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Abstract

Higher fertility slowly increases the workers-to-retirees ratio over the long run, which can ease the pension financing challenge brought about by population aging. It may or may not increase production per capita. Existing simulation studies all find a positive impact on public finances over the long run. They however differ on the impact on output per capita. Whether differences are due to model designs or country characteristics is unknown. Using the same macroeconomic model for a sample of 14 European countries, I find that the long-run pension deficits are reduced 27% on average, if one woman out of five had one more child in her lifetime. Variations across countries are small. On the other hand, I find that output per capita increases in all countries from my sample, with one exception. Differences in population structures, age-productivity profiles and pension systems can explain the exception. Fertility-promoting policies will always ease the public finance challenge due to population aging, but may worsen output per capita if pension payments are too loosely connected to earnings histories or if age-productivity profiles are very steep.

Keywords: fertility, population aging, pensions, productivity profiles, computable general equilibrium

JEL-Classification: C68, H55, J11, J13

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1 Introduction

Fertility impacts the workers-to-retirees ratio and thus the level of taxation needed to finance public pay-as-you-go pension systems, as well as labor supply incentives and, ultimately, production. Higher fertility also leads to capital dilution, an opposite impact on output. I investigate to which extent the long-run economic impact of fertility differs across countries. I find similar public finance impacts in a sample of 14 European countries, but differences in output impacts. These differences can be explained by population structures, age-productivity profiles and pension systems. As an implication, policy measures promoting fertility should be associated to pension designs where payments depend closely on earnings histories.

Driven by increases in the life expectancy and sluggish fertility rates, population aging slowly reduces the ratio of workers-to-retirees, putting pressure on the financing of old-age social security. Higher fertility would reduce the drop of the workers-to-retirees ratio, easing the public finance challenge, and vice-versa. Hirte (2002) finds for instance that taxes would have to be increased by 25 percentage points in Germany over the long run if the population growth rate dropped from 0.85% to -0.3%, while Imrohoroglu et al. (2016) find that public debt would increase by more than 0.2 percentage points of GDP in Japan if women had on average 0.2 less child over their lifetimes.

Absent reforms of pay-as-you-go pensions, their increasing costs are often financed by the general government budget. The consequence of increased taxation is a drop in labor supply incentives, which can hurt production per capita. Higher fertility reduces the need to increase taxes, which can have a positive impact on production, if capital dilution effects are small. Existing studies obtain different results. Krueger and Ludwig (2007) for instance find a negative long-run impact on output per capita, while Fehr et al. (2008) find a positive impact. Whether these differences are due to country characteristics or model design is unknown.

In this paper, I make a systematic investigation of the long-run impact of fertility on public finances and output and how the impacts can differ across countries. For large differences, I identify some explanation factors.

To make this investigation, I use the same macroeconomic model for a sample of 14 European countries. As the impact of fertility is slow, I consider impacts over the next five decades. Because population aging takes place over that time horizon, I use an overlapping-generations model of the Auerbach and Kotlikoff (1987) family, with a detailed modelling of pension systems and their influence on labor supply decisions. A country-specific calibration will allow to compare the impact of the same fertility shock across countries.

In line with the literature, I find that an increase in fertility leads to long-run public finance gains in every country. Averaged over my country sample, I find that the financing deficit of public pay-as-you-go pensions would be 27% lower in 50 years if every woman had 0.2 more children in their lifetime. Output per capita, on the other hand, increases in all countries of my sample, except Sweden. Averaged over the entire sample, I find that GDP per capita would be 0.7 percentage points higher in 50 years for the same fertility shock. GDP per capita would increase most in Poland, with a 2.0 percentage points increase. In Sweden however, GDP per capita would drop by 1.0 percentage points.

To explain the Swedish exception, I investigate the role of a number of factors identified by the literature, namely private intergenerational transfers (e.g. Bental, 1989), public intergenerational transfers (e.g. Cigno, 1993; Michel and Pestieau, 1993) and age-productivity profiles (following Pestieau and Ponthiere, 2017). As population age-structures already differ now and are projected to differ even more in the future, I also consider the role of demographic differences. Counterfactually applying to Sweden the same profile for intervivo transfers and voluntary bequests as in Germany, the same pension system as in Germany, the same age-productivity profile as in Germany and the same age structure as in Germany, I find that the Swedish GDP per capita would increase by 0.8 percentage points. The largest impact is the age structure, followed by the age-productivity profile and then the pension system.

The investigation of the Swedish exception shows in particular that the labor supply incentives of the pension system play an important role. In Germany for instance, there is a tight link between the earnings history and the pension payments, which has a strong influence on labor supply decisions. That link is looser in Sweden, among other countries, because of flat pension payments for certain retirees. Increased fertility reduces the need to rely on taxation to finance the increasingly costly pension system. Positive labor supply effects are stronger when pension payments are tightly connected to earnings histories. Differences in the modelling of pension systems can explain why findings in Krueger and Ludwig (2007) and in Fehr et al. (2008) differ. From a policy perspective, fertility-promoting measures are more interesting if pension payments are made very dependent on earnings histories.

The next section provides a brief overview of the literature. The overview includes important factors identified by the literature which are related to fertility, public finance and output. Section 3 describes the model used in this paper and section 4 provides the quantitative results. Policy implications and comparisons with the literature are given in section 5. Section 6 concludes.

2 Literature overview

The literature on fertility, pensions and growth is very large. This section provides an overview of selected parts of the theoretical literature which are relevant for the analysis of fertility impacts on output and public finances. The other direction, the well-documented economic and policy impacts on fertility, is not covered here. The goal of the overview is not to be comprehensive but to build intuition useful for explaining the results presented in this paper[1]. I organize the overview by channel.

Capital dilution: when capital is used in production, higher fertility reduces output per capita, because of a capital-dilution effect. The increase in labor supply, which

[1] Given its goal, the overview does not do justice to many important contributions to the literature. For more complete overviews, see for instance Cigno (1992), Hotz et al. (1997) or Werding (2014).

results from higher fertility, indeed decreases the capital-labor ratio and thus output (see Cigno, 1993; Michel and Pestieau, 1993).

Private intergenerational transfers: when there are no pensions and when children are altruistic (or follow a social norm), higher fertility leads to lower output per capita because the need for parents to save to finance consumption in old-age decreases, reducing capital accumulation (see Bental, 1989).

Public intergenerational transfers: when there are pay-as-you-go pensions, higher fertility leads to higher output per capita and improves pension financing because the higher workers-to-retirees ratio allows to reduce the social security contribution rate. As a result, net income is higher, increasing savings, capital accumulation and output per capita (see Cigno, 1993; Michel and Pestieau, 1993). This social intergenerational transfer effect generates a fiscal externality of fertility, households neglecting social benefits of having one more child in their fertility decisions (see Cigno, 1993; Kolmar, 1997).

Age-productivity profile: higher fertility increases output per capita when mature workers are not much more productive than young workers, but otherwise reduces it. When the age-productivity profile is very steep, the added production following the arrival of young workers does not compensate for the stronger reduction of average productivity (following Pestieau and Ponthiere, 2017; see appendix A).

3 Model

To quantify and compare the long-run impact of fertility variations in different countries, I use the same model with country-specific calibrations.

Over the long run, the population is aging. I thus use a model with an overlapping-generations structure, as in Auerbach and Kotlikoff (1987). As the analysis will show, the characteristics of pension systems influence the impact of fertility on the economy. I thus model the pension system in detail. Because unemployment changes earnings-related pension benefits, I use a model similar to Jaag et al. (2010) as basis, which has overlapping generations and unemployment. Because pension systems have redistributive components, I introduce an exogenous skill difference between households. An exogenous profile for intervivo transfers and voluntary bequests will be used to capture private intergenerational transfers.

First, I present the model. I continue then with the calibration approach and model evaluation information[2].

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

[2]Details on the model are contained in the technical appendix Davoine (2021), available upon request.

probability of dying $1-\gamma^a$. Conditional on surviving, they move from stage a to stage $a+1$ at rate $1-\omega^a$, with $\omega^A=1$. For simplicity and without any impact on the results presented in this paper, fertility is exogenous[3]. Demographic laws of motion are then

$$\begin{aligned} N_{t+1}^1 &= \gamma^1\omega^1 N_t^1 + f_{t+1}, \\ N_{t+1}^a &= \gamma^a\omega^a N_t^a + \gamma^{a-1}(1-\omega^{a-1})N_t^{a-1}, \end{aligned}$$

where N_t^a denotes the number of persons alive in stage a and f_{t+1}, the fertility parameter, denotes the inflow into the first age group.

Households differ in skills, birth date and death date[4]. 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[5].

Labor market: After education, households can enter the labor market. I follow Jaag et al. (2010) and others in the public finance literature in assuming that labor supply decisions are endogenous but do not depend on fertility[6]. Households choose whether to participate in the labor market 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 ($s^{a,i} \geq 0$). 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

[3] The macroeconomic impact of higher fertility is the same if the fertility increase is endogenous or exogenous.

[4] Households also differ in the the speed at which they go through the stages of the life cycle, as controlled by ω^a. This heterogeneity 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 heterogeneity. Aggregation results allow to deal with the heterogeneity (for details, see the technical appendix Davoine (2021)).

[5] 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.

[6] In section 5, I will compare my results with those from the literature. All papers whose results can be compared use the assumption that labor supply is independent from fertility.

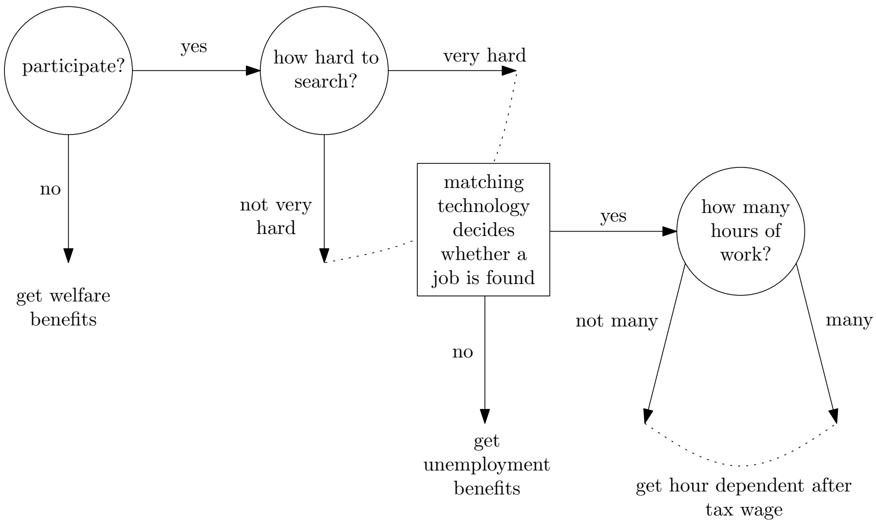


Figure 1: Sequence of households decisions related to the labor market

equals

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

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. The age-productivity profile $\theta^{a,i}$, which is skill- and country-specific, allows to better capture the influence of the age structure and population aging on output.

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. Households also make intervivo transfers to younger or older members of their families as well as voluntary bequests, in an exogenous fashion. 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:

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

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

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

and $\bar{\varphi}^{a,i}$ a convex increasing function in all its arguments[7]. Specifically,

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

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.

Households can make intervivo transfers to younger or older members of their families. When old, they can add voluntary bequests. For simplicity, I take an exogenous and constant profile summing up intervivo transfers and voluntary bequests, calibrated to match aggregate consumption expenditures by age class[8]. To ease the presentation, intervivo transfers will refer to the sum of intervivo transfers and voluntary bequests in the reminder of the paper.

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

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

where $A^{a,i}$ represent assets, $y^{a,i}$ net income flows, $iv^{a,i}_t$ net intervivo received transfer 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 pension benefits $y^{a,i}_{pens} = \nu^a P^{a,i} + P^{a,i}_0$, where $P^{a,i}_0$ is a flat part, $P^{a,i}$ represents acquired pension rights and $\nu^{a,i}$ is a conversion factor between pension rights and pension payments. Pension rights can be accumulated with labor earnings, following $P^{a,i}_{t+1} = \delta^{a,i}_t\left(1-u^{a,i}_t\right)y^{a,i}_{lab,t} + P^{a,i}_t$. Beyond wages, the pay-as-you-go pension system also influences labor supply: the stronger the earnings-related part $\nu^{a,i}P^{a,i}$, the larger the incentive for workers to provide labor supply along all margins, ceteris paribus.

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 em-

[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]Transfers are made within skill classes so that the age distribution of given and received transfers matches the empirical age distribution of aggregate consumption, absent any reforms. After calibration, it turns out that youngest households receive most transfers, consistent with what one would expect from life-cycle optimization and stylized facts on transfers.

ployment) is visited in each time period[9], net income amounts to:

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

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).

The production function is linear homogeneous[10]:

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

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, which equals the stream of discounted dividend payments χ:

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

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[11].

Government: Government provides welfare benefits, unemployment insurance, pay-as-you-go pensions and investment subsidies. The state has other expenditures, all

[9]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.

[10]Following the literature, I assume away the role of land in production. Increasing fertility and population size do not lead to land scarcity, in this case.

[11]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, $r = F_K^Y - \delta^K$.

bundled as public consumption. These expenditures include investments in public infrastructure, education, long-term care and health expenditures, as well as expenditures for the provision of generic public goods, all defined exogenously in per capita terms and generating no utility. Because public consumption is defined in per capita terms, the model takes the impact of fertility on public education expenditures into account.

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).

Single-country equilibrium: In a single-country setting, I assume that the gross interest rate $R_{t+1} = 1 + r_{t+1}$ is endogenously defined, as in a closed economy[12]. Savings can be invested in firms or government debt. Assuming no arbitrage, the net returns on these two types of assets are the same and equal to the interest rate r_{t+1}. The goods market clears with adjustments of the interest rate:

$$Y_t = C_t + I_t + G_t,$$

where C_t is the aggregate private consumption[13] and G_t is government expenditure.

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

$$A_t = W_t + D_t^G.$$

Model calibration: The model covers 14 European countries[14]. Standard data sources and procedures are used to calibrate the model for each of the 14 countries. 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. Appendix B contains details.

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

[12] In the quantitative analysis, I consider a variation where there is some trade with the rest of the world, so that the calibration of the model is more accurate. The trade balance per capita is then kept constant.

[13] So, $C_t = \sum_i \sum_a N_t^{a,i} C_t^{a,i}$ 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.

[14] Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Italy, the Netherlands, Poland, Slovakia, Spain, Sweden and the UK.

Shock	Long run GDP/capita variation		Comparison source
	My simulations	Comparison	
Population aging	-14 pp	-10 pp	Krueger and Ludwig (2007)
		-15 pp	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 for the population aging shock 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 shock for Europe, different models

second evaluation approach consists in choosing a shock and comparing the impacts simulated by the model with impacts simulated and reported in the literature. I compare outcomes for population aging in Europe., a large and standard shock, easy to compare with literature results. As table 1 shows, predictions are comparable. Details can be found in appendix C.

4 Quantitative analysis

Using the same model, I compare the long-run economic impact of increased fertility in different countries. The fertility increase, applied in each country, consists in one woman out of five having one more kid over her lifetime in the next seven decades. I will show that the fertility shock leads to higher GDP per capita in all countries except Sweden.

After defining simulation scenarios, I provide the impacts and analyses for Germany, the largest country in my sample. I then provide impacts for all 14 European countries in the sample and conclude with an in-depth analysis of the Swedish exception.

4.1 Simulation scenarios

Fertility variations have a slow impact over the population structure, and, as a result, over the economy. I thus consider economic impacts after five decades. Over that time span, significant demographic changes are expected, driven by changes in fertility behavior and mortality rates. I thus take the projected population aging into account.

In the baseline scenario, I change fertility and mortality rates so that the population structure matches the demographic projections from Eurostat (2018). I will compare outcomes for this scenario to outcomes for a high fertility scenario. In that scenario, one woman out of five has one more kid over her lifetime in the next seven decades, on top of the fertility variations applied to the baseline scenario[15].

In both scenarios, population aging leads to an increase of pension expenditures.

[15]The fertility is then reduced gradually over the next 20 years to the values from the baseline scenarios, in a linear fashion, for computational reasons.

Most European countries have scheduled reforms to secure the long-term financial sustainability of their pay-as-you-go pension systems. I ignore these reforms, as they play no role when I compare scenario outcomes. Retirement ages and social security contributions, in particular, are kept constant. Public health- and long-term care are also projected to increase. In all scenarios, I use the projected age-dependent per capita cost variations from the Ageing Working Group (2018). To finance the increase in social security expenditures, I assume that governments use labor income taxes, keeping per capita public debt constant in a closed economy setting.

4.2 Economic impacts in Germany

Table 2 provides selected economic outcomes five decades after the start of the fertility increase in Germany. Values are provided for the initial steady-state (*ISS* column), before the fertility increases, and in 50 years for the baseline scenario (*Base* column) and the higher fertility scenario (*High* column). The difference in outcomes between the two scenarios is included for three economic indicators (*High-Base* column), related to macroeconomic impacts (GDP per capita), public finance impacts (pension system deficit) and welfare impacts (consumption-equivalent variation).

The table shows that the German population is projected to shrink slowly, being almost 2% smaller in 50 years (*Base* scenario). That decline is driven by reductions in fertility rates. Adding increases in life expectancy would lead to an older population, the old-age dependency ratio rising from 34.5% to 53% over the next five decades[16]. With a constant retirement age, the fraction of the adult population in retirement would move from 32% to 40%. By contrast, the population would grow by more than 11% in 50 years, if fertility was higher (*High* scenario). The larger fertility would dominate the increase in life expectancy. With more young people alive, the old-age dependency ratio would only increase to 47%, instead of 53%, and the fraction of the population in retirement would be 37%, instead of 40%.

These different demographic evolutions would lead to different economic outcomes. As is well known (see for instance Auerbach and Kotlikoff, 1987), population aging leads to a mechanical reduction of labor supply per capita, production inputs and thus GDP per capita, as there are less working-age people in society. The larger public expenditures for old-age social security requires an increase of government revenue, leading in our scenarios to an increase of the labor income tax rate. Higher taxes reduce the incentive to look for jobs when unemployed and to work when employed, resulting in higher unemployment rates and lower working hours. Combining extensive and intensive margins, yearly working hours per capita drop over time, a behavioral impact adding to the mechanical reduction of labor supply per capita.

The negative impact on labor supply and output per capita is however smaller when fertility is higher. As the table shows, the smaller fraction of retired households in the high fertility case leads to a smaller increase of pension expenditures (rising from 10.1% of GDP to 13.9% in the *High* scenario, compared to 15.5% in the *Base* scenario).

[16]The old-age dependency ratio is equal to the size of the population older than 65 years divided by the size of the population aged between 15 and 64 years.

		Selected outcomes in 50 years		
		Germany		
	ISS	Base	High	High-Base
Demographics				
Population (15+)	100.0	98.3	111.1	
Old-age dependency ratio	34.5	52.9	47.0	
Pensioners (% population)	31.8	40.4	37.4	
Labor markets				
Gross wage rate (%)		7.8	3.6	
Net wage rate (%)		-11.2	-10.1	
Unemployment rate	6.2	6.4	6.6	
Working hours (yearly hours/worker)	1388.0	1381.7	1382.4	
Labor supply (yearly hours/capita)	683.0	590.8	609.7	
Public finance				
Labor tax rate	12.1	25.7	22.3	
Pension expenditures (% GDP)	10.1	15.5	13.9	
Pension system deficit (% GDP)	2.00	6.87	5.40	-1.47
Macroeconomics				
Interest rate	3.00	1.94	2.46	
GDP/capita (%)		-10.81	-10.15	0.66
Welfare				
CEV % (Avg HH born years 1-50)				3.56

Legend: *Base* = baseline fertility scenario; *High* = higher fertility scenario; *ISS* = initial steady state; *%* = percentage variation, compared to the initial steady state; *CEV* = consumption-equivalent variation, on average, for households born in years 1-50; GDP/capita variations are given relative to the productivity growth trend.

Table 2: Selected outcomes, Germany, baseline and higher fertility

The required increase in labor income taxes is smaller (rising from 12.1% to 22.3% in the *High* scenario, compared to 25.7% in the *Base* scenario), which has less of a disincentive effect on labor supply (working hours dropping from 1388.0 to 1382.4 in the Hi*gh* scenario, compared to 1381.7 in the *Base* scenario)[17]. Combining mechanical and behavioral effects, labor supply drops less when fertility is larger (from 683 hours per year per capita, to 610 hours in the *High* scenario, compared to 591 in the *Base* scenario). As a result, GDP per capita drop less when fertility is larger (-10.15% in the *High* scenario, compared to -10.81% in the *Base* scenario)[18]. The macroeconomic gain of higher fertility, in 50 years, is thus 0.66% percentage points of GDP (per capita).

Higher fertility also delivers public finance gains over the long run. The financing deficit of the pension system, for instance, increases to a lower extent (from the current 2.0% of GDP to 5.4% of GDP in the *High* scenario, compared to 6.9% of GDP in the *Base* scenario). Using this deficit as indicator, higher fertility leads to a pension deficit which is 1.5 percentage points of GDP smaller.

Both the expenditure and the revenue sides explain the lower pension deficit with higher fertility. Because the fraction of retirees is smaller, pension expenditures are lower when fertility is high (13.9% of GDP in the *High* scenario, compared to 15.5% of GDP in the *Base* scenario). Higher labor supply per capita also means that the contribution base is larger, resulting in larger social security contributions (610 yearly working hours per capita in the *High* case, compared to 591 in the *Base* case, with the same social security contribution rate).

Consumption-equivalent variations (CEV) provide a measure of the gains for households (or welfare gains). The CEV measure in table 2 reports the lifetime increase in consumption that would be needed in the baseline scenario so that households reach the same lifetime utility than households from the same age and the same skill class in the higher fertility scenario. As the gains differ by age groups and by skill classes, the table provides the average for all households born after the fertility starts to increase, for the next five decades and for all skill classes. The table shows that households in the baseline scenario would need to have a lifetime consumption bonus of 3.6% (in each year of their life), compared to the high fertility scenario. In other words, households in the second scenario have a higher lifetime utility.

This welfare gain comes from the fact that labor income taxes do not have to be increased as much, when fertility is higher (from 12.1% to 22.3% in the *High* scenario, compared to 25.7% in the *Base* scenario). This leads to a lower drop of net wages (-10.1% in the *High* scenario compared to -11.2% in the *Base* scenario) and higher net income, allowing for more consumption.

4.3 Economic impacts in all European countries

Table 3 provides the macroeconomic impacts (difference in GDP per capita), public finance impacts (variation in pension system deficit) and welfare impacts (consumption-

[17]The unemployment risk is on average higher for younger workers, which explains why the unemployment rate is larger in the *High* scenario than the *Base* scenario.

[18]All GDP per capita figures provided in this paper are relative to the productivity growth trend.

	Difference High fertility - Baseline fertility		
	GDP/capita (pp) Year 50	Pension deficit (pp GDP) Year 50	Welfare impact (CEV %, Avg) Years 1-50
Austria	0.80	-1.97	3.20
Belgium	0.21	-1.38	2.50
Czech Republic	1.00	-1.40	1.95
Denmark	-0.03	-1.88	3.14
Finland	0.31	-1.89	2.10
France	0.23	-1.68	3.25
Germany	0.66	-1.47	3.56
Italy	1.16	-2.49	2.76
Netherlands	0.14	-1.73	2.27
Poland	1.98	-2.81	2.51
Slovakia	1.23	-1.81	1.69
Spain	0.02	-2.04	3.30
Sweden	-0.98	-1.28	2.69
United Kingdom	1.73	-1.20	3.77
Average impact	0.69	-1.74	3.17

Legend: *CEV* = consumption-equivalent variation, on average, for households born in years 1-50.; *Average impact* = average impacts over all European countries in the sample, weighted by economic size. GDP/capita variations are given relative to the productivity growth trend.

Table 3: Macro, public finance and welfare impacts, high versus baseline fertility

equivalent variation) due to the fertility increase for all European countries in the simulation sample. The same numbers as in column *High-Base* from table 2 are provided, not only for Germany but for all countries.

With some exceptions, outcomes for all European countries are similar to outcomes for Germany: there are long-run macroeconomic, public finance and welfare gains from increased fertility in all countries. The notable exception are macroeconomic impacts for Sweden: while there is a gain of 0.66 percentage points of GDP (per capita) in Germany and 0.69 on average for all European countries, there is a loss of 0.98 percentage points in Sweden in 50 years[19]. In other words, Swedish GDP per capita would be larger with low fertility in 50 years than with higher fertility, unlike all other countries in the sample. This exception will be investigated in section 4.4.

Across countries, the public finance gains are close, ranging from a pension deficit reduction of 1.2 percentage points of GDP in the UK to a reduction of 2.8 percentage points in Poland. Relative to the pension deficit projection from the baseline scenario, deficit reductions are similar: the deficit increase is smallest in the UK, at 3.6 percentage points of GDP in the baseline scenario, and largest in Poland, at 14.4 percentage points. On average, higher fertility leads to a decrease of the pension deficit of 27%, with a

[19]There is also a small loss (0.03 pp) in Denmark, whose discussion is similar to that for Sweden.

minimum of 19% in Poland and a maximum of 35% in Belgium (unreported figures).

To a lower extent, welfare gains are also similar across countries, with an average consumption-equivalent variation of 3.2% across Europe, a minimum of 1.7% in Slovakia and a maximum of 3.8% in the UK.

Macroeconomic gains on the other hand differ across countries: in one country, Sweden, there is a loss; in six other countries, gains are smaller than 0.31 percentage points of GDP; for the remaining 7 countries, the gains are bigger than 1.0 percentage points of GDP. The analysis of the Swedish exception, in the next section, will shed some light on the reasons for such cross-country differences.

4.4 Analysis of the Swedish exception

Unlike other European countries, the long-run macroeconomic impacts of higher fertility, in the scenarios considered in this paper, are negative in Sweden: GDP per capita would be lower with an increased fertility, in 50 years. In this section, I consider a number of decomposition scenarios where some demographic or economic features of the model for Sweden are changed, to help understand and identify factors which play a role in this exception. I will use Germany as benchmark, an arbitrary choice which has no impact on the conclusions of the analysis.

As summarized in section 2, the literature has identified a number of factors which connect fertility with output: capital dilution, private intergenerational transfers, public intergenerational transfers and age-productivity profiles. I will consider the last three factors and add another one, demographics. For each of these factors (or channels), I consider a decomposition scenario where I change the calibration of the Swedish model such that the attached model component has the same value as in Germany.

In the first decomposition scenario, I ignore the Swedish exogenous age-productivity profile and apply the German profile. The profile has a direct influence on production when the demography evolves, as young workers are less productive. Higher fertility may thus reduce average productivity and output. The scenario thus allows to measure the role of age-productivity profiles in the link between fertility and output.

In the second decomposition scenario, I change the exogenous intervivo transfer profile and, again, apply the German profile. In the model, households can make transfers to their parents or to their children[20]. Such transfers decisions are not endogenous. Instead, I take an exogenous profile for net transfers such that the age-consumption profile resulting from the model calibration matches the empirical data. In all countries from the sample, the resulting net transfers go from old to young households. In this decomposition scenario, old households transfer the same fraction of their wealth to their children and grandchildren as in Germany. The scenario allows to measure the role of (some) private intergenerational transfers in the link between fertility and output.

In the third decomposition scenario, I change the public pension system so that its basic components are the same as in Germany. Specifically, flat benefits and earnings-related are changed so that the respective gross replacement rates are the same as in

[20] Recall that I use the word *intervivo transfer* for short, adding actual intervivo transfers and voluntary bequests.

Germany[21]. Furthermore, the social security contribution rate is adjusted to compensate for the resulting variation in contribution revenue. As Germany has a smaller pension system as Sweden, the contribution rate is lowered. This decomposition scenario allows to measure the role of (some) public intergenerational transfers in the link between fertility and output.

The fourth decomposition scenario deals with the fact that current and expected demographic structures differ across country. Sweden is younger and is projected to age at a slower pace than Germany. Production and public finance challenge may thus differ, as well as the benefit from higher fertility. In the fourth decomposition scenario, I thus give the same initial population structure and use the same population aging targets as in Germany, which allows to measure the role of demographics in the link between fertility and output.

In a final scenario, I apply all changes considered in the first four decomposition scenarios at the same time. For each decomposition scenario, I consider the base and the high fertility cases, as in section 4.3.

Note that the capital dilution effect takes place in every scenario, as saving and investment decisions are endogenous in the model. It is however difficult to change the model such that saving and investment decisions in Sweden are made in the same way as in Germany. I thus can not assess the role of the capital dilution channel in the link between fertility and output in general, nor in the Swedish example in particular.

Table 4 provides selected outcomes in Sweden for all the decomposition scenarios. For comparison purposes, the baseline scenario, identical to section 4.3, is also reported.

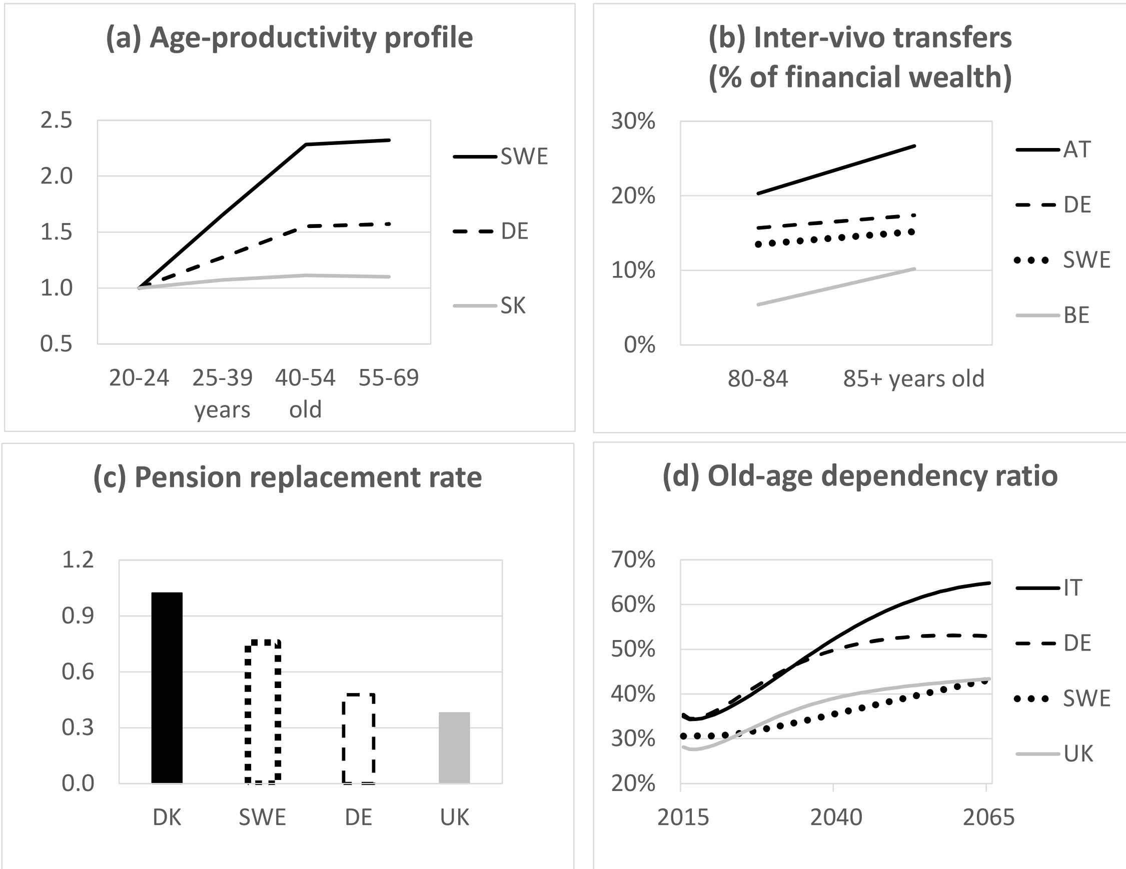
The table shows that the first channel, age-productivity profiles, has a large impact on the link between fertility and output. Instead of a drop of 0.98 percentage points of GDP (per capita) in the baseline, higher fertility lead in the first decomposition scenario to a smaller drop, namely 0.39 percentage points. To a large extent thus, the Swedish exception can be explained by the fact that the age-productivity profile in Sweden is very different than in other countries. As shown in panel (a) of figure 2, it is much steeper. In fact, the Swedish profile is the steepest among all European countries that I consider in this paper. As discussed in section 2 (and appendix A), higher fertility leads to the arrival of new, young workers in the labor market, which contributes to the production. However, young workers are less experienced and less productive. When the age-productivity profile is steep, the added production following the arrival of young workers does not compensate for the strong reduction of average productivity, reducing production per capita. The table shows that GDP per worker declines with base fertility to the same extent with the original age-productivity profile and the German profile (-0.7% in columns *Base*). In both cases, higher fertility leads to a drop of GDP per worker, as average productivity declines. However, the additional decline is stronger with the original age-productivity profile than with the flatter German profile (-2.2% in column *Base* from the baseline case, compared to -2.0% in column *Base* from the German age-productivity profile).

[21]In other words, the ratio of before-tax flat pension payments over the average pre-retirement income becomes the same as in Germany, and the ratio of the before-tax earnings-related pension payments over the average pre-retirement income also becomes the same as in Germany.

	Selected outcomes in 50 years — Sweden																	
	Baseline			German age-productivity profile			German intervivo transfers			German pension system			German population structure			All 4 German characteristics		
	ISS	Base	High	ISS	Base	High	ISS	Base	High	ISS	Base	High	ISS	Base	High	ISS	Base	High
Demographics																		
Population (15+)	100	139	157	100	139	157	100	139	157	100	139	157	100	98	111	100	98	111
Old-age dependency ratio	30.7	43.1	38.6	30.7	43.1	38.6	30.7	43.1	38.6	30.7	43.1	38.6	34.5	52.9	47.0	34.5	52.9	47.0
Pensioners (% population)	24.8	31.3	28.9	24.8	31.3	28.9	24.8	31.3	28.9	24.8	31.3	28.9	26.9	35.8	33.1	26.9	35.8	33.1
Labor markets																		
Net wage rate (%)		-16.2	-16.0		-16.5	-15.2		-16.2	-16.0		-16.8	-16.6		-21.5	-20.1		-22.5	-20.1
Labor supply (yearly h/capita)	899	796	804	892	785	798	899	796	804	909	789	801	878	736	753	880	721	743
Public finance																		
Labor tax rate	21.8	36.2	34.0	21.8	36.6	33.6	21.8	36.1	34.0	24.3	38.6	36.5	21.8	42.5	39.5	24.2	45.6	41.9
Pension expenditures (% GDP)	11.7	16.0	14.5	12.3	17.1	15.3	11.7	16.0	14.5	6.4	8.7	7.9	13.0	20.8	18.8	7.3	11.8	10.5
Pension system deficit (% GDP)	2.6	6.4	5.1	3.7	8.0	6.4	2.6	6.4	5.1	1.8	4.0	3.2	3.6	10.7	8.9	3.0	7.1	5.9
Macroeconomics																		
GDP/capita (%)		-11.4	-12.4		-11.8	-12.2		-11.5	-12.4		-13.4	-14.0		-13.6	-13.7		-16.0	-15.3
GDP/worker (%)		-0.7	-2.9		-0.7	-2.6												
Difference High - Base																		
Pension deficit (pp GDP)		-1.28			-1.59			-1.28			-0.74			-1.84			-1.17	
GDP/capita (pp)		-0.98			-0.39			-0.96			-0.60			-0.04			0.75	

Legend: *Base* = baseline fertility scenario; *High* = higher fertility scenario; *ISS* = initial steady state; *%* = percentage variation, compared to the initial steady state; *pp* = percentage points; *pp GDP* = percentage points of GDP. GDP/capita variations are given relative to the productivity growth trend.

Table 4: Selected outcomes, Sweden with counterfactual German characteristics



Notes: the plain black lines represent the maximum values among all countries from the sample and the plain gray lines represent the minimum values. Panel (a) provides the age-productivity profile for the medium-skilled househoulds (source: Mincer regressions from EU-SILC data). Panel (b) provides the fraction of financial wealth used for inter-vivo transfers and voluntary bequests (source: calibration output to match age-consumption profiles from National Accounts). Panel (c) provides net pension replacement rates (source: OECD). Panel (d) provides projections of the old-age dependency ratio between 2015 and 2065 (source: Eurostat)

Figure 2: Selected economic and demographic characteristics, Germany and Sweden

Table 4 also exhibits the limited impact of the second channel, intervivo transfers. The impact of higher fertility on GDP per capita is only marginally better when the German intervivo transfers profile is used: instead of a drop of 0.98 percentage points (per capita) in the baseline, higher fertility results in a drop of 0.96 percentage points with the German profile. This outcome is not surprising. Indeed, panel (b) of figure 2 shows that the intervivo (and voluntary bequests) profiles are very similar in Sweden and Germany, especially when compared to the maximum (Austria) and minimum (Belgium) values. It is thus not possible to draw conclusions on the role of private intergenerational transfers in the link between fertility and output, from this particular decomposition approach.

As can be seen from table 4, the third channel, pension systems, has some impact on the link between fertility and output. Higher fertility indeed leads to a drop of 0.60 percentage points of GDP (per capita) when the pension system has the same characteristics as in Germany, compared to a drop of 0.98 percentage points in the baseline. The impact is smaller than German age-productivity profiles (drop of 0.39 percentage points), but still visible. The impact of pension systems, displayed in the table, is driven by the characteristics of pension payments more than the size of the system. Panel (c) of figure 2 shows that the German pension system is smaller than the Swedish system, pension replacement rates being smaller in Germany than in Sweden. As noted in section 2, higher fertility should lead to higher output per capita in bigger pension systems: a higher workers-to-retirees ratio allows to reduce the social security contribution rate more. Yet, the output per capita gains are smaller with the larger, Swedish pension system (-0.98 pp) than with the smaller, German-like pension system (-0.60 pp). In the simulations, the size effect is dominated by the payment characteristics' effect. In the German pension system, most of pension payments are earnings-related. In the Swedish system, some of the payments are flat and unrelated to earnings. On average, only 4% of the payment value is unrelated to earnings in the German calibration of the model, compared to 15% in Sweden. Yet, flat payments have a negative impact on labor supply incentives. As a result, there is a larger supply response to the tax benefits that high fertility brings with the German-like system than with the Swedish system (per year and per capita, households supply 801 - 789 = 12 hours more with high fertility and the German-like pension system, while households supply only 804 - 796 = 8 hours more with high fertility and the Swedish baseline pension system). This explains why higher fertility has a more beneficial impact on GDP per capita with the German pension system than with the baseline Swedish system.

Table 4 further shows that the fourth channel, demographics, has a large impact on the link between fertility and output. When fertility is high and the Swedish population structure now and in the future is counterfactually the same as in Germany, GDP per capita only drops 0.04 percentage points. By contrast, high fertility in the baseline Swedish population leads to a drop of 0.98 percentage points. As shown in panel (d) of figure 2 and also visible from the table, the current old-age dependency ratio is lower in Sweden than in Germany, at 31% compared to 34%. Furthermore, that ratio should only increase to 43% in 50 years, compared to 53% in Germany, a considerable difference. In short, Sweden is younger and should age at a much slower pace than Germany. With the German population structure, higher fertility leads to a bigger tax differential (the labor income tax rate is 42.5 - 39.5 = 3 percentage points lower with high fertility and a German population structure, compared to 36.2 - 34.0 = 2.2 percentage points with high fertility and the baseline Swedish population). On top of this, older workers are more productive and thus more responsive to net-of-tax wage gains. When the population is counterfactually as old as in Germany, net-of-tax wage gains translate in a higher labor supply increase. Combined, these phenomenons lead high fertility to have a bigger impact on labor supply when the population structure is similar to Germany's (per year and per capita, households supply 753 - 736 = 17 hours more with high fertility and the German population structure, while households supply only 804 - 796 = 8 hours more with high fertility and the Swedish baseline pension system).

Finally, table 4 provides the cumulated impact of all four channels on the link between fertility and output. With high fertility and the four German characteristics, there would be a GDP per capita gain, of 0.75 percentage points. In the baseline case, high fertility leads to a *loss* of 0.98 percentage points. The macroeconomic gains of higher fertility, if Sweden had the four German characteristics, would be close to the gain in Germany, equal to 0.66 percentage points (see table 4.3).

The decomposition approach used in this section uses some of the key channels identified by the literature (see section 2), but not all. Other channels than those considered here could also play a role. The fact that the macroeconomic gains computed for Sweden with the four German characteristics and for Germany are close is thus a coincidence. It remains remarkable and points to important roles for some of the four channels considered in this paper. Except the intervivo transfers channel, all other channels lead to more positive impacts of fertility on GDP per capita, when assigned the German value: age-productivity profiles, public pensions and demographics. None of these three channels alone closes the gap between Sweden and Germany. Together, however, they can eliminate the gap. Recall too that the fact that no role was identified for the intervivo transfers channel in this paper is due to the chosen format of the decomposition. That channel may thus play a role in other cases.

5 Discussion

I derive implications for policy design out of the results from section 4 and then compare these results with those from the related literature. I will close with a brief discussion of differences between existing studies.

5.1 Policy implications

Consistent with intuition and the existing literature, I find that higher fertility eases the challenge of financing public pay-as-you-go pensions created by population aging. If one woman out of five had one more kid, my simulations show that the pension system deficit would be 1.7 percentage points of GDP lower on average in the 14 European countries from my sample, in 50 years. As the average deficit with the baseline fertility projection is 6.8 percentage points of GDP, it means that the deficit would be cut 27% on average. Measures promoting higher fertility should thus be encouraged, from a long-run public finance standpoint.

My analysis also identifies long-run macroeconomic gains from higher fertility, as GDP per capita would be higher by 0.7 percentage points in 50 years, on average, for the same sample of 14 European countries and the same fertility increase. However, the magnitude of gains varies across countries, and there can be exceptions. For one of the 14 countries (Sweden), I even find that higher fertility would lead to a drop (of 1.0 percentage points) in 50 years. Investigations of that exception also deliver policy implications. Policy measures promoting higher fertility make more sense, from a macroeconomic standpoint, when the following conditions are met: a) the productivity difference between experienced and inexperienced workers is not too high; b) pension payments unrelated to earnings are small, compared to earnings-related payments; c) the population ages at a fast pace.

It may be difficult to influence directly the age-profile of worker productivity with policy. Indirectly, incentives could be given to firms for supporting knowledge transfer from experienced to inexperienced workers, for instance with tax reductions for firms actively participating in vocational education programmes. Such incentives could be associated to fertility-promotion measures. On the other hand, direct influence on pension is possible. There may be a joint benefit for coordinated policy actions related to fertility and to pensions. Policy actions promoting fertility may be best associated with pay-as-you-go pension designs which keep flat, earnings-unrelated payments at a low level.

5.2 Comparison with the literature

Outcomes from a number of studies can be compared to results from this paper (in particular from table 4.3). Many published studies have other focuses than the impact of fertility on the economy but run sensitivity analyses which deliver useful information. As my analysis deals with long-run outcomes, I compare it to studies reporting long-run outcomes, which implies the use of overlapping-generations model to deal with population aging. Most of the studies deliver information on public finance impacts, a few on output impacts and only one on welfare impacts.

It turns out that my results are generally consistent with results from the literature on public finance and welfare impacts. Literature conclusions on the impact of fertility on output however differ across studies. My results will thus sometime differ with literature results on output, but can also shed light in differences across existing studies. I start with welfare and public finance impacts, before turning to the longer discussion on output impacts.

From published studies using overlapping-generations model, only Ludwig and Reiter (2010) report impacts of fertility variations on welfare. This study finds a positive link between fertility and long-run welfare, consistent with my findings. Specifically, they find that welfare, measured in consumption-equivalent variations, drops by 0.9% for German households born in 50 years, when women give birth on average to 0.35 less children in their lifetime. By comparison, I find that welfare increases by 3.6% in Germany when women give birth on average to 0.20 more children in their lifetime (see table 2). Signs are identical but effects in my analysis are roughly 2.5 times larger. The difference in magnitude may be due to the choice of household preferences, which differs in the two analyses.

Table 5 summarizes public finance impacts generated by fertility variations reported in the existing literature. As the table makes clear, studies consider different dimensions of public finances (as well as different types of fertility shocks), making comparisons difficult. However, all of the studies find a positive link between fertility and public finance outcomes: an increase of fertility leads to improved public finance positions, such as lower public debt, lower taxes, lower social security contribution rates or larger pension benefits, and vice-versa. These outcomes are consistent with my findings of reduced pension system deficit with higher fertility (see section 4.3).

Table 6 provides a summary of the long-run impact of fertility variations on output found by the literature. Comparisons are easier, as studies use the same type of fertility shock (with one exception). The table shows that literature outcomes are not consistent, as one study finds a positive link between fertility and output per capita (Fehr et al., 2008), while the other studies find a negative link. As section 4.3 reported, I find a positive link for all 14 European countries in my sample, except for Sweden.

In spite of the modelling and country coverage differences, outcomes from my simulations are remarkably close to results reported by Fehr et al. (2008). On average, I find that a fertility increase of 0.2 child per woman leads to an average increase of output per capita equal to 0.7%, in 50 years (table 3). Fehr et al. (2008) find an increase of 0.8% for the US and the same fertility shock. Assuming proportional impacts, the increase would be 0.9% for Europe (as a region) and almost 1.0% for Japan, in the same study.

The other three literature studies (Attanasio et al., 2007; Krueger and Ludwig, 2007; and Kudrna et al., 2015) find opposite results: an increase in fertility leads to a decrease in output per capita, over the long run. In the continuation, I provide possible explanations for these outcome differences.

The discussion of the public pension and the demographic channels in my outcomes for the Swedish exception made clear that labor supply responses play an important role in the link between fertility and output (see section 4.4). One long-run benefit of higher fertility is a lower tax or social security contribution rate, which should lead to a relative increase in labor supply per capita, and thus output. In Attanasio et al. (2007), labor supply is exogenous. The benefits of higher fertility may thus be underestimated in that study, allowing for negative impacts on output.

The discussion of the public pension channel in the Swedish exception also showed the importance of the link between pension payments and working history. When the link is tight, the likelihood of a positive impact of fertility on output is larger, because of stronger labor supply incentives: higher fertility allows for lower tax or social security contribution rates, stimulating labor supply; if more of the increase in earnings is accumulated as pension rights, the labor supply incentives are stronger. In Krueger and Ludwig (2007), pension benefits are related to past wages, but not to past earnings.

Table 5: Simulation findings from the literature, impact of fertility on public finances

Study	Location	Fertility shock	Public finance impact
Attanasio et al. (2007)	North	+ 0.5 child per woman	Wage tax reduced by 3.0 pp
Bielecki et al. (2016)	Poland	Eurostat projected decline	Pension deficit increased by 2.8 pp GDP
Braun and Joines (2015)	Japan	Anticipated TFR increase from 1.3 to 2.0	Value added tax reduced by 12 pp
Coeurdacier et al. (2014)	China	- 2.0 child per woman	Value added tax increased by 7.5 pp
Fehr et al. (2008)	US	+ 0.2 child per woman	Taxes and SSC reduced by 1.3 pp
Fehr et al. (2008)	Europe	- 0.4 child per woman	Taxes and SSC increased by 4.6 pp
Fehr et al. (2008)	Japan	- 0.6 child per woman	Taxes and SSC increased by 8.3 pp
Hirte (2002)	Germany	Lower population growth rate	Taxes and SSC increased by 25 pp
Imrohoroglu et al. (2016)	Japan	- 0.23 child per woman	Public debt increased by 0.23 pp GDP
Krueger and Ludwig (2007)	US	UN projected increase	Pension replacement rate increased by 0.4%
Kudrna et al. (2015)	Australia	+ 0.2 child per woman	Government budget gain of 14%
Ludwig and Reiter (2010)	Germany	- 0.35 child per woman	Pension benefