Aggregate welfare impacts due to aging differentials in integrated capital markets

Thomas Davoine[*†]

February 9, 2024

Abstract

When the speed of population aging differs across countries, capital will in theory flow from fast-aging to slow-aging countries. Aggregate impacts of such aging differentials are little known. I investigate aggregate welfare and production impacts with a multi-country overlapping-generations model calibrated for 14 European countries. If capital can flow across borders due to aging differentials, I find welfare losses in some countries and welfare gains in other countries, compared to the case where borders are closed but aging differentials the same. As gains dominate losses, there are aggregate welfare gains. Households gain on average the equivalent of 0.8% of lifetime consumption in fully integrated capital markets, with capital flowing across borders, compared to separated markets. Lifetime consumption would incease by 5% in some countries but decline by 2% in other countries. Aggregate production would be smaller, with a yearly average drop of per capita GDP of 0.5 percentage points. Cross-country differences savings behaviors are key to the results. As life expectancy increase, households in more patient countries increase savings more to maintain consumption after retirement. When capital markets are closed, interest rates drop much in these countries. With integrated capital markets, these households could increase returns on savings by shifting investments to other countries, generating large welfare gains.

Keywords: welfare, capital markets, globalization, population aging, computable general equilibrium

JEL-Classification: C68, F21, F41, F62, J11

[*]University of Applied Sciences Western Switzerland (EHL, HES-SO), Route de Cojonnex 18, 1000 Lausanne, Switzerland. Contact: `thomas.davoine@ehl.ch`

[†]Institute for Advanced Studies (IHS), Josefstaedter Strasse 39, 1080 Vienna, Austria.

1 Introduction

The aggregate impacts of financial markets integration have received considerable attention in the literature. With integrated markets, analytical results for instance show aggregate welfare gains from trade tariff agreements (Johnson, 1953 and many more; see Grossman, 2016 for an overview), tax harmonization (Wilson, 1986, Zodrow and Mieszkowski, 1986 and many more; see Zodrow, 2003 for an overview) or monetary policy spillovers (Obstfeld and Rogoff, 1995 and many more; see Corsetti et al., 2010 for an overview). Aggregate welfare gains in integrated markets have also been quantified, due for instance to international risk-sharing (e.g Cole and Obstfeld, 1991; Coeurdacier et al., 2020 among many others), trade tariff removals (e.g Costinot and Rodriguez-Clare, 2014), tax harmonization (e.g Fajgelbaum et al., 2019), productivity growth spillovers (e.g Hsieh and Ossa, 2016) or the joint integration of labor and goods markets (e.g Caliendo et al., 2021). A number of other benefits from capital markets integration have been identified (for an overview, see for instance Kose et al., 2009).

Whether or not population aging leads to aggregate welfare gains when capital markets are integrated has however never been investigated. The country-level impacts of population aging and associated social security reforms with isolated capital markets have been thoroughly analysed (often building on Auerbach and Kotlikoff, 1987). Country-levels impacts due to population aging with integrated capital markets have also been quantified by a few studies (Fehr et al., 2005; Boersch-Supan et al., 2006; Attanasio et al., 2007; Krueger and Ludwig, 2007; Attanasio et al., 2016; Vogel et al., 2017). These studies however do not consider aggregate impacts over all countries.

Yet, there can be welfare spillovers from country-level population aging phenomena. Ito and Tabata (2010) analytically show in a two-country model that a decrease in mortality in one country increases the welfare of the other country in some cases, and decreases it in other cases. When investigating the impacts of cross-country differences in population aging, the bulk of the attention has been devoted to impacts on international capital flows and current accounts (for instance, adding to some of the references mentioned above, Brooks, 2003; Domeij and Flodén, 2006; Backus et al., 2014; Auclert et al., 2021; Barany et al., 2023). Other impacts have also been considered on occasion, such as country-level impacts on gross domestic production (Attanasio et al., 2007; Krueger and Ludwig, 2007; Attanasio et al., 2016; Vogel et al., 2017).

The main goal of this paper is to investigate and quantify the aggregate welfare impacts of population aging resulting from capital markets integration, taking cross-country demographic differences into account. Beyond welfare impacts, the paper also considers macroeconomic impacts, focusing on production.

To do so, I use a multi-country overlapping-generations model calibrated for 14 European countries and 2 stylized Rest-of-the-world regions, one region representing developed and old countries such as Canada, the US or Japan, the other region representing developing, young but fast-aging countries such as Brazil, China or India. For more precise quantitative results, the model has a large-scale nature, taking into account key cross-country differences in demographics, production, skills, labor markets, public pensions and other components of welfare systems. To isolate the impact of population aging, catch-up growth phenomena will on the other hand be ignored.

Overall, I find that population aging and capital markets integration lead to cross-country redistribution, both in long-run welfare terms and in production terms. Countries which gain in welfare terms tend to lose in production terms, and vice-versa. I also find that welfare gains dominate welfare losses, leading to aggregate welfare gains over my country and region sample. On average, a household currently alive or born in the next 100 years would enjoy a lifetime consumption which is 0.8% higher with integrated capital markets than with separated capital markets. Differences across countries are noticeable: average lifetime consumption would drop close to 2% for households in Slovakia but increase by 5% for households in the Netherlands. I also find that capital markets integration would generate aggregate production losses, equal to a yearly average loss of 0.5 percentage points of per capita production over the next 50 years.

Cross-country differences in aging and savings behavior are two important factors explaining redistribution outcomes. Households in fast-aging countries or with more patience respond to the aging shock with a larger increase in savings, to maintain consumption after retirement, as life expectancy increases. When capital markets are separated, these large increases in savings lead to a strong decline of the interest rate. When capital markets are integrated on the other hand, these households can benefit from higher returns on their savings if they shift part of their investments to slow-aging or impatient countries, where the capital-labor ratio does not increase as much and thus returns to investments are larger. Households in fast-aging or more patient countries thus can generate larger capital income, consumption and welfare when capital markets are integrated. Conversely, households in slow-aging or impatient countries will experience welfare losses over the long run, because international capital inflows will drop the interest rate and reduce returns on their investments. Firms in these countries, on the other hand, will have more capital and be able to increase production, when capital markets are open.

Aging and savings differentials also explain aggregate impacts. Welfare gains in fast-aging and patient countries are particularly large, because households in these countries save much in the first place, so that the interest rate gain generated by capital markets integration leads to large capital income gains. Households in slow-aging and impatient countries do not save much, so the reduction in interest rates leads to smaller capital income losses.

Quantitative decompositions also show that aging and savings differentials play a key role in outcomes for some countries, but not all countries. Additional factors are needed for a full account of cross-country redistribution patterns.

The paper is organized as follows. The next section describes the model used in the analyses. Section 3 performs a two-country analysis to identify basic redistribution mechanisms, useful in the explanation of the full-fledged quantitative analysis, presented in section 4. Section 5 then provides concluding remarks.

2 Model

To quantify the aggregate impacts of population aging I use a multi-country model with overlapping-generations. Standard features are used to allow for comparisons with previous literature results. Because labor markets differ across countries and can influence earnings-related pension income after retirement, and thus individual welfare, I take unemployment into account. I thus start from an existing OLG model featuring unemployment and pay-as-you-go pensions, Jaag et al. (2010). I add differences in skills to this model because pension systems have redistributive components, which may influence individual welfare. The result is a single-country model, calibrated with country-specific values. The extension to a multi-country model follows Boersch-Supan et al. (2006) and the related literature, assuming perfect mobility of capital across borders.

I present first the single-country basis, then the extension to a multi-country model and conclude with the calibration approach and performance[1].

2.1 Single-country setting

Demographics: Households go through several stages $a \in \{1, \dots, 8\}$ in their life. A stage a lasts several time periods. After birth, households educate, then enter the labor market and retire. Several stages a cover labor market activity, reflecting different productivity levels (typically hump-shaped). Households face a constant, age-dependent probability of dying $1 - \gamma^a$. They differ in skills, birth date and death date[2]. After they are born, they are randomly assigned one of three skill levels, low, medium or high, $i \in \{l, m, h\}$. Medium and high skills are acquired through further education, which has no monetary cost but delays access to the labor market. Education for medium skills takes place in stage $a = 1$, for high skills in stages $a \in \{1, 2\}$. Retirement is defined exogenously and happens some time during stage $a^R = 5$. Stages $a \in \{6, 7, 8\}$ are full retirement stages but with different probabilities of dying $1 - \gamma^a$, to better replicate the empirical age structure of the population. As in Blanchard (1985), a reverse life insurance allocates assets at death[3].

Labor market: After education, households can enter the labor market. They choose whether to participate or not (at a rate $\delta^{a,i} \in [0, 1]$, which represents the number of time periods of the life-cycle stage with participation). The labor market is imperfect, leading to unemployment. Households who join the labor market start unemployed. Further, households who have a job may be hit by idiosyncratic unemployment shocks with probability $1 - \varepsilon^{a,i}$ in each time period. Depending on search efforts, a job may or may not be found. If unemployed, households choose job search efforts ($s^{a,i} \geq 0$).

[1]Details of the model are contained in the technical appendix Davoine (2023), available upon request.

[2]In the implementation, households also differ in the the speed at which they go through the stages of the life cycle, which reflects differences in appetite for effort, luck or other unobserved attributes, a generalization of Gertler (1999) used in Jaag et al. (2010). For ease of presentation, I ignore this model feature. The complexity arises in numerical simulations. Aggregation results, presented in the technical appendix Davoine (2023), help to deal with it.

[3]I use an implementation where the average durations of stay in each life-cycle stage correspond to ages 15-19, 20-24, 25-39, 40-54, 55-69, 70-79, 80-84 and 85+. I later use the words "*life-cycle stage*" and "*age group*" interchangeably.

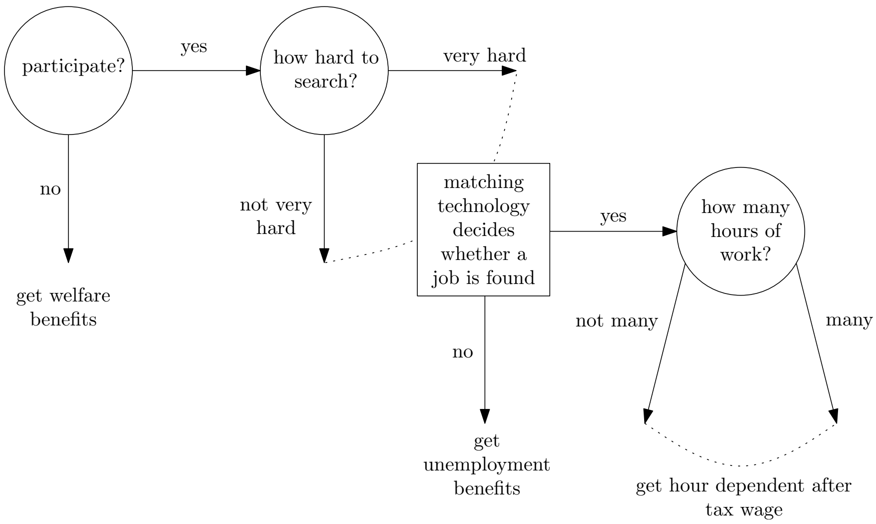

Figure 1: Sequence of households decisions related to the labor market

If they have a job, they decide how many hours to work ($l^{a,i} \geq 0$). Being spared the unemployment shock leads to rents, which are bargained with firms to define wage rates, building on the static search and matching setting of Boone and Bovenberg (2002). The wage rates then influence job search efforts, defining the fraction of time spent in unemployment ($u^{a,i} \in [0,1]$). As in Jaag et al. (2010), non-participation in life-cycle a^R is interpreted as retirement. The sequence of households decisions related to the labor market is summarized in figure 1.

Conditional on labor market participation and employment, gross labor income equals

$$y_{lab}^{a,i} = l^{a,i} \cdot \theta^{a,i} \cdot w^i, \tag{1}$$

where $\theta^{a,i}$ is an exogenous age-productivity profile calibrated with micro-data and w^i is the bargained wage per efficiency unit, assuming separate labor markets for each skill class.

Household maximization: Households make labor decisions $\left(\delta^{a,i}, s^{a,i}, l^{a,i}\right)$ and consumption decisions $C^{a,i}$ to maximize their expected life-time utility $V_t^{0,i}$, where $V_t^{a,i}$ is the expected remaining life-time utility of a household in life-cycle stage a with skill level i at time t. Preferences are expressed in recursive fashion and restrict households to being risk neutral with respect to variations in income but allow for an arbitrary intertemporal elasticity of substitution:

$$V_t^{a,i} = \max \left[\left(Q_t^{a,i} \right)^{\rho} + \gamma^a \beta \left(G V_{t+1}^{a,i} \right)^{\rho} \right]^{1/\rho}, \tag{2}$$

where ρ defines the elasticity of intertemporal substitution $1/(1-\rho)$, β is a time discounting factor, $Q_t^{a,i}$ is effort-adjusted consumption, $G = 1 + g$ is the gross factor of growth by which the model is detrended.

Labor market activity generates disutility. Effort-adjusted consumption $Q^{a,i}$ captures the utility cost of labor market activity expressed in goods equivalent terms, with

$$Q^{a,i} \quad = \quad C^{a,i} - \bar{\varphi}^{a,i}\left(\delta^{a,i}, s^{a,i}, l^{a,i}\right), \tag{3}$$

and $\bar{\varphi}^{a,i}$ a convex increasing function in all its arguments[4]. Specifically,

$$\begin{aligned} \bar{\varphi}^{a,i} \quad = \quad & \delta^{a,i}\left[\left(1-u^{a,i}\right)\varphi^{L,i}\left(l^{a,i}\right)+\left(1-\varepsilon^{a,i}\right)\varphi^{S,i}\left(s^{a,i}\right)\right] \; + \\ & \varphi^{P,i}\left(\delta^{a,i}\right) \; - \; \left(1-\delta^{a,i}+\delta^{a,i}u^{a,i}\right)h^{a,i}, \end{aligned} \tag{4}$$

where $h^{a,i}$ is the value of home production if the household is not working, $\varphi^{L,i}$ captures the disutility of working, $\varphi^{P,i}$ the disutility of participation and $\varphi^{S,i}$ the disutility of job search efforts.

