating technologies and migration. Our previous research Barker and Bijak (2024*a*,*b*) has shown that even though neither migration nor job automation are singular solutions, both can contribute towards *aspects* of a comprehensive solution package. Automation is not a straight answer (robots and algorithms do not pay taxes, at least not yet!) and the availability/supply of migrants is insufficient to maintain a population age structure in the long-term (see e.g Bijak et al., 2008). In this context, another caveat worth noting is that job automation is expensive, so developed economies that are most exposed to the challenges of population ageing also have more financial capability to invest in automation.

[2]Source: Eurostat table demo_pjangroup, accessed as of 1 December 2025.

For the analysis of different policy options to tackle the challenges of ageing, an ideal choice would be to use the dynamic stochastic generalised equilibrium (DSGE) models, although due to the short horizon these models use (typically around five years, which is too short for our purposes), another style of modelling is required. Hence, in this report, we put forth an overlapping generations (OLG) model in the form of a computable general equilibrium (CGE) to form an OLG-CGE model. Such models are increasingly becoming used both in research and as policy tools[3]. This approach allows us to assess the effects of policy changes for longer horizons. The demographic data used for calibration come from the Wittgenstein Centre Human Capital Data Explorer (KC et al., 2024*b*), which allows calibrating the model trajectories up to the year 2100. In conjunction with the extensive calibration of the model to the existing population sizes and structures based on the Eurostatd data, this enables creating scenarios a high levels in specification[4]

To examine the possible policy scenarios to address the challenges of population ageing, in this report we therefore analyse the effects of ageing and migration in the long-run on the macroeconomy, with particular focus on: (i) pension systems and sustainability, (ii) pension reforms; (iii) labour market dynamics; (iv) age-related labour market policies; (v) adaption of AI and automation technologies; and (vi) long-run sustainability of fiscal policies. The remainder of this report is structured as follows: to begin with, Section 2 provides some detailed background on the challenges of ageing, including the impact of demography on pensions, and Section 3 discusses selected threads from the existing literature. Subsequently, Section 4 presents the model, including some details on model calibration. In Section 5 the main results of the evaluation of policy scenarios are presented, which are subsequently discussed in the concluding Section 6.

[3]The UK's Office for Budget Responsibility (OBR) oversees the government's economic policy, with their new OLG-CGE model described in Brzezinski et al. (2025); see also Sánchez-Romero et al. (2025)

[4]The calibration in this model utilises age groups from 0-100+, gender, education levels and citizenship, with assumptions made on how the firms utilise traditional capital and job automation technologies in the form of AI algorithms and robots.

2 Background: The challenges of population ageing

The population dynamics

The age distributions of European populations are changing. In Figure 1, we plot the population pyramids including the labour market activity status of people in five-year age groups. People aged 15 and under are all assumed to be economically inactive – this is due to labour laws for which the minimum working age in EU countries is 15[5]. The age groups of which unemployment is most relevant are 20–64. Some individuals aged 15–19 are unemployed, but most of those who do not work are economically inactive, given that education in most countries is often compulsory until the age of 16 or 18[6]. Figure 2 shows the gradual increases of the median age and old-age dependency ratio (OADR, the ratio of population aged 65+ years to those aged 15–64) of the horizon up to 2100. In 2024, across the EU-27, the OADR was 33.9% and the median age was 44.7 years: an increase by over two years, compared to a decade before (42.5 years in 2014)[7]. The 2024 median ages ranged between 39.4 in Ireland to 48.7 in Italy. The values forecasted for 2100 in the most recent official population projections of the Eurostat, EUROPOP 2023, are the median age of 50.2 years and the OADR of 59.7%.

In countries with an ageing population sees a growing demand on some key aspects of social and economic policies, including health and social care and social security systems, most notably pensions. Contemporarily, population ageing is a universal trend, due to declining fertility and increasing longevity worldwide, but it is most closely associated with OECD countries, which experience the effects to different extents. Japan is arguably one of the countries most advanced in terms of ageing, with South Korea rapidly following suit, due to its extremely low total fertility rate which reached a new low of 0.72 in 2023[8]. Besides low fertility, these two countries are also distinguishable by a lack of substantive net immigration, in comparison with other developed nations.

Other OECD countries such as Australia, Canada, New Zealand, and the United States are experiencing similar issues as the median age of the population increases, which,

[5]See EU employment laws, at the European Commission website. There are exceptions, however, these would be so small to be considered insignificant

[6]Source: European Commission Compulsory education in Europe. First accessed 21 July 2025.

[7]Sources for all data cited in this section: Eurostat tables demo_pjanind, tps00198 and lfsa_eftpt.

[8]Source OECD Fertility Rates, access as of 15 December 2025.

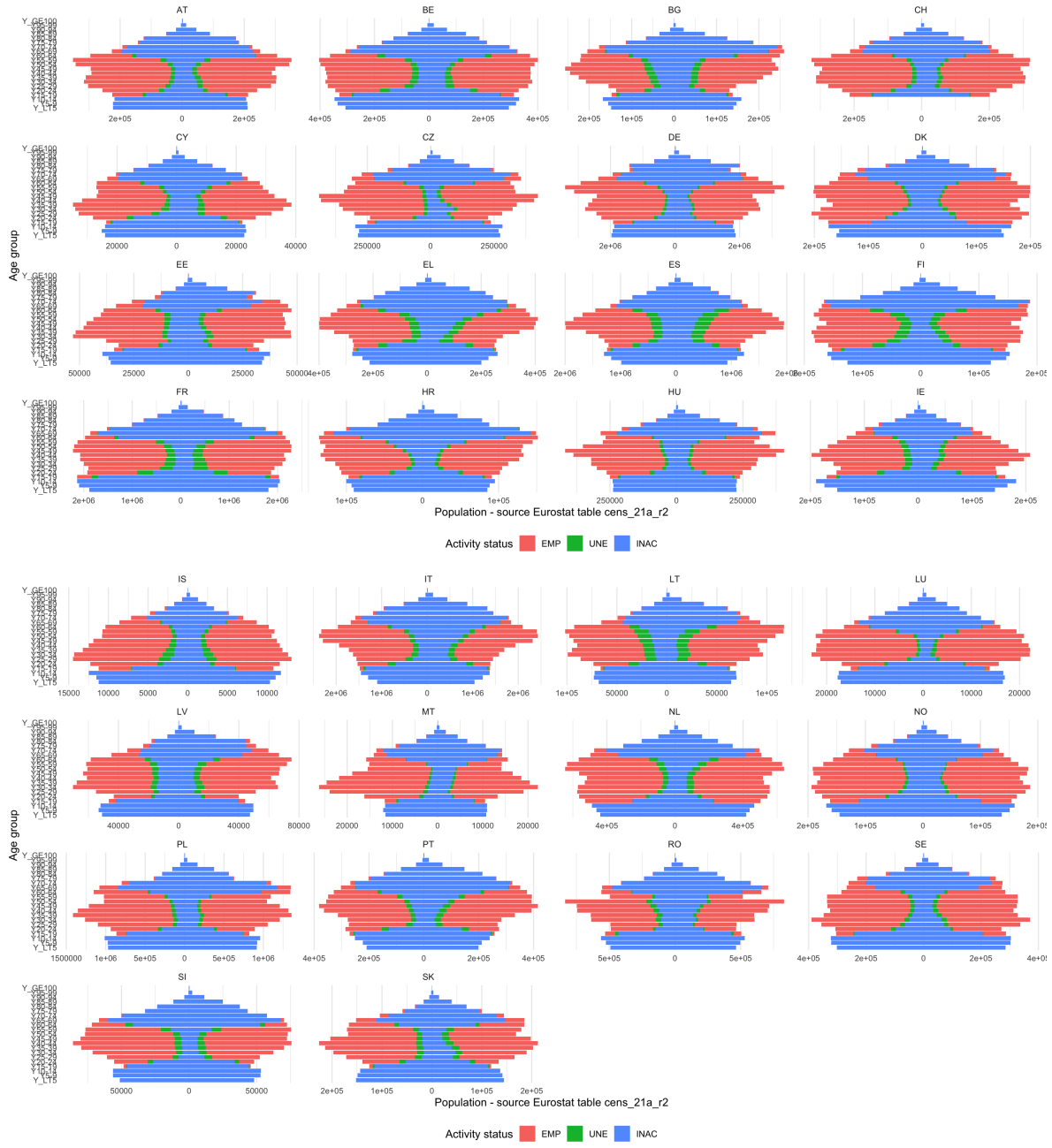


Figure 1: Population pyramids by age group and activity status

Countries are identified by their 2 letter ISO-code. The values for each country are given in the respective x axis, and age group; in the y axis. The left sides of the pyramid are for males, and right sides for females. The five year age groups begin at less than 5 years old (Y_LT5), between 5 to 9 years old (Y5-9), continuing in increments up to 95-99 years old (Y95-99) and finally aged 100 years or older (Y_GE100). Employed individuals are given by red, green by unemployed, and blue by inactive. Source: 2021 census round via Eurostat table cens_21a_r2.

however, has so far been mitigated by significant net immigration flows. One of the main

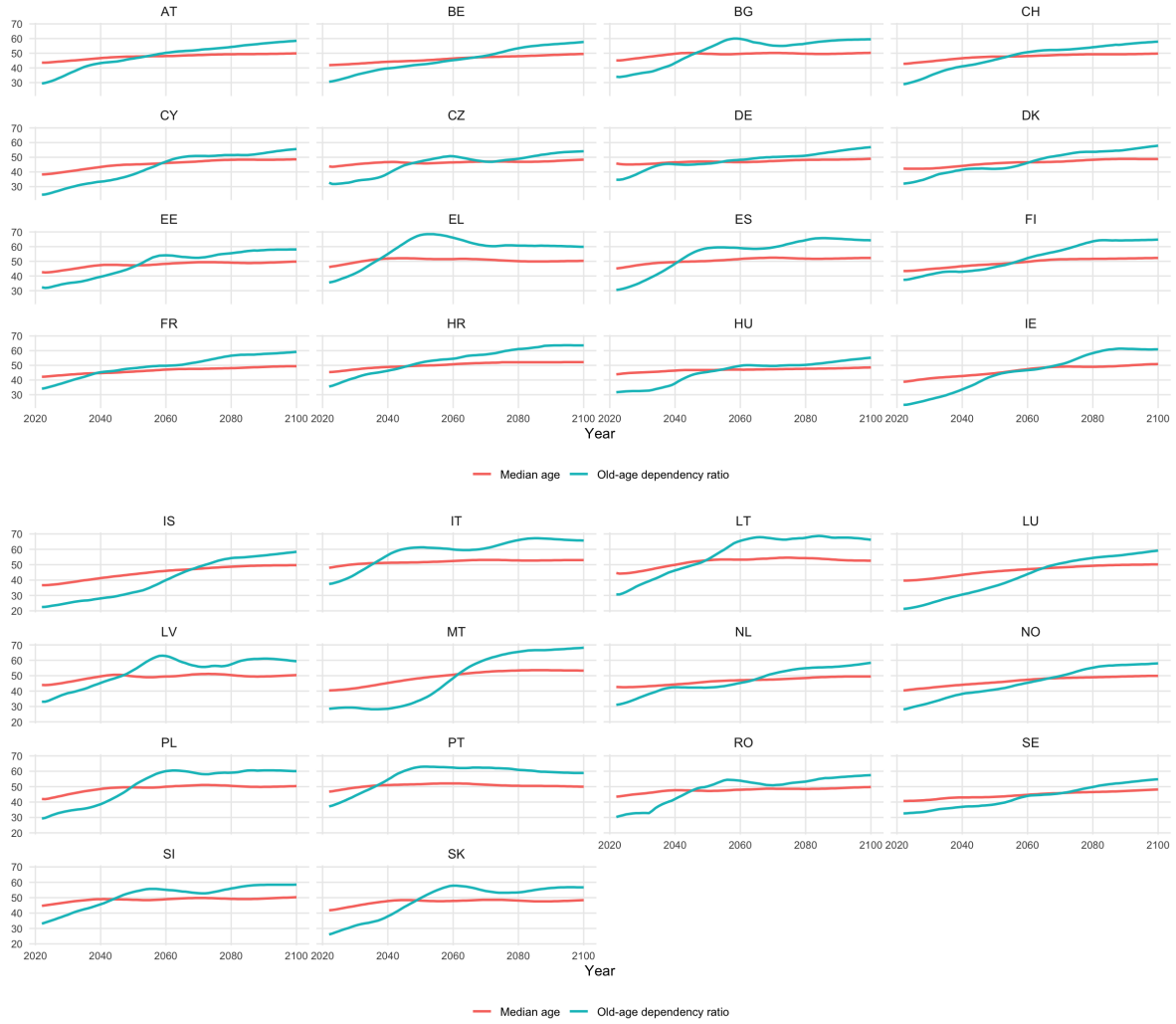


Figure 2: Predictions for median age and old-age dependency ratio

Countries are identified by their 2 letter ISO-code. The subplots show country-specific forecasts for the median age and the old-age dependency ratio (aged 15-64) using the EUROPOP 2023 forecasts for the period 2022–2100. The data presented used the baseline calibration scenario for each. The values for age are given in years, with the value for the old-age dependency ratio given in percentages (%). The axes are normalised across countries to allow for comparisons. Source: Eurostat table proj_23ndbi.

concerns here has been the retirement of the *baby boom generation*[9], either has already reached or will soon reach the standard retirement age of 65, in the period between 2011 and 2029. Given the large size of the baby-boom cohort, and that the effective retirement age is in reality closer to 60 than 65, this has already led to reductions in the workforce and increasing the associated financial pressures on the economy and the government.

[9]Defined as the cohorts born roughly between 1946 and 1964.

Pension systems in ageing societies

Financing the government spending in the economy is predominantly made possible by those who are employed, as they pay the most taxes. Consequently, it is important to acknowledge the level of employment with respect to the older-age population. Using the population and employment figures for 2024, in the EU-27 the average ratio of the number of people 65+ to the population aged 15-64 years, is 33.9%, and if the denominator only includes the employed persons, this ratio increases to 48.4%, rising further to 58.9% when full-time only employment is concerned (with the range between 36.8% in Malta and 74.5% in Italy). The employment statistics are similar whether the age group used is defined as 15-64 or 20-64. To that end, conceptually, in Italy, for every 4 people in full-time employment aged 20-64, there are three people aged 65+, with only 40.6% of Italians employed, and only 33.7% are employed full-time. However, it needs stressing that the most challenging aspect is not the dependency ratio *per se*, but the 'employment dependency ratio', which takes into account labour force participation. As the country continues to age, having such a low employment dependency ratio is unsustainable.

Figures 3 and 4, respectively, show the geographic distribution of the employment old-age dependency ratios and the demographic dependency ratios in the EU-27, here defined as ratios of the numbers of (employed) people aged 65+ to those aged 20–64, and expressed as a percentage. The median age at which people actually retire is subject to the definition of retirement. Some people can be 'retired' while still working part-time or be in receipt of other taxable income, for example from capital gains. Figure 5 shows the percentage of people of different ages who report their labour market status as economically inactive or retired, which includes people in receipt of capital income[10].

As can be seen in Figure 5, the retirement age patterns are not uniform across Europe, with different policy changes implemented in different countries to address the future challenges of population ageing. Figure 6 plots the the official retirement age in 2022 and the one envisaged for 2070 according to the current policies. By that time, it is assumed that most gender disparities will have been eliminated, with most policies increasing

[10]Capital income recipients includes people who are economically inactive due to their income from e.g. trust funds being sufficient to enable them not to work, but this does not necessarily mean that they do or do not claim a pension.

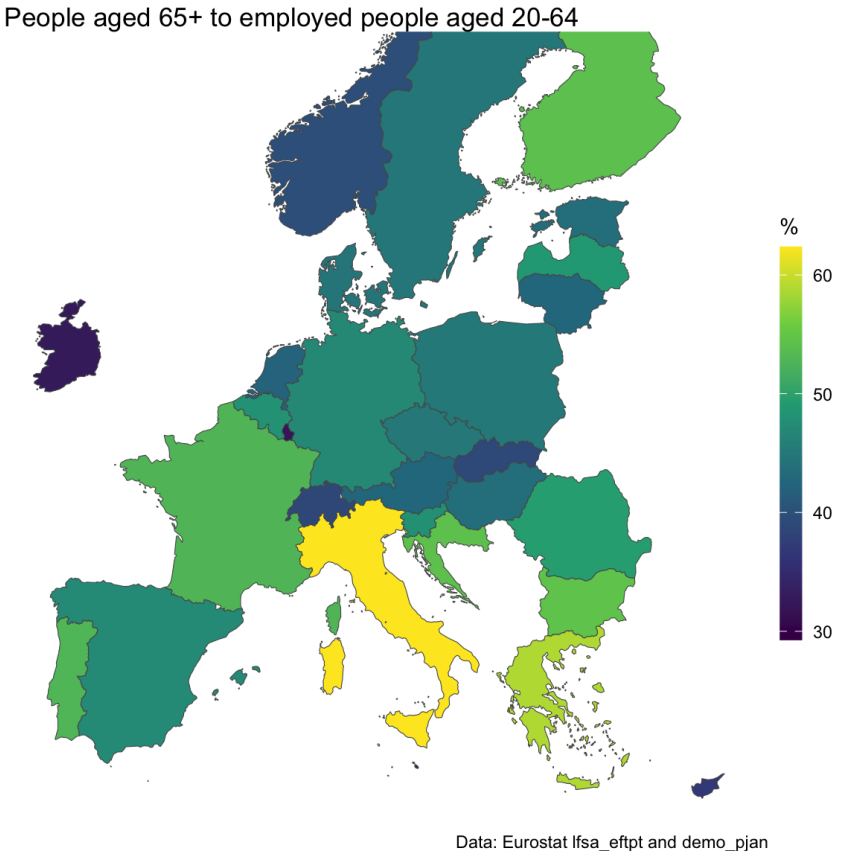


Figure 3: Employment old-age dependency ratio

The map shows the ratios of the number of people aged 65+ relative to the number of people employed (full and part-time) aged 20–64 expressed as a percentage. Source: Authors' calculations using Eurostat tables lfsa_eftpt and demo_pjan.

female retirement age to that of male, rather than lowering male to match female. Even for those countries that do not envisage any changes now, there will be very likely some changes in the future that are not part of the current policy packages.

Since people are eligible to claim pensions longer, then there is further pressure on the financing of statutory pensions in particular. Pensions are broadly classified into three types (pillars), according to how they are funded:

1. State pensions, funded through national insurance schemes, providing basic income
2. Funded occupational pensions with both employee and employer contributions
3. Private savings plans: personal pension plans and other individual savings

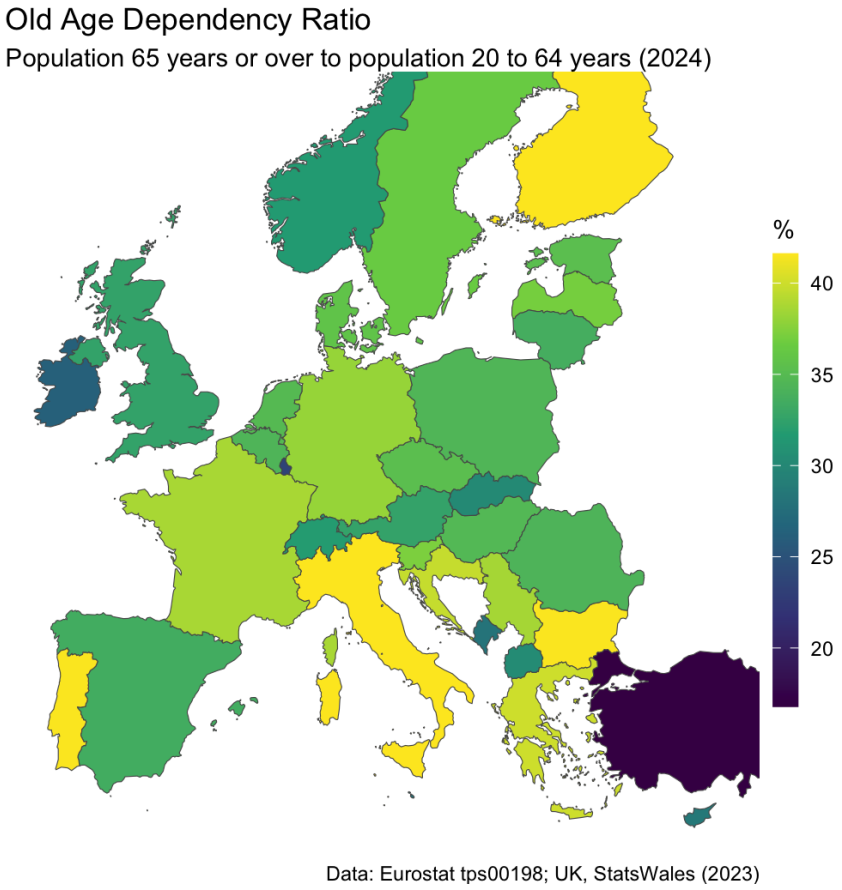


Figure 4: Old-age dependency ratio

The map shows the values for the number of people aged 65+ relative to the number of people aged 20-64 expressed as a percentage. Source: Eurostat tables demo_pjanind.

Pension policy reforms: Selected options

In the context of population ageing, pension reforms are needed to maintain the sustainability of government finances. Whitehouse et al. (2009) has shown that there have been significant policy reforms since the 1990s, as the challenges of population ageing became a reality and a growing concern. The policies have gone some way to increase the financing of pensions particularly, however, the take-up rate especially of private pensions has been relatively low. For example, by 2009 the voluntary private pensions in Poland only extended to 1% workforce, and in Portugal only to 4% of the labour force. Uptakes were higher in Germany (64%), Czechia (45%), and Hungary (31%).

At the same time, the existing dependence on the statutory old-age pension is unsustainable for the majority of countries. Of the reporting countries to the recent ad-hoc

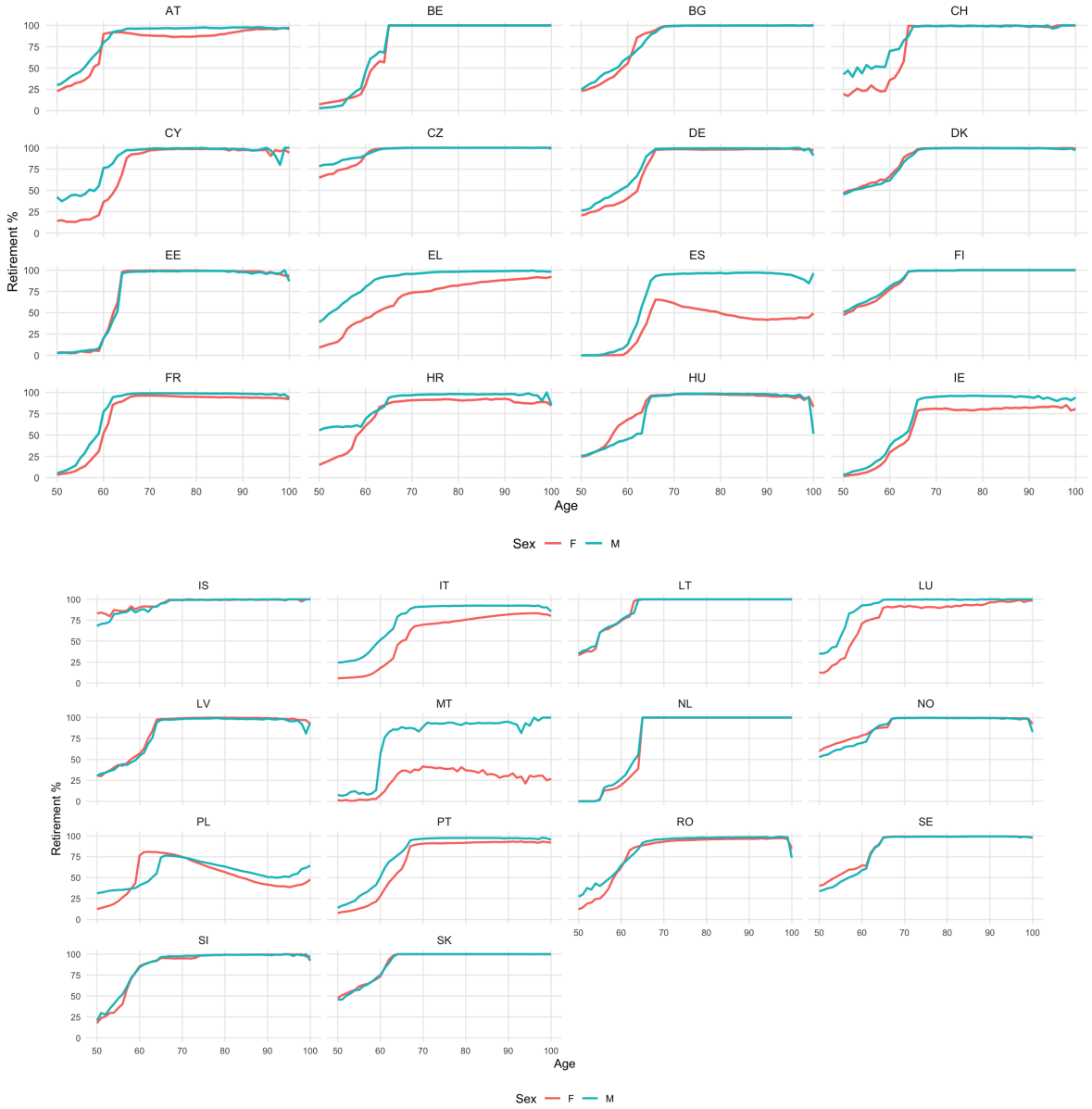


Figure 5: Retired and inactive population by age (50+) as a percentage of the total

Countries are identified by their 2 letter ISO-code. The age is given on the horizontal axis which ranges from 50-100, and the vertical axis indicates the percentage of that age who identified themselves as retired on the 2021 census. Note some statistical anomalies in reporting, likely due to different interpretation of questions (especially for women) or local specificities (e.g. treatment of farmers) – these are particularly pronounced for Poland, Malta and Spain, as well as for Hungary and Romania (for the age 100+). Source: 2021 census round via Eurostat table cens_21a_r2.

modules of the Labour Force Surveys, only Sweden (10.1%), Netherlands (12.5%), Denmark (31.8%), Norway (35.7%), Switzerland (37.9%), and Ireland (43.3%) have fewer than a half of pension claimants aged 50–74 relying solely on the statutory pension. Figure 7 shows the percentage of people who receive only a statutory pension (from the

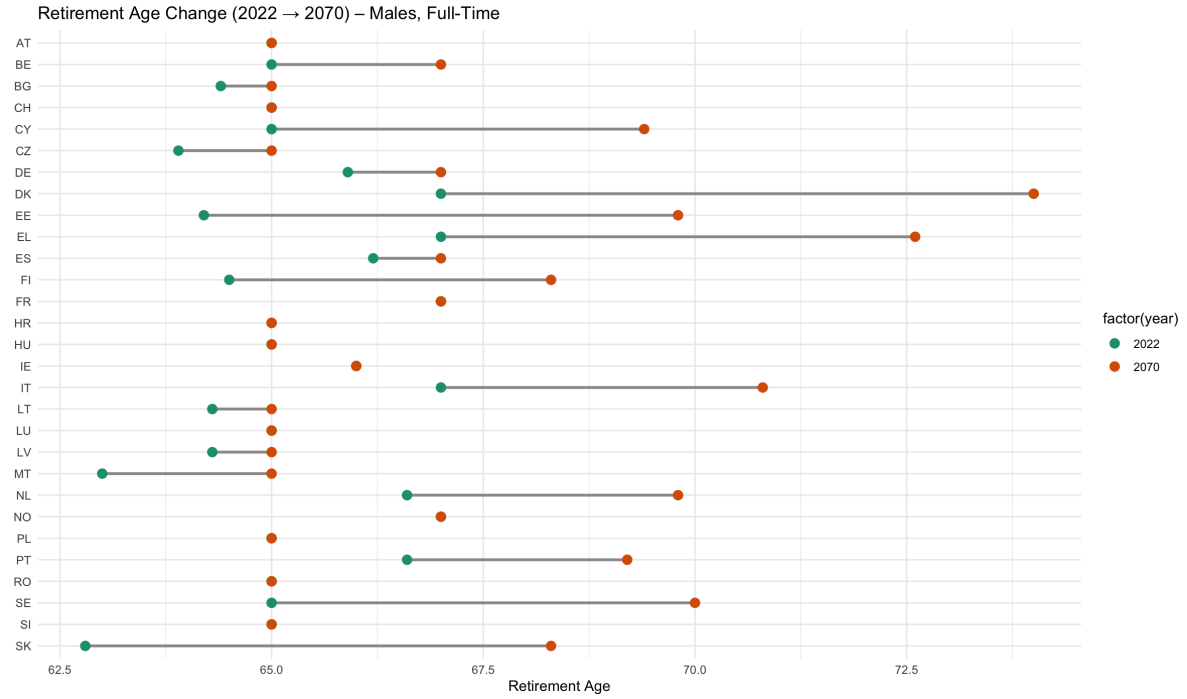


Figure 6: Old-age dependency ratio

Full retirement age for men in 2022 and 2070 using existing policy.

first pillar) in 2023. As outlined in the MISSOC (Mutual Information System on Social Protection) database, people can defer their pensions, which is sometimes limited in time (e.g. Italy up to 70 years and 3 months). In addition, eligibility to claim pensions is also sometimes subject to a minimum number of contributory years.

For the second pillar of workplace pensions, a key topic is *auto-enrolment* – automatic enrolment of all workers into (pseudo-mandatory) pension schemes. In workplace schemes that exist, uptake is often large, because such schemes require members to actively opt-*out*. Indeed, having a workplace pension used to be a quasi-indicator of a highly respected profession or a job. Workplace pension schemes typically require both the employers and the employees to contribute. Starting the pension contributions at a low level before building them up is also essential to maintain participation. For the countries that have fully mandatory workplace schemes, minimum contribution levels typically exist[11]

The EU has encouraged the use of auto-enrolment schemes as a way to boost the public assets and reduce dependence on the state pension. As of 2025, Lithuania had

[11]For example, the Netherlands: 7.44% for employees and 11.16% for employers. Source: OECD Pensions at a Glance Finances of retirement-income systems - Table 8.1.

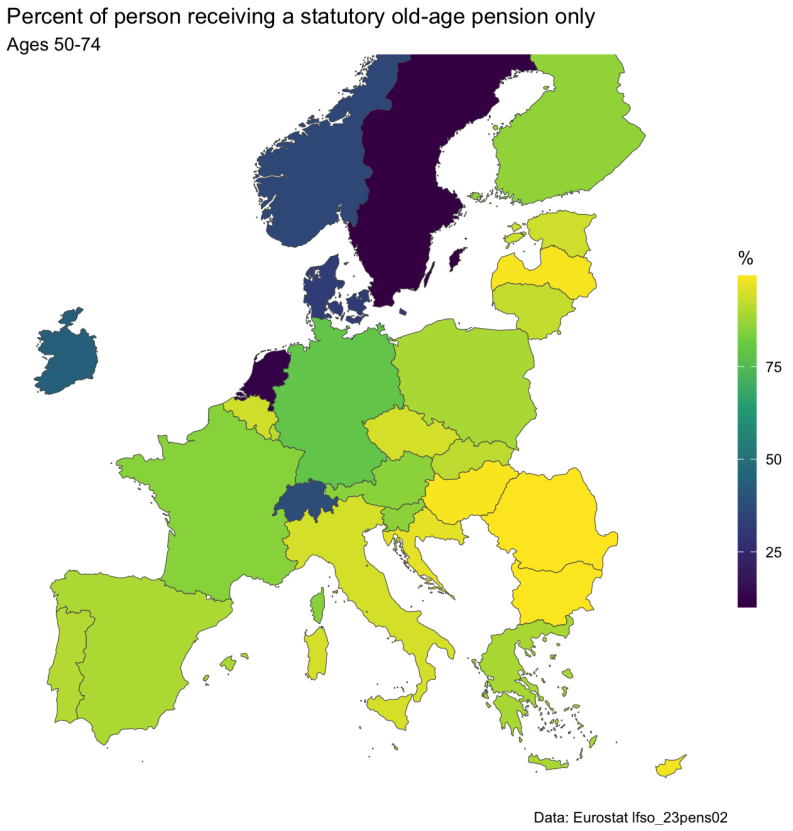


Figure 7: Percentage of old-age pension recipients only receiving statutory pensions, 2023

Note: Old-age pensions claimants are classified as 'statutory', 'statutory and and occupational and/or personal pension', or 'occupational and/or personal pension only'. The claimants are aged 50-74. Source: The 2023 ad-hoc module of the Labour Force Survey on Pensions and Labour Market Participation, Eurostat table lfso_23pens02.

a 70% participation rate in the mandatory auto-enrolment scheme.[12] Several schemes uses tax incentives for people to contribute to the pension, for example, in the UK, the government provides a tax relief on a portion of the employee contributions.

