Financing pensions with an aging population: estimate biases with single-country models

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Abstract

The small open or closed economy assumptions may lead to biased macroeconomic evaluations for large countries in an ever more integrated world economy. Using a multi-country model covering 14 European countries with perfect capital markets integration as benchmark, I investigate the emergence of such biases over the long run. For large worldwide shocks such as population aging, small open economy estimates are particularly pessimistic, predicting an average 11.8% decline of GDP per capita in Europe, 7.0 %-points worse than closed economy and multi-country estimates, which encapsulate the true expected outcome. For reforms limited to a set of countries weighing a third of the worldwide economy or less, small open economy estimates are closest to the benchmark. While multi-country estimates are bracketed by small open and closed economy estimates at the European level, it is not the case at the country level. For slow aging countries, both small open and closed economy estimates with population aging are too pessimistic because they miss cross-country redistribution effects, sometimes by 2.0 %-points of GDP per capita.

Keywords: small open economy, closed economy, multi-country modelling, computable general equilibrium

JEL-Classification: C68, E60, F21, F41, J11

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1 Introduction

There are two approaches to define the interest rate in single-country macroeconomic models. In a closed economy setting, capital markets are assumed to be separated along country lines. In a small open economy setting, capital markets are assumed to be perfectly integrated and so large that they are not impacted by changes in the country. In an increasingly integrated world where the size of some countries is moderate or large, both of these assumptions may be problematic. Using a large-scale multi-country model with perfectly integrated capital markets as benchmark, I investigate to which extent these two assumptions lead to biased long-run estimates.

The small open and closed economy assumptions lead to different long-run outcomes in a variety of contexts related to social security (including financing: Huang et al., 1997; privatization: Kotlikoff et al., 1999; risk sharing: Nishiyama and Smetters, 2007; unemployment: de la Croix et al., 2013). The first question that I consider is which of the two assumptions deliver long-run outcomes closest to the reality of partially integrated capital markets.

Since the small open economy case and the closed economy case are polar opposites (as noted for instance by Auerbach et al., 1989; Kotlikoff et al., 1999; de la Croix et al., 2013), one intuitive answer to the question is that the real outcomes must lie in between outcomes predicted with the small open economy assumption and those predicted with the closed economy assumption. The second question that I consider is whether this intuitive expectation is correct.

In short, my answer to the first question will be “it depends” and my answer to the second question will be “no, not always”. As a result, the use of multi-country models appears necessary in some cases, such as the impact of population aging in France, the United States or any other slow aging country.

To come to these answers, I compare the long-run outcomes of standard fiscal policy reforms and demographic shocks in different single-country and multi-country model setups for a representative sample of 14 European countries and stylized rest-of-the-world regions. Because of the long-run focus, I take population aging into account in some cases and therefore use the same overlapping-generations model basis, abstracting from business cycles and price rigidities. For simplicity and because there is evidence that the integration of capital markets proceeds at a much larger pace than the integration of labor markets (Lane, 2006), the multi-country version assumes perfect integration of the capital markets only and that projected migration flows are unaffected by economic developments. Because cross-country spillovers play an important role and skill differentials across countries impact the size of spillovers (Davoine and Molnar, 2017), I use an overlapping-generations model with three different skill groups, endogenous consumption, labor supply and investment decisions.

The first general finding of this paper is that small open economy estimates are closest

\footnote{The other reason for using an overlapping-generations model, even when population is not aging, is to protect fiscal reform evaluations from Ricardian equivalence (Ganelli, 2005; Freedman et al., 2010).}

\footnote{Ignoring business cycles and price rigidities because of the long-run focus does not mean that the small open economy and closed economy assumptions are neutral in these short-run contexts (see for instance Clarida et al., 2001).}
to multi-country estimates when reforms or shocks apply at the country or regional level, while closed economy estimates are closest to multi-country estimates when reforms or shocks apply at the worldwide level, such as population aging. Regional level can involve a set of countries which account for as much as a third of worldwide economic activity, by no means a small fraction. Under population aging, the small open economy estimates come with a notable pessimistic bias. If the rise in social security expenditures due to aging is financed by labor income taxes and the retirement age remains constant, small open economy estimates averaged over the European countries in my sample predict that GDP per capita declines 11.8% each of the next fifty years, at least 7.0 %-points more than closed economy and multi-country estimates, which encapsulate the true predictable outcome. As expected, the smaller the macroeconomic impact of the shock or reform, the smaller the difference between small open economy, closed economy and multi-country estimates. For a moderate fiscal devaluation where labor income taxes are cut a quarter for instance, the difference between small open economy and multi-country estimates does not exceed 15%.

The second general finding is that small open economy and closed economy estimates do not always bracket the multi-country estimates, which implies that multi-country macroeconomic models are necessary in some cases. Continuing with the example of population aging and labor income tax financing, the same model with a small open economy assumption predicts an average GDP per capita decline of 9.4% each of the next fifty years in France, while it predicts a 4.9% decline with the closed economy assumption and a 2.8% decline in its multi-country version with perfectly integrated capital markets.

The reason for such an outcome is twofold. First, aging reduces labor supply per capita and increases households’ savings, as life expectancy increases but not the retirement age. The resulting rise in the capital-labor ratio drops the price of capital, when the interest rate is flexible. The small open economy assumption, which keeps the interest rate constant, misses this positive incentive on investment. Second, cross-country aging differentials lead to cross-country redistribution (Davoine, 2018). France is indeed projected to age at a much slower pace than other European countries. Its labor supply per capita should thus drop less and its capital-labor ratio increase less. Returns to investments made in France should thus be higher. If capital markets are integrated, foreign investors will notice and shift their investments towards France, a positive impact on capital stock and production there3.

This paper links two branches of the literature. One the one hand, there are analyses which discuss small open economy and closed economy outcomes (see above for references). On the other hand, there are analyses which discuss closed economy outcomes and multi-country outcomes under perfect capital markets integration (for instance, Mendoza and Tesar, 1998; Fehr et al., 2005; Boersch-Supan et al., 2006; Attanasio et al., 2007; Krueger and Ludwig, 2007). The present paper discusses all three: small open economy, closed economy and multi-country outcomes under perfect capital markets integration.

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3Davoine (2018) further investigates cross-country redistribution patterns, in particular the role of social security reforms, but does not consider small open economy outcomes.
integration.

I continue with a presentation of the model in the next section. Section 3 follows with the quantitative analysis and section 4 with implications for macroeconomic evaluations. Section 5 concludes.

2 Model

To investigate the role of interest rates, I will use the same model basis in three versions: a single-country version, once with a small open economy assumption and once with a closed economy assumption, and a multi-country version with perfectly integrated capital markets.

The single-country overlapping-generations model is routinely used for policy evaluation and the multi-country extension follows the Buiter (1981) procedure. The model belongs to the Auerbach and Kotlikoff (1987) family. Because unemployment varies across countries, the single-country model builds on an overlapping-generations model with imperfect labor markets, Jaag et al. (2010). Because the skill distribution also differs across countries, this basis is extended to include three skill classes.

I start with a description of the single-country model, continue with the multi-country version and finish with calibration.

2.1 Single-country setting

Demographics: Households go through several stages \( a \in \{1, \ldots, 8\} \) 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\(^5\). 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\(^6\).

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

\(^4\)The model I use is the same as Davoine and Molnar (2017), except for the addition of population aging. The presentation below builds on Davoine and Molnar (2017).

\(^5\)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 help to deal with it.

\(^6\)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

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 $1 - e^{a,i}$ in each time period. Depending on search efforts, a job may or may not be found. If unemployed, households choose job search efforts ($s^{a,i} \geq 0$). 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 the wage, building on the static search and matching setting of Boone and Bovenberg (2002). 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

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

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 $(\delta^{a,i}, s^{a,i}, l^{a,i})$ 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:

$$V_{t}^{a,i} = \max \left[ \left( Q_{t}^{a,i} \right)^{\rho} + \gamma^{a} \beta \left( GV_{t+1}^{a,i} \right)^{\rho} \right]^{1/\rho},$$

where $\rho$ defines the elasticity of intertemporal substitution $1/(1 - \rho)$, $\beta$ 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

$$Q^{a,i} = C^{a,i} - \varphi^{a,i}(\delta^{a,i}, s^{a,i}, l^{a,i})$$

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

$$\varphi^{a,i} = \delta^{a,i} [(1 - u^{a,i}) \varphi^{L,i}(l^{a,i}) + (1 - \varepsilon^{a,i}) \varphi^{S,i}(s^{a,i})] + \varphi^{P,i}(\delta^{a,i}) - (1 - \delta^{a,i} + \delta^{a,i} u^{a,i}) h^{a,i},$$

where $u^{a,i} \in [0, 1]$ represents the fraction of time in unemployment, $h^{a,i}$ 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:

$$G^{a,i} A^{a,i}_{t+1} = R^{t+1} \left( A^{a,i}_{t} + y^{a,i}_{t} - C^{a,i}_{t} \right),$$

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

**Social security:** Before retirement, non-participants receive (net) welfare benefits $y^{a,i}_{\text{nonpar}}$ while unemployed workers receive (gross) unemployment benefits $b^{a,i} = b^{i} \cdot y^{a,i}_{\text{lab}}$, where $b^{i}$ is the skill-dependent replacement rate. After retirement, households receive (net) pension benefits $y^{a,i}_{\text{pens}} = \nu^{a} P^{a,i} + P_{0}^{a}$, where $P_{0}^{a}$ is a flat part, $P^{a,i}$ represents acquired pension rights and $\nu^{a}$ is a conversion factor between pension rights and pension payments. Pension rights accumulate with labor earnings, following $P^{a,i}_{t+1} = \delta^{a,i}_{t} (1 - u^{a,i}_{t}) y^{a,i}_{\text{lab},t} + P^{a,i}_{t}.$

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, net household income amounts to:

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

**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).

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

8 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 homogenous:

\[ Y_t = F^Y \left( K_t, L_t^{D,1}, L_t^{D,2}, L_t^{D,3} \right). \]

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 \( W_t \), which equals the stream of discounted dividend payments \( \chi_t \):

\[
W_t = W(K_t) = \max_{I_t, L_t^{D,i}} \left[ \chi_t + \frac{GW_t(K_t+1)}{R_{t+1}} \right],
\]

s.t. \[
\chi_t = Y_t - I_t - J(I_t, K_t) - \sum_i (1 + \tau F, a) w^i L_t^{D,i},
\]

\[ GK_{t+1} = (1 - \delta^K) K_t + I_t, \]

where \( J(\cdot) \) denotes the adjustment costs and \( \tau F, a \) the firms social security contribution rate. 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\(^9\).

**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 (with or without premium on the interest rate) to finance public debt, to meet some exogenously defined target (kept constant in simulations presented in this paper).

**Single-country equilibrium:** In a single-country setting, I assume that the gross interest rate \( R_{t+1} = 1 + r_{t+1} \) is either exogenously defined, as for small open economies, or endogenously defined, as in a closed economy. 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 \( r_{t+1} \). Under the small open economy assumption, the goods market clears because of trade with the rest of the world:

\[ Y_t = C_t + I_t + G_t + TB_t, \]

\(^9\)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, \( r = F^K - \delta^K \).
where $C_t$ is the aggregate private consumption$^{10}$, $G_t$ is government expenditure and $TB_t$ is the trade balance. Holding of foreign assets by domestic households evolves with changes in the trade balance:

$$D_{t+1}^F = R_{t+1} (D^F_t + TB_t).$$

Under the closed economy assumption, adjustments of the interest rate clear the goods market. Trade balance $TB_t$ and foreign debt $D^F$ have zero values$^{11}$.

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

$$A_t = W_t + D^G_t + D^F_t.$$

### 2.2 Multi-country setting

I follow Boersch-Supan et al. (2006), an extension of the two-country Buiser (1981) procedure to any number of countries and capital adjustment costs. 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 they either belong to the same currency union, or that exchange rates are constant. The interest rate is endogenous.

**Equilibrium:** 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 $j \in \{1, \ldots, M\}$. 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

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

$^{10}$So, $C_t = \sum_i \sum_a N^a_{i,t} C^a_i$ where $N^a_{i,t}$ 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 $A_t$.

$^{11}$In the quantitative analysis I consider a variation where the trade balance is not zero, but kept constant. This allows me to compare outcomes with the small open economy assumption and the closed economy assumption, 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\textsuperscript{12}, 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

The basis for the multi-country model is a single country model calibrated for 14 European countries used for policy evaluation. The calibration of the multi-country model is thus 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. Production function specifications are adopted from Jaag (2009). 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, 2015), which are used in the Ageing Working Group (2015). 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\textsuperscript{13}. In

\textsuperscript{12}In the implementation, the subset contains 14 countries member of the European Union, namely Austria, Belgium, 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. In reality, exchange rate variations absorb some of the country-specific shocks over the short run, reducing the size of cross-country spillovers for these four countries, ceteris paribus.

\textsuperscript{13}Social security contributions rates are seldom scheduled to change, if at all (Ageing Working Group, 2015).
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 (2015) 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 to some extent without including many single countries, we model and calibrate a *North rest-of-the-world* country (NROW) and a *South rest-of-the-world* country (SROW). While we do not model impacts outside the EU, we capture the impact of forces coming from outside of the EU, in line with our objective. We choose to aggregate Canada, Japan and the USA to form the stylized NROW country while we choose Brazil, China and India to 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, we ignore micro-level data specific to Rest-of-the-world countries. We follow instead a three step approach. First, for each of the six Rest-of-the-world country, we identify a twin country (or a set of countries) from our sample of 14 calibrated countries whose demographic, economic and policy characteristics are the closest. Second, we use the micro-level data inputs for this twin country in the calibration process of the NROW and SROW. Third, we make stylized corrections to the resulting calibration outcome 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.

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14 Because the project focuses on demographic and economic components and not on health technology components, which may differ across countries, I apply the same reduction to all countries, taking the projections for Germany from the Ageing Working Group (2015).

15 With these choices we are capturing close to 60% of the actual real world GDP and five of the eleven most important trade partners of the EU, together reflecting more than 40% of total trade of the EU.

16 For details on the calibration of the Rest-of-the-world countries, see Davoine and Molnar (2017).
3 Quantitative analysis

To assess the bias generated by the small open economy or the closed economy assumption in macroeconomic quantitative evaluations, I will use the same model basis and compare the simulated outcomes of standard reforms or demographic shocks in different versions of the model for a panel of 14 European Union countries.

Model versions: The three main versions will be a single-country model using the small open economy assumption (denoted SOE), the same single-country model version using the closed economy assumption (denoted CE) and a multi-country model with perfectly integrated capital markets (denoted MC). At the country level, the multi-country version is the same as the single-country versions. The only difference is the definition of the interest rate, which is identical to all countries when capital markets are perfectly integrated. In reality, capital markets are getting more integrated over time but are not yet fully integrated, while the degree of integration appears difficult to quantify in an unambiguous fashion (see e.g. Poterba, 2001; Obstfeld and Taylor, 2003). For ease of presentation, I will assume that capital markets are fully integrated and refer to the outcomes of the multi-country model (MC) as the benchmark or true outcome. I will return to this simplification in section 4. The small open economy bias will thus refer to the difference between the small open economy and the benchmark multi-country outcomes, while the closed economy bias will refer to the difference between the closed economy and multi-country outcomes.

Shocks and reforms: I consider three standard reforms and shocks, as the biases may depend on their type and magnitude. The first is a fiscal devaluation, where labor income taxes are reduced and consumption taxes increased in a budget-neutral fashion. Specifically, the income tax rate is decreased 20% and the consumption tax increased to keep public debt constant, a mild reform. The second reform is larger in magnitude and corresponds to unusual measures typical of crises. I consider a financial bailout comparable to the support provided by the German government after the 2007 subprime crisis. According to the International Monetary Fund (2013), the net public support to the financial sector following the subprime crisis amounted to 10.8% of GDP, as of 2012. Allowing for support in other sectors, I consider public expenditures increases of 25% during 5 years, or 2.5% of GDP in Germany, to support the recovery efforts of private agents in a pure balance sheet fashion. Whether of own decision or because of external pressure, governments keep their public debt constant at all times with an increase in labor income taxes. Because public debt is a safe asset issued in nominal terms during a crisis, the price of public debt is lower than the price of private debt. The third reform is combined with a demographic shock, namely population aging. I assume that there are no social security reforms and that the increase in social security expenditures - public pensions, long-term care and healthcare - due to aging is financed with the general government budget. Specifically, labor income taxes are increased to keep public debts constant. As the population in Europe is projected to age at a rapid pace over the next decades, the magnitude of the shock and reforms is largest over the long run.
Figure 2: GDP impacts, aging and labor tax reforms in 3 cases, 2 countries, 2015-2065.

For analysis purposes, I will consider variations of these three reforms, providing details when needed.

To build intuition and get a sense of possible biases, I first look at the population aging case in isolation. In-depth analysis follows, starting with a characterization of biases in general and continuing with explanations. A last look at a special case will close the section.

3.1 A first look at the bias

Population aging over the next decades is a large shock on the economy, especially when the retirement age increases slower than life expectancy. The limit case with constant retirement age is considered here. Country-specific population aging follows the demographic projections from Eurostat for the 14 European countries and the United Nations for the two stylized Rest-of-the-world countries.

Outcomes are provided for the two largest European countries, France and Germany, in figure 2 and table 1. Results for the entire country set are deferred to section 3.2.

The figure shows the simulated variations of GDP per capita, the main macroeconomic indicator in this paper, between 2015 and 2065 for the three cases, \(SOE\), \(CE\) and \(MC\). There are some significant differences, the small open economy (\(SOE\)) case in particular leading to more pessimistic outcomes than the other two cases. The average GDP per capita difference between the small open economy (\(SOE\)) and benchmark (\(MC\)) case is close to 6.5 %-points over the time period (as reported in table 1). Also notable is
<table>
<thead>
<tr>
<th></th>
<th>France</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SOE</td>
<td>CE</td>
</tr>
<tr>
<td>Labor tax (pp)</td>
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</tr>
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</tr>
<tr>
<td>Labor/capita**</td>
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<tr>
<td>Capital/capita**</td>
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<td>-2.0</td>
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<td>GDP/capita**</td>
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<td>-4.9</td>
</tr>
<tr>
<td>GDP/capita Gap***</td>
<td>-6.6</td>
<td>-2.1</td>
</tr>
</tbody>
</table>

**Legend:** SOE = single-country with small open economy assumption; CE = single-country with closed economy; MC = multi-country with perfect capital market integration; (pp) = percentage points variation in 2065 compared to 2015; (%) = percentage variation in 2065 compared to 2015; ** = average variation over years 2015 to 2065, compared to 2015 (in %); *** = difference of the average GDP/capita variation with the MC case (in percentage points).