Given the Blanchard (1985) insurance, the budget constraint of households is:

$$G\gamma^{a,i}A^{a,i}_{t+1} = R_{t+1}\left(A^{a,i}_t + y^{a,i}_t - C^{a,i}_t\right), \tag{5}$$

where $A^{a,i}$ represent assets, $y^{a,i}$ net income flows and $R = 1 + r$ the gross interest rate.

Social security: Before retirement, households who do not participate in the labor market receive welfare benefits y^a_{nonpar} while unemployed workers receive unemployment benefits $b^{a,i} = b^i \cdot y^{a,i}_{lab}$, where b^i is the skill-dependent replacement rate.

After retirement, households receive (net) pension benefits $y^{a,i}_{pens} = \nu^a P^{a,i} + P^a_0$, where P^a_0 is a flat part, $P^{a,i}$ represents acquired pension rights and ν^a is a conversion factor between pension rights and pension payments. Pension rights accumulate with labor earnings, following $P^{a,i}_{t+1} = \delta^{a,i}_t\left(1-u^{a,i}_t\right)y^{a,i}_{lab,t} + P^{a,i}_t$.

Taking labor income taxes and social security contributions $\tau^{a,i}_t$ into account and assuming that each labor market state (i.e. non-participation, unemployment and employment) is visited in each time period[5], net household income amounts to:

$$y^{a,i} = \begin{cases} \left(1-\tau^{a,i}\right)\left[\delta^{a,i}\left(1-u^{a,i}\right)y^{a,i}_{lab} + \delta^{a,i}u^{a,i}b^{a,i} + \left(1-\delta^{a,i}\right)y^{a}_{nonpar}\right] & \text{if } a < a^R, \\ \left(1-\tau^{a,i}\right)\left[\delta^{a,i}\left(1-u^{a,i}\right)y^{a,i}_{lab} + \delta^{a,i}u^{a,i}b^{a,i} + \left(1-\delta^{a,i}\right)y^{a,i}_{pens}\right] & \text{if } a = a^R, \\ \left(1-\tau^{a,i}\right)\; y^{a,i}_{pens} & \text{if } a > a^R. \end{cases} \tag{6}$$

Production: Production is made by a competitive representative firm taking input prices as given, namely wage rates, the interest rate and the price of the output good, which serves as numeraire. Changes in the production process are costly variations in the capital stock, and are subject to convex capital adjustment costs, following Hayashi (1982).

[4]This approach for modelling the preference structure is taken from Greenwood et al. (1988) and is applied, among others, in Jaag et al. (2010).

[5]The assumption follows Jaag et al. (2010). Alternatively, one can assume income pooling (perfect insurance) within each age and skill class, as used for instance by Andolfatto (1996) in his real business cycle and unemployment theory.

The production function is linear homogeneous:

$$Y_t = F^Y \left(K_t, L_t^{D,i=1}, L_t^{D,i=2}, L_t^{D,i=3} \right). \tag{7}$$

The labor inputs $L_t^{D,i}$ from different skill classes are not perfect substitutes. I assume capital-skill complementarity, a feature which can account for wage inequality variations (Krusell et al., 2000) and which is consistent with empirical evidence (Griliches, 1969).

Firms make investment I_t and hiring decisions to maximize the flow of dividends they can generate. Formally, the firm maximizes its end of period value W, which equals the stream of discounted dividend payments χ:

$$\begin{aligned} W_t = W(K_t) &= \max_{I_t, L_t^{D,i}} \left[\chi_t + \frac{GW(K_{t+1})}{R_{t+1}} \right], \\ s.t. \quad & \chi_t = Y_t - I_t - J(I_t, K_t) - \sum_i (1 + \tau^{F,a}) w_t^i L_t^{D,i} - T_t^F, \\ & GK_{t+1} = \left(1 - \delta^K\right) K_t + I_t, \end{aligned} \tag{8}$$

where $J(\cdot)$ denotes the adjustment costs, $\tau^{F,a}$ the firms social security contribution rate and T^F the total tax bill of firms, net of subsidies they receive. Labor demands are pinned down by the marginal products and the labor costs, which consist of wage and contribution rates, i.e. $Y_{L^{D,i}} = (1+\tau^{F,a})w^i$. Given an interest rate, investment is defined so that the return on financial investments (the interest rate) equals the marginal cost of investment (Tobin's q), which depends on the marginal product of capital, net of capital adjustment costs and depreciation[6].

Government: Government provides welfare benefits, unemployment insurance, pay-as-you-go pensions and investment subsidies. State expenditures also include public consumption, long-term care and health expenditures, all defined exogenously in per capita terms and generating no utility.

To finance expenditures, the government collects consumption taxes, labor and capital income taxes, profit taxes, firm and worker social security contributions. The government can borrow on the capital market to finance public debt, to meet some exogenously defined target (kept constant in simulations presented in this paper).

Markets: In a single-country setting, I assume that the gross interest rate $R_{t+1} = 1 + r_{t+1}$ is either exogenously defined, if capital markets are integrated, or endogenously defined, if capital markets are separated. Savings can be invested in firms, government debt and, if available, foreign assets. Assuming no arbitrage, the net returns on these three types of assets are the same and equal to the interest rate r_{t+1}. With integrated capital markets, the goods market clears because of trade with the rest of the world:

$$Y_t = C_t + I_t + G_t + TB_t, \tag{9}$$

[6]In steady-state, the capital stock is stable so that there are no capital adjustment costs. In this case, investment satisfies the standard condition where the interest rate equals the marginal product of capital net of depreciation, $r = F_K^Y - \delta^K$.

where C_t is the aggregate private consumption[7], G_t is government expenditure and TB_t is the trade balance. Holding of foreign assets by domestic households evolves with changes in the trade balance:

$$D_{t+1}^F = R_{t+1}\left(D_t^F + TB_t\right). \tag{10}$$

With separated capital markets (in a closed economy setting), adjustments of the interest rate clear the goods market. Trade balance TB_t and foreign debt D^F have zero values[8].

Private household assets A_t are invested in the domestic representative firm W_t, government debt D_t^G and (if available) foreign assets D_t^F, so that the asset market clearing condition is satisfied:

$$A_t = W_t + D_t^G + D_t^F. \tag{11}$$

2.2 Multi-country setting

I follow the Buiter (1981) procedure to transform a single-country overlapping-generations model into a multi-country model. The main assumption is that labor is immobile but capital is perfectly mobile. This assumption can be relaxed by allowing mobility of labor with exogenously defined international flows, as will be done in the quantitative analysis. One also assumes that all countries produce the same composite good and that countries either belong to the same currency union, or that exchange rates are constant. The interest rate is endogenous.

Markets: Under these assumptions, the equilibrium interest rate is the same in all countries. The intuition is as follows. Assume there is an arbitrage opportunity. Investors in the low interest rate country start to invest in the high interest rate country. The capital stock in the first country declines, increasing the marginal product of capital and thus the interest rate in that country. The opposite happens in the second country. This continues until an equilibrium is reached where the two interest rates are identical.

As a whole, the set of countries is a closed economy, where the interest rate adjusts so that the goods market clear. The resulting equilibrium interest rate is thus the unique value such that the goods market clear over all countries. Formally, consider M countries indexed by $j \in \{1, ..., M\}$. Assume that terms of change are fixed and that each variables are normalized so that the numeraire value, after currency-exchange corrections, is the same in all countries. The interest rate is then the unique value such that

$$\sum_{j\in\{1,...,M\}} TB_{j,t} = 0. \tag{12}$$

[7] To be specific, $C_t = \sum_i \sum_a N_t^{a,i} C_t^{a,i}$ where $N_t^{a,i}$ is the number of households alive at time t, member of age group a and skill group i. Other households-related aggregate variables are defined in a similar fashion, including aggregate financial assets A_t.

[8] In the quantitative analysis I consider a variation where the trade balance is not zero, but kept constant. This allows comparing outcomes with integrated capital markets, as both economies start from the same equilibrium.

Rest of the world: I do not consider all countries in the world but restrict policy analysis to a smaller subset, too small to be isolated from the world capital markets. Consistent with empirical evidence, the goods market, as a whole, will not clear over this subset. I thus consider a large synthetic *Rest-of-the-world* country (or a small group of Rest-of-the-world countries), which will account for trade with the rest of the world. The goods market will clear over all countries which are either part of the subset, or one of the Rest-of-the-world countries. Compared to a case without a Rest-of-the-world country, the adjustment of the equilibrium interest rate is dampened. This reflects access of all countries to the world capital markets.

2.3 Calibration and evaluation

Model calibration: The model covers 14 European countries[9] and 2 Rest-of-the-world regions, North and South. Standard data sources and procedures are used to calibrate the single-country basis for each of the 14 European countries. The calibration of the North Rest-of-the-world region is derived from aggregate data for Canada, the US and Japan as well as parameters for the UK, while the calibration of the South Rest-of-the-world region is derived from aggregate data for Brazil, China and India and from parameters for the Czech Republic, Slovakia and Poland. Fertility and mortality parameters are set so that the population and its age-structure in the model evolve as the demographic projections from Eurostat (2018) for the 14 European countries and by the United Nations (2015) for the two Rest-of-the-world regions. Details are provided in appendix A.

Model evaluation: Two evaluation approaches are used. The first follows the literature (such as Braun, Kopecky, and Koreshkova, 2017) by comparing endogenous outcomes in the initial steady-state with the data. All in all, outcomes are reasonably close to the data, taking data constraints and model simplifications into account. The second evaluation approach consists in choosing a reform or shock and comparing the impacts simulated by the model with impacts simulated and reported in the literature. I use population aging as shock, as it is large and more standard across studies than reforms of economic policy. As table 1 shows, predictions are comparable. Details can be found in appendix A.

3 Inspecting the mechanism

In this section, I investigate demographic and economic elements which can influence aggregate outcomes. I present this inspection before the main quantitative results (provided in the next section) to ease the explanation of these results. Two elements are

[9]Austria, Belgium, the Czech Republic*, Denmark, Finland, France, Germany, Italy, the Netherlands, Poland*, Slovakia, Spain, Sweden* and the UK*. In this list, stars identify the four countries whose currency is neither the Euro nor pegged to the Euro, and thus do not meet our assumption of fixed exchange rates. I keep these countries in the list to have broader diversity and because exchange rate variations vanish over the long run.

Shock	Long run GDP/capita variation		Comparison source
	My simulations	Comparison	
Population aging	-12 pp	-10 pp -15 pp	Krueger and Ludwig (2007) Boersch-Supan et al. (2014)

Notes: GDP/capita variations are reported for changes in 50 years, except for Boersch-Supan et al. (2014) (in 45 years); figures are deviations from the growth trend; variations are reported for Europe, either as region or as average for different countries, which depends on the model.

Table 1: Simulated impact of aging and fertility shocks for Europe, different models

considered: cross-country differences in the strength of population aging and in savings behavior.

To isolate the role of each element, I consider two identical countries in all respects but the element under investigation. Three scenarios are considered:

- in scenario A, the two countries differ in the strength of population aging;
- in scenario S, households in the two countries differ in their saving behavior;
- scenario AS combines scenario A and scenario S

The model is calibrated to German values, with some adjustments presented below and related to scenarios. In all scenarios, population is aging, increasing old-age social security expenditures. I assume that governments keep public debt constant by adjusting labor income taxes.

For each scenario, I compute the long-run economic impacts of population aging in each countries in two cases. In the first case, capital markets are separated. In the second case, capital markets are fully integrated. I thus use the closed economy version of the model from section 2 in the first case and the multi-country version restricted to the two countries in the second case. Comparing outcomes in the first and second case allows quantifying the impact of capital markets integration. The question I then consider is: are the impacts of capital markets integration different in scenarios A, S and AS? The answer will be positive and explain why in some circumstance there are aggregate welfare gains from capital markets integration with aging populations, among other outcomes.

3.1 Aging differentials

The role of aging differentials is investigated with scenario A. In this scenario, the population of country REG is projected to age according to the demographic forecasts from Eurostat (2018) for Germany. In other words, the fertility and mortality parameters in country REG are equal to the standard calibration of the model. Parameters in the other country, LOW, are chosen so that the country ages to a lower extent than projected and at a slower speed. While the old-age dependency ratio rises from 34% to 53% in five decades in scenario REG, consistent with projections from Eurostat (2018), it only rises from 34% to 46% in scenario LOW.

All other characteristics of countries REG and LOW are identical in this scenario. To have identical savings behavior in particular, trade balances are identical in the initial steady state and equal to zero[10]. International capital flows may however occur over time in this scenario. According to the analytical results from the literature (e.g. Barany et al., 2023), aging differentials will lead to such capital flows, in which cases trade balances will deviate from zero over time in the simulations.

Figure 2 and table 2 provides the simulated economic impacts of population aging for the two countries in scenario A over the next decades.

Plot (a) of the figure provides the old-age dependency ratio over time. It shows, as designed, that country REG is getting older and at a faster rate than country LOW.

Plot (b) of the figure reports the evolution of current accounts (as percentage of GDP). As expected, they remain at zero in the closed economy cases (*CE* curve in the plot). When capital markets are integrated, in the multi-country cases, the plot shows that aging differentials lead to international capital flows, consistent with earlier findings from the literature (*CMU* curve in the plot). In the first three decades, capital flows from country REG to country LOW. Faster aging in country REG leads to fewer workers, thus smaller labor supply, larger capital-labor ratios and thus lower returns on investment than in country LOW. Investors in REG thus shift some of the their investments towards country LOW. After three decades, capital flows take the other direction, because of repatriated capital income towards REG (in other words, because of the interest payments on growing foreign assets held by REG households).

Plot (c) of the figure provides the GDP per capita variations in the different cases, relative to the growth trend[11]. Consistent with the findings of the macroeconomic public finance literature on population aging, per capita GDP declines over the long-run when the retirement age is held constant, because of a drop in labor supply per capita. The plot also exhibits a cross-country production re-distribution effect due to capital markets integration and aging differentials. In the fast-aging country REG, per capita GDP declines more when capital markets are integrated than when they are separated. The opposite takes place in the slow-aging country LOW. In other words, REG loses from capital markets integration in production terms, while LOW gains from it. This redistribution effect is driven by international capital flows, which deplete the capital stock in REG and build it in LOW.

Plot (d) of the figure reports the welfare consequences of capital markets integration with aging populations for households born at different times in each country. The welfare impact is measured as consumption equivalent variation, comparing separated and integrated capital markets outcomes. For every household, one computes the percentage

[10] The calibration of country REG is thus 100% identical to the calibration of Germany in the full model version with 14 European countries and two Rest-of-the-world region, except for the initial trade balance (zero here, and positive in the full model, consistent with the data).

[11] Throughout the paper, GDP variations are reported as deviation from the growth trend.

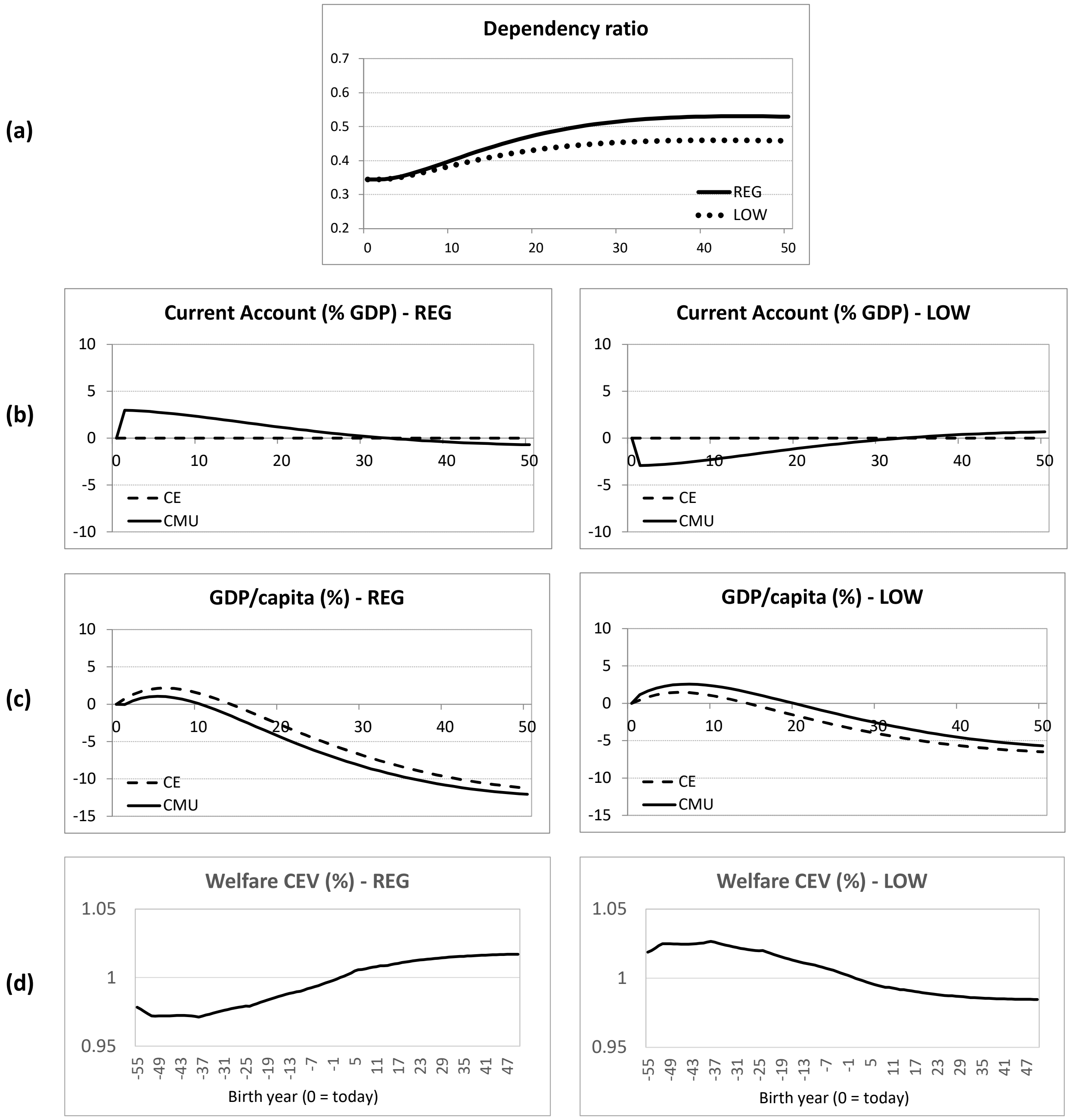

Figure 2: Demographic and economic outcomes, two countries aging at different speed

change in lifetime consumption with separated capital markets so that expected lifetime utility with this modification is equal to the expected lifetime utility with integrated capital markets. When the change is positive, households gain from capital markets integration. When it is negative, they lose from such integration. Plot (d) reports the average over skill classes.

As the plot shows, born households from country REG suffer from the capital markets integration, while future generations in REG would benefit from it. The opposite takes place in LOW: households already born benefit from capital markets integration while generations not yet borne will lose from it. These cross-generational welfare redistribution effects are driven by international capital flows and their impact on government resources. When capital flows out of the fast-aging country REG with integrated capital markets, capital-labor ratios and wages are smaller than in a closed economy case, requiring the government to increase labor income taxes to maintain tax revenue, a negative impact on households' net income and thus consumption. Returns on investments are also higher with integrated capital markets. Old households however do not live long enough for large accrued benefits on capital income. Overall, the loss caused by higher labor income taxes dominates the gains from accrued capital income. Young households in REG on the other hand live long enough that accrued gains from capital income dominate the loss due to higher labor taxes. The opposite takes place for households and government in the slow-aging country LOW. Aggregate impacts are considered in table 2, which exhibits a cross-country welfare redistribution effect but not long-run aggregate variations.

Table 2 summarizes with numbers the information provided in figure 2. The old-age dependency ratios in 50 years show clearly that country REG is older than country LOW then, with a ratio of 53% compared to 46%. The current account information summarizes the international capital flows over the next five decades, when markets are integrated (CMU column). On average, the fast-aging country REG sends capital equivalent to 0.8 percentage points of GDP towards the slow-aging country LOW, for reasons explained above.

The table also shows that per capita GDP drops 4.7% on average in the next five decades in the fast-aging country REG with separated capital markets, and 6.0% if capital markets are integrated. On average thus, capital markets integration leads to an average 1.3 percentage points loss of per capita production in that country. The slow-aging country on the other hand gains 1.2 percentage points of per capita production with capital markets integration. These figures illustrate the magnitude of the cross-country production redistribution generated by population aging and capital markets integration. At the aggregate level however, per capita production in REG and LOW is the same with separated and integrated capital markets. In both cases, there is an average per capita drop of 3.7%. Capital markets integration with two identical countries aging at different speed thus generates cross-country redistribution in production terms, from the fast- to the slow-aging country, but has no aggregate impacts.

The same conclusion can be drawn in long-run welfare terms, with the role of countries reversed. The last lines of table 2 provide the CEV variation averaged over different

	ISS	Outcomes 50 years CE	 50 years CMU	CMU impact
Regular-aging country REG				
Old-age dependency ratio	34.5	52.9	52.9	
Current account (pp GDP, avg 1-50)	0.0	0.0	0.8	
GDP/capita (%, avg 1-50)		-4.7	-6.0	-1.3
Welfare CEV % for ...				
... (Avg households alive in ISS)				-2.0
... (Avg born years 1-50)				1.2
... (Avg born years 50-100)				1.7
... (Avg alive + born years 1-100)				0.2
Slow-aging country LOW				
Old-age dependency ratio	34.5	45.8	45.8	
Current account (pp GDP, avg 1-50)	0.0	0.0	-0.8	
GDP/capita (%, avg 1-50)		-2.7	-1.5	1.2
Welfare CEV % for ...				
... (Avg households alive in ISS)				1.8
... (Avg born years 1-50)				-1.1
... (Avg born years 50-100)				-1.5
... (Avg alive + born years 1-100)				-0.2
Aggregate (REG + LOW)				
GDP/capita (%, avg 1-50)		-3.7	-3.7	0.0
Welfare CEV % for ...				
... (Avg households alive in ISS)				-0.1
... (Avg born years 1-50)				0.0
... (Avg born years 50-100)				0.1
... (Avg alive + born years 1-100)				0.0

Legend : *ISS* = Initial Steady Sate; *CE* = Closed Economy (separated capital markets); *CMU* = Capital Markets Union (integrated capital markets); *Welfare CEV %* = average lifetime consumption variations for households born in different years so that expected lifetime utility with CE is equivalent to that in CMU (a positive number indicates that CMU is on average beneficial)

Table 2: Economic impacts, two countries aging at different speed, 50 years

time periods. For households who are alive today and live in the fast-aging country REG, capital markets integration leads to an average loss of 2.0% of lifetime consumption. Households also alive today but living in the slow-aging country LOW gain on the other hand an average 1.8% of lifetime consumption. The table also shows that households born in the next 50 years gain an average lifetime consumption of 1.2% in the country REG but lose 1.1% in the country LOW. Future generations, born after 50 years but before 100 years gain on average 1.7% in the country REG and lose on average 1.5% in the country LOW.

I assume that the government (or social planner) values outcomes for households born at different points in time in these time horizons equally, over the long-run. I will thus take the average CEV variation for households alive today or born in the next 100 years as a summary welfare impact. It shows that households in the fast-aging country REG on average gain the equivalent of 0.2% of lifetime consumption with capital markets integration, relative to isolated capital markets. Households in the slow-aging country LOW on the other hand would lose the equivalent of 0.2% of lifetime consumption. Computing welfare impacts for all households in REG and LOW shows that capital markets integration would have a neutral impact on average, the CEV index being at 0.0%. Capital markets integration with two identical countries aging at different speed thus generates cross-country redistribution in welfare terms, this time from the slow- to the fast-aging country, with no aggregate impacts[12].

The main reason for this cross-country long-run welfare redistribution, as detailed above, is the fact that households in the fast-aging country get a better return on their investments with integrated capital markets, because there are more workers and capital-labor ratios are higher in the slow-aging country than at home.

3.2 Savings differentials

The role of savings differentials is analyzed with scenario S, where two countries differ in their trade balance in the initial steady-state but are otherwise identical. The country GER is calibrated to the values of Germany, including the average trade surplus that is observed in the data (2.8% of GDP)[13]. The country IMP is also calibrated to German values, except that we assume a commensurate average trade deficit (that is, a trade surplus of -2.8 % of GDP). As the patience parameter is endogenously chosen in the calibration to match the trade balance target, households in GER are more patient than households in IMP. The former thus tend to save more than the latter.

Figure 3 and table 3 provide the simulated economic impacts of population aging for the two countries in scenario S over the next decades[14].

Two outcomes are noteworthy. First, there are cross-country production and wel-

[12] The definition of the time horizon of the government (or social planner), who stops caring for households born in 101 years or later, is arbitrary. In most scenarios considered in this paper, long-run welfare outcomes remain unaffected by this choice.

[13] The calibration of country GER is thus 100% identical to the calibration of Germany in the full model version with 14 European countries and two Rest-of-the-world regions.

[14] In the closed economy cases I still assume that there are non-zero trade balances, to have the same savings behavior as in the multi-country case and thus be able to compare outcomes. In my closed economy cases, I therefore allow for trade flows but require them to be constant over time.

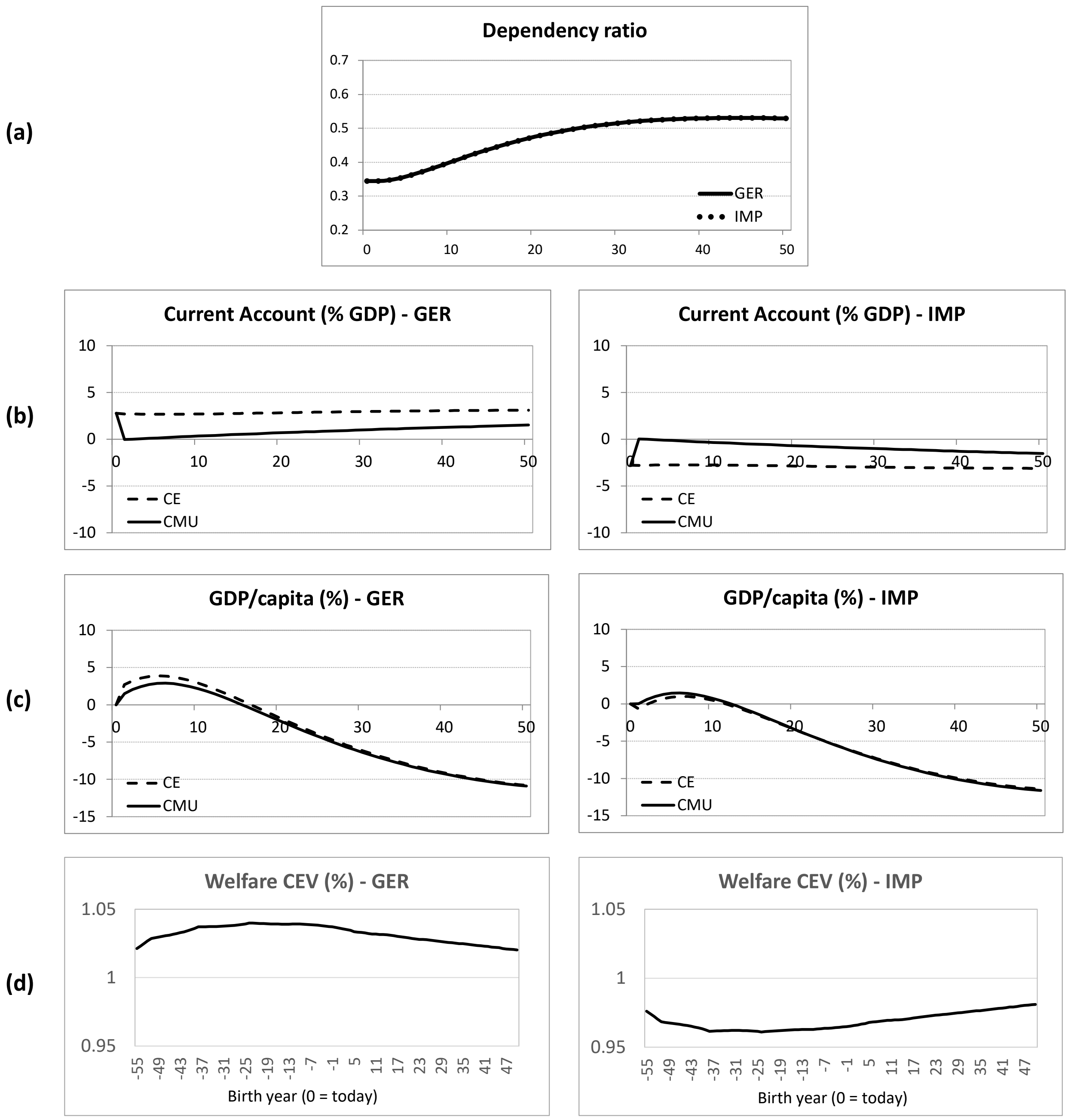

Figure 3: Demographic and economic outcomes, two countries with different savings behavior

	ISS	Outcomes 50 years CE	 50 years CMU	CMU impact
Patient country GER				
Old-age dependency ratio	34.5	52.9	52.9	
Current account (pp GDP, avg 1-50)	2.8	2.9	0.8	
GDP/capita (%, avg 1-50)		-3.7	-4.1	-0.4
Welfare CEV % for ...				
... (Avg households alive in ISS)				3.6
... (Avg born years 1-50)				2.8
... (Avg born years 50-100)				1.5
... (Avg alive + born years 1-100)				2.7
Impatient country IMP				
Old-age dependency ratio	34.5	52.9	52.9	
Current account (pp GDP, avg 1-50)	-2.8	-2.9	-0.8	
GDP/capita (%, avg 1-50)		-5.3	-5.2	0.1
Welfare CEV % for ...				
... (Avg households alive in ISS)				-3.6
... (Avg born years 1-50)				-2.7
... (Avg born years 50-100)				-1.4
... (Avg alive + born years 1-100)				-2.6
Aggregate (GER + IMP)				
GDP/capita (%, avg 1-50)		-4.5	-4.7	-0.2
Welfare CEV % for ...				
... (Avg households alive in ISS)				0.0
... (Avg born years 1-50)				0.1
... (Avg born years 50-100)				0.0
... (Avg alive + born years 1-100)				0.0

Legend : see table 2

Table 3: Economic impacts, two countries with different savings behavior, 50 years

fare redistribution effects taking place. Second, there are aggregate production impacts losses. I differ the discussion of the second outcome to section 3.3, where aggregate impacts are similar but of larger magnitude.

As the figure and the table show, the patient country GER loses from capital markets integration in production terms, but gain in welfare terms. Averaged over the next fifty years, capital markets integration leads every year to a per capita GDP loss of 0.4 percentage points. Lifetime consumption for households currently alive or born in the next 100 years would on the other hand increase by 2.7%. The opposite takes place in the impatient country IMP. Per capita GDP increases on average by 0.1 percentage points but lifetime consumption declines on average by 2.6%.

International capital flows explain the cross-country redistribution patterns, together with savings differentials. The population aging shock, driven by increases in life expectancy, leads households to increase their savings to finance consumption after retirement, whose age is kept constant. In the patient country GER, the savings' increase are larger than in the impatient country IMP. When capital markets are separated, the resulting increase in the supply of domestic capital is larger in GER than in IMP, leading to a larger drop of the interest rate there (1.9% in 50 years in GER, versus 2.1% in IMP). When capital markets are open, this differences in savings' behavior leads to capital flows from the patient country GER to the impatient country IMP, because households in the patient country seek better returns on their investments in the impatient country[15]. These international capital flows[16] deplete the capital stock in the patient country GER and build it in the impatient country IMP, which explains the capital and thus production redistribution effects. The higher returns that households in the patient country GER can obtain with capital markets integration leads on the other hand to long-term financial gains, translating in higher consumption and welfare. The opposite welfare effects take place in the impatient country IMP[17].

3.3 Combined aging and savings differentials

The combined role of aging differentials and savings differentials across countries is investigated with scenario AS, which merges scenario A, investigated in section 3.1, and scenario S, considered in section 3.2. The first country, GER, corresponds to the model representation of Germany. The model calibration is identical to that of the full model (in section 2) and that of the country GER in scenario S (in section 3.2). The second country, LOWIMP is aging as slowly as the country LOW in scenario A (in section 3.1) and has the same trade deficit in the initial steady state as the country IMP in scenario S (in section 3.2). Households in LOWIMP are thus as impatient as households in IMP.

[15] In the impatient country, the capital/labor ratio does not increase as much as in the patient country, because domestic savings do not increase that much.

[16] These flows are not directly visible in the current account data shown in figure 3, where other flows are more visible and go in opposite direction (namely, the increase in payments on foreign assets held by households in the patient country GER due to the increase in the interest rate).

[17] With aging differentials, there are cross-generational redistribution patterns (see section 3.1). No such patterns appear with savings differentials (in this section). One tentative explanation, to be confirmed, is the following: old households in the fast-aging country REG have an average patience, unlike old households in the high-patience country GER; the former thus exploit the interest gain that capital markets integration brings to a lower extent than the latter.

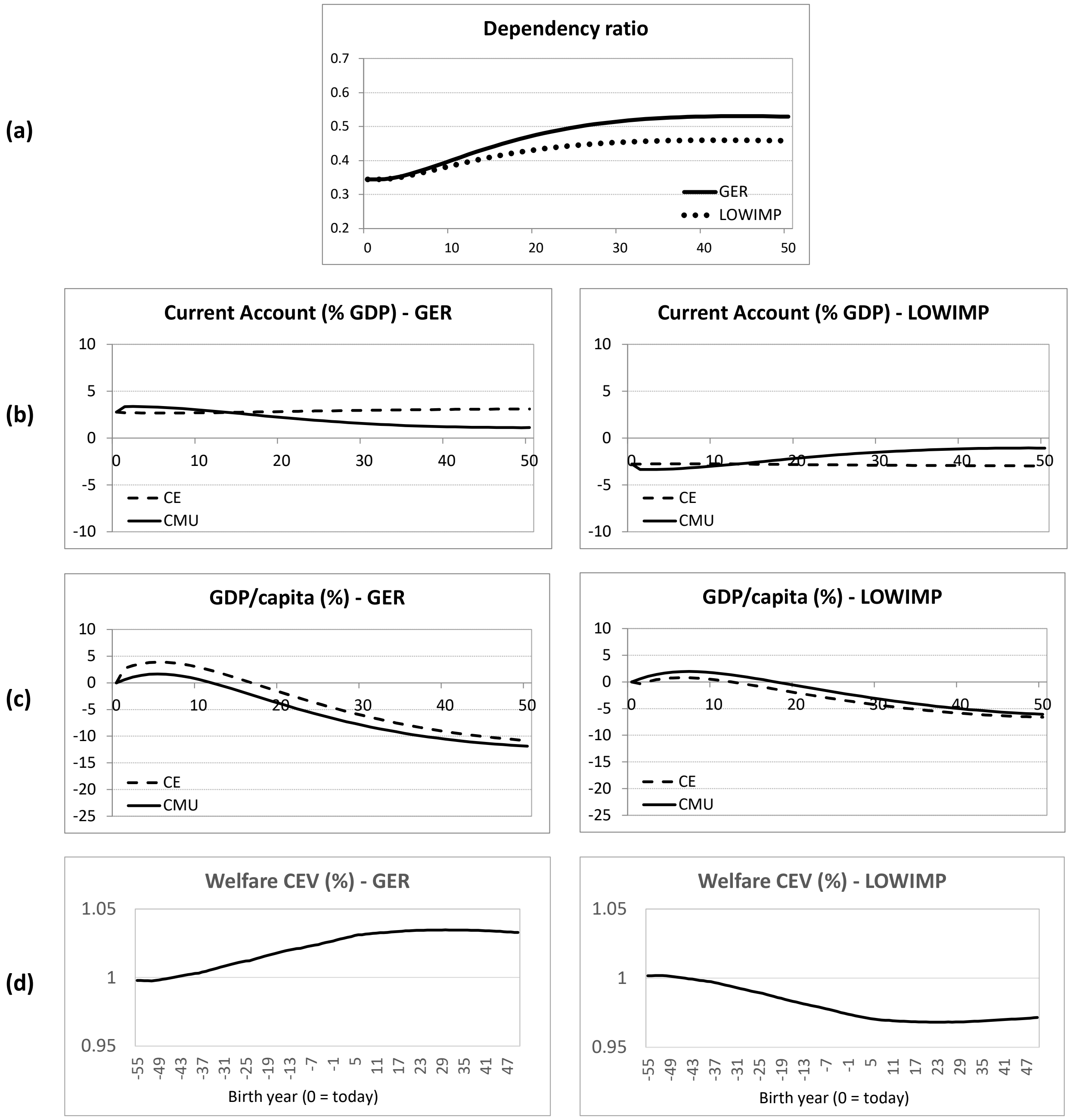

Figure 4: Demographic and economic outcomes, two countries with different aging and savings behavior

	ISS	Outcomes 50 years CE	 50 years CMU	CMU impact
Regular-aging and patient country GER				
Old-age dependency ratio	34.5	52.9	52.9	
Current account (pp GDP, avg 1-50)	2.8	2.9	2.1	
GDP/capita (%, avg 1-50)		-3.7	-5.6	-1.9
Welfare CEV % for ...				
... (Avg households alive in ISS)				1.1
... (Avg born years 1-50)				3.3
... (Avg born years 50-100)				2.9
... (Avg alive + born years 1-100)				2.4
Slow-aging and impatient country LOWIMP				
Old-age dependency ratio	34.5	45.8	45.8	
Current account (pp GDP, avg 1-50)	-2.8	-2.9	-2.0	
GDP/capita (%, avg 1-50)		-3.1	-2.0	1.1
Welfare CEV % for ...				
... (Avg households alive in ISS)				-1.0
... (Avg born years 1-50)				-3.1
... (Avg born years 50-100)				-2.5
... (Avg alive + born years 1-100)				-2.1
Aggregate (GER + LOWIMP)				
GDP/capita (%, avg 1-50)		-3.4	-3.8	-0.4
Welfare CEV % for ...				
... (Avg households alive in ISS)				0.0
... (Avg born years 1-50)				0.1
... (Avg born years 50-100)				0.2
... (Avg alive + born years 1-100)				0.1

Legend : see table 2

Table 4: Economic impacts, two countries with different aging and savings behavior, 50 years

Figure 4 and table 4 give the simulated economic impacts of population aging for the two countries in scenario AS over the next decades.

The same findings can be made through the analysis of the figure and the table as in sections 3.1 and 3.2: there is cross-country redistribution in production terms (from the fast-aging and patient country GER to the slow-aging and impatient country LOWIMP) as well as cross-country redistribution in long-run welfare terms (in opposite direction, that is from LOWIMP to GER). As in section 3.2, capital markets integration also generates aggregate production losses, equivalent to an average 0.4 percentage point drop of per capita GDP each of the next fifty years. A new finding however emerges: capital markets integration leads to a long-run aggregate welfare gains equivalent to 0.1% of lifetime consumption on average for any household alive or born in the next 100 years and living either in one or the other country.

The explanation for the redistribution findings combines explanations provided in sections 3.1 and 3.2. In short, when capital markets open, capital flows from the the fast-aging and patient country GER to the slow-aging and impatient country LOWIMP because the capital-labor ratio and thus returns on investment are higher in LOWIMP, and because patient households in GER respond to the aging shock with a larger increase in savings than impatient households in LOWIMP, which further drops the capital-labor ratio and investment returns in GER. These international capital flows drop production in GER and increase it in LOWIMP. They also increase long-run financial gains for households in GER, but generate financial losses for households in LOWIMP, because capital markets integration leads to an interest rate which is higher than with separated capital markets in GER but lower than the interest rate with separated capital markets in LOWIMP.