Modifying the pension entitlement is another policy option that has been implemented in some countries, even though it was unpopular. For example, the UK used to have a scheme where pensioners were able to claim an "additional state pension" that was related to contributions. This was changed so that there is a pension that qualifying people can claim which was invariant whether you were a high- or low- earner. The controversy surrounding this change was significant because those who retired on or after 6th April 2016 were no longer eligible for this additional pension[13]. Whether or not

[12]Source: Pensions Europe. First accessed 7th March 2025.

[13]The weekly basic pension for 2025/26 is £230.25. At the same time, the minimum wage in the UK is £12.21 an hour for those aged 21+ (£488.40 for a 40-hour week), which makes the state pension less than

such pension reforms will be passed in other countries following the roll out of auto-enrolment is questionable, but given the financing problems the likelihood is greater than before. Where public pension pots are small, additional provisions often exist for further social security support to help pensioners avoid poverty, in the form of social benefits or other forms of income top-up. However, the increased use of auto-enrolment or enhanced workplace and private pensions can reduce the reliance on such additional measures.

An alternative policy option is the shift from the *defined benefit* system, to a *defined contribution* one, whereby the calculation of the pension is based on a given period of contributions rather than final earnings. One issue pointed our by Whitehouse et al. (2009) is the administrative efficiency that comes with changes to pension policies, especially where there are perhaps poor records of contribution periods. Further difficulties arise when a worker has contributed to multiple pension pots due to job changes. The documentation of contributions and earnings has become simpler with a switch to the digital age, however, this would have poorer coverage of self-employed individuals who traditionally have lower accuracy in reporting of contributions, or people that could be below earning thresholds enabling them to participate in auto-enrolment schemes. From a long-term perspective, a pension scheme is a element of the social contract, running from the time of the first contribution, around the age of 20, to the final withdrawal at the end of life, so currently around the age of 80 in most of Europe. However, due to individual circumstances, the length of the contribution periods can vary a lot.

The prevalence of pension types, and the relative value of the pension pots, are highly variable. Figure 7 showed the high dependence on state pensions, with 83% of EU27 members depending on the state pension implying the requirement for substantial of public financing. A majority of the remaining 17% do not *exclusively* claim private or occupational pensions: 15% claim *both* the state and occupational pensions, with only the remaining 2% claiming the occupational or private pension alone.

The dependence of pension entitlements on various socio-demographic characteristics makes the analysis even more complex[14]. The minimum (state) retirement ages range from 60 (Poland, women) or 62 (France) to 67 (Denmark, Iceland, Italy, Norway, the

half minimum wage. Source: UK Office for National Statistics, accessed 10th September 2025. Pension income above a minimum threshold is subject to tax, but pensioners receive many additional benefits.

[14]For Europe, the differences are illustrated by the MISSOC tables.

Netherlands) though each come with their own caveats. Some systems allow early retirement, some depend on a minimum number of contributory years, in some women can retire earlier than men (although this is largely being phased out), the number of children can reduce the retirement age for women, or some retirement ages are scheduled for review depending on the future life expectancy trajectories. Retirement can be either early or late, respectively decreasing or increasing the pension benefits.

The effective age of retirement is even more complex: the most reliable indicator is the first age at which the old-age pension is drawn, however, on average 10.3% workers across the EU continued to work after first receiving their pension[15] The fact of claiming an old-age pension on its own is not necessarily a perfect indicator of official retirement. Figure 8 shows the average age at which people in the 50–69 years age group claimed their first old-age pension. Notably, the age at which a pension can be first claimed differs across Europe, with private pensions offering earlier retirement, as well as the offering of early retirement from a statutory pension.

Some older workers claim a pension and work only part-time to top-up their monthly income. Re-entering the labour market (not only staying in the labour market) is a common occurrence as well. Figure 9 shows the percentage of pension claimants that re-entered the labour market. Only for some countries full survey results on the reasons *why* retirees returned to the labour market are available: where they are, the categories include: financial, enjoyed working, and other reasons. The average responses for the EU27 countries with available data included: financial necessity for 30.2% of the respondents, "enjoying working/being productive" for 28.4%; and "other reasons" for 41.4%.

The comparisons above confirm that the international differences in retirement policies and practice make complicate a meaningful policy analysis. This is a partial explanation as to why comparative literature is so limited. Even though large-scale policy simulations using country-specific data are possible, they would require many idiosyncratic features for different countries.

Also in the context of possible pension reforms in the face of population ageing, numerous studies into whether migration can be a solution found that immigration is a mere temporary relief (Bijak et al., 2008; Serrano et al., 2011; Aslanyan, 2014). As pointed

[15] Eurostat Statistics Explained and Table lfso_23pens03, accessed on 21 January 2025.

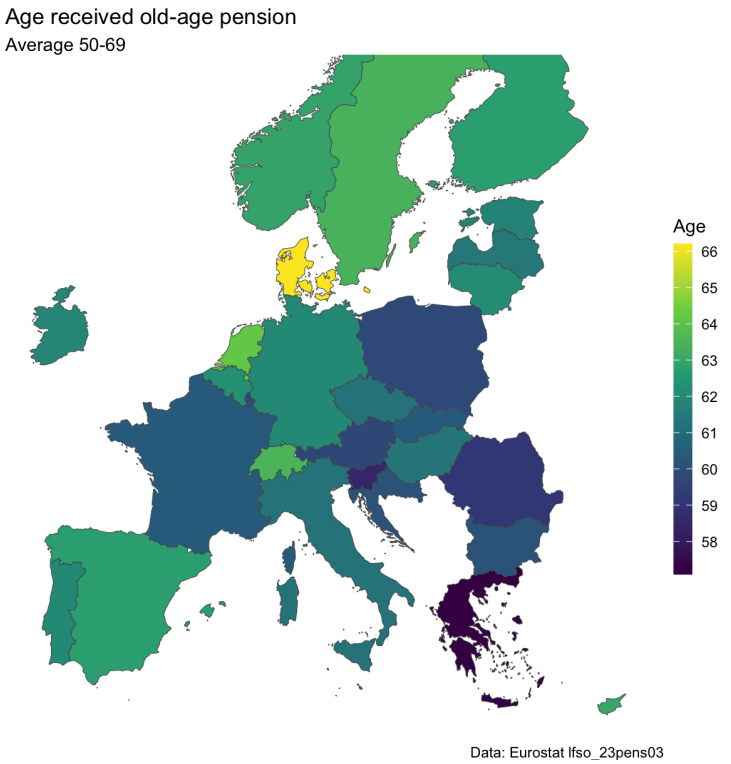


Figure 8: Average age of first pension receipt

The map shows the reported value for average age at which the old-age pension is first received for 50–69 year old persons in 2023. Source: Eurostat table lfso_23pens03. The values are from the LFS ad-hoc module for 2023: Pension and labour market participation.

out by Poufinas (2021), immigration may boost the value of pension funds, however, a rise in *employment* would be much more preferable and sustainable in the long-run.

Perspectives for job automation

The question 'Will robots take our jobs?' has become a standard feature of discussion surrounding the rise of higher-level job automation by artificial intelligence (AI) algorithms centred around the use of natural language. Much research on job automation has been done, but from an economic standpoint, the threat of a robot takeover remains as far away as ever. Bachmann et al. (2024) studied the role of robots on labour market transitions in several European countries. By using the labour market job finding probability framework, based on the data for the 2000s and 2010s, the authors found a small reduction in job separations and no effects on finding jobs. The further research in that paper then suggested that robots, rather than being a threat, provide an opportunity for increasing productivity of human workers.

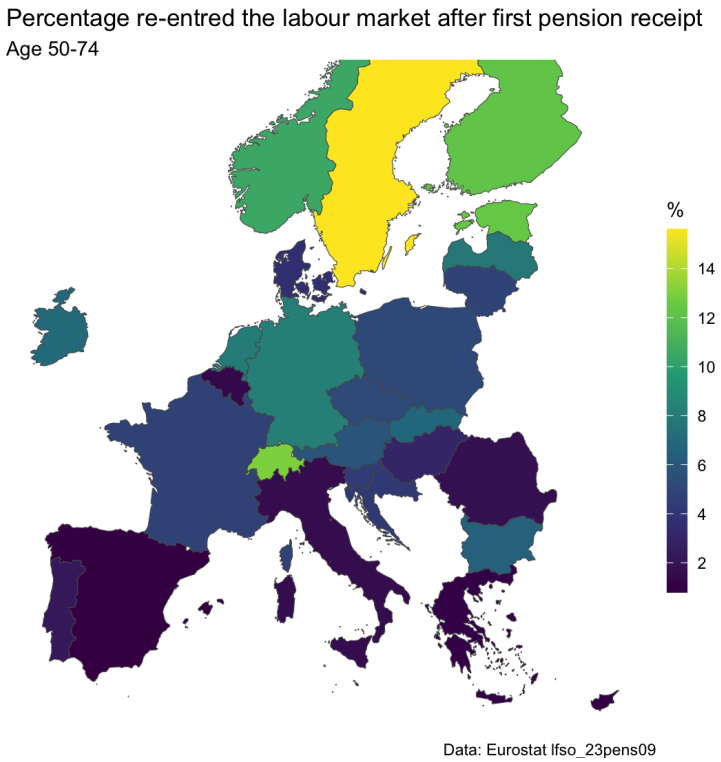


Figure 9: Re-entering the labour force after receiving pension

The map shows the percentage of people who have already claimed their first old-age pension who re-entered the labour market. Source: Eurostat table lfso_23pens09. The values are from the ad-hoc module for 2023: Pension and labour market participation.

Our research is among the first ones to include AI Preparedness Index (AIPI) as a variable to calibrate the macroeconomic models introduced in Section 4. The AIPI is a measure that is produced by the International Monetary Fund (IMF), showing of how countries are ready for AI adoption across a range of factors, ranging from the human capital to legislative frameworks[16]. In Figure 11 we show a summary of automation progress across Europe. We see AI as yet another form of job automation, by which, small and simple tasks typically more associated with higher-skill professions can be done by a machine: examples include data entry or processing. Germany is a leader in employment of manufacturing robots, and is advanced in the preparedness of AI in which Denmark leads, with the countries of Central and Eastern Europe, and in particular the Balkan ones, lagging behind in terms of both indicators. A thorough discussion of different economic aspects of job automation, and their intersection with migration in the context of ageing populations, has been provided in Barker and Bijak (2024*b*).

[16]For details, see the AIPI documentation and data on the IMF website, as of 1 December 2025.

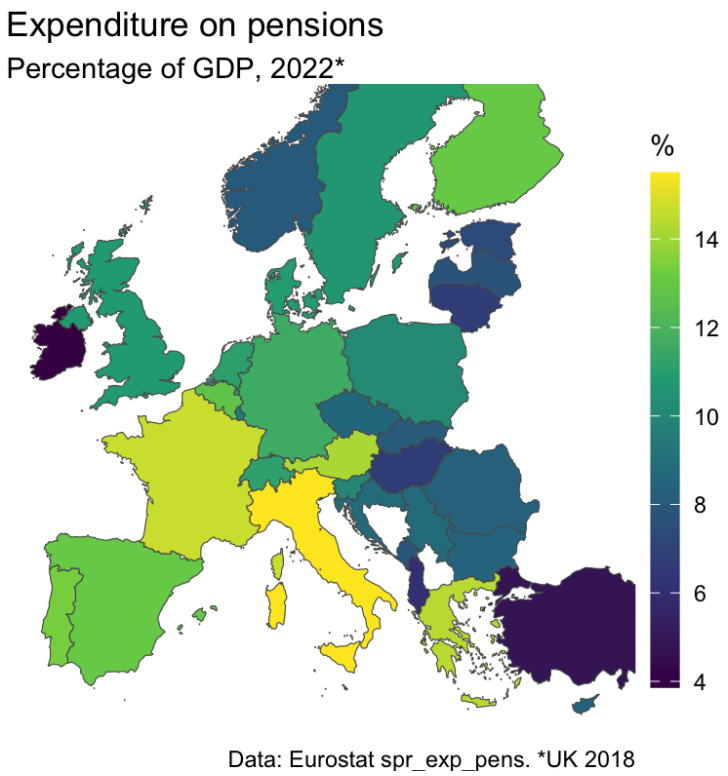
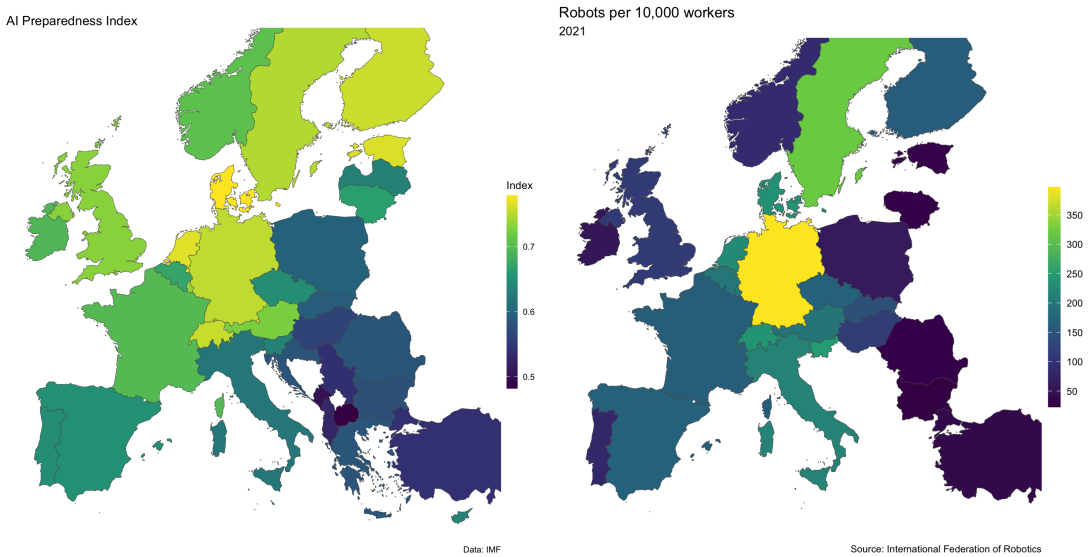


Figure 10: Old-age pension spendning (% of GDP)

The map shows the reported value for expenditure on pensions (all types) as a percentage of GDP. The values are from 2022, or 2018 in the case of the UK (for comparability purposes).



(a) AI Preparedness (b) Robots rate

Figure 11: AI preparedness and robots per 10,000 workers

The left graphic shows the preparedness (as a probability) of a country for AI. The right graphic shows the number of robots per 10,000 workers - missing figures indicate low or insignificant value.

3 Modelling pension reforms: Selected literature

The earlier research from our FutuRes deliverables (Barker and Bijak, 2024*a*,*b*) employed Dynamic Stochastic General Equilibrium (DSGE) models in short-run analysis of the impact of job automation and migration on ageing. These style of models have a short-run (approximately 5 years) focus, where population sizes remain stable. Existing longer-term macroeconomic modelling of ageing and pension systems is relatively limited, especially as far as the most advanced DSGE models are concerned. A different style of model is required to study the long-run effects. There are examples of studies using Computable General Equilibrium (CGE) models, though, which are better suited for analyses for longer temporal horizons. This is in part due to the complexities of the modelled economic systems, and in part to the the evolving nature of the challenge, with the increase in retirement ages and the rise of non-social security pensions. As we demonstrate throughout this report, the challenges of population ageing are wide-ranging, multifaceted and complex, which necessarily restricts the practical implementation in economic models.

An example of a state-of-the-art CGE model is Börsch-Supan et al. (2006), who a focus on pension reform and international capital flows within context of a multi-region analysis with a forecast to 2070. The demographic calibration is based on United Nations (2002), and the model additionally includes the Overlapping Generations (OLG) mechanism. In the time since that publication, parameters used for calibration have changed significantly in several of the countries studied due to the impact of the global financial crisis and the COVID-19 pandemic. Importantly, the proposed changes in the pension reforms suggested by the research have been largely not implemented.

In later work, Godínez-Olivares et al. (2016) sought ways of restoring the long-run affordability of PAYG pension schemes by simulating main policy changes including contribution rates, retirement age and indexation of pensions with the automatic balancing mechanism. The importance of making government-backed pensions sustainable is critical due to the number of pensioners that depend on them. In a related piece of research, Arbatli et al. (2016) looked at Automatic Adjustment Mechanisms (AAMs) and Automatic Balancing Mechanisms (ABMs) of pension systems, with an application for China, Japan and South Korea.These three countries experience or will experience population

ageing to a large extent, as discussed in Section 2. As with Godínez-Olivares et al. (2016), a time gap in modelling does not account for the reduction in fertility rates. Arbatli et al. (2016) highlighted an important difference with respect to the variables triggering automatic pension adjustments: their effects varied depending on whether they were based on forecasts (ex-ante) or observed changes (ex-post).

Hyams et al. (2020) use the AAM style model to optimise a 'rule of thumb' to give guidance to younger workers for what will give them a safer retirement pot. The estimate provided by Hyams et al. (2020) is calculated at 23% of average UK earnings. Their research was done prior to the hike in interest rates that have been seen since 2022 which has an impact, however, any changes to the above recommendations will of course depend on the long-term trents in the interest rates. With a higher return on savings, it might be possible to reduce the 23% contributions somewhat, however, there are still several other factors, such as market volatility or general performance of the economy and returns on investments, that are likely to keep this rate at a higher level. At the same time, having such a rule of thumb can encourage higher employer contributions which can become a part of a more general policy portfolio.

Whether households save enough to account for pre-retirement *consumption* is necessary for calculating theoretical minimum savings and contribution rate. The existence of private pensions is increasing, however, this is primarily focused towards people in long-term high-ranking professions and/or highly-educated people that have been preparing for retirement. As an example of a relative success story (so far), in a recent research on Denmark, Larsen et al. (2025) found that the majority (85%) are able to maintain 90% of their pre-retirement consumption. The lack of available workplace pension schemes was found to be an important factor for those unable to maintain their pre-retirement consumption levels, while the financial resources for maintaining consumption came mostly from savings and pensions. In addition, Denmark has the highest full and effective retirement age in Europe, and the highest one scheduled for 2070 under the current policy plans. More years of employment enable savings to build up. On the other hand, whilst maintaining pre-retirement consumption levels may be broadly achievable in Denmark, this is not true for most other European countries, especially those with workplace pensions being less popular. This already leads to a clear policy recommendation: supporting

workplace pension schemes, including mandatory ones, promotes retirement savings and helps maintain future levels of consumptions after retirement.

Recently, Aisa et al. (2023) examined the impact of job automation on the labour market participation of older workers. High-skilled workers were found to be able to prolong their working lives, as their jobs can be more adaptable to technological change, whilst low-skill workers were more affected by skill mismatches and forced to exit the labour market sooner. Aisa et al. (2023) emphasised the requirement for upskilling even in later life, to keep up with the evolving labour market. Upskilling enables workers to remain economically active for longer, reducing pressures on PAYG pension systems. Increasing prevalence of private pensions also mainly affects highly-educated people in long-term jobs and high-ranking professions.

Finally, Beetsma et al. (2025) examined the interplay of demography and population growth in the role of financial pressure on pension systems. They consider higher and lower rates of migration, survival and fertility and the impact they have on growth required to maintain government debt-to-GDP ratios. Different migration trajectories were found to have the largest effect on GDP growth, which is not surprising given the immediate effect on production through increasing the labour supply instantly. Still, as discussed before, migration alone does not resolve the long-term challenges of ageing.

In terms of methodology, a common feature of various OLG-style models, is a concept of probabilistic ageing (PA) based on transitions between successive age groups, akin to the demographic cohort-component projection models. As an early example, Grafenhofer et al. (2006) used PA in an OLG model in which for each period, agents can move to the next age category (age), stay in the same age category (not age) or die. The use of age groups, typically covering five-year age span e.g. 25–29, is common and matches the reported data and calibration requirements. Sample sizes in surveys rarely allow for analysing single years of age, and using five-year groups is convenient enough to cover similar life stages. PA has been also used in Berger and Strohner (2020), and the EU Labour Market Model (EU-LMM) (Berger et al., 2024).

At the same time, many OLG models tend to only evaluate two generations, which is insufficient for long-run studies. There are exceptions, though: some earlier versions of OLG-CGE models began to use longer horizons with focus on tax policies. A seminal

paper of Auerbach and Kotlikoff (1987) used 55 generations, aged 21–75. Since then, there have been significant developments to incorporate extensions, such as an open economy (Auerbach, 1996), human capital accumulation (Taber, 2002; Fehr et al., 2013). A recent work by Schmied (2023), provided recommendations regarding the pension replacement rate – the ratio of the pension to the last salary – for Germany for different households.

In this strand of the literature, the state of the art approach has been proposed in the FutuRes OLG model developed by Sánchez-Romero et al. (2025), the results of which allow for exploring a range of detailed policy scenarios for a selection of European countries, from the point of view of different socio-economic objective functions. An alternative approach would be to use high-resolution microsimulations informed by detailed micro-level data on the economic behaviour of specific groups of people. At the same time, as acknowledged in Curley et al. (2025), this may be also difficult, not least due to privacy reasons, the presence of different sources of error and uncertainty, and requirement for high-level computational skills to conduct such simulations. For these reason, in the work presented in this report, we present results of scenarios produced by a dedicated OLG-CGE model, the specification of which is discussed next.

4 A model for testing policy scenarios

4.1 OLG-CGE models: General considerations

The population dynamics of existing macroeconomic models are typically relatively simple, with a notable exception of Sánchez-Romero et al. (2025). In most studies household members only exist at a given age, with policy evaluated in the short-term. Our motivation for this work lies in the lack of long-run population dynamics modelling that would incorporate the different age groups from 0 to 100 years. As an expansion on existing models, such as Börsch-Supan et al. (2006) or Godínez-Olivares et al. (2016), also include education levels, labour market status, gender, migration status as individual characteristics, and look at policy tools related to fiscal and labour market sustainability. We use extensive data from Eurostat and the Wittgenstein Centre Human Capital Data Explorer (WCDE), as described in KC et al. (2024*b*) to calibrate fertility, survival rates by education level and cohort, and use the WCDE forecasts (KC et al., 2024*b*) to establish

long-run population trajectories for the EU27, Norway, and Switzerland. In addition to Berger and Strohner (2020), we use the specific rates by gender, education, and use single years of age rather than age groups, eliminating the need for probabilistic ageing.

In general, OLG-CGE models are a useful policy tool for examining the short and long-run macroeconomic effects of tax reforms across a wide array of economic factors (Zodrow and Diamond, 2013; Sánchez-Romero et al., 2025). Calibrating extensive OLG-CGE models is challenging due to the data restrictions, and even problematic when using intra-country comparisons when policies differ. For example, the data on final goods consumption is available in the national accounts, but little is known about the age-specific consumption levels. Final consumption is considered a bell-shaped curve which peaks at the middle age or towards the end of optimal working life when employment is generally full-time and well paid, with retirement considerations not in the short-term. The disposable income of working individuals of the age 20–35 is lower due to lower wages, while for those 60+ the main source of income is coming from pensions, and the typical trend in the savings rate is becoming negative. There are also many policy decisions which are too complex to model within this framework, such as tax rates, age related policies, and existing labour market policies.

Given the extent to which OLG-CGE models can cover the possible policy decisions, their use has been relatively limited when it comes to retirement policy. Aside from the state of the art FutuRes model of Sánchez-Romero et al. (2025), other existing examples include Fehr et al. (2013), who offered a model similar to the one presented in this report. Relative to that paper, our contribution consists in a broad, extensive and up to date calibration, reflecting the recent changes in demographic behaviour, in particular, the drop in fertility rates across the EU since the late 2010s. The main building blocks of our OLG-CGE model are discussed in turn.

4.2 Population dynamics

The economy consists of individuals aged 0–100, with the population $N_t^{a,e,g}$ evolving over a time between 2022 and 2099. These are based on current and expected rates:

- Survival rate: $s_t^{a,e,g}$,

- Fertility rate: $f_t^{a,e}$,
- Migration rate: $\mu_t^{a,e}$,

where a identifies age, e identifies education level of the individual[17], and g identifies gender. A person can be aged 0–100; have education of low, medium, or high; be female or male and either be a native or a migrant. In particular, migration status is designed to reflect the establishment of a person within the host country, distinguishing between natives, established migrants and recently-arrived migrants. For simplicity, fertility and survival rates are assumed not to differ between immigration statuses.

Births The total number of births at time t, is given by

$$B_t = \sum_{a=15}^{49} f_t^{a,e} N_t^{a,e,F} \tag{1}$$

The births are split 105:100 (M:F), the default sex ratio at birth. Eurostat table `demo_fasec` indicates for 2022 a range 50.7% (Lithuania) to 52.4% (Iceland), with an average of 51.3%.

$$N_{t+1}^{0,M} = 0.513 B_t \qquad\qquad N_{t+1}^{0,F} = 0.487 B_t \tag{2}$$

It is well known that fertility rates have been falling across Europe since the COVID-19 pandemic. The total fertility rates are now well below the replacement levels in all European countries. Bar major cultural changes, a push for higher education and upskilling is only likely to reduce the fertility rate further. It is unlikely that Western countries will see fertility rates return to replacement rates, but stopping the decline for medium and higher-educated women may be a viable policy target. At present, women who delay having children often do so because they have to weigh up the financial penalty that comes with having a child in terms of career progression and income.

Changing cultural and societal norms goes beyond modelling as norms can be ingrained into decisions over generations. Now, it is no longer socially unacceptable for a woman not to have children, and the age of first child is close to 30 in Western and Northern Europe. The decisions to have large families are often not financially viable, given the

[17] Fertility rate by education applies to the education of the mother.

high costs of living. Providing affordable childcare to reduce time outside of the labour force is an obvious part of the solution, but the actual provision is often insufficient.

In addition, removing or reducing some of the labour force participation penalties for women would help with pension contributions in the long-run. If a woman spends more time outside the labour force during relatively early working years (late 20s–30s) there is a financial penalty that will never close. Striking the balance is important, and some policies aimed at increasing fertility may backfire through reducing pension contributions, but if done correctly, they have a potential of alleviating some of the challenges in the long-run. A thorough discussion of the issues related to recent fertility trends in Europe and possible policy options, seen through the lens of societal resilience, is offered in two dedicated FutuRes reports: Chłoń-Domińczak et al. (2024) and Grzenda et al. (2024).

Migration Migration status is designed to reflect the establishment of a person within the host country, distinguishing between natives, established migrants and recently-arrived migrants. For simplicity, fertility and survival rates are assumed not to differ between immigration statuses. There is an annual inflow of immigrants, IM_t, and outflow emigrants, EM_t, using the forecasts from KC et al. (2024*a*). A further index of migrant status, c, is introduced. Those who hold the reporting country's citizenship ('natives') are always able to migrate, therefore, assuming that only those with EU citizenship (excluding reporting country) and non-EU citizenship can immigrate in this model is unrepresentative. We calculate the migration flows per age and migration status from tables migr_imm1ctz, migr_emi1ctz, and allocate by exact age (rather than five-year age groups) migr_netmigr, subject to the overall constraint:

$$\sum^{a,e,g} M_t^{a,c,e,g} = \sum_{a=0}^{100} IM_t^{a,c,e,g} - \sum_{a=0}^{100} EM_t^{a,c,e,g} \tag{3}$$

Dependent on skill specific policy targets and labour demands, migration flows can be composed of different groups by skill level. Working-age adults make up the majority of the immigration, while the migration of adults over the retirement age decreases significantly. In the model, assumptions for some of the migration flows can be controlled by policies, although return of natives or migration of EU27 citizens is not. Non-EU27 migration is thus easier to model as it is possible to set some limits, at least theoretically.

Survival Each *cohort* follows the (partially simplified) population transition rule.

$$N_{a+1,t+1} = \sum s_t^{a,e,g} N_{a,e,g} \tag{4}$$

The survival rate is the same for each type of citizenship status for continuity purposes. The survival rate includes that of newborn children, and a distinguishing from those of age 0 that survive childbirth. All births are assigned to the none to low-education (ISCED0-2) descriptor.

Education decisions To introduce an education-related policy analysis we additionally look at how individuals may decide to pursue a given level of education. Each period there is a fraction of the population aged a that graduates with an intermediate education (ISCED3-4) or a teriary education (ISCED5-8). This is specifically calibrated to each country and for those in the age range 15 to 24. Figure 12 shows the transition probabilities for intermediate and tertiary education transitions for the ages 15 to 29. For each age there is a movement between education level of up-skill between ISCED0-2 to ISCED3-4, or ISCED3-4 to ISCED5-8. Transition from ISCED0-2 to ISCED3-4 occurs generally in the ranges of 17-20, and ISCED3-4 to ISCED5-8 between the ages of 20-24. The total population excluding migration remains constant.

Total population balancing equation In our setup, given the considerations above, the key demographic accounting equation for the total population then becomes:

$$\mathbb{N}_{\approx} = \sum^{a,c,e,g} s_t N_{t-1} + B_t + \sum^{a,c,e,g} M_t^{a,c,e,g} \tag{5}$$

4.3 Labour market dynamics

The employment dynamics follow standard methodological approaches in economics. A person's type of employment aligns with their education level. Employment status is given by $E_t^{a,c,e,g}$ for employment, $U_t^{a,c,e,g}$ for unemployment, and $I_t^{a,c,e,g}$ for labour market inactivity, such that the following relationship holds:

$$N_{t+1} = \sum E_t^{a,c,e,g} + U_t^{a,c,e,g} + I_t^{a,c,e,g} \tag{6}$$

Inactive workers include those in education (and out of the labour market) as well as

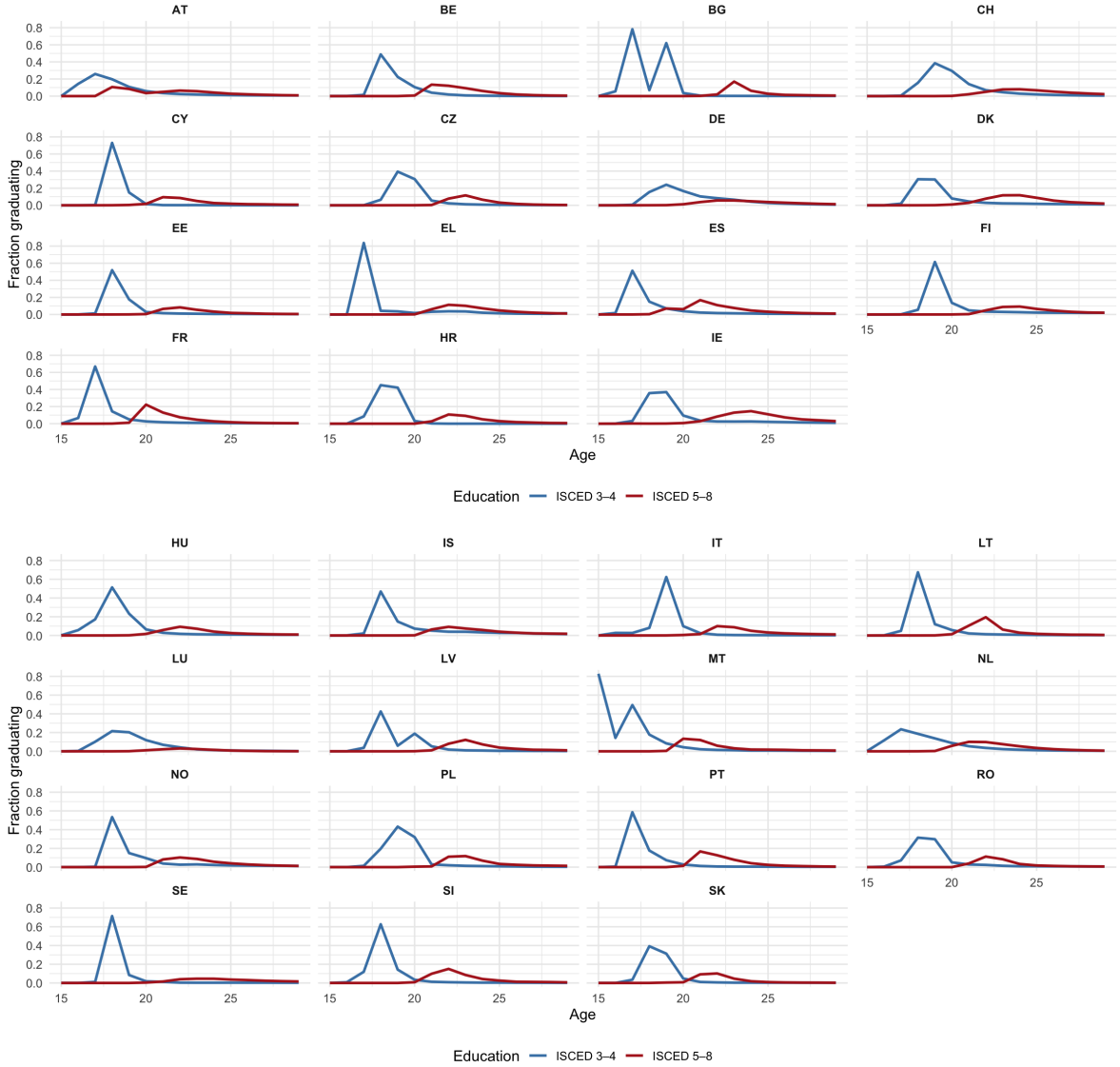


Figure 12: Graduates for intermediate and tertiary education by age.

Countries are identified by their 2 letter ISO-code. The subplots show country-specific fractions of the population by age that graduate from intermediate and tertiary education each year. The data is calculated from Eurostat table educ_uoe_grad01 (graduates by education level) and demo_pjan (age specific population). The blue line identifies the intermediate education and red line the tertiary education. Multiple spikes in intermediate education represent completion of ISCED3 (upper high school) and then ISCED4 (post-secondary less than tertiary).

retirees. Employment evolves from the previous period of the retained workers, less those with expiring contracts (at a rate ρ^e), and an addition of new employment matches, m_t:

$$E_t^{a,c,e,g} = (1 - \rho^e) E_{t-1}^{a,c,e,g} + m_t^{a,c,e,g} \tag{7}$$

As a result, the respective aggregate rates for labour market participation, employment

and unemployment are given by:

$$\text{Partic}_\text{t} = \frac{\sum E_t^{a,e,g} + \sum U_t^{a,e,g}}{\sum N_t^{a,e,g}}, \quad \text{Emp}_\text{t} = \frac{\sum E_t^{a,e,g}}{\sum N_t^{a,e,g}}, \quad \text{Unemp}_\text{t} = \frac{\sum U_t^{a,e,g}}{\sum E_t^{a,e,g} + \sum U_t^{a,e,g}} \quad (8)$$

Higher-skill workers have a greater matching efficiency and probability of finding employment. Under the EU law, EU (and EFTA) workers have equal opportunities, whereas non-EU27+ workers require a visa or sponsorship. Nevertheless, those holding the citizenship of the reporting country are going to have a greater matching efficiency due to recognition of skills and other non-quantifiable factors, with the EU27+ workers having greater matching efficiency than non-EU27+ workers. Employment matches, m_t are given as a function of the number of unemployed persons, U_t and the number of vacancies, v_t, mediated by the matching rate a:

$$m_t^{a,c,e,g} = a^{a,c,e,g} f(U_t^e, v_t^e) \quad (9)$$

The probabilities of filling a vacancy q_{v_t} and finding employment q_{u_t}, as well as the labour market tightness θ_t are respectively given by:

$$q_{v_t}^e = \frac{\sum m_t^e}{v_t^e} \qquad q_{u_t}^e = \frac{\sum m_t^e}{U_t^e} \qquad \theta_t^e = \frac{v_t^e}{U_t^e} \quad (10)$$

4.4 Household

The household optimises consumption and labour market participation. Calibration for labour market status preference dependents on age, education and legal status. The minimum age for employment is set to 15, however, for young ages the work preferences are low given the low wages and need to be in education. The choice to become inactive begins to increase again once an individual reaches 55, and is dependent on wealth.

Employed individuals have the binary option to work full-time or part-time. Younger adults and older/pre-retirement adults are more likely to work part-time. Part-time hours are variant to education (approximated by occupation level), gender, and age.[18] To calculate the total labour supply by the population, we assess the contribution of

[18] Calibrations are approximated from Eurostat table lfsa_ewhuis.

part-time vs full-time employment and the number of hours. The labour supply is then:

$$LabourSupply = \Sigma E_{FT_t}^{a,c,e,g} H_{FT_t}^{a,c,e,g} + E_{PT_t}^{a,c,e,g} H_{PT_t}^{a,c,e,g} \tag{11}$$

The generalised period budget constraint of households is given by:

$$C_t(1+\tau^C)+FAP_t+X_t+PPens_t+Tax_t = w_t(1+\tau^W)e_t+u_t\chi+FAW_t+Pens_t+r_t^K K_{t-1}, \tag{12}$$

where C_t is private consumption, which is taxable at a rate τ^C, FAP_t is the new financial asset investment, X_t is the new physical capital investment, $PPens_t$ are the contributions to private pensions, and Tax_t are lump-sum taxes. The households earns income from labour by employed individuals w_t, receive unemployment insurance χ, receive a pension $Pens_t$, or make withdrawals from their financial assets FAW_t. The financial returns on previously invested capital K_{t-1} are reinvested unless funds are withdrawn at a rate r_t.

The pensions are calculated using the *net* replacement rates and are therefore not subject to further taxation. Wealth is accumulated separately. Any returns on previous financial investments are retained in the investment pot:

$$W_t = W_{t-1}(1+r_t) + FAP_{t-1}(1+r_t) - FAW_{t-1} \tag{13}$$

4.5 Retirement policy

When a person retires, they reduce their income. This is dependent on the type of pension they draw, whether there is a statutory, workplace or private pension. Early retirement can reduce income levels. One key indicator of policy is retirement age, which may still vary between genders, as is still the case in *some* countries. Such distinction stems from a range of reasons: originally envisaged as welfare improving for women, it is generally being phased out as exacerbating the pension inequality by gender. At the same time, there will be some long-lasting gender inequality issues with respect to the women who have already had their careers and income penalised due to raising families. In the current systems, whether through earlier retirement or fewer labour years, women stand to lose out financially due to having a smaller pot of pension savings (Lee et al., 2022).

For people of retirement age, the decision to exit the labour market is similar to that of unemployed working-age persons. The labelling of anyone aged 65+ as 'unemployed'

is rare in labour force surveys, however, the return to the labour force after the receipt of the first pension payment is not uncommon. In such circumstances, the replacement rates differ, though, and people over the retirement age are (mostly) unable to claim unemployment insurance in addition to pension.

Raising the retirement age is a policy option, although to what age and how it should be raised remains an open question. Different approaches include: (i) for every year of increase in life expectancy, raise the statutory retirement age by 1 year; (ii) raise retirement age by a fraction, e.g. 2/3 of the increase in life expectancy; or (iii) increase the retirement age by a constant number of years. A key factor against a 1:1 approach with life expectancy is that healthy life expectancy is shorter than life expectancy generally[19].

For resident migrants, claiming a pension would come with a minimum number of contributory years, unless a person has migrated specifically for retirement purposes (e.g. to move to warmer climates). Either way, a person still needs to be receiving a form of income which allows them to maintain a standard of living.

4.6 Firm

The representative firm follows the production function:

$$Y_t = \psi_t f(\psi_t^{AI}, K_t)^{\alpha}(f(L_t^H, L_t^M, L_t^L, A_t))^{(1-\alpha)} \tag{14}$$

The firm has inputs of AI, job automating robots (A_t), physical capital (K_t), and labour (L_t) at different education levels (H, M, L). The total factor productivity (TFP) is given by ψ_t. High-skill workers are the most productive. For simplicity, in the baseline steady-state model the capital markets and financial markets are combined such that the return on capital is the same as the return on assets. Given that in many countries there is a lack of growth in productivity, and investment has levelled off, there is scope for opportunity here that can be brought about for example by technological change.

The baseline calibration of AI efficiency is calibrated to the AI preparedness index calculated by the IMF. The job automating robots are calibrated to the number of robots

[19] As an example, the Netherlands' adjustment policy is the retirement age will rise by 3 months for every 4.5 months of increasing life expectancy. In 2023 the life expectancy of a female aged 65 was 21.5, by 2035 this is projected to increase to 22.8, according to Eurostat's projections (table proj_23nalexp). The target is for there to be 18 years of retirement.

per 10,000 workers as given by the IFR. A steady state TFP is calculated from the production equation. The elasticity of substitution is taken from the Eurostat AMECO tables which are specific to each country. The model employs a constant returns to scale Cobb-Douglas production function. The scaling parameters for relative productivity of high, medium, vs low-educated workers are given by ϕ.

Firms pay social security contributions for their employees, proportionally to income at different education levels. For calibration purposes, and to ensure continuity, we use the 67%, 100% and 167% levels of worker income, respectively.

4.7 Fiscal policy and interest rates

Several taxes are already discussed above in the forms of the relevant taxation rates (VAT, employee and employer salary contributions). Additional factors extend beyond the scope of this model, as they would make the analysis too complicated, whilst detracting from its main purpose. For instance, additional taxes or subsidies for people with children or medical conditions would normally come under the umbrella of tax reliefs (OECD, 2025).

We run the model as a small open economy, with the interest rate, r_t exogenously determined by financial markets. The interest rate is defined as a function of assets b_t relative to the GDP, and operationalised thus:

$$r_t = r^* \exp(-\phi \frac{b_t}{GDP}) \tag{15}$$

4.8 Model calibration

There are two aspects of calibration of the model presented throughout Section 4. The first one relates to matching the population demographic structures and the associated characteristics to the observed past data. The existing population variables are therefore extensively calibrated to data from Eurostat, with a few additions from the OECD. The details are listed in Table 1. The second aspect is related to the plausibility of the future paths of the development of demographic rates, starting from 2025, which need to be calibrated to existing projections. It is worth noting that, unlike demographic projections, the long-run forecasts of the macroeconomy are highly variable and thus infrequently used in OLG-CGE models, so are not used in the calibration exercise.

Table 1: Data Sources for Model Calibration

Variable	Source
Baseline population	Eurostat
Labour status (employment and activity rates)	Eurostat
Labour supply (full time vs part time and corresponding hours)	Eurostat
Demographic rates: fertility and survival by age and education	(WCDE, KC et al., 2024*b*)
Replacement rates (unemployment and pensions)	OECD
Wealth	Eurostat, ECB, Swiss National Statistics
Pension wealth	OECD
Retirement ages	EU ageing report and own research
Retirement requirements, penalty and bonuses	MISSOC
Pension contribution rates	OECD (2023), European Commission (2024)
Migration calibration	EUROSTAT
migration forecasts	WCDE
Social security contributions	OECD, Eurostat
AI Preparedness Index	IMF
Robots per 10,000 workers	International Federation for Robots (IFR)
Tax rates (corporation, VAT)	European Commission and own research
Macroeconomic parameters	Eurostat, Swiss National Statistics, own calibration
Production parameters	AMECO database European Commission

The projections of demographic rates are taken from the most recent version (v3) of the Wittgenstein Centre Human Capital Data Explorer (WCDE, KC et al., 2024*b*) with respect to fertility, survival, immigration and emigration, broken down by age, gender and education level[20]. For calibration, we focus on education levels corresponding to to ISCED 0–2 (low), 3–4 (medium) and 5–8 (high), which are also used by Eurostat. Education is an important driver of demographic trends: survival rates of highly-educated individuals are typically greater than that of medium-educated people, which in turn have at least the same or higher survival chances than low-educated ones. Using the most up-to-date version of WCDE is also important, as it already reflects the recent drop and delay in fertility discussed above, particularly for highly-educated women.

For migration flows, where available, we chose the age reached during the year to calibrate the year of birth (cohort). Otherwise, age in completed years is used. For net migration by age (Eurostat table migr_netmigr), values by age are available for 2022, except for a few countries, including France and Portugal, which do not report the specific age year, and countries with latest data available for different years: Belgium (2019), Switzerland (2020), Denmark (2021), Greece (2021), Hungary (2021), and Poland (2020), for which we used the same shares by age until 2022. We use the citizenship variable to establish the migrant status, including natives, other EU nationals representing established migrants, and non-EU nationals to representing more recent immigrants.

[20]Data sourced from the https://dataexplorer.wittgensteincentre.org/wcde-v3/, as of 1 November 2025.

5 Evaluation of policy scenarios: Modelling results

5.1 Evaluation of policy scenarios

Due to the complexities inherent in the model presented in Section 4, to evaluate different policy scenarios we need to simplify the model to incorporate the expected population changes, based on the projections from the Wittgenstein Center Human Capital Data Explorer. In this section we employ the calibrated baseline model to explore different policy options regarding pensions and their long-run sustainability in the face of ageing.

To balance PAYG pension systems and ensure their sustainability, contributions must be equal or greater than pension payments. Conceptually, this can be written as:

$$\tau^P(\Sigma E_t^H w_t^H + \Sigma E_t^M w_t^M \Sigma E_t^L w_t^L) = \Sigma Ret_t^H Pens_t^H + \Sigma Ret_t^M Pens_t^M + \Sigma Ret_t^L Pens_t^L \quad (16)$$

The contribution rate τ^P determines the level of contributions made by each employed person. We assume a constant rate across all education levels.[21]. For baseline calculations, median wages are used.

5.2 Required contribution rate

To establish the balance of the PAYG system we first attempt to satisfy equation (16) above. In the calibration, we have collected the current contribution rates for Pillar I and Pillar II systems. In Figure 13 we plot the required contribution rate given equation (16). The horizontal axis indicates the year in the range from 2023 to 2099, the black line is the existing sum of Pillar I and Pillar II contributions by both employers and employees, with the red line indicating the required contribution rate. Countries with the highest contribution rates, exceeding 30%, include Portugal, Spain, Italy and Croatia. At the lower ends of the scale, the rates for Lithuania, Denmark, Ireland and Bulgaria are below 15%. The mean for all countries is 21.7%. It is worth noting here that these contributions come from mainly Pillar I pensions.

[21] This analysis does not include any early-retirement or delayed retirement penalty or bonus, due to the lack of reliable data.

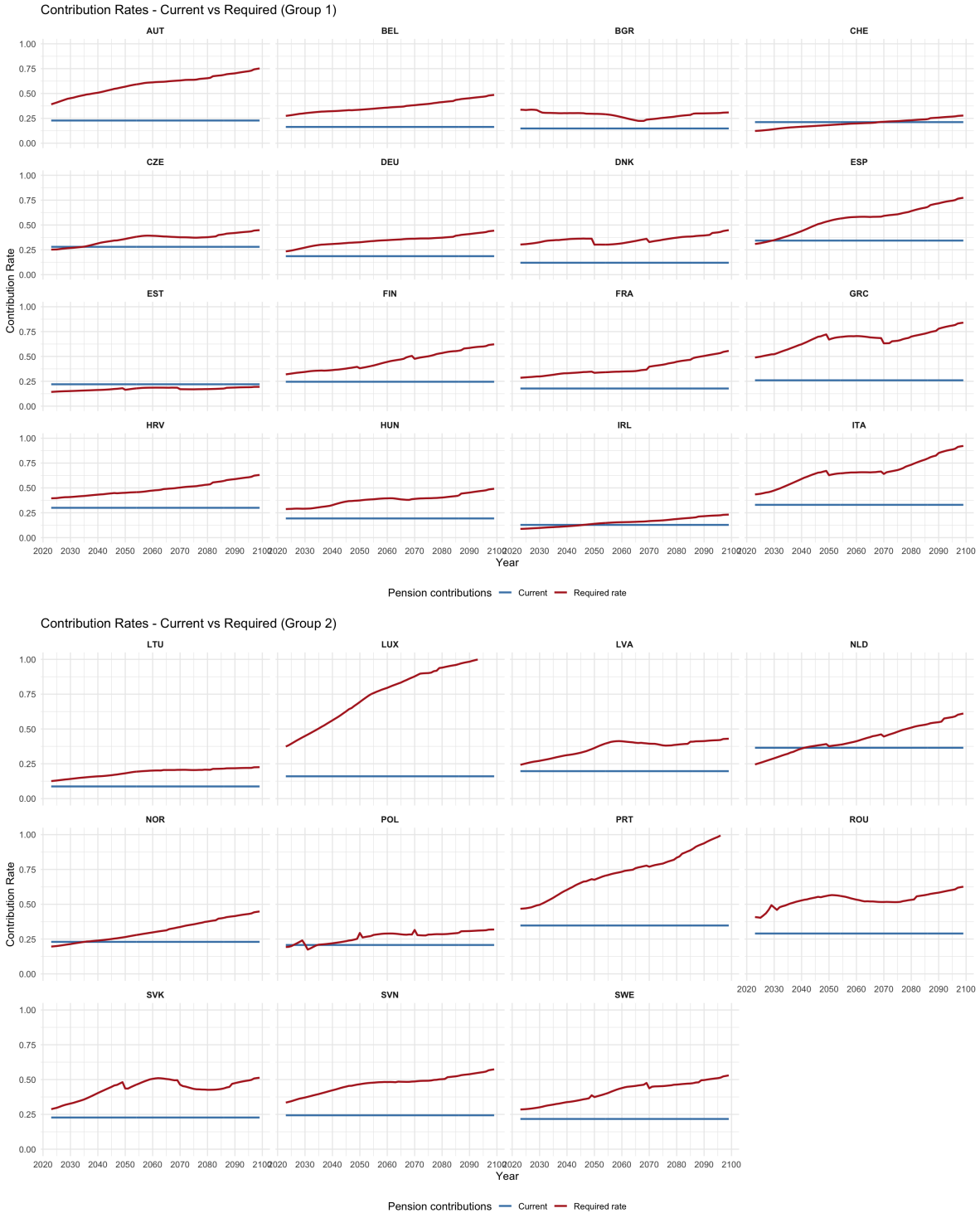


Figure 13: Current and required pension contribution rates

The graphs show the current and required pension contribution rates for 27 EU+ countries. The countries are labelled with ISO Alpha-3 codes and are split into two groups purely for presentational purposes. Source: Authors' calculations and OECD, European Commission (2024) Explorer.

The results show that the PAYG systems for all countries are currently in deficit. In 2023, the majority of retirees only received an old-age pension. The decrease in the required contributions here is an indirect result of the increase in the human capital accumulation, which leads to higher wages and employment levels, as well as feedback from the demographic side. A notable outlier, Luxembourg, has very high pensions and replacement rates, which – *ceteris paribus* – would need a significant boost in contributions in order to be sustained.

One of the reasons for disparity in the contribution rates is the existing composition of relative sizes of employment and wage premiums. If the baseline wage is set to one for the median low-educated worker, then the relative wage of the high- and medium- educated, ϕ_H and ϕ_M are clearly expected to be higher. Hence, ϕ_H ranges from 1.35 for Norway to 2.32 for Romania, with a mean of 1.75. For ϕ_M the range is from 1.14 for France to 1.7 for Denmark, with a mean of 1.37. The population composition by education, along with the range of possible educational outcomes and associated skills acquisition, influences the broad scope of the required policy changes.

The increase in the size of the necessary contributions simply to balance the PAYG system is unquestionably unrealistic in the short-term. Shortfalls in the contributions have to be made from government budgets elsewhere. Nonetheless, shifts towards increasing the contribution rates and making changes to other elements of the fiscal policy are important complements in establishing long-term pension sustainability.

In addition, there is an assumption that everyone who is retired is eligible to at least an early retirement pension. There is insufficient data at an aggregate level that provides the detail. The constraints that cannot be replicated in the model is such that minimum years of contributions, ones that are substitutes by childcare years, or further caveats that could prevent a (full) pension being claimed.

5.3 Retirement ages

The second stage of the analysis is to consider what would be a target retirement age for the *existing* contribution rate. Both retirement age and contribution rates need to evolve slowly as people make preparations for retirement long in advance. If people are unable to contribute more, or are resistant to increasing the contributions to such high

levels, then the alternative is postponing the age at which the (full) state pension can be claimed. The delay of being able to receive a pension enables more receipts to be given by a person who had worked longer, with proportionally fewer years of eligibility to claim pension afterwards. Figure 14 shows the effect of small increases in the employment and activity rates. For some countries there is a greater increase which depends on their existing ages and contribution rates.

In terms of formal retirement age, the countries with disparities between genders (as of 2022) include Bulgaria, Czechia, Croatia, Lithuania, Austria, Poland, Romania, Slovakia, and Switzerland. By 2030, only Bulgaria, Czechia, Austria, Poland, Romania will have disparity. With only Poland and Slovakia having existing policies that continue gender disparity in retirement ages. Due to the less than half the countries experiencing gender disparity in retirement ages, we do not focus analysis on this area. Nevertheless, eliminating gender disparity by equalising the women's retirement age with men's would be another beneficial factor contributing towards balancing the PAYG systems.

Increasing the *official* retirement age will also inevitably increase the *effective* retirement age. Data from Eurostat shows that the effective retirement age has already been increasing[22], which can be explained by the financial need to maintain both the current and future living standards. By following on from the current policy of a retirement age of e.g. 65, we can model a one-year increase with a simple assumption of extending those employment rates by one year. Such a one-year increase in isolation is negligible, as the labour supply of pre-retirement workers is approximately 1%. However, there are greater pension contributions because of the increased labour supply and fewer withdrawals, and as the contribution rate is less than the replacement rate there is a disparity that makes it less than 1:1 net gain.

5.4 Employment old age dependency ratios

Despite the ever-increasing old-age dependency ratio (OADR) being a policy concern in its own right, there are not too many options that policy makers can implement to address this: as argued above, increasing fertility through policy interventions is difficult, and migration is mainly a short-term solution. Instead, more realistic policy targets

[22] Eurostat First accessed 22nd January 2025.

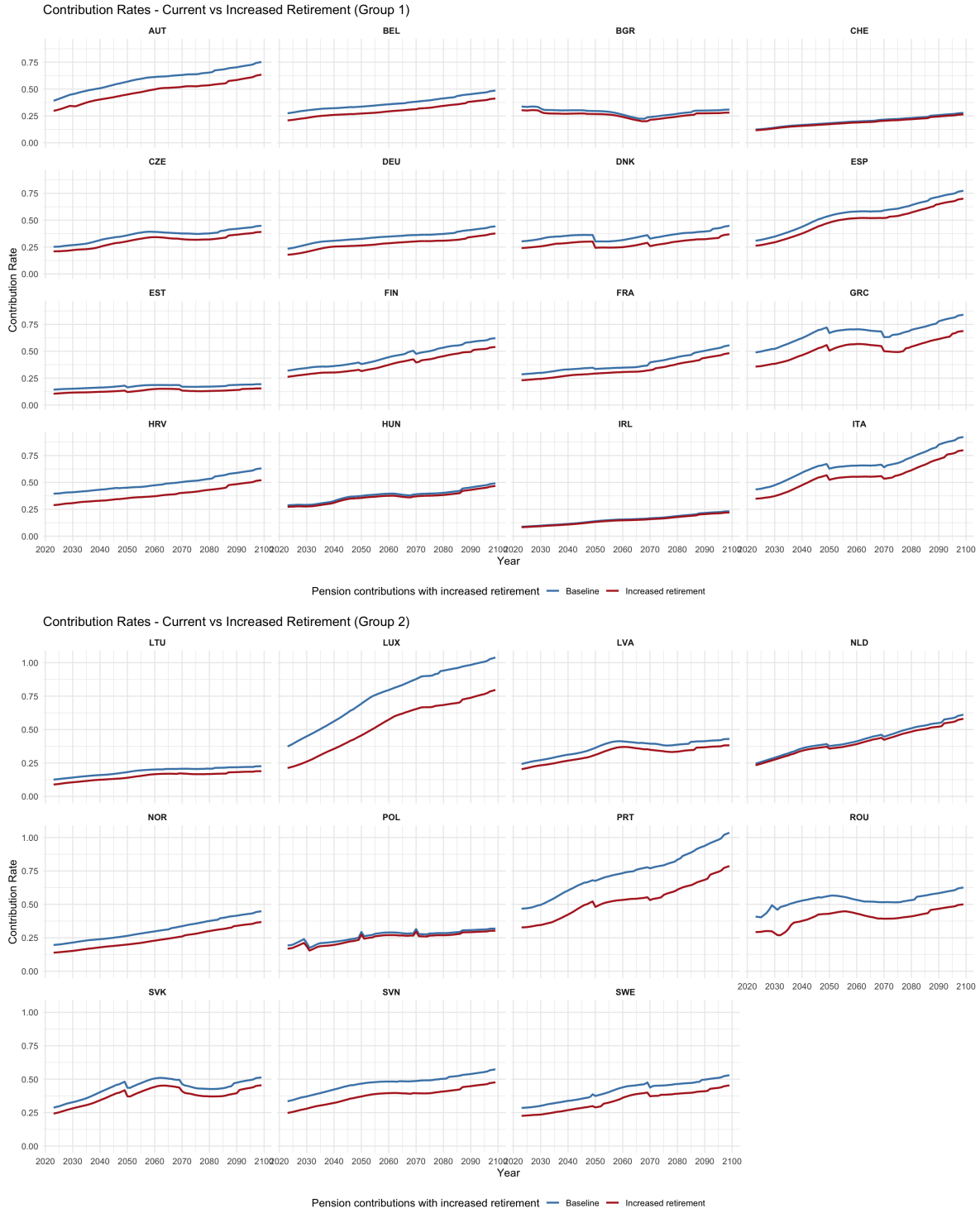


Figure 14: Current pension contribution rates and with increased retirement

The graphs show the current contribution rates and those with increased retirement age for 27 EU+ countries. The countries are labelled with ISO Alpha-3 codes and are split into two groups for presentational purposes. Source: Authors' calculations and OECD, European Commission (2024) Explorer

could be expressed in terms of the *Employment* OADR (EOADR), which additionally takes into account economic activity.

The role of EOADR is to aid financing the economy as a whole, through general taxation, not only providing pension contributions. For some countries with low activity (participation) rates, e.g. Italy, this is of especially high concern because there is a realistic possibility that the old-age dependency ratio, relative to the employment-age population, will soon exceed 50%. This would be extremely problematic for any economy to deal with as there would be less than two workers for every person aged over 65.

To address this challenge, maintaining a constant level of the EOADR would require (i) increases in existing residents' employment rates, or (ii) increase to working-age immigration, or both. Targeting policies for *only* working-age immigration is difficult as migrants can bring their own dependents and ultimately get older. In this exercise, we evaluate the increase in participation rate required to maintain the constant level of the EOADR. Even though increases in retirement age would also push the standardised 65+ age threshold upwards, in this exercise we maintain this upper limit of the notional "employment age" for consistency purposes. This is also due to the fact that those aged 20–64 years, and especially 25–54, make up the bulk of the labour supply as after the age of 55 both labour force participation rates and hours worked tend to decline.

In the case that the required employment rate exceeds 1, this implies that even an employment rate of 100% of 20-64 year-olds is not sufficient to maintain the EOADR of the baseline year (2023). Figure 15 shows the baseline model of the EOADR and OADR. The OADR is greater than the EOADR as it is relative to the total population vs employed population of 20-64 year olds. Figure 16 shows the same scenario in terms of the employment rates.

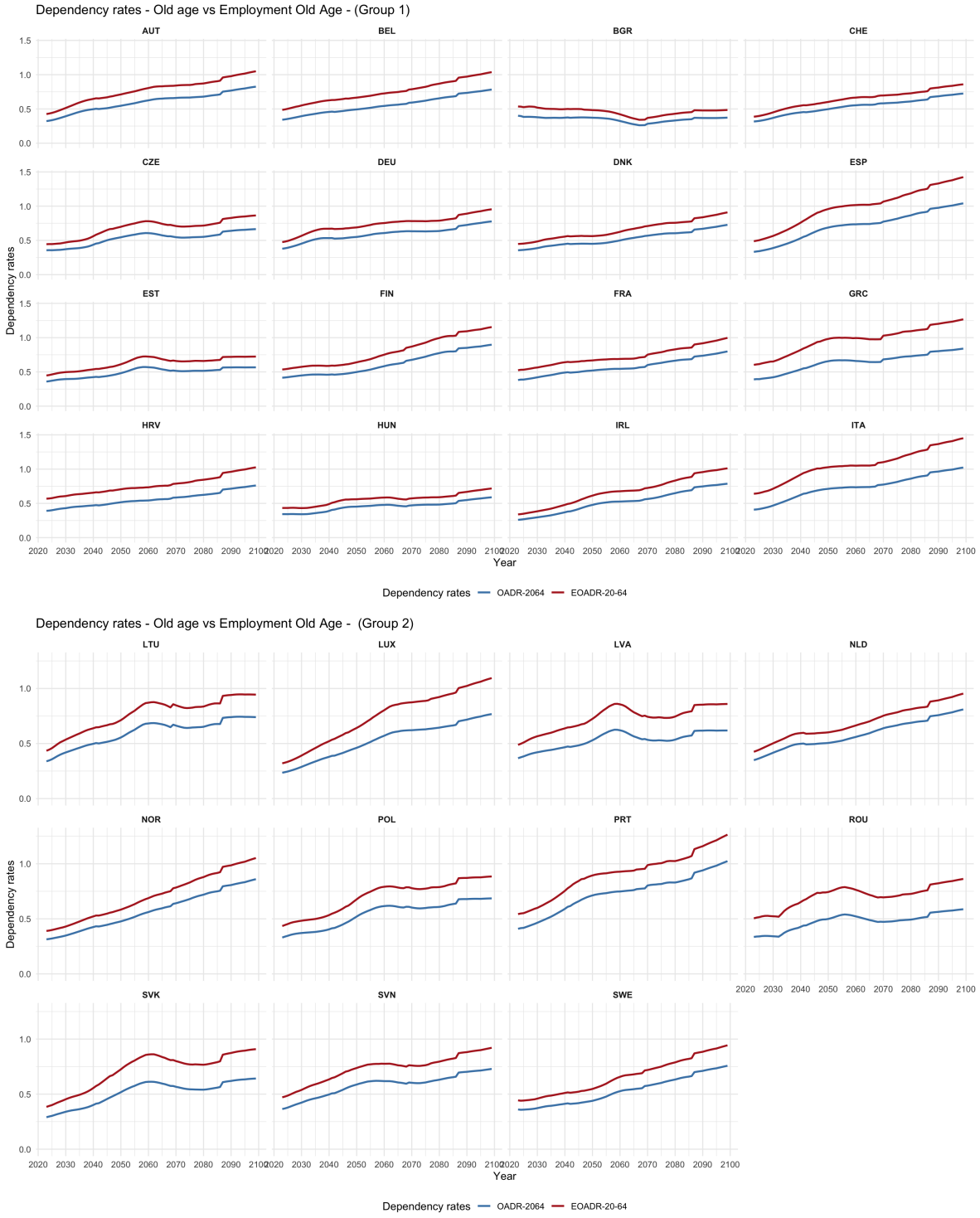


Figure 15: Old Age Dependency Ratio (OADR) and Employment OADR

The Old Age Dependency Ratio (OADR) and Emploument OADR, calculated as the size of the population aged 65+ relative to, respectively, the total population or employed population aged 20–64. The countries are labelled with ISO Alpha-3 codes and are split into two groups for presentational purposes. Source: Authors' calculations

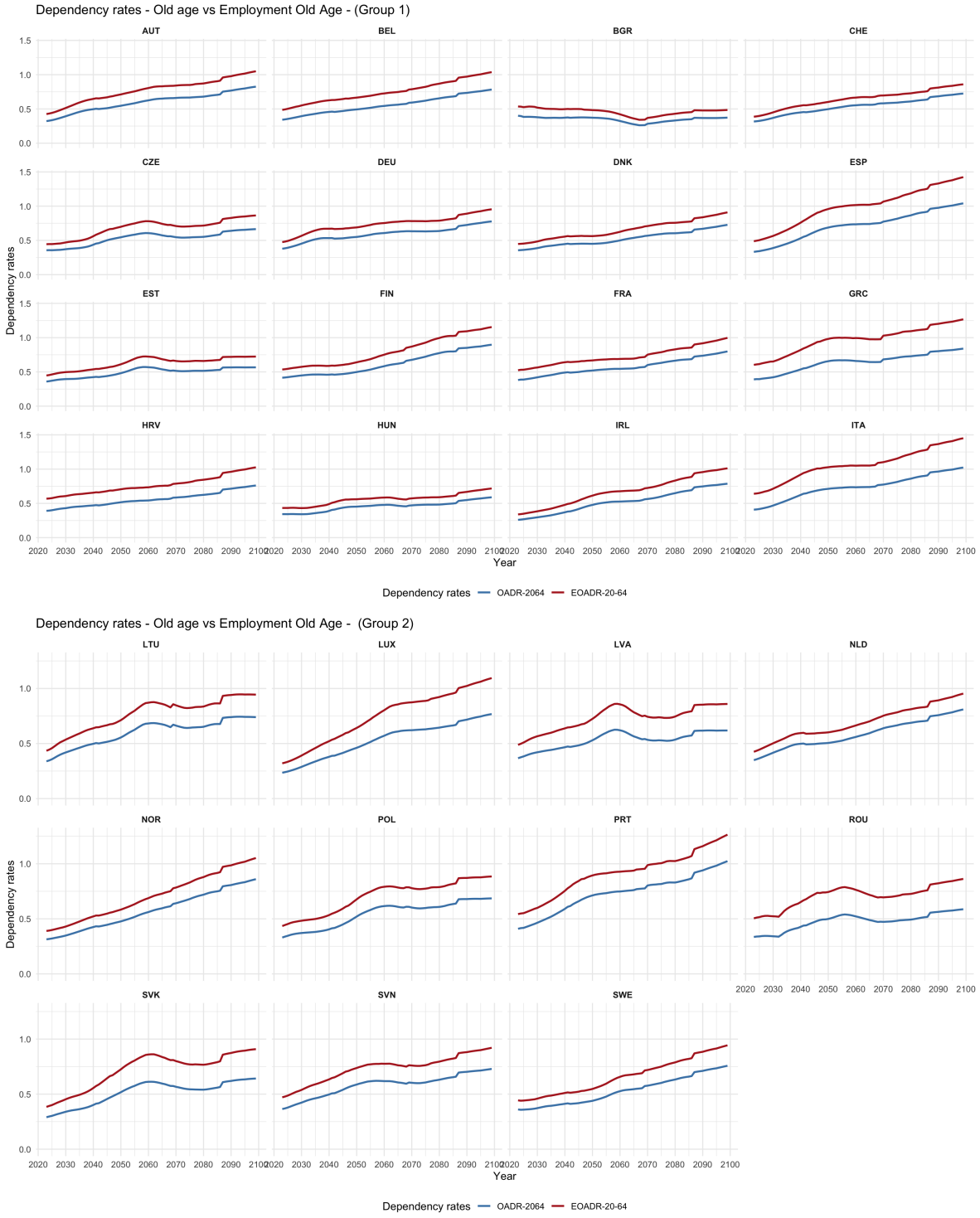


Figure 16: Employment rates - modelled and required

The employment rates, projected and required to maintain the 2023 values of the Economic OADR. The countries are labelled with ISO Alpha-3 codes and are split into two groups for presentational purposes. Source: Authors' calculations

6 Discussion and Conclusions

6.1 Discussion: Beyond retirement

Asking people to work longer before they retire is possible to an extent, but as healthy life expectancy is shorter than life expectancy, it is not a problem-free solution, either. As European Commission (2024) and numerous other research and policy reports have shown, there are no quick or permanent solutions to the challenges of ageing, especially concerning the oldest age groups, such as 85+ (Figure 17).

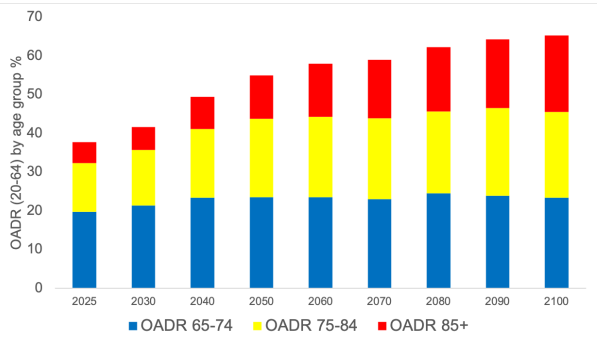


Figure 17: Contributions of age-groups to the OADR for selected years

The projected the old-age dependency ratios for age groups 65–74 (blue), 75–84 (yellow) and 85+ (red) to population aged 20-64, are shown for the EU27. Source: Eurostat table proj_23np, own calculations.

Building on this research, and taking healthy life years into considerations, those in the age group 85+ are highly unlikely to be able to work to a great extent. At the same time, the demands on the health and social care systems is expected to increase further – and these sectors are already struggling to fill all labour needs, with nursing and long-term care work are some of the most in-demand professions. With low fertility rates, the mismatch between care demand and supply will increase further. Caring responsibilities – for younger and older family members – have already been a downwards pressure on female labour force participation. Therefore, as highlighted by the European Commission (2021), there is a rising need and long-term requirement for care provisions.

One of the best ways to optimise the future care availability is to prolong the time until which long-term care is required. Policy makers *can* promote healthy ageing, which includes living active lives and tackling rates such as obesity and smoking, which put pre-existing pressures on the healthcare system. This would help maximise the potential of the existing workforce by reducing economic inactivity of people in the working age.

Further research can examine the effects of the health benefits of more people working but work fewer hours. This is to be distinguished from the 'lump of labour fallacy' that comes from job-sharing that was promoted in the 1980-90s. Only recent research has allowed this *always-on* culture that has evolved has eroded the standardisation of working hours. The subject is discussed further in Burchell et al. (2024). Of course, there are heavy pressures on the fiscal budget as the gaps to balance allow for the shortfall from contributions to expenditure have to come from the governments' budget elsewhere. This either drives up government debt or necessitates making sacrifices elsewhere.

6.2 Conclusions

In this report, we have presented an extensively calibrated overlapping generations–computable general equilibrium (OLG-CGE) model to analyse selected scenarios of long-run sustainability of pension systems and the labour markets by the end of the 21st century. We have used high performance computing to run a range of policy simulations, focused on pension reforms and labour market changes, that incorporate as much information about the current and likely future macroeconomic conditions as feasible.

Addressing the challenges of population ageing cannot rely on any quick fixes, nor it is a temporary problem that is only related to the retirement of the baby-boom generation. With the decline in natural population growth, fertility rates consistently below the replacement level, and migration not being a sustainable long-term solution, either, the number of people coming into the workforce will consistently lower than the number of people exiting the workforce. Consequently, the potential remedies to the expected shortfalls of pension system finances need to be sought elsewhere, beyond demography. In this context, it is important to recognise that technological change – robots or AI – will have their place in the production process for the long-run. However, we cannot depend on robots and AI alone to address the ageing challenges. A desirable outcome of job automation would be to make workers more efficient for longer, allowing to compensate for some of the current health limitations, especially in the older ages.

Delaying the *effective* retirement age by increasing deferment, especially of Pillar I (statutory) pensions, is another option, which is currently underutilised. Even though only The Netherlands does not employ a deferment policy as of 2025, and deferment

options are available in most countries, Spasova and Airoldi (2025) noted that the take-up of these is limited.Nevertheless, a revision of the retirement age and associated incentives seems necessary in the long term, despite political opposition. At the same time, the pension systems are diverse, and even though the EU has tried to increase the dependence on workplace pensions there is a long way to go for some countries to reach that stage.

The results from our research reaffirm that in the absence of reforms, the current pensions system and retirement ages are not sustainable. It is important to increase pension provision, but this is likely to come with limitations on when pensions can be accessed. For example, The Netherlands and Ireland have no early retirement. This is a policy option that should be considered by other countries, too, even as a proxy to increasing the effective retirement age. Disability pensions or a form of pension for people unable to work due to medical issues should be used in addition to the standard social security systems. As argued above, changes to unemployment insurance and other benefits could also be considered.

On the whole, increasing the sustainability of pension policies can come down to (i) tightening eligibility restrictions; (ii) adjusting the benefit levels; and (iii) increasing the contribution rates. Eligibility restrictions include linking retirement age to either life expectancy or minimum contribution years, or both. At present, many EU countries do not have policies that will adjust the retirement age beyond 2040, though some do specify that the age either can or will be revised as life expectancy increases. This is particularly relevant for the Eastern European countries, which currently have the lower life expectancies (see Figure 18). Another consideration here are any future increases to healthy life expectancy, which would enable longer working lives.

There are other considerations, too. The Bureau of Labour Statistics (2025) report on forecasting the labour market until 2034 shows that AI and population ageing can be stimulators of employment. The care sector for age-related and critical illness is a significant driver, as is technological change, driving employment in the renewable energy sectors and engineering jobs, especially related to electric vehicles. The demand for AI is expected to increase in the professional, scientific, and technical services. AI is also expected to reduce demand for labour in some office-based and administrative support jobs, with the growth of the online sales market changing the employment needs of the

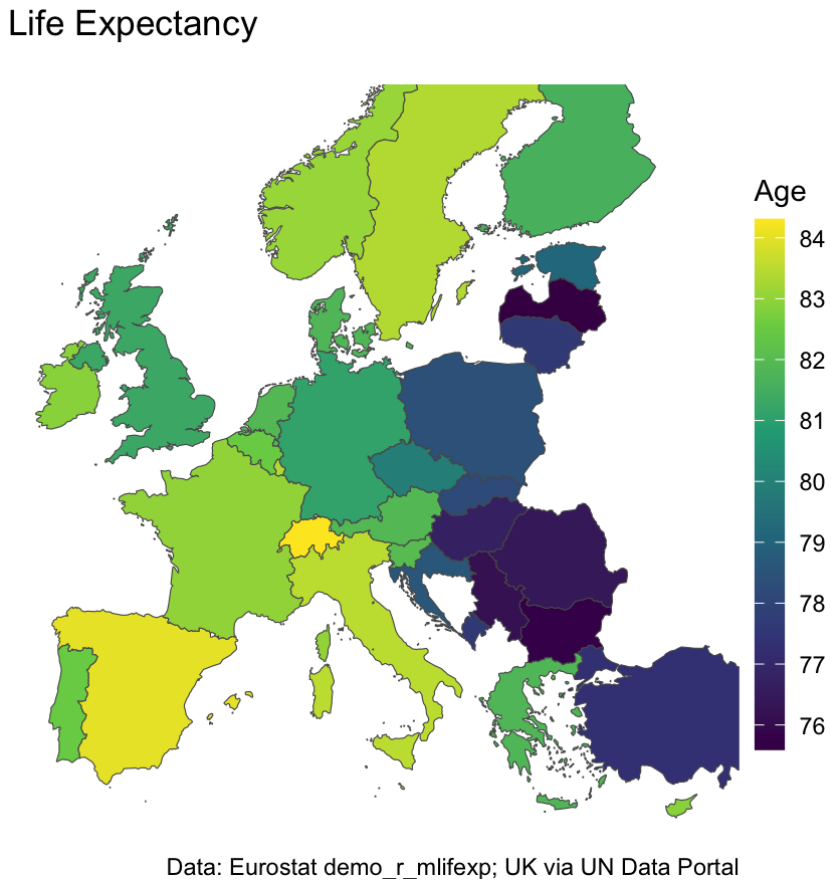


Figure 18: Life expectancy in 2023

The map shows the life expectancy for a person born in 2023. Source: Eurostat table demo_r_mlifexp, and for the UK the value is taken from the UN World Population Prospects.

retail sector. These forecasts emphasise that robots are not going to replace workers, but rather change our job definitions. The expected rise in technology, driving the demand for mathematicians, scientists and engineers, requires being matched by the education sector. Especially in the age of ubiquitous AI, requiring ability not only to prompt, but also to critically verify the answers, to the days when 'I cannot do maths' – or broadly, 'I do not want to have requisite skills' – were a socially acceptable excuse need to end. Indeed, a push for more real life applied mathematics is a strategy to aid future generations in adapting to the needs of the labour market at an appropriate level.

In addition, even though the wealth defined in this model includes all types of assets, the main asset that people hold in retirement is typically housing. Unaffordable housing has become a recurring theme common across many countries, so if and when the current 'generation rent' reach retirement without owning a home then there is more need for

higher incomes during retirement, if people are to depend on the private rental market for housing. That issue, however, remains beyond the scope of this report. The model presented here has focused on pensions, and we have not extended it beyond pension assets. There is further scope to make the macroeconomic model as comparable to the EU-LMM (Berger et al., 2024) as possible, or to make the demographic dynamics even more realistic, as in Sánchez-Romero et al. (2025). The extensions of modelling in both directions – macroeconomic and demographic, with housing providing an important link between economic situation of families and their fertility decisions – promises to offer further, more nuanced insights into the socio-economic policy options for ageing Europe, illuminate further trade-offs between them, and make the conclusions even more robust.

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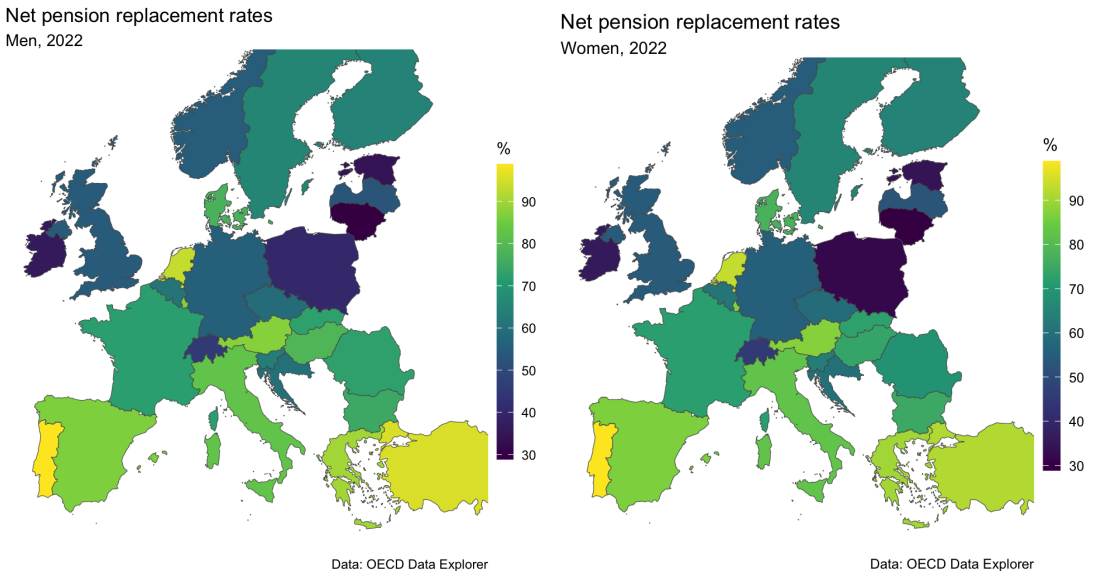
Appendix

A Modelling pensions: Additional information

A.1 General remarks

The model presented in this report is run for the remainder of the twenty-first century. As retirement ages, pension systems, and the underlying demographic trends and processes can differ greatly between European countries, there is also a great variation in terms of the pension entitlements and replacement rates, which can serve as an indicator of sustainability of the existing pension systems.

Generally, there is not much difference in replacement rates between genders, however, especially for some countries, the differences are marked: for gross (net) replacement rates, respectively, the gender differences are: 3.4% (5.1%) for Hungary, 6.4% (8.8%) for Poland, 2.5% (3.8%) for Romania, and 2.7% (3.8%) for Turkey. The EU27 gross (net) average in 2020 was 54.8% (68.1) for men and 54.3% (67.3) for women. Of the (reporting) non-EU OECD countries, only Australia and Turkey exhibit visible gender differences in this indicator (for net pension replacement rates across Europe, see Figure A.1).



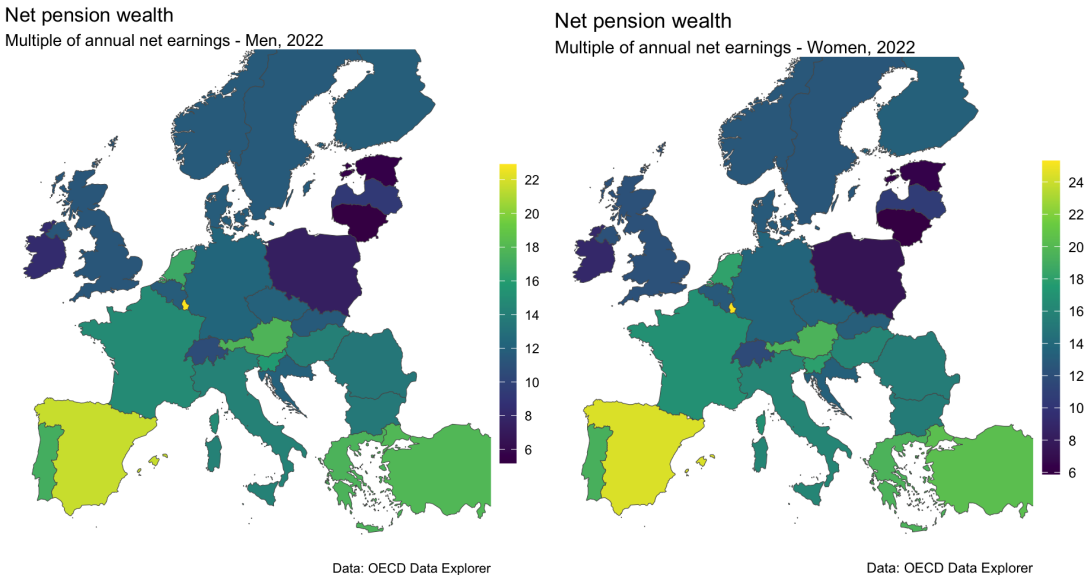
(a) Male (b) Female

Figure A.1: Net pension replacement rate

The maps indicate the net replacement rate of pensions with respect to pre-retirement income. Source: OECD Data Explorer

In previous work (Barker and Bijak, 2024*a*,*b*), we have used DSGE models that share similar foundations to the one presented in this paper. However, in the current report we have changed and simplified the model somewhat, to remove the assumptions around the traditional physical capital being complementary to high-skill labour. Our focus here has been on demonstrating how robots and technology will change our jobs, for which employing a traditional form of capital is unsuitable.

An important variable strongly related to pensions and financial resilience in retirement is individual wealth. Retirees can be dependent on savings to complement their reduced income which is one of the determinants of whether they may need to re-enter the labour force. The OECD measures wealth as multiple of annual gross or net earnings, with the geographic distribution of the latter indicator visualised in Figure A.2.



(a) Male (b) Female

Figure A.2: Net pension wealth

The maps indicate the wealth as a multiple of annual net earnings. Source: OECD Data Explorer

A.2 The macroeconomics of pensions

Pensions, whether private of public, make up an increasing percentage of GDP. The global size of pension assets is illustrated in Figure A.3, with the distribution of the pension expenditure shown in Figure A.4. For the latter indicator, in 2022, the EU27 average was 12.27%, with the highest value for Italy (15.49%), and the lowest for Ireland (3.87%).

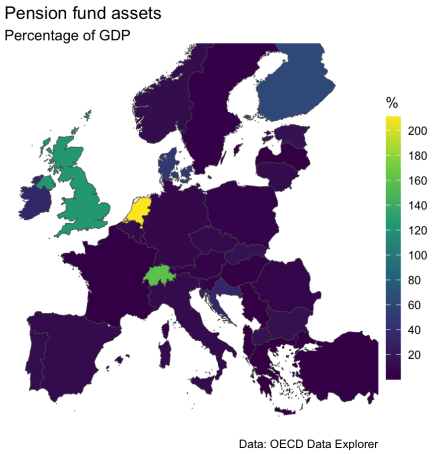


Figure A.3: Pension fund assets

The map shows the assets of pension funds as a percentage of GDP. Source: OECD Data Explorer

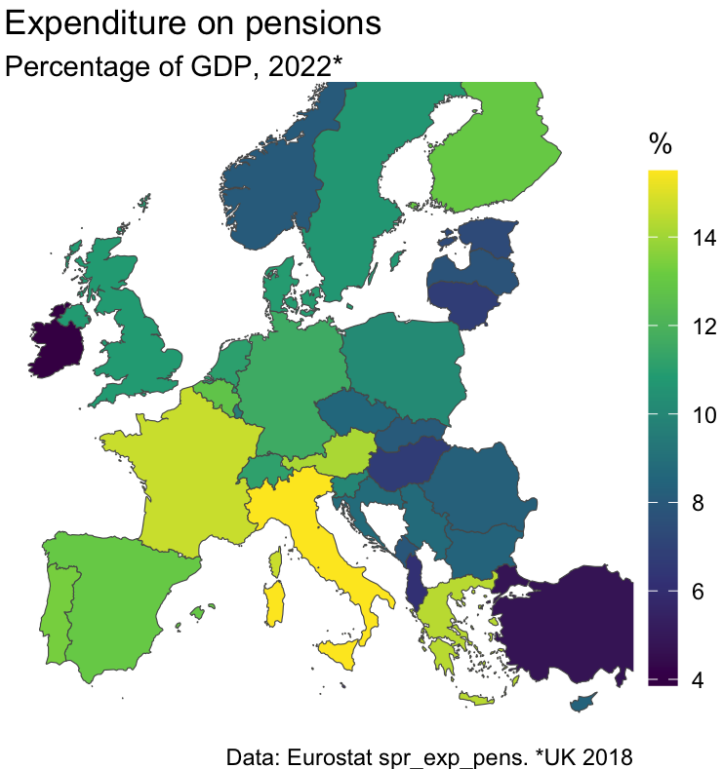


Figure A.4: Average expenditure on pensions, as a percentage of GDP, 2022

The map shows the percentage of GDP spend on pensions as a percentage of GDP in 2022. Source: Eurostat table spr_exp_pens, and for the UK the value is for 2018.

In the face of population ageing and changing demand for pensions, governments are increasingly being forced into implementing policies that mask or find new sources of pension-related investments for firms. However, accessing funding from pension pots to

stimulate economic growth would be a risky and short-termist strategy. Several countries have some form of a tax-free savings accounts, designed to help save towards retirement by offering cash or investment-based incentives. With the savings rate on average decreasing household investment (Figure A.5), the access to financing growth is reduced[23].

Saving rates vary across Europe, with Germany and Belgium dominating the highest values in the first quarter of the 21^{st} century, and Greece dominating the lowest ones (Greece experienced 43 quarters of negative savings rates between 2001 and the end of 2024, which all occurred from 2011Q4 onwards). Negative savings rates indicate that the average household is withdrawing from savings to finance their existing expenditures[24]. In contrast, Germany's saving rate in that period averaged 17.6%, with only Finland, Poland, Portugal, Spain, and the UK (up until 2020Q3) averaging less than 10%.

With respect to investment rates, there is no sweeping statement to correspond to the savings rates. The highest investment rates were observed for Finland, Ireland and the Netherlands, and the lowest for Greece and Romania[25] Unsurprisingly, if Greek residents require accessing their savings to keep financing their current expenditure, then the household investment will be inevitably low.

From the firm perspective, the highest values of the gross profit share of non-financial corporations were observed in Ireland, Sweden and Estonia, and the lowest in France and Spain. Investment rates of non-financial corporations show a different picture: Romania, Czechia, Estonia, Hungary and Ireland have some of the most frequently-observed highest values of this indicator, with the lowest ones mainly seen in the Netherlands and Greece.

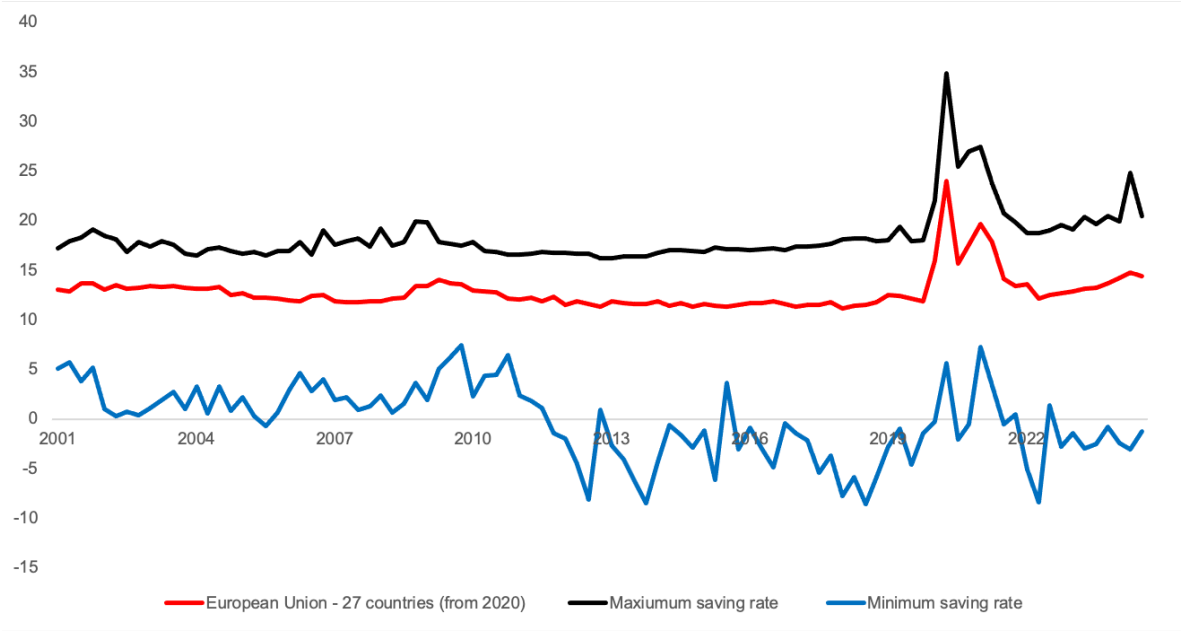
In addition to taxing income from work or investments, governments are also taxing sales of goods and services, for example in the form of the value added tax (VAT). In 2023, VAT income equated to 15.7% of total government tax revenue or 7.2% of the EU's GDP[26]. In that regard, saving rates tend to increase with age during the working life as wages rise. Consequently, an ageing population removes further private consumption from the economy considered 'productive', and from the tax base.

[23]Savings rate is defined as the amount of money saved by individuals as a percentage of their household income, and the household investment as a percentage of household income directed towards gross fixed capital formation.

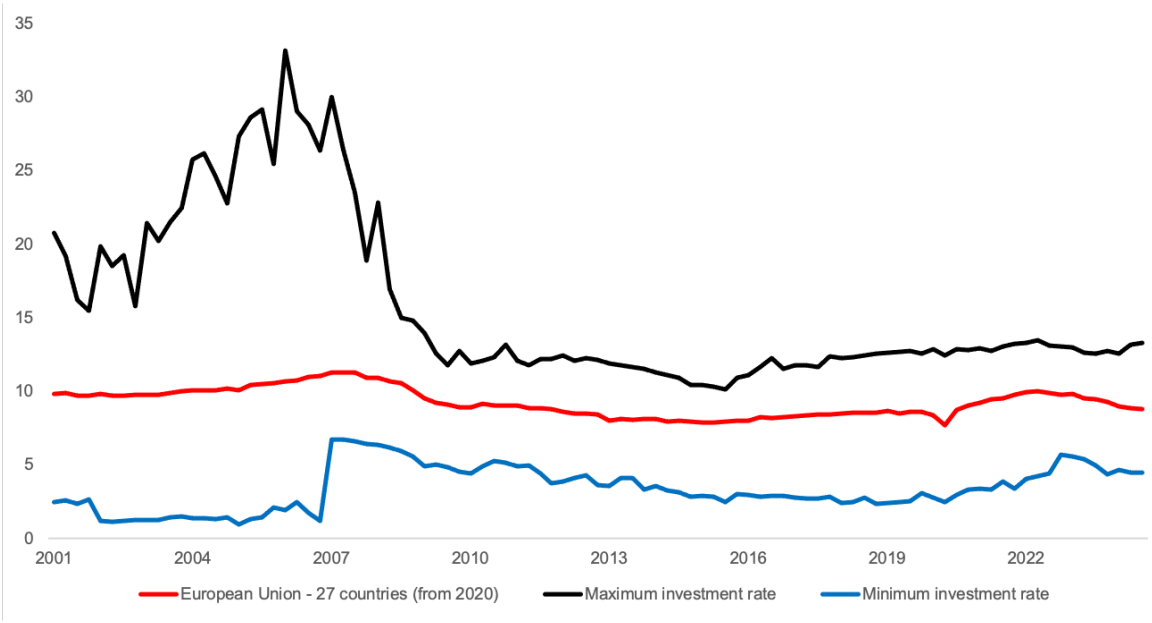
[24]The only other countries to experience negative savings rates in that period were Denmark (2005Q3,2014Q3,2014Q4) and Romania (2021Q3).

[25]Romania does not report values from 2008Q1 onwards which will distort this evaluation somewhat.

[26]Source: European Commission. First accessed 5 March 2025.



(a) Saving rate



(b) Investment rate

Figure A.5: Household saving and investment rates

The red line shows the average values for the EU27 (2020-) from 2001Q1 to 2024Q3. The black line shows the maximum value for the period from the EU27 and Norway, with the blue line the corresponding minimum value.

B Further notes on data

Eurostat ad-hoc LFS modules The main source of data for EU27 countries is the Pension and labour market participation ad-hoc LFS module, 2003 (lfso_23)

- Persons receiving an old-age or disability pension by type and labour status (lfso_23pens01)
- Persons receiving an old-age pension by type (lfso_23pens02)
- Age at which the person started receiving an old-age pension (lfso_23pens03)
- Persons receiving an old-age pension by first statutory pension receipt with/without reduction or bonus (lfso_23pens04)
- Age at which the person started receiving a disability pension or other periodic disability cash benefits (lfso_23pens05)
- Persons receiving an old-age pension by their work situation at the beginning of pension receipt (lfso_23pens06)
- Persons receiving an old-age pension and stopped working at the beginning of pension receipt by reason (lfso_23pens07)
- Persons receiving an old-age pension and continued working at the beginning of pension receipt by reason (lfso_23pens08)
- Persons receiving an old-age pension and re-entered the labour market after the beginning of pension receipt (lfso_23pens09)
- Persons receiving an old-age pension and re-entered the labour market after the beginning of pension receipt by reason (lfso_23pens10)
- Persons receiving an old-age pension by their work situation at the beginning of pension receipt and current or previous professional status (lfso_23pens11)
- Persons receiving an old-age pension by their work situation at the beginning of pension receipt and current or previous occupation (lfso_23pens12)
- Persons not receiving a statutory nor an occupational old-age pension by type of financial old-age provision (lfso_23pens13)

Migration The proportions of migrants are calibrated to the values for 2022 by cohort, gender, and citizenship group. Depending on data availability, the migration flows for each category included in the model are calculated as a percentage of the total migration flow. The primary table by age and gender is taken from Eurostat, Tables `migr_imm8` and `migr_emi2`. Emigration is not as well reported as immigration, with Spain not reporting any emigration by age, and Belgium, Denmark, France, Hungary, and Poland not reporting gender. The citizenship status is taken from `migr_immi1ctz` and `migr_emi1ctz`, with migration reported in five-year age groups.

Net Assets Reporting of net assets is limited. We use the report by the European Central Bank (ECB) (ECB, 2023) to estimate assets by age. Some countries in this report do not data on assets (specifically Bulgaria, Switzerland, Denmark, Norway, Poland, Romania and Sweden). Based on the values for GDP per capita (Eurostat table nama_10_pc), earnings in PPS (Eurostat table earn_ses22_30), home ownership (Eurostat table ilc_lvho02), and pension fund assets as a percentage of GDP (OECD collection DSD_FP@DF_PA) we approximate the values for Bulgaria and Romania by using those from Lithuania, for Switzerland by using values from the Netherlands, for Denmark from Finland, for Norway from Belgium, for Poland from Czechia, and for Sweden from France.

Wage curve To aid model computations, we introduce a wage curve that aims to make best use of the data available to reflect the higher wages earned by older relative to younger people. We use the employment by age figures from the 2021 census (Eurostat table cens_21a_r2) and the structure of earnings survey (table earn_ses22_27) to approximate a log-quadratic curve wage regression on age. The Structure of Earnings Survey (SES) uses age groups: under 30, aged 30-49, and 50+. Using mid-points, the values were then weighted by the census employment by age to estimate average wages. To project them forward, we estimated an adjustment factor that was employed in the OLG-CGE model to scale wages accordingly. Figure B.1 shows the estimated wage curves.

Hours of work: part-time vs full-time employment The number of hours worked by a person in full vs part-time employment varies between countries and occupations. Eurostat does not report hours worked by education level (which is understandable,

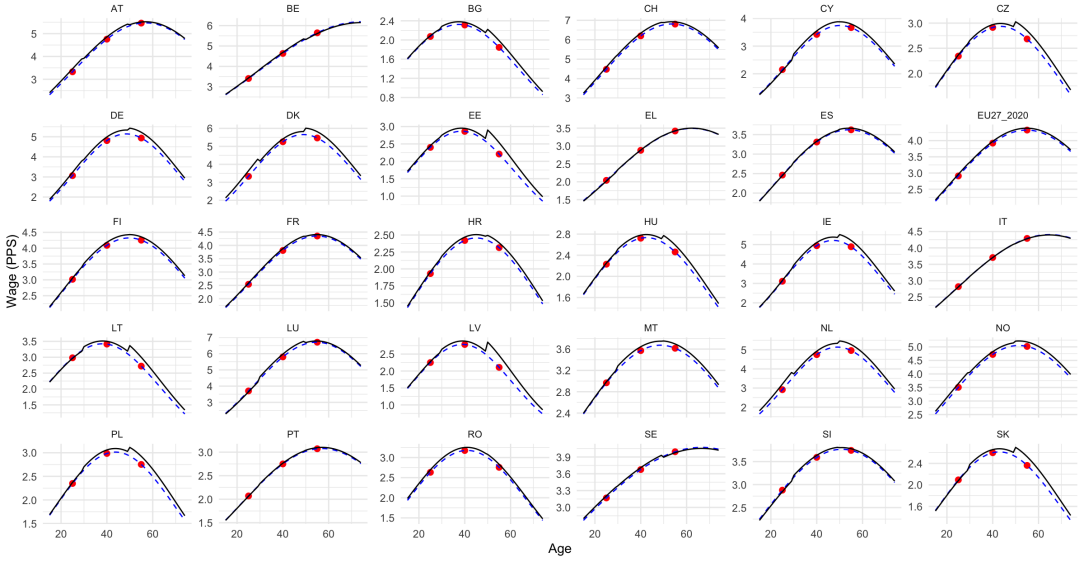


Figure B.1: Fitted wage curves by country (10,000)

The values are in € 10,000 (PPS). The red dots are the SES age-group averages; the blue dashed line is the fitted curve, and the black line is the adjusted curve. Wage values given in purchasing power standards (PPS). The horizontal axis indicated the age (15-74).

since underemployment exists). We have approximated the number of working hours by a person in their respective job and age by occupation. Occupation does not perfectly reflect education level, but we use 'Professionals' as a proxy for high-skill workers; 'Service and sales workers' for medium-skill, and 'Elementary occupations' for low-skill workers. These three groups are widely the most popular careers in the categorisation jobs into those requiring high, medium, or low level of skills.

Depreciation Depreciation rates are calculated through the AMECO tables of the European Commission's Directorate General for Economic and Financial Affairs, using the variables Gross fixed capital formation, total economy and sectors (OIGT), as well as Net capital stock at constant prices, total economy (OKND).