Table 1: Selected impacts, aging and labor tax reforms in 3 cases, 2 countries, 2015-2065.

The fact that outcomes are more pessimistic with a closed economy (CE) than in the benchmark case (MC) for Germany, but more optimistic in France. As discussed further in section 3.3, capital markets integration indeed leads to cross-country redistribution, from fast aging countries, such as Germany, to slow aging countries, such as France.

The closed economy bias is however smaller in magnitude than the small open economy bias, as can be seen in table 1. The closed economy bias averages 2.1 %-points of GDP per capita over the next five decades in France and 2.9 %-points in Germany (in magnitude), while the small open economy bias reaches 6.6 %-points in France and 6.5 %-points in Germany. As will be seen in section 3.2, the small open economy bias is even larger in other countries, reaching 11 %-points in Spain.

I finish with a focus on the small open economy bias, which is larger, and refer to Davoine (2018) for the closed economy bias. Borrowing information for all countries in the sample from table 2, one can summarize:

**Finding 1. (Bias magnitude with population aging)** Long run projections of the impact of population aging where labor income taxes are used to keep public debts constant are more pessimistic under the small open economy assumption, sometimes by a significant margin: in 9 countries out of 14, the predicted GDP per capita for each of the next 50 years drops at least 6 %-points more with the small open economy assumption than either of the two other assumptions; in one case, the gap is larger than 11 %-points.

The reason for such a finding is directly tied to the assumptions on the interest rate. Life expectancy increases with population aging. With a constant retirement age, households increase saving to maintain consumption after retirement, an intertemporal smoothing mechanism (assets per capita increase 13% or more in France, 22% or more in
Germany). When the interest rate is flexible (in the closed economy and multi-country cases), the increasing supply of capital drops its price (the interest rate drops 26% or more in France, 36% or more in Germany), which stimulates investment, builds the capital stock (relative to the small open economy case, capital per capita increases 6 %-points or more in France and 11 %-points or more in Germany) and thus reduces the GDP per capita drop. When the interest rate is constant (small open economy case), there is no such investment stimulation mechanism.

On top of investment incentives is an additional reinforcing mechanism. The relative increase of the capital stock in the flexible interest rate cases pushes the capital-labor ratio up, thus increasing the wages and stimulating labor supply (relative to the small open economy case, labor supply per capita increases 2.5 %-points or more in France and 4.0 %-points or more in Germany), which further contributes to sustaining production in the closed economy and multi-country cases.

3.2 A detailed look at the bias

Section 3.1 showed that the small open economy projections of the macroeconomic impact of population aging are significantly more pessimistic than the benchmark multi-country projections, while the closed economy bias is smaller, more optimistic for some countries and more pessimistic for others. In this section I investigate whether these findings hold for other types of reforms or shocks and consider all countries in the sample. For analysis purposes, I include some cases which are not realistic. I move from largest to small shocks, starting with aging, continuing with financial bailouts in crises times and finishing with a reform typical of normal times, fiscal devaluation.

Table 2 provides the macroeconomic impacts of the population aging scenario, where labor income taxes are used to finance increasing social security expenditures and keep public debts constant. The GDP per capita variations, the summary macroeconomic indicator, averaged over the next five decades, are provided for all European countries in the sample. The average impact for these countries scaled by economic size (GDP) is also provided. Compared to section 3.1 another case is reported, namely a counterfactual case where there is population aging in all European countries but not in the rest of the world (denoted $MC^*$). This unrealistic case will be useful to summarize findings on single-country biases and will be discussed later.

Outcomes reported in table 2 reflect those presented and discussed in section 3.1. Projections with the small open economy assumption are systematically more pessimistic than the benchmark multi-country projections, with an average bias of 7 %-points of GDP per capita, a minimum of 4 %-points (Poland) and a maximum of 11 %-points (Spain). Because of cross-country redistribution from fast to slow aging countries, the closed economy bias is sometimes optimistic and sometimes pessimistic, a point I will further discuss below. In magnitude however, the closed economy bias is smaller than the small open economy bias, never exceeding 5 %-points.

Table 3 provides the same outcomes as table 2 but for a different shock, namely financial bailouts comparable to those following the 2007 subprime crisis. Because the bailout measures only last 5 years, a smaller time horizon is considered, long enough
### Table 2: Average GDP per capita impacts, Aging and labor tax reforms.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
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<td>-15.74</td>
<td>-8.07</td>
<td>-13.30</td>
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<td>-8.11</td>
<td>7.64</td>
<td>-0.04</td>
</tr>
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<td>-8.39</td>
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<td>-4.87</td>
<td>5.07</td>
<td>-1.26</td>
</tr>
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<td>-1.64</td>
</tr>
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<td>-2.62</td>
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<td>2.10</td>
</tr>
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<td>-4.62</td>
<td>8.53</td>
<td>1.29</td>
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<td>-7.89</td>
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<td>-8.84</td>
<td>6.34</td>
<td>-1.07</td>
</tr>
<tr>
<td>Spain</td>
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<td>-4.23</td>
<td>-12.51</td>
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<td>-5.24</td>
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<td>Sweden</td>
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<tr>
<td>Average Europe</td>
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<td>-9.57</td>
<td>2.22</td>
<td>-5.10</td>
<td>-4.84</td>
<td>6.95</td>
<td>-0.38</td>
</tr>
</tbody>
</table>

**Legend:** SOE = single-country with small open economy assumption; CE = single-country with closed economy; MC = multi-country with perfect capital market integration; MC* = as MC but reforms in Europe only, no reform in rest of the world; Average Europe = average for all 14 European countries in the sample.

However to take full recovery into account (25 rather than 50 years). Here again, the small open economy bias is larger (averaging 1.0 % -points of GDP per capita, in magnitude) than the closed economy bias (averaging 0.3 % -points). Unlike with aging however, the alternative scenario where the bailout only takes place in Europe (denoted MC*) is realistic. One can even argue that this scenario is more realistic than the scenario where all countries around the world perform a bailout (denoted MC). In this Europe-only case, results are overturned: the small open economy bias (averaging 0.5 % -points) is smaller than the closed economy bias (averaging 0.8 % -points).

The pattern is similar with the third set of reforms, namely fiscal devaluation, whose simulated outcomes are reported in table 4. Because the magnitude of the reform is smaller, impacts are also smaller. As for the bailouts, the small open economy bias is larger than the closed economy bias when all countries around the world perform the reform (respective averages 0.11 and 0.06 % -points of GDP per capita), but the opposite when non-European countries abstain (respective averages 0.02 and 0.03 % -points, in magnitude).

Getting back to the unrealistic case where Europe only is aging from table 2, the same observation can be made on the single-country biases. To sum up:
### Table 3: Average GDP per capita impacts, Bailouts.

**Finding 2. (Best average single-country approximation)** Closed economy estimates of the average impacts in Europe are closer to the benchmark multi-country estimates than small open economy estimates when all countries around the world are submitted to the demographic shock or reform, and vice-versa when non-European countries are not submitted to the shock or reform.

As a corollary, the finding can be extended to cases where only one European country performs the reform. In these cases, the small open economy bias is smaller than the closed economy bias\(^{17}\).

The finding, which holds for the average impacts at the European level, can also be extended at the country level, in most but not all cases. The finding holds for instance for each country in case of population aging, as seen in table 2. Because shocks are smaller and there are cross-country redistribution effects\(^ {18}\), the finding holds for most but not all countries in case of a bailout. As shown in table 3, in the realistic case where non-European countries do not perform a bailout, the small open economy bias is smaller for all countries except three (Austria, Slovakia and Spain).

Three further observations are worth making. The discussion of table 2 mentioned

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\(^{17}\)Unreported results available upon request.

\(^ {18}\)These cross-country redistribution effects are interesting but out of scope of this paper. See Davoine (2018) for cross-country redistribution due to population aging and capital markets integration.
### Table 4: Average GDP per capita impacts, Fiscal Devaluation.

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<tr>
<th>Country</th>
<th>SOE</th>
<th>CE</th>
<th>MC*</th>
<th>MC</th>
<th>MC*-SOE</th>
<th>MC*-CE</th>
<th>MC-CE</th>
<th>MC-SOE</th>
<th>MC-CE</th>
</tr>
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<td>0.08</td>
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<td>0.09</td>
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<tr>
<td>Average Europe</td>
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<td>-0.03</td>
<td>0.56</td>
<td>0.11</td>
<td>0.06</td>
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</table>

**Legend:** SOE = single-country with small open economy assumption; CE = single-country with closed economy; MC = multi-country with perfect capital market integration; MC* = as MC but reforms in Europe only, no reform in rest of the world; Average Europe = average for all 14 European countries in the sample.

That the closed economy bias was sometimes optimistic and sometimes pessimistic, because of cross-country redistribution. The bias is optimistic for Germany for instance, as the closed economy estimates predict an average GDP per capita drop of 1.2% while the benchmark multi-country estimates predict a 4.1% drop, a -2.9 %-points bias. Conversely, the bias is pessimistic for a country like France, at +2.1 %-points. The small open economy bias is however always pessimistic. The outcome for France means that the benchmark multi-country outcome (-2.8%) is not bracketed by the small open economy outcome (-9.4%) and the closed economy outcome (-4.9%). Summing up:

**Finding 3. (Bracketing exceptions)** While the benchmark multi-country outcome is bracketed by the small open economy outcomes and the closed economy outcomes at the European level, it is not always the case at the country level, when population is aging and labor income tax increases keep the public debts constant.

The small open economy case and the closed economy case are polar opposites when it comes to interest rate variations, with the multi-country case an intermediate case. Intuitively, one would thus expect that multi-country outcomes are intermediate between small open and closed economy outcomes. Finding 3 shows that it is not the case.

Section 3.1 showed that estimates with the small open economy assumption were
Reform or shock | In | GDP/capita change (%)
|---|---|---
| | Average Europe 2015-2065* | SOE | CE | MC | Gap | Gap
| | | MC-SOE | MC-CE
| Fiscal Devaluation | Germany only | 0.08 | 0.10 | 0.08 | 0.00 | -0.02
| | Europe only | 0.46 | 0.50 | 0.48 | 0.02 | -0.03
| | World | 0.46 | 0.50 | 0.56 | 0.11 | 0.06
| Bailout* | Germany only | -0.20 | -0.48 | -0.22 | -0.02 | 0.26
| | Europe only | -0.58 | -1.81 | -1.03 | -0.45 | 0.78
| | World | -0.58 | -1.81 | -1.55 | -0.96 | 0.26
| Aging | Europe only | -11.79 | -4.47 | -9.57 | 2.22 | -5.10
| | World | -11.79 | -4.47 | -4.84 | 6.95 | -0.38

Legend: SOE = single-country with small open economy assumption; CE = single-country with closed economy; MC = multi-country with perfect capital market integration; * = Average 2015-2040 (not 2015-2065) for Bailout; ; Average Europe = average for all 14 European countries in the sample.

Table 5: Results overview, average GDP per capita impacts in Europe.

Pessimistic when population is aging in all countries. Does the same happen in all cases? Examination of outcomes in tables 2, 3 and 4 shows that it does not. One can summarize the examination as follows:

**Finding 4. (Optimistic versus pessimistic biases)** One cannot conclude that the single-country estimates with the largest bias are always pessimistic, or always optimistic, compared to the benchmark multi-country outcomes, or that either the small open economy bias or the closed economy bias are always too pessimistic, or always too optimistic. Pessimism or optimism rather depend on the shock or reform, and exceptions occur. On average and for all countries, the small open economy estimates are too pessimistic when population is aging and too optimistic in case of financial bailouts. Except for a few countries, closed economy estimates are too pessimistic in case of financial bailouts.

Given the small size of single-country biases with fiscal devaluation, they are not considered in the finding. As noted in the discussion of finding 3, there are cross-country redistribution patterns due to population aging and capital market integration, which explains why closed economy estimates appear pessimistic for some countries and optimistic for other countries in population aging cases.

For the last observation, it is useful to collect the average outcomes presented above and similar experiments where only one country reforms, which is done in table 5.

The table shows that average single-country biases are small with fiscal devaluations (at most 0.11 %-points of GDP per capita), medium with financial bailouts (less than 1.0 %-points) and large with population aging (up to 7.0 %-points). One can also note that the magnitude of the shocks grow in a parallel way, considering for instance the average GDP per capita impacts (respectively less than 0.6%, less than 1.6% and up to 11.8%). One can thus loosely summarize:
Finding 5. (Size of single-country biases) The larger the impact of the shock or reform, the larger the sizes of the small open economy bias and the closed economy bias.

3.3 Explaining the bias

This section provides explanations for the findings formulated in section 3.2. Explanations are given for the aging and bailout cases, where effects are most visible, and rely on detailed outcomes for two countries reported in tables 6 and 7. Appendix A supplies the information which confirms that the same explanations apply to the last case, fiscal devaluation.\(^1\)

According to finding 2, the closed economy bias is smaller when all countries are exposed to the shock or reform, while the small open economy bias is smaller when the shock or reform takes place in Europe only. I start the explanation with the aging shock, and then extend it to the bailout reforms.

When population ages and the retirement age is constant, households’ savings increase to finance consumption after retirement (table 6 shows that assets per capita increase 12% or more in France and 22% or more in Germany), a supply shock on the capital markets which leads to a drop in the interest rate when it is flexible. When capital markets are integrated, the interest rate drops 13% when Europe only is aging (case \(MC^*\) in table 6) but 36% when all countries around the world are aging (case \(MC\)). The first case is thus closer to the small open economy case (SOE), where the interest is constant by design. By contrast, the interest rate drops in significant fashion in the closed economy case (CE), 26% in France and 59% in Germany (and an unreported average of 40% in all European countries), which is closer to the case where all countries in the world are aging. Because interest rate variations drive savings behavior and impact aggregate equilibrium, it is not a surprise that the small open economy predictions are closer to the multi-country benchmark outcome where Europe only is aging, while closed economy predictions are closer to the benchmark outcome where the entire world is aging. The reason for the limited drop of the interest rate (13%) with integrated capital markets and aging only in Europe is the smaller supply shock on the capital markets, the European countries in the simulation model weighing about one third of the worldwide economy.

A similar explanation holds for the bailout reforms. As reported in table 7, the interest rate increases 0.7% with integrated capital markets and bailouts restricted to Europe (\(MC^*\)) but 1.4% when bailouts take place around the world (\(MC\)). The closed economy estimates (CE), where the interest rate increases between 1.8% and 2.3%, are thus closer to the benchmark estimates with worldwide reforms.

Finding 3, which shows that multi-country outcomes are not always bracketed by small open and closed economy outcomes when population is aging, is due to cross-

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\(^{1}\)This section provides explanation for biases in estimates, not for estimates themselves. As a brief reminder, GDP per capita declines with population aging and a constant retirement age because labor supply per capita is dropping (for more, see Auerbach and Kotlikoff, 1987). GDP drops with financial bailouts because the increase in government spending crowds out private investment (for more, see Daveine and Molnar, 2017).
Table 6: Selected impacts, aging and labor tax reforms in 4 cases, 2 countries, 2015-2065.

country redistribution from fast aging to slow aging countries (Davoine, 2018). In a fast aging country, labor supply per capita drops faster, the capital-labor ratio increases faster and thus the returns to investment drop, relative to slow aging countries. When capital markets are integrated, investors re-balance their portfolio over time, generating capital outflows in fast aging countries and capital inflows in slow aging countries, ceteris paribus.

Finding 4 contends that optimism or pessimism in single-country biases in general depend on reforms and shocks, rather than the single-country assumption on the interest rate. Aging with constant retirement age leads households to save to finance consumption in old-age, a positive supply shock on the capital markets. Bailouts by governments constitute a drag on the capital markets which crowds out private investment, a negative demand shock on the capital markets. When flexible, the interest rate thus declines with aging and increases with bailouts, which eases investment in the first case and depresses it in the second case. Under the closed economy assumption, effects are larger than in the benchmark case with integrated capital markets. In the aging case, non-European countries are indeed projected to age at a slower pace, leading to a milder supply shock on the integrated capital markets than in a closed economy setting with domestic capital markets. In the bailout case, non-European countries have smaller government expenditures and the bailout reforms are defined by a proportional (25%) increase of these expenditures, leading to a milder average demand shock on the integrated capital markets than in domestic markets. Ceteris paribus and ignoring cross-country redistribution effects, there is an optimistic bias in investment and thus output with population aging with closed economy estimates, and a negative bias under financial bailouts. The converse applies for the small open economy estimates.

Finding 5, which contends that the single-economy biases increase with the size of the shock or reform, is intuitive. Compared to the benchmark multi-country model with integrated capital markets, key components are missing in single-economy models. In models using the small open economy assumption, investment and saving behaviors are
Table 7: Selected impacts, bailouts in 4 cases, 2 countries, 2015-2040.

<table>
<thead>
<tr>
<th></th>
<th>France</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SOE</td>
<td>CE</td>
</tr>
<tr>
<td>Labor tax (pp)</td>
<td>0.38</td>
<td>0.72</td>
</tr>
<tr>
<td>Assets/capita**</td>
<td>-1.81</td>
<td>-2.29</td>
</tr>
<tr>
<td>Labor/capita**</td>
<td>-0.13</td>
<td>-0.45</td>
</tr>
<tr>
<td>Interest rate (%)</td>
<td>0.00</td>
<td>1.75</td>
</tr>
<tr>
<td>Capital/capita**</td>
<td>-0.19</td>
<td>-2.24</td>
</tr>
<tr>
<td>GDP/capita**</td>
<td>-0.50</td>
<td>-1.62</td>
</tr>
</tbody>
</table>

Legend: (pp) = percentage points variation in 2040 compared to 2015; (%) = percentage variation in 2040 compared to 2015; ** = average variation over years 2015 to 2040, compared to 2015 (in %); SOE = single-country with small open economy assumption; CE = single-country with closed economy; MC = multi-country with perfect capital market integration; MC* = as MC but reforms in Europe only, no reform in rest of the world.

distorted, because interest rate variations are exogenous. In models using the closed economy assumption, supply shocks on the capital markets are too strong, leading to large interest rate variations, and thus distorted savings and investment behaviors variations. The larger the shock on the economy, the larger the distortion.

3.4 A final look at the bias

The first look at the bias, in section 3.1, helped to build intuition and a general understanding of the performance of single-country evaluations in a global context, a general understanding subsequently refined in sections 3.2 and 3.3. As a final look at the bias this section considers a special case, which helps to define the limits of single-country evaluations.

Specifically, I consider two realistic pension reform options in a population aging context and focus on Belgium. Confronted with the public finance challenge of aging, many governments have implemented or scheduled social security reforms, including retirement age increases and reductions in pay-as-you-go pension benefits. Over the sample of European countries considered in this paper, own reform plans range from a 2% cut of the pension benefit ratio over the next 50 years (Belgium) to a 39% cut (Poland), the average being a 19% cut. I thus consider the following hypothetical scenarios: either each country sticks to its own pension cut plans, or they all implement the average pension cut. When needed, labor income taxes are increased to keep public debts constant.

Table 8 provides simulated outcomes in Belgium for the two scenarios, using the three different interest rate modelling options.

Consistent with finding 1, the simulated impact on GDP per capita is visibly pessimistic with the small open economy assumption, predicting an average decrease of 9.5 %-points or more while the benchmark multi-country outcome is a decrease smaller than 5.0 %-points.

The comparison of the closed economy and multi-country outcomes for the two pen-
Finding 6. (Opposite policy implications in specific cases) Closed economy comparisons of two pension cut options in all European countries with aging populations lead to opposite conclusions for Belgium than the benchmark multi-country comparisons with perfectly integrated capital markets (country-specific pension cuts deliver an average 0.8 %-points of GDP per capita gain each of the next 50 years with a closed economy, while average pension cuts deliver an average 0.4 %-points gain with integrated capital markets).

It is worth noting that the finding does not apply to other countries, although the magnitude of the gains for one or the other reforms may differ between closed economy and multi-country projections for a few countries.

The explanation for such an outcome has two steps. Notice beforehand that the scheduled own pension cuts of 2% are small and require variations of labor income taxes which are close to a scenario with no pension cuts at all. To simplify the exposition, I thus compare a tax hike scenario with the average pension cut scenario.

First, tax hikes can be preferable to a 19% pension cuts in a closed economy setting, where capital markets are separated. Each of the two options has advantages and disadvantages. Tax hikes directly reduce labor supply incentives. Pension benefit cuts reduce the value of accumulated pension rights in pay-as-you-go pension systems with earnings-related components, thus indirectly reduce labor supply incentives. Which of the negative and positive effects dominate depends on the specifics of the tax and pension systems. One remarkable feature in Belgium is that the tax and social security contri-
bution burden is distributed relatively evenly over the life-cycle, retirees being exposed to an average cumulative rate which is 90% of the average cumulative rate of working households. By comparison, the (unweighted) average is 56% in the other countries of the simulation sample. Unlike in other countries, financing with labor income taxes is preferable to financing with pension cuts with a closed economy.

The second step involves capital markets integration. Another effect weighs on the balance between tax hikes and pension cuts, namely aging differentials across countries. Ceteris paribus, tax hikes reduce labor supply incentives more directly, thus increasing the capital-labor ratio and dropping returns to investments more. With an integrated capital markets, investments will flow abroad with large tax hikes. Pension cuts avoid this capital outflow, because taxes do not need to be increased as much.

4 Implications

Implications from section 3 results can be derived for policy analysis, rather than policy itself. Before starting, it is useful to remember that capital markets are getting increasingly integrated (Longin and Solnik, 1995), but are not yet fully integrated (e.g. Gropp and Kashyap, 2010; Morelli, 2010). Outcomes of the multi-country simulations assuming perfectly integrated capital markets thus represent a benchmark with partial but increasing relevance. These benchmark outcomes are particularly relevant for analyses of population aging effects, typically considered over the next five decades. In the meantime, the true effects lie somewhere between those simulated with the closed economy assumption and those simulated with the multi-country model with perfectly integrated markets.

Implication 1: the use of the small open economy assumption leads to severely pessimistic projections of the macroeconomic impact of population aging and should be avoided.

As finding 1 notes and table 2 displays, the average GDP per capita is projected to be 7 %-points lower with the small open economy assumption, when labor income taxes finance the increase in social security expenditures. In one country, the gap is as large as 11 %-points. Davoine (2018) finds similar results when other means of financing are used than labor income taxes, such as pension cuts or increases in retirement age.

Ideally, one should use projections with multi-country models having perfectly integrated capital markets and projections with a single-country model relying on the closed economy assumption, the reality lying somewhere in the middle. Over the long-run and as argued above, a greater weight should be placed on the multi-country projections.

Implication 2: if no multi-country model is available and population aging is involved or reforms are applied at the worldwide level, a single-country model with a closed economy assumption should be used and a rule-of-thumb interpretation applied.

As shown in table 2 for instance, the differences between closed economy projections and multi-country projections are indeed notably smaller than with small open economy
projections. Projections with the closed economy assumption are sometimes too optimistic and sometimes too pessimistic, as noted in finding 3. When capital markets are (partially) integrated, a redistribution phenomenon takes place from fast aging to slow aging countries, as countries with a lower capital-labor ratio offer higher investment returns, ceteris paribus. The rule of thumb is thus to consider closed economy projections as too optimistic in fast aging countries and too pessimistic in slow aging countries.

**Implication 3:** when reforms or shocks take place at the country or regional level and no multi-country model is available, a single-country model with a small open economy assumption should be used.

Finding 2 indeed shows that projections with the small open economy assumption are closer to the benchmark multi-country projections than projections with a closed economy assumption. The finding holds even for reforms or shocks applied to the whole Europe, or any aggregate accounting as much as one third of the worldwide economy activity. This may come as a surprise, a third of the economy activity not sounding very “small”.

**Implication 4:** for standard reforms in normal times implemented in one or a few countries, the small open economy estimates can be considered close to the true effects.

The true effects indeed lie between the closed economy estimates and the multi-country estimates with perfect capital markets integration. As finding 2 notes and table 4 illustrates for instance, the small open economy estimates (SOE) are near the multi-country estimates (MC*), the difference never exceeding 10% (with the exception of Slovakia, at 15%). Further and as finding 5 notes, the single-country biases are small when reforms impacts are moderate, which are typical of normal times.

**Implication 5:** absent a multi-country model, averaging outcomes from single-country analysis with the small open economy assumption and outcomes with the closed economy assumption, in the hope of obtaining more accurate outcomes, is not recommended.

Finding 3 indeed shows that small open and closed economy outcomes do not always enclose the benchmark multi-country outcomes, because of cross-country redistribution patterns due to capital market integration. While small open economy estimates are always too pessimistic under population aging, open economy estimates are sometimes too pessimistic, sometimes too optimistic. Averaging two pessimistic projections will not help.

**Implication 6:** as a cautionary tale, there are reform cases with population aging where policy implications from closed economy evaluations and from multi-country evaluations are opposite.

In these cases, no alternative to using multi-country models for policy evaluation appears. Specifically, I refer to findings 1 and 6, focusing on pension reforms options in Belgium with an aging population. As population is aging, finding 1 implies the use of closed
economy assumptions in the absence of multi-country model projections. Finding 6 however shows that analyses of pension reform options with a closed economy assumption would lead to mistaken policy recommendations, as these analyses would recommend to the Belgium government to prefer their own pension cuts (where the replacement ratio is cut 2%) to the average pension cut scheduled by the European countries in our sample (where the replacement ratio is cut 19%). Such evaluations quantify an average gain of 0.8 %-points of GDP per capita with the small pension cuts, each of the next 50 years. The multi-country projections assuming perfect capital markets integration, which I argued above is an ever more realistic assumption in a population aging context, recommend the implementation of the large pension cut, for an average yearly gain of 0.4 %-points of GDP of capita. Relying on single-country projections may thus lead to unfortunate policy recommendations, at some point of capital markets integration. Whether the use of multi-country models with perfect capital markets integration is already preferable or not depends on the extent to which capital markets are currently integrated, an open empirical and modelling question left for future research.

**Summary:** the following rules of thumbs summarize the key implications for policy analysis, when no multi-country model is available. First, the small open economy assumption leads to pessimistic estimates and should be avoided when population aging is involved. In this case, a closed economy assumption is preferable and comes, ceteris paribus, with an optimistic bias if the country is aging fast and a pessimistic bias if it is aging slow. Second, small open economy estimates are preferable when the shock or reform takes place at a country or regional level. Third and as a reminder, there are exceptional cases with population aging where closed economy approximations lead to unfortunate policy recommendations.

5 Concluding remarks

In a globalized economy with ever more integrated markets, the use of single-country models for macroeconomic evaluations may become problematic. The capital markets in particular are becoming increasingly integrated, begging the question of the appropriate modelling of interest rate variations. To shed light on the question, I compare long-run simulation outcomes for a sample of 14 European countries using three modelling options, constant interest rate in a single-country setting assuming small open economies, endogenous interest rate in a single-country setting assuming closed economies and endogenous interest rate in a multi-country setting assuming perfectly integrated capital markets.

I find small differences between the three options for reforms of moderate magnitude, typical of normal times. Differences increase however with the size of the shocks. If population ages and governments use labor income taxes to finance increasing old-age social security expenditures, the small open economy estimates are too pessimistic in a significant way. Averaged over all European countries in my sample, they indeed predict that GDP per capita declines 11.8% each of the next fifty years, 7.0 %-points more than
closed economy and multi-country estimates, which encapsulate the true predictable outcome.

When no multi-country model is at hand, I find however that small open economy estimates may be preferable to closed economy estimates in some cases, namely when the reforms or the shocks take place at the country or regional level (as opposed to the global level, such as population aging). The finding holds for regional aggregates accounting up to a third of the global aggregate, a high fraction which does not sound "small" and may come as a surprise.

Among further other findings are cases with population aging which act as cautionary tales, where policy implications from closed economy estimates and multi-country estimates are opposite. In general and because of cross-country redistribution, small open economy and closed economy estimates do no bracket multi-country estimates in slow aging countries. If capital markets stay on their integration course, there may be no alternative to the use of multi-country models for policy evaluation with an aging population.

Capital markets are getting increasingly integrated but are not yet fully integrated. They also have different components, such as banking or the stock market, which may integrate at different speed. For simplicity, this paper has ignored these realities and used a multi-country model with a unique and perfectly integrated capital market. Future research could extend the analysis presented in this paper by defining and implementing an index for the degree of integration of a unique capital market, relying on consensual empirical estimates of the degree of integration of the various sub-markets. I suspect that the findings presented in this paper remain identical, at least from a qualitative standpoint. Some findings should even remain similar from a quantitative point of view, such as the small open economy bias under population aging.
References


## Appendix: details for fiscal devaluation

Table 9 provides details on outcomes of the evaluation of fiscal devaluation reforms.

<table>
<thead>
<tr>
<th></th>
<th>France</th>
<th></th>
<th></th>
<th>Germany</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SOE</td>
<td>CE</td>
<td>MC*</td>
<td>MC</td>
<td>SOE</td>
<td>CE</td>
</tr>
<tr>
<td>Labor tax (pp)</td>
<td>-2.76</td>
<td>-2.76</td>
<td>-2.76</td>
<td>-2.76</td>
<td>-2.42</td>
<td>-2.42</td>
</tr>
<tr>
<td>Assets/capita**</td>
<td>1.12</td>
<td>1.21</td>
<td>1.16</td>
<td>1.33</td>
<td>1.81</td>
<td>1.90</td>
</tr>
<tr>
<td>Labor/capita**</td>
<td>0.54</td>
<td>0.55</td>
<td>0.55</td>
<td>0.57</td>
<td>0.33</td>
<td>0.36</td>
</tr>
<tr>
<td>Interest rate (%)</td>
<td>0.00</td>
<td>-0.23</td>
<td>-0.10</td>
<td>-0.59</td>
<td>0.00</td>
<td>-0.40</td>
</tr>
<tr>
<td>Capital/capita**</td>
<td>0.40</td>
<td>0.47</td>
<td>0.43</td>
<td>0.57</td>
<td>0.39</td>
<td>0.54</td>
</tr>
<tr>
<td>GDP/capita**</td>
<td>0.44</td>
<td>0.48</td>
<td>0.46</td>
<td>0.54</td>
<td>0.35</td>
<td>0.43</td>
</tr>
</tbody>
</table>

**Legend:** (pp) = percentage points variation in 2065 compared to 2015; (%) = percentage variation in 2065 compared to 2015; ** = average variation over years 2015 to 2065, compared to 2015 (in %); SOE = single-country with small open economy assumption; CE = single-country with closed economy; MC = multi-country with perfect capital market integration; MC* = as MC but reforms in Europe only, no reform in rest of the world.

Table 9: Selected impacts, fiscal devaluation reforms in 4 cases, 2 countries, 2015-2065.