I provide the explanation for aggregate welfare gains first, and then for aggregate production losses. Figure 5 illustrates a number of arguments provided in the explanations. Some of the arguments also play a role in redistribution patterns. I repeat them for the sake of completeness.

Because households in the fast-aging and patient country GER are more patient, they respond to the population aging shock with a larger increase in savings than households in the slow-aging and impatient country LOWIMP (see plot (a) in figure 5). When capital markets are separated, this increase in capital supply leads to a larger drop of interest rates in GER than in LOWIMP (see plot (b), curves CE). When capital markets open, households in GER shift some of their investments to LOWIMP, to benefit from higher returns. The interest rate with integrated capital markets is thus higher than in a closed economy case in GER, but lower than in a closed economy case in LOWIMP (see plot (b), curves CE compared to CMU). Capital markets integration thus leads to larger capital income in GER and lower in LOWIMP than in closed economies. As households in GER are very patient, they accumulate much assets to deal with the aging shock. The increase in returns (interest rate), that capital markets integration brings, thus leads to large increases in capital income there. Conversely, households in LOWIMP accumulate less assets with aging. The loss in returns thus does not translate in much of a loss in capital income, and it is dominated by the gains for households in LOWIMP (see plot (c)). Overall thus, average capital income over the two countries increases with capital markets integration, which allows for more average consumption and leads to aggregate welfare gains.

Said differently, aggregate welfare gains are due to savings differentials, not to aging differentials. Aging differentials have a magnifying role, however. Capital markets integration redistributes from impatient households to patient households across borders, through interest rate differentials: for impatient households, returns on savings are lower with integrated capital markets, due to incoming capital flows; for patient households, returns on savings are higher with integrated capital markets. As the impatient households do not care so much on returns' losses and future capital income (which makes them impatient), the redistribution leads to aggregate welfare gains.

The aggregate production loss are an added consequence from the impatient nature of households in the slow-aging country LOWIMP. Part of the inflows of capital in

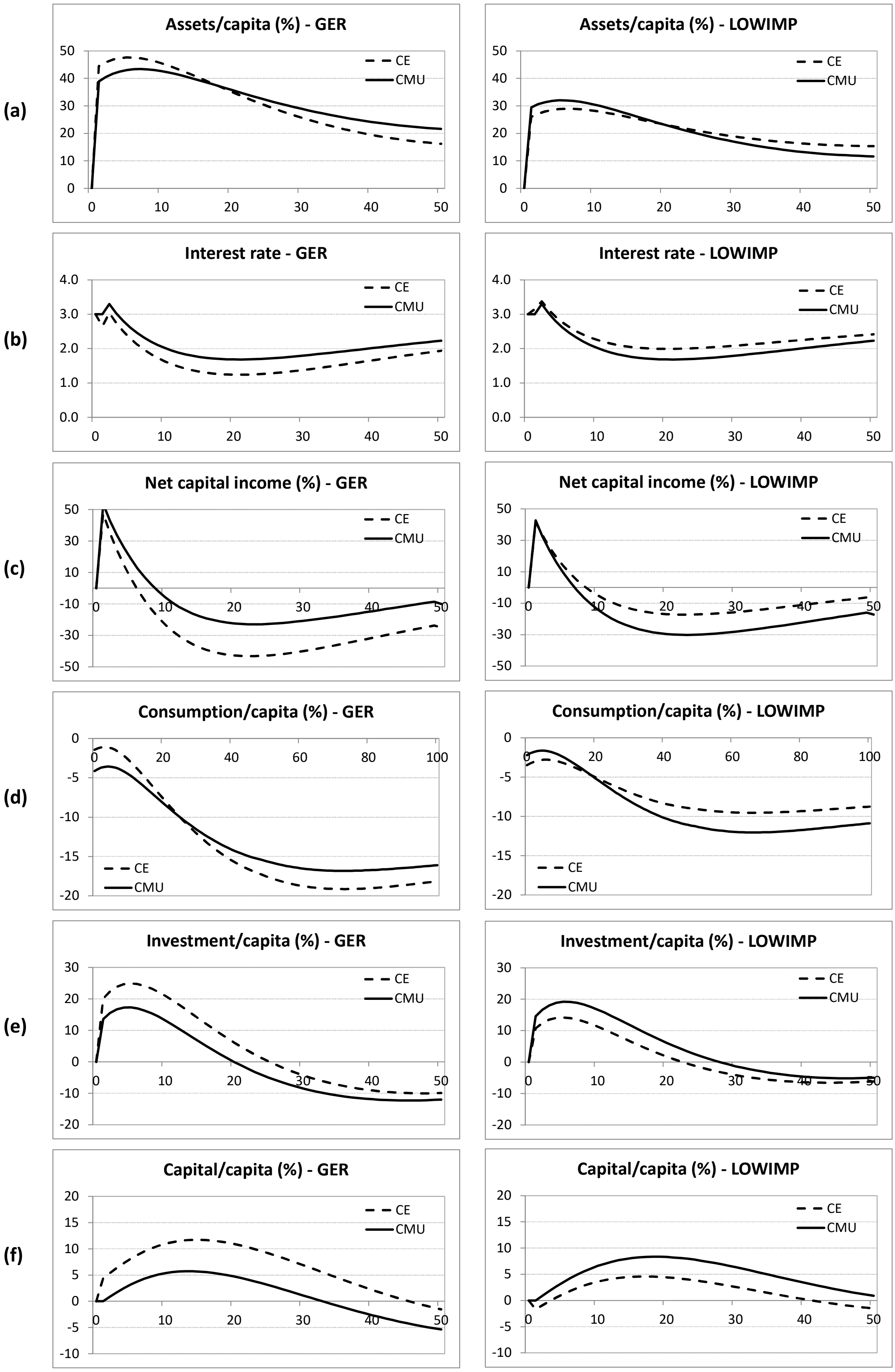

Figure 5: Details on economic outcomes, two countries with different aging and savings behavior

LOWIMP are used for increases in investment there. As households are impatient, another part of the capital inflows is used for larger immediate consumption in LOWIMP (see plot (d) in figure 5). The capital outflows from the fast-aging and patient country GER also lead to a drop in investment there. That drop is however not matched by the increase in investment in the impatient country LOWIMP, given the initial consumption increase there (see plot (e)). As a result, capital stocks deplete at a faster rate in GER than they build in LOWIMP (see plot (f)), which leads to aggregate production losses.

3.4 Summary of findings

The following findings have been made in the analysis of aging and savings differentials between two otherwise identical countries. First, capital markets integration leads to cross-country redistribution in long-run welfare terms from slow-aging to fast-aging countries, because households in the second type of countries have access to higher returns on investment. Second, capital markets integration leads, in the presence of population aging, to cross-country redistribution in long-run welfare terms from impatient to patient countries, because households in patient countries save a lot to deal with aging and benefit from larger returns on their investments if they can invest in impatient countries. Third, cross-country welfare redistribution from one country to another one comes with cross-country production redistribution in the other direction, because capital flows towards slow-aging or impatient countries. Fourth, capital markets integration leads, in the presence of population aging, to aggregate production losses when there are savings differentials. Households in impatient countries indeed consume a part of incoming capital, rather than invest all of it. Fifth, capital markets integration leads to long-run aggregate welfare gains when one country is fast-aging and patient, while the other country is slow-aging and impatient. Households in the first country indeed have a strong savings' response to aging, transforming the gains on returns to investment in large capital income gains. Households in the second country on the other hand will not lose as much capital income with a drop in interest rates, because they did not save so much in the first place.

4 Quantifying aggregate impacts

I apply the large-scale, multi-country overlapping-generations model developed in section 2 to identify and quantify the aggregate impacts, if any, of capital markets integration in the presence of population aging. Among others, mechanisms identified in section 3 will influence outcomes.

Aggregate welfare impacts as well as aggregate macroeconomic impacts will be considered. As measure of welfare impacts, I use a consumption equivalent measure with a utilitarian aggregation for all households alive now and born in the next 100 years (see details in section 3.1). Macroeconomic impacts are measured in production terms, using the standard per capita GDP variation indicator.

In the simulations, every country of the model is aging to match the demographic projections from Eurostat (2018) for the 14 European countries and from the United

Nations (2015) for the two Rest-of-the-world regions. One of the main economic challenge of population aging in developed countries is the rise in old-age social security expenditures. To deal with this challenge, many countries have scheduled reforms of their welfare systems in the future. To isolate the impact of aging alone, I do not apply any of these future reforms in my investigation. Retirement ages are in particular unchanged. Public debts are instead kept constant in every country through variations of labor income taxes.

To further isolate the impact of population aging on welfare, I ignore simultaneous and important long-run trends which may influence the benefits of capital markets integration, such as catch-up growth or further increases of female labor market participation. In particular, the projected growth rate of total factor productivity is taken to be the same across countries, constant and equal to the average historical trend in Europe.

I first present the quantification of aggregate impacts, the main results of the paper. As will be seen, cross-country redistribution takes place between countries. I then investigate the role of demographics differentials in this redistribution, before moving to the role of savings differentials. A summary of findings closes the section.

4.1 Aggregate impacts

Table 5 provides demographic, macroeconomic and welfare impacts of population aging in the 14 European countries and 2 Rest-of-the-world regions of the model. Current values (ISS) and outcomes in 50 years are included for demographic and macroeconomic impacts, as well as average welfare impacts for households currently alive or born in the next 50 (resp. 100) years.

As the demographics columns show, countries age at a different speed. Sweden for instance is projected to grow in size by almost 40% over the next 5 decades while Poland is projected to shrink in size by 14%, as a result of low fertility. The old-age dependency ratio (OADR) is projected to increase from 24% today in Poland, a relatively low value, to 61% in 50 years, a staggering increase by a factor 2.5. In Sweden, on the other hand, the dependency ratio should only increase by a factor of 1.4. In other words, Poland is relatively young today but will age very fast, while Sweden is projected to age slowly. Among European countries and for the sake of the presentation, one can (informally) identify young and slow-aging countries (Belgium, Denmark, Finland, France, Netherlands, Sweden and the UK) and old or fast-aging countries (the Czech Republic, Poland, Slovakia and Spain), comparing the old-age dependency ratio now and in 50 years (50y/ISS column).

Three patterns emerge. First, for most fast-aging European countries, capital markets integration leads to welfare gains over the long-run most of the time but leads to production losses. In the Czech Republic for instance, per capita GDP would drop by 7.1% with separated capital markets and by 10.1% with integrated capital markets. Capital markets integration thus leads to a 2.9 percentage points loss. Averaging outcome for all households currently alive or born in the next 100 years, lifetime consumption would increase by 0.4% with integrated capital markets, compared to separated capital

	Demographics				Macroeconomics			Welfare	
	Pop (%)	OADR			GDP/capita (%)			CEV (%)	
	50y	ISS	50y	50y/ ISS	CE	CMU	CMU impact	Alive + born 1-50y	Alive + born 1-100y
Austria	19.5	0.29	0.50	1.7	-9.4	-9.1	0.3	1.4	0.9
Belgium	24.4	0.29	0.44	1.5	-2.7	-6.0	-3.3	2.9	2.9
Czech Republic	-3.4	0.27	0.54	2.0	-7.1	-10.1	-2.9	0.0	0.4
Denmark	22.2	0.29	0.43	1.5	-7.6	-10.2	-2.6	2.5	2.7
Finland	5.0	0.31	0.48	1.5	-4.6	-5.0	-0.3	4.7	3.3
France	17.3	0.30	0.47	1.6	-5.6	-3.6	2.0	0.5	-0.3
Germany	-1.7	0.34	0.53	1.5	-3.7	-5.3	-1.6	3.2	2.3
Italy	-5.1	0.34	0.65	1.9	-3.9	-6.4	-2.5	1.3	1.3
Netherlands	17.0	0.28	0.44	1.6	-4.4	-7.2	-2.8	5.6	4.8
Poland	-13.9	0.24	0.61	2.5	-8.8	-11.1	-2.3	0.8	-0.1
Slovakia	-4.7	0.22	0.53	2.4	-7.9	-9.3	-1.4	-1.9	-1.8
Spain	6.6	0.29	0.64	2.2	-4.5	-5.8	-1.2	-3.8	-1.2
Sweden	38.7	0.31	0.43	1.4	-5.0	-5.1	0.0	4.7	5.3
United Kingdom	26.3	0.28	0.43	1.6	-8.7	-7.1	1.5	-0.3	-1.5
NROW	16.3	0.29	0.48	1.7	-5.7	-5.1	0.6	0.0	0.2
SROW	21.8	0.13	0.39	3.0	-9.6	-11.4	-1.8	0.4	1.0
EU14					-4.6	-5.2	-0.6	0.9	0.6
World					-9.5	-10.0	-0.5	0.3	0.8

Legend: *ISS* = Initial Steady Sate; *CE* = Closed Economy (separated capital markets); *CMU* = Capital Markets Union (integrated capital markets); *Welfare CEV %* = average lifetime consumption variations for households born in different years so that expected lifetime utility with CE is equivalent to that in CMU (a positive number indicates that CMU is on average beneficial); *NROW* = North Rest-of-the-world region; *SROW* = South Rest-of-the-world region; *EU14* = average for all 14 European countries in the model; *World* = average for all 14 European countries and 2 Rest-of-the-world regions; *GDP/capita (%)* = average GDP per capita variation over the next 50 years, compared to ISS values and relative to the growth trend.

Table 5: Economic impacts of population aging, Europe and Rest of the World

markets[18]. Aging differentials explain these patterns, as seen in section 3.1 and verified in section 4.2. In short, opening the capital markets allow households in fast-aging countries to seek higher returns on their savings in slow-aging countries, where there are more workers and thus lower capital-labor ratios. The price is a loss in production capacity, as capital flows out.

Second, capital markets integration leads to long-run welfare losses but production gains for a part of slow-aging European countries (France and the UK), and the opposite for the other part (Belgium, Denmark, Finland, Netherlands and Sweden). Aging differentials explain patterns for the first group of slow-aging countries: there, the larger proportion of workers in society leads to lower capital-labor ratio and higher returns on investments, which attracts foreign capital, increases domestic production capacity but depresses domestic returns on savings, and thus leads to lower long-run domestic welfare.

As seen in section 3.2 and will be verified in section 4.3, savings differentials are one reason which explain why the other part of slow-aging European countries have a fate similar to fast-aging European countries. In short, this part of slow-aging European countries all have had large trade surpluses in past decades, pointed to larger patience in these countries and thus a different savings' behavior[19]. Because of their patience, households in these countries react to the population aging shock with constant retirement by a larger increase of savings than in standard-patience countries, to finance consumption after retirement. When capital markets are separated, this large increase in supply on the capital markets leads to a big drop of the interest rate, and thus returns to domestic investments. When capital markets are integrated, households in these patient, slow-aging countries invest abroad, because capital-labor ratios do not increase as much. Unlike standard slow-aging countries thus, capital flows *out* of patient slow-aging countries, as investors benefit from larger returns abroad. Long-run welfare thus increases in these countries, but domestic production drops.

Overall, differences across countries and thus redistribution phenomena can be large. Per capita GDP can drop by as much as 3.3 percentage points each of the next 50 years (Belgium) and rise by as much as 2.0 percentage points (France). Average lifetime consumption for households alive today or born in the next 100 years can drop by as much as 1.8% (in Slovakia) or increase by more than 5.0% (in Sweden).

The third finding which emerges from table 5 are the long-run aggregate welfare gains from capital markets integration coupled with an aggregate production loss. Averaged for all households currently alive or born in the next 100 years, lifetime consumption would be 0.6% higher with integrated capital markets in Europe, relative to separated capital markets. It would be 0.8% larger in our world sample. On the other hand, per capita production would be lower by about 0.5 percentage points in Europe and

[18]There are welfare gains in Poland if the shorter time horizon is considered (households currently alive or born in the next 50 years). There are however welfare losses for all time horizons in Slovakia and Spain. One explanation, under investigation, is that households in these two countries are particularly impatient.

[19]Compared to an average European trade surplus of 0.9% of GDP, the trade surplus used for calibration of the model is 2.3% of GDP in Denmark, 3.0% in Belgium, 3.5% in Finland, 4.4% in Sweden and 5.0% in the Netherlands.

the world with fully integrated capital markets, on average over the next 50 years and compared to separate capital markets.

One reason for aggregate welfare gains are aging and savings differentials, consistent with the mechanism identified in section 3.3. In short, households in patient countries increase savings more than in other countries, to finance old-age consumption with constant retirement ages and increases in life expectancy. With separated capital markets, the large increase in supply leads to a larger drop in interest rate. When capital markets open, households in these countries will benefit from larger returns on their investment. As they save much in the first place, the capital income gains will be large. By contrast, households in impatient countries do not save as much. They will suffer from a lower returns on investments when capital markets integrate. But, since they do not save much in the first place, the capital income losses will be small. Overall thus, the capital income gains from patient countries will dominate the capital income losses from impatient countries, which leads to aggregate capital income gains and aggregate welfare gains. There will also be an aggregate production loss, because part of the capital inflows into low-patience countries is used by households there as extra consumption, decreasing the aggregate level of investment, the buildup of the capital stock and thus production.

4.2 Demographic differentials

As seen in section 3.1, aging differences across countries have redistribution effects but no aggregate impacts. One of the three findings from the previous section is that fast-aging countries, such as the Czech Republic, Poland, Slovakia and Spain, suffer from production losses but benefit from long-run welfare gains when capital markets integrate. The explanation was based on the aging-differential mechanism identified in section 3.1. In this section, I quantify the impact of demographic differentials alone on cross-country differences, not expecting any significant aggregate impact.

To do so, I assume that a country projected to age fast has in fact the same demographic structure and evolution as a slow-aging country. We would expect then the same experience as regular slow-aging countries, production gains but long-run welfare losses. Below, I report outcomes for Poland, and I assume that it has the same initial age-population structure and the same variation of fertility and mortality as France, a slow-aging country[20].

Table 6 reports the simulation outcome. The table has the same structure as table 5. The only difference in table 6 is that Poland has the same demographics as France, as can be seen from population and old-age dependency ratio information.

We now see that this counterfactual slow-aging Poland has the same experience as other slow-aging countries, such as France and the UK. It no longer suffers from production losses with capital markets integration: on average every year over the next five decades, per capita GDP is higher by 2.0 percentage points in this counterfactual Poland, compared to separated capital markets (table 6); per capita GDP would be 2.3 percentage points lower in the standard calibration for Poland and 2.0 percentage

[20]Outcomes are similar for the Czech Republic, Slovakia and Spain, but not reported to save space.

	Demographics				Macroeconomics			Welfare	
	Pop (%)	OADR			GDP/capita (%)			CEV (%)	
	50y	ISS	50y	50y/ ISS	CE	CMU	CMU impact	Alive + born 1-50y	Alive + born 1-100y
Austria	19.5	0.29	0.50	1.7	-9.4	-9.2	0.2	1.4	0.8
Belgium	24.4	0.29	0.44	1.5	-2.7	-6.1	-3.4	2.9	2.9
Czech Republic	-3.4	0.27	0.54	2.0	-7.1	-10.1	-3.0	0.0	0.4
Denmark	22.2	0.29	0.43	1.5	-7.6	-10.3	-2.7	2.5	2.7
Finland	5.0	0.31	0.48	1.5	-4.6	-5.1	-0.4	4.6	3.3
France	17.3	0.30	0.47	1.6	-5.6	-3.6	2.0	0.5	-0.4
Germany	-1.7	0.34	0.53	1.5	-3.7	-5.4	-1.7	3.2	2.3
Italy	-5.1	0.34	0.65	1.9	-3.9	-6.5	-2.7	1.2	1.3
Netherlands	17.0	0.28	0.44	1.6	-4.4	-7.3	-2.9	5.6	4.8
Poland (CTF)	**17.3**	**0.30**	**0.47**	**1.6**	**-5.9**	**-3.9**	**2.0**	**-2.8**	**-3.5**
Slovakia	-4.7	0.22	0.53	2.4	-7.9	-9.4	-1.5	-1.9	-1.8
Spain	6.6	0.29	0.64	2.2	-4.5	-5.9	-1.4	-3.8	-1.2
Sweden	38.7	0.31	0.43	1.4	-5.0	-5.1	-0.1	4.7	5.2
United Kingdom	26.3	0.28	0.43	1.6	-8.7	-7.2	1.5	-0.3	-1.6
NROW	16.3	0.29	0.48	1.7	-5.7	-5.2	0.5	0.0	0.1
SROW	21.8	0.13	0.39	3.0	-9.6	-11.5	-1.9	0.4	1.0
EU14					-5.2	-5.7	-0.6	0.6	0.2
World					-9.5	-10.0	-0.5	0.3	0.7

Legend: *Poland (CTF)* = Poland with counterfactual initial population structure and aging, matching French values; see table 5 for more.

Table 6: Economic impacts of population aging, Europe and Rest of the World, Poland aging as France

points higher in France (table 5). On the other hand, households in this counterfactual Poland would suffer from a welfare loss over the long run. For instance, households who are alive or born in the next fifty years would on average lose 2.8% of lifetime consumption with capital markets integration in this counterfactual slow-aging Poland (table 6). By comparison, these households would benefit from an increase of 0.8% of lifetime consumption in the standard fast-aging Poland (table 5).

Aging differentials thus appear to be an important factor, sufficient to account on its own for much of the cross-country differences involving fast-aging countries. Other factors may however also play a role.

Worldwide production and welfare impacts in tables 5 and 6 also appear identical, consistent with the finding from section 3.1 that aging differentials alone have cross-country redistribution impacts but no aggregate influence.

4.3 Savings differentials

One of the findings from section 4.1 is that foreign capital flows to slow-aging countries, increasing their production but decreasing the returns that households in these countries can obtain and thus their long-run welfare. However, outcomes are opposite for some slow-aging countries, namely Belgium, Denmark, Finland, Netherlands and Sweden. In these countries, capital markets integration leads to production losses but long-run welfare gains. One possible explanation for these different outcomes is that households are very patient in these countries and save much, according to the mechanism identified in section 3.2. The goal of this section is to investigate whether such savings differentials account for a large part or a small part of the special outcomes for these slow-aging countries.

To do so, I assume that a country with a large initial trade balance, which points to large patience by households, has the same initial trade balance as in France. The Netherlands, for instance, has an average trade surplus equal to 5% of GDP. France, on the other hand, has neither trade surplus nor trade deficit, on average. Table 7 reports outcomes if Netherlands was calibrated with the same trade balance as France[21].

Table 7 shows that the counterfactual, less patient Netherlands would have an experience which is closer to what regular slow-aging countries experience. For instance, per capita production in the Netherlands would no longer drop 2.8 percentage points over the next five decades (table 5), but only drop 0.1 percentage points (table 7), which is closer to what France and the UK experience (respective gains of 2.0 and 1.5 percentage points, table 5). Long-run welfare gains would no longer be experienced in Netherlands (4.8% larger average lifetime consumption for households alive or born in the next 100 years, table 5), but small losses (0.2% smaller average lifetime consumption, table 7). Again, the gap with France and the UK is smaller (respective losses of 0.3% and 1.5% of average lifetime consumption, table 5).

These figures show that the gap between the patient, slow-aging Netherlands and the regular slow-aging countries France and the UK is significantly reduced when we assume that Netherlands is as patient as France. However, a gap remains. There would

[21] Conclusions are similar for Belgium, Denmark, Finland and Sweden, but not reported to save space.

	Demographics				Macroeconomics			Welfare	
	Pop (%)	OADR			GDP/capita (%)			CEV (%)	
	50y	ISS	50y	50y/ ISS	CE	CMU	CMU impact	Alive + born 1-50y	Alive + born 1-100y
Austria	19.5	0.29	0.50	1.7	-9.4	-9.1	0.3	1.4	0.9
Belgium	24.4	0.29	0.44	1.5	-2.7	-6.0	-3.3	2.9	2.9
Czech Republic	-3.4	0.27	0.54	2.0	-7.1	-10.0	-2.9	0.0	0.4
Denmark	22.2	0.29	0.43	1.5	-7.6	-10.2	-2.6	2.5	2.7
Finland	5.0	0.31	0.48	1.5	-4.6	-5.0	-0.3	4.7	3.4
France	17.3	0.30	0.47	1.6	-5.6	-3.5	2.0	0.5	-0.3
Germany	-1.7	0.34	0.53	1.5	-3.7	-5.3	-1.6	3.2	2.3
Italy	-5.1	0.34	0.65	1.9	-3.9	-6.4	-2.5	1.2	1.3
Netherlands (CTF)	**17.0**	**0.28**	**0.44**	**1.6**	**-8.3**	**-8.4**	**-0.1**	**0.3**	**-0.2**
Poland	-13.9	0.24	0.61	2.5	-8.8	-11.1	-2.3	0.8	-0.1
Slovakia	-4.7	0.22	0.53	2.4	-7.9	-9.3	-1.4	-2.0	-1.8
Spain	6.6	0.29	0.64	2.2	-4.5	-5.7	-1.2	-3.9	-1.2
Sweden	38.7	0.31	0.43	1.4	-5.0	-5.1	0.0	4.7	5.3
United Kingdom	26.3	0.28	0.43	1.6	-8.7	-7.1	1.5	-0.3	-1.5
NROW	16.3	0.29	0.48	1.7	-5.7	-5.1	0.6	-0.1	0.0
SROW	21.8	0.13	0.39	3.0	-9.6	-11.4	-1.8	0.4	1.0
EU14					-5.3	-5.7	-0.4	0.6	0.3
World					-9.6	-9.9	-0.4	0.3	0.7

Legend: *Netherlands (CTF)* = the Netherlands with counterfactual initial trade balance, matching French values; see table 5 for more.

Table 7: Economic impacts of population aging, Europe and Rest of the World, Netherlands with initial trade balance as France

still for instance be a (small) domestic production loss in the Netherlands, where gains would be expected.

Savings differentials thus appear to be one important factor to account for the special outcomes of some slow-aging countries. However, other factors are required for a full account of these special outcomes. Further research may identify such additional factors.

4.4 Summary of findings

The main quantitative finding of the paper is the following: capital markets integration leads with aging populations to aggregate welfare gains equivalent to an increase of average lifetime consumption of 0.8% for all households alive today or born in the next 100 years in one of the country or region covered by the model[22]. The second finding are aggregate production losses in the same circumstances, equal to a yearly average loss of 0.5 percentage point of per capita production over the next 50 years. The third quantitative finding is a notable cross-country redistribution phenomenon, in production terms (per capita GDP variations ranging from -3.3 percentage points in Belgium to +2.0 percentage points in France), and in welfare terms (average lifetime consumption declining by almost 2% in Slovakia but increasing by about 5% in the Netherlands or Sweden).

Among the European countries covered by the model, three categories appear: regular slow-aging countries (France, the UK), patient slow-aging countries (Belgium, Denmark, Finland, Netherlands and Sweden) and fast-aging countries (the Czech Republic, Poland, Slovakia and Spain). The rest of the countries have intermediate characteristics.

In general, regular slow-aging countries benefit from capital markets integration in production terms, as foreign investors are attracted by the low capital-labor ratio and thus high returns to investments. The resulting drop in interest rates, compared to separated capital markets, will result in financial and welfare losses for households born in these countries.

Patient slow-aging countries and fast-aging countries have a similar fate. capital markets integration represents an opportunity for investors, who shift some of their investments to regular slow-aging countries to benefit from higher returns. Households' welfare in these countries tend in general to be higher as well, although there are exceptions among fast-aging countries. Domestic production, on the other hand, is always negatively impacted.

Relative to regular slow-aging countries, demographic differences account for most of the divergence in long-run outcomes that fast-aging countries experience. Savings differences account for a significant part of the divergence in long-run outcomes between regular slow-aging countries and patient slow-aging countries, but not entirely. Other factors, to be identified, play a role in these divergences.

[22] Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Italy, the Netherlands, Poland, Slovakia, Spain, Sweden, the UK and two Rest-of-the-world regions, one representing Canada, the US and Japan and the other one representing Brazil, China and India.

5 Concluding remarks

Using a large-scale overlapping-generations model calibrated for 14 European countries and 2 stylized Rest-of-the world regions, I quantify the economic impacts of population aging over the long run when capital markets are separated and when they are integrated. I also analyze the effect of cross-country differences in population aging as well as differences in savings' behavior.

I find that both aging and savings differentials lead to cross-country redistribution effects, in production terms or in welfare terms. Households in patient or fast-aging countries shift some of their investments to other countries if capital markets are open, as capital-labor ratios in these countries are lower and thus returns to investments larger. Over the long-run, the welfare of these households improves, at the cost of the welfare of households in other countries. Capital outflows however reduces per capita production, to the benefit of other countries.

I also find that welfare increases in patient and fast-aging countries will dominate the welfare losses in impatient and slow-aging countries, ceteris paribus. In other words, capital markets integration can lead to aggregate welfare gains.

Over all countries and regions covered in the model, I find that capital markets integration leads with aging populations to aggregate welfare gains equivalent to an increase of average lifetime consumption of 0.8% for all households alive today or born in the next 100 years. Cross-country differences are large however, ranging from a drop of almost 2% of lifetime consumption to an increase of 5%. Aggregate production drops, per capita GDP being on average 0.5 percentage points lower every year over the next five decades.

The aggregate welfare gains that I find for capital markets integration with aging populations is comparable to literature estimates for other economic phenomena. According to **?** for instance, the removal of business cycle fluctuations in the US would be equivalent to lifetime consumption increases ranging from 0.1% to 1.0%, depending on unemployment models. Fajgelbaum et al. (2019) find that the harmonization of taxes across US states would correspond to lifetime consumption increases ranging from 0.6% to 1.2%, depending on cases. In their baseline estimates, Coeurdacier et al. (2020), find that international risk sharing corresponds to lifetime consumption increases approaching 0.5%. Investigating the joint integration of goods and labor markets in the European Union, Caliendo et al. (2021) find that the 2004 enlargement, which added 10 countries to the existing 15 members at that time, was equivalent to an increase of lifetime consumption a little above 0.2%.

Results presented in this paper have implications for policies related to the opening and standardization of capital markets. Capital markets have become more and more integrated over time (e.g Longin and Solnik, 1995) but are not fully integrated (e.g Morelli, 2010). Whether or not to open domestic capital markets to foreign investors is still a matter of policy debate among developing countries (Erten et al., 2021). Even if some countries agree on a mutual opening of their capital markets, as in the European Union, differences in national laws can create obstacles to full markets integration. Differences in insolvency laws can for instance reduce cross-border investments (for an overview, see Veron and Wolff, 2016). Yet, eliminating all barriers to capital markets integration requires significant effort for policy change (e.g European Commission, 2015). My results, which exhibit aggregate welfare gains from capital markets integration over the long-run, provide another motivation for policy efforts promoting further integration of financial markets.

Two factors influencing cross-country redistribution and aggregate patterns have been identified in this paper, aging differentials and savings differentials. Other factors may also play a role, such as differences in social security policies. Investigating the role of other factors is an opportunity for future research.

References

Ageing Working Group (2018): *The 2018 Ageing Report: Economic and budgetary projections for the EU Member States (2016-2070)*, Institutional Paper 079, European Economy.

Andolfatto, D. (1996): "Business Cycles and Labor-Market Search," *American Economic Review*, 86, 112–32.

Attanasio, O., A. Bonfatti, S. Kitao, and G. Weber (2016): "Global Demographic Trends: Consumption, Saving, and International Capital Flows," *Handbook of the Economics of Population Aging*, 1, 179–235.

Attanasio, O., S. Kitao, and G. L. Violante (2007): "Global demographic trends and social security reform," *Journal of Monetary Economics*, 54, 144–198.

Auclert, A., H. Malmberg, F. Martenet, and M. Rognlie (2021): "Demographics, Wealth, and Global Imbalances in the Twenty-First Century," NBER Working Papers 29161, National Bureau of Economic Research, Inc.

Auerbach, A. J. and L. J. Kotlikoff (1987): *Dynamic Fiscal Policy*, Cambridge, UK: Cambridge University Press.

Backus, D., T. Cooley, and E. Henriksen (2014): "Demography and low-frequency capital flows," *Journal of International Economics*, 92, Supplement 1, S94 – S102.

Barany, Z. L., N. Coeurdacier, and S. Guibaud (2023): "Capital flows in an aging world," *Journal of International Economics*, 140.

Blanchard, O. J. (1985): "Debt, Deficits, and Finite Horizons," *Journal of Political Economy*, 93, 223–47.

Boersch-Supan, A., K. Haertl, and A. Ludwig (2014): "Aging in Europe: Reforms, International Diversification, and Behavioral Reactions," *American Economic Review*, 104, 224–229.

Boersch-Supan, A., A. Ludwig, and J. Winter (2006): "Ageing, Pension Reform and Capital Flows: A Multi-Country Simulation Model," *Economica*, 73, 625–658.

Boone, J. and L. Bovenberg (2002): "Optimal Labour Taxation and Search," *Journal of Public Economics*, 85, 53–97.

Braun, R. A., K. A. Kopecky, and T. Koreshkova (2017): "Old, Sick, Alone, and Poor: A Welfare Analysis of Old-Age Social Insurance Programmes," *Review of Economic Studies*, 84, 580–612.

Brooks, R. (2003): "Population Aging and Global Capital Flows in a Parallel Universe," *IMF Staff Papers*, 50, 3.

Buiter, W. H. (1981): "Time Preference and International Lending and Borrowing in an Overlapping-Generations Model," *Journal of Political Economy*, 89, 769–97.

Caliendo, L., L. D. Opromolla, F. Parro, and A. Sforza (2021): "Goods and Factor Market Integration: A Quantitative Assessment of the EU Enlargement," *Journal of Political Economy*, 129, 3491–3545.

Coeurdacier, N., H. Rey, and P. Winant (2020): "Financial integration and growth in a risky world," *Journal of Monetary Economics*, 112, 1–21.

Cole, H. L. and M. Obstfeld (1991): "Commodity trade and international risk sharing : How much do financial markets matter?" *Journal of Monetary Economics*, 28, 3–24.

Corsetti, G., L. Dedola, and S. Leduc (2010): "Optimal Monetary Policy in Open Economies," in *Handbook of Monetary Economics*, ed. by B. M. Friedman and M. Woodford, Elsevier, vol. 3 of *Handbook of Monetary Economics*, chap. 16, 861–933.

Costinot, A. and A. Rodriguez-Clare (2014): "Trade Theory with Numbers: Quantifying the Consequences of Globalization," in *Handbook of International Economics*, ed. by G. Gopinath, E. Helpman, and K. Rogoff, Elsevier, vol. 4, chap. 0, 197–261.

Davoine, T. (2023): "A multi-country overlapping-generations model covering 14 EU countries - Technical Appendix," February 2023.

Domeij, D. and M. Flodén (2006): "Population Aging And International Capital Flows," *International Economic Review*, 47, 1013–1032.

Erten, B., A. Korinek, and J. A. Ocampo (2021): "Capital Controls: Theory and Evidence," *Journal of Economic Literature*, 59, 45–89.

European Commission (2015): "Action Plan on Building a Capital Markets Union," COM(2015) 468 final, Brussels.

Eurostat (2018): "Population projections, Europop 2015," European Commission.

Fajgelbaum, P. D., E. Morales, J. C. S. Serrato, and O. Zidar (2019): "State Taxes and Spatial Misallocation," *Review of Economic Studies*, 86, 333–376.

Fehr, H., S. Jokisch, and L. Kotlikoff (2005): "The Developed World's Demographic Transition - The Roles of Capital Flows, Immigration, and Policy," in *Social Security Reform*, ed. by R. Brooks and A. Razin, Cambridge University Press.

Gertler, M. (1999): "Government Debt and Social Security in a Life-Cycle Economy," *Carnegie-Rochester Conference Series on Public Policy*, 50, 61–110.

Greenwood, J., Z. Hercowitz, and G. W. Huffman (1988): "Investment, Capacity Utilization, and the Real Business Cycle," *American Economic Review*, 78, 402–17.

Griliches, Z. (1969): "Capital-Skill Complementarity," *The Review of Economics and Statistics*, 51, 465–68.

Grossman, G. M. (2016): "The Purpose of Trade Agreements," in *Handbook of Commercial Policy*, ed. by K. Bagwell and R. W. Staiger, North-Holland, vol. 1, 379–434.

Hayashi, F. (1982): "Tobin's Marginal q and Average q: A Neoclassical Interpretation," *Econometrica*, 50, 213–24.

Hsieh, C.-T. and R. Ossa (2016): "A global view of productivity growth in China," *Journal of International Economics*, 102, 209–224.

Immervoll, H., H. J. Kleven, C. T. Kreiner, and E. Saez (2007): "Welfare Reform in European Countries: a Microsimulation Analysis," *Economic Journal*, 117, 1–44.

Ito, H. and K. Tabata (2010): "The spillover effects of population aging, international capital flows, and welfare," *Journal of Population Economics*, 23, 665–702.

Jaag, C., C. Keuschnigg, and M. Keuschnigg (2010): "Pension Reform, Retirement, and Life-Cycle Unemployment," *International Tax and Public Finance*, 17, 556–585.

Johnson, H. G. (1953): "Optimum Tariffs and Retaliation," *Review of Economic Studies*, 21, 142–153.

Kose, M. A., E. Prasad, K. Rogoff, and S.-J. Wei (2009): "Financial Globalization: A Reappraisal," *IMF Staff Papers*, 56, 8–62.

Krueger, D. and A. Ludwig (2007): "On the consequences of demographic change for rates of returns to capital, and the distribution of wealth and welfare," *Journal of Monetary Economics*, 54, 49–87.

Krusell, P., L. E. Ohanian, J.-V. Rios-Rull, and G. L. Violante (2000): "Capital-Skill Complementarity and Inequality: A Macroeconomic Analysis," *Econometrica*, 68, 1029–1054.

Longin, F. and B. Solnik (1995): "Is the Correlation in International Equity Returns Constant: 1960-1990?" *Journal of International Money and Finance*, 14, 3–26.

Morelli, D. (2010): "European Capital Market Integration: An Empirical Study Based on a European Asset Pricing Model," *Journal of International Financial Markets, Institutions and Money*, 20, 363–375.

Obstfeld, M. and K. Rogoff (1995): "Exchange Rate Dynamics Redux," *Journal of Political Economy*, 103, 624–660.

O'Mahony, M. and M. P. Timmer (2009): "Output, Input and Productivity Measures at the Industry Level: The EU KLEMS Database," *Economic Journal*, 119, 374–403.

Sachs, J. D. (2018): "Geography, geopolitics, and policy in the performance of transition economies," *The Economics of Transition*, 26, 841–849.

United Nations (2015): "World Population Prospects: The 2015 Revision," Department of Economic and Social Affairs, Population Division.

Veron, N. and G. B. Wolff (2016): "Capital Markets Union: a vision for the long term," *Journal of Financial Regulation*, 2, 130–153.

Vogel, E., A. Ludwig, and A. Boersch-Supan (2017): "Aging and pension reform: extending the retirement age and human capital formation," *Journal of Pension Economics and Finance*, 16, 81–107.

Wilson, J. D. (1986): "A theory of interregional tax competition," *Journal of Urban Economics*, 19, 296–315.

Zodrow, G. R. (2003): "Tax Competition and Tax Coordination in the European Union," *International Tax and Public Finance*, 10, 651–671.

Zodrow, G. R. and P. Mieszkowski (1986): "Pigou, Tiebout, property taxation, and the underprovision of local public goods," *Journal of Urban Economics*, 19, 356–370.

A Appendix: calibration and model outcomes

The calibration approach and data sources are presented first. Calibration values and model outcomes follow.

A.1 Calibration

The calibration of the multi-country model is inherited from the single-country models, with the exception of the Rest-of-the-world country. I first summarize the calibration part which is inherited, then continue with aging-related processes and finish with the calibration of the Rest-of-the-world country.

Calibration of the single country basis: Where available, I take consensual empirical estimates from the literature. Labor supply elasticities are derived from Immervoll, Kleven, Kreiner, and Saez (2007) and productivity profiles from Mincer wage regressions on EU-SILC microdata. Average participation rates, unemployment rates and working hours per age and skill classes are computed from LFS and EU-SILC datasets. Parameters for institutions are derived using the European Commission MISSOC database and OECD's Tax-Benefit model. Intervivo transfer parameters are calculated to generate life-cycle consumption profiles in line with empirical evidence.

Calibration of aging-related processes: I choose fertility and mortality rates for the 14 European countries in the model to match the demographic projections from Eurostat (Eurostat, 2018), which are used in the Ageing Working Group (2018). Fertility and mortality rates for the two Rest-of-the-world countries are chosen to match the projections from the United Nations (2015).

A number of European countries have scheduled pension reforms, in order to deal with the future financing challenges created by an aging population. Typically, the statutory retirement age is scheduled to be increased and pension benefits reduced[23]. In order to quantify the effects from population aging alone and isolate them from policy reforms influences, pension parameters will be kept unchanged in most scenarios.

Public health- and long-term care are also expected to change over time. There is a large debate over cost drivers and how they will change in the future. Unlike pension expenditures however, there are cost drivers which are neither demographic nor economic, such as technological progress. In its reference scenario, the Ageing Working Group (2018) assumes that age-dependent per capita costs will be declining. Because social security policy has little (direct) influence on technological improvements, I therefore follow these projections and apply a gradual age-dependent per capita reduction of health- and long-term care costs.

Calibration of the rest of the world: To be able to reflect large economic differences between countries without including many single countries, the calibration uses a *North rest-of-the-world* country (NROW) and a *South rest-of-the-world* country

[23]Social security contributions rates are seldom scheduled to change, if at all (Ageing Working Group, 2018).

(SROW). While impacts outside the EU are not modelled, the impact of forces coming from outside of the EU are included, in line with our objective. Aggregating Canada, Japan and the USA forms the stylized NROW country while Brazil, China and India form the SROW country.

The calibration process rests on macro- and micro-level data, either as direct inputs or as calibration targets. Macro-level data is in general available for all six countries forming the NROW and SROW, in data sources which include the ILO, the OECD, the UNESCO and the World Bank.

Micro-level data on the other hand is not available for all of the six countries. For the sake of consistency, micro-level data specific to Rest-of-the-world countries is ignored. Instead, a three step approach is used. First, for each of the six Rest-of-the-world country, a twin country (or a set of countries) is identified from our sample of 14 calibrated countries whose demographic, economic and policy characteristics are the closest. Second, the micro-level data inputs for this twin country is used in the calibration process of the NROW and SROW. Third, stylized corrections are made where there are documented differences.

This approach results in using micro-level calibration inputs from the UK for Canada, Japan and the USA and an average of calibration inputs from the Czech Republic, Slovakia and Poland for Brazil, China and India. The most important stylized corrections are proportional adjustments to the participation and unemployment rates by age and skill classes to match the aggregate participation and unemployment rates.

Tables 8 and 9 provide calibration values for the main parameters as well as calibration outcomes. The model performance can be evaluated along two dimensions.

A.2 Calibration values and model outcomes

The value for some variables is not calibrated but an outcome of the calibration process. These variables are indicated with a star in tables 8 and 9 . When compared to benchmark values, they allow for a first evaluation of the model and the calibration performance[24].

The second evaluation consists in comparing the predictions of the model to the predictions of analogous models, applying a population aging shock. Attention is restricted to models with an overlapping-generations structure. Table 1 provides the comparison of the simulated impacts of population aging in 50 years for the main macroeconomic indicator, GDP per capita, relative to the growth trend. Predictions are shown for different model set-ups and different countries.

All in all, model outcomes along the first dimension are close to the benchmark values, taking data availability, data comparability and the simplification process inherent to model building into account. The main gaps concern the labor revenue share and the capital depreciation rate. Along the second evaluation dimension, predictions of the macroeconomic impact of population aging are consistent across models, in spite of the differences in the details of model designs and the differences in the sources used for the

[24]Columns *Mod* in tables 8 and 9 report model values, while columns *Data* provide the benchmarking values.

demographic projections.

Along the first evaluation dimension, gaps for labor revenue shares come from the fact that the model does not include transition phenomenon in eastern European countries. To some extent however, such phenomenon is still on-going (e.g. Sachs, 2018). The lack of a consensual way to measure capital stocks accurately creates measurement noise which can carry to capital depreciation rates (e.g. O'Mahony and Timmer, 2009). Catch-up phenomenon due to technological transfer, which are not included in the model, can explain the large gap for the SROW region, which is representative of countries similar to Brazil, China or India. Unusual data classification can explain the few large gaps which appear for other model outcomes, namely the tax/GDP ratio for Spain and the private consumption/output ratio for Denmark and Italy.

	AT		BE		CZ		DE		DK		ES		FI		FR	
	Mod	Data	Mod	Data	Mod	Data	Mod	Data	Mod	Data	Mod	Data	Mod	Data	Mod	Data
Demographics																
Low skills share (%)	16.2		29.4		8.6		22.9		23.7		48.5		18.0		29.6	
Med skills share (%)	65.6		37.2		75.9		55.7		42.0		21.8		44.7		41.7	
High skills share (%)	18.2		33.4		15.5		21.4		34.3		29.7		37.3		28.7	
*Old age dependency ratio (%)	28.2	27.0	29.0	27.1	27.1	25.1	35.3	31.8	28.8	27.9	28.9	26.8	31.2	29.6	30.1	27.9
Production																
Exo. productivity growth (%)	1.21		1.21		1.21		1.21		1.21		1.21		1.21		1.21	
Capital/Output	3.7		3.0		3.7		3.5		3.4		4.4		3.0		3.2	
*Capital depreciation rate (%)	5.5	4.4	6.7	4.5	7.1	4.1	4.5	3.9	5.8	4.4	5.9	3.7	6.7	4.2	5.7	3.9
*Labor revenue share (%)	67.6	67.5	72.6	68.5	61.7	59.1	72.3	67.8	69.1	64.6	55.3	63.7	70.1	67.3	67.8	68.6
Labor Markets																
Average participation rate (%)	64.7		60.8		66.3		64.3		68.9		65.5		66.3		64.4	
Average unemployment rate (%)	5.5		8.4		7.0		6.2		4.6		10.8		7.3		9.8	
Average retirement age	59.4		59.6		61.2		60.6		62.7		61.1		62.4		60.2	
*Net earnings low vs med skills	0.72	0.78	0.91	0.94	0.75	0.77	0.71	0.82	0.84	0.91	0.86	0.86	0.94	0.95	0.78	0.92
*Net earnings high vs med skills	1.45	1.39	1.21	1.26	1.52	1.44	1.51	1.38	1.17	1.14	1.28	1.30	1.31	1.38	1.51	1.41
Savings																
Annual interest rate (%)	3.0		3.0		3.0		3.0		3.0		3.0		3.0		3.0	
Intertemp. elasticity of substitution	0.40		0.40		0.40		0.40		0.40		0.40		0.40		0.40	
Trade balance/GDP (%)	0.70		2.67		-0.05		2.77		1.92		-1.91		3.01		0.01	
*Consumption/Output (%)	54.7	53.0	46.6	51.0	49.4	49.0	55.4	55.0	41.5	47.0	51.6	57.0	50.3	50.0	55.0	55.0
Social Security																
Net pension replac. rate - low skills	0.85		0.60		0.86		0.47		1.17		0.98		0.74		0.90	
Net pension replac. rate - med skills	0.79		0.57		0.62		0.48		1.04		0.92		0.72		0.92	
Net pension replac. rate - high skills	0.62		0.42		0.47		0.43		0.90		0.81		0.66		0.83	
Net UI replacement rate - low skills	0.48		0.41		0.34		0.46		0.53		0.24		0.49		0.41	
Net UI replacement rate - med skills	0.39		0.37		0.34		0.36		0.50		0.21		0.46		0.42	
Net UI replacement rate - high skills	0.31		0.27		0.24		0.34		0.40		0.17		0.33		0.35	
Pension expenditure/GDP (%)	13.8		12.1		8.2		10.1		14.9		12.2		13.4		15.0	
Health and LTC expenditure/GDP (%)	8.9		8.2		6.7		8.8		9.3		6.6		8.3		9.5	
Public Finance																
Public debt/GDP (%)	78.7		100.4		46.7		87.6		55.1		64.5		57.5		93.3	
Avg labor tax rate - low skills (%)	10.1		17.1		4.5		9.2		30.3		11.4		18.9		12.8	
Avg labor tax rate - med skills (%)	17.0		21.7		6.7		13.5		33.6		15.0		20.7		13.9	
Avg labor tax rate - high skills (%)	23.8		28.5		10.1		19.0		38.2		20.6		27.5		16.0	
Average SSC employee rate (%)	15.6		9.5		10.0		14.6		8.9		6.5		5.7		13.6	
Average SSC firm rate (%)	26.0		21.7		30.9		14.5		12.0		30.5		19.8		35.9	
Average SSC retiree rate (%)	4.7		2.8		0.0		7.6		0.0		0.0		1.4		1.0	
*Average consumption tax rate (%)	19.1	20.2	23.1	19.4	19.8	20.8	18.4	17.8	33.5	29.2	17.2	13.6	24.5	23.7	19.1	18.2
*Tax ratio/GDP (%)	41.2	42.0	40.8	43.5	32.2	34.2	38.0	36.1	49.8	47.6	38.7	32.3	41.3	42.5	48.1	42.9

Table 8: Model parameter values, outcomes and benchmark data, part 1

	IT		NL		PL		SE		SK		UK		NROW		SROW	
	Mod	Data	Mod	Data	Mod	Data	Mod	Data	Mod	Data	Mod	Data	Mod	Data	Mod	Data
Demographics																
Low skills share (%)	45.7		26.6		12.0		19.3		9.1		25.4		8.0		63.2	
Med skills share (%)	39.8		40.6		66.8		47.6		75.2		41.2		48.0		28.6	
High skills share (%)	14.5		32.8		21.2		33.0		15.8		33.4		44.0		8.2	
*Old age dependency ratio (%)	33.9	32.8	27.9	25.9	24.4	20.5	30.7	30.2	21.9	18.7	27.7	26.6	28.6	26.7	12.8	10.7
Production																
Exo. productivity growth (%)	1.21		1.21		1.21		1.21		1.21		1.21		1.21		1.21	
Capital/Output	3.5		3.5		3.0		2.6		4.5		2.5		3.0		2.0	
*Capital depreciation rate (%)	5.5	3.9	5.2	3.9	6.7	4.8	6.8	4.6	5.4	5.2	6.3	3.8	6.4	4.4	21.0	5.0
*Labor revenue share (%)	68.1	68.6	69.6	68.8	69.8	54.6	74.3	65.1	61.0	52.5	74.1	69.6	68.5	62.2	48.9	?
Labor Markets																
Average participation rate (%)	59.5		66.7		60.5		71.5		64.7		66.3		70.0		68.0	
Average unemployment rate (%)	7.7		4.0		13.8		6.5		14.4		5.0		5.6		4.4	
Average retirement age	59.8		61.6		59.4		64.1		58.0		62.1		62.7		58.5	
*Net earnings low vs med skills	0.85	0.85	0.83	0.86	0.73	0.74	0.89	0.92	0.75	0.76	0.81	0.81	0.81	0.77	0.74	?
*Net earnings high vs med skills	1.17	1.39	1.33	1.41	1.80	1.67	1.20	1.22	1.37	1.30	1.36	1.39	1.36	1.47	1.60	?
Savings																
Annual interest rate (%)	3.0		3.0		3.0		3.0		3.0		3.0		3.0		3.0	
Intertemp. elasticity of substitution	0.40		0.40		0.40		0.40		0.40		0.40		0.40		0.40	
Trade balance/GDP (%)	0.53		4.48		-2.54		3.81		-3.43		-0.94		-0.19		0.04	
*Consumption/Output (%)	53.4	60.0	49.9	46.0	59.5	62.0	44.5	45.0	57.5	57.0	61.9	65.0	62.6	61.7	42.7	50.3
Social Security																
Net pension replac. rate - low skills	0.75		0.63		0.65		0.76		0.51		0.58		0.59		0.36	
Net pension replac. rate - med skills	0.77		0.62		0.58		0.75		0.52		0.41		0.45		0.34	
Net pension replac. rate - high skills	0.75		0.61		0.50		0.73		0.48		0.26		0.24		0.27	
Net UI replacement rate - low skills	0.11		0.57		0.09		0.37		0.18		0.12		0.24		0.02	
Net UI replacement rate - med skills	0.10		0.64		0.09		0.38		0.21		0.09		0.18		0.02	
Net UI replacement rate - high skills	0.09		0.45		0.05		0.29		0.22		0.06		0.11		0.01	
Pension expenditure/GDP (%)	15.6		12.3		11.2		11.7		8.6		7.7		7.3		3.3	
Health and LTC expenditure/GDP (%)	8.0		9.6		4.7		10.2		6.5		9.3		9.5		3.5	
Public Finance																
Public debt/GDP (%)	126.4		70.9		61.4		49.5		44.1		81.8		149.7		55.0	
Avg labor tax rate - low skills (%)	13.0		4.5		11.5		19.4		4.3		11.9		13.4		1.0	
Avg labor tax rate - med skills (%)	18.7		9.0		13.3		21.7		6.1		15.1		16.6		2.9	
Avg labor tax rate - high skills (%)	24.7		20.5		15.4		26.6		9.5		19.8		21.4		5.8	
Average SSC employee rate (%)	7.5		14.9		8.4		6.1		8.9		6.0		2.9		3.4	
Average SSC firm rate (%)	25.3		23.3		11.3		32.7		23.4		7.9		3.9		7.9	
Average SSC retiree rate (%)	0.0		10.8		0.0		0.0		0.0		0.0		0.0		1.3	
*Average consumption tax rate (%)	18.7	16.2	22.7	21.8	21.3	19.3	24.9	26.3	18.6	16.1	15.6	14.7	9.6	8.3	18.5	?
*Tax ratio/GDP (%)	40.9	42.9	41.9	38.7	33.5	31.7	48.0	45.5	28.4	28.3	37.4	34.9	31.1	32.4	20.0	22.2

Table 9: Model parameter values, outcomes and benchmark data, part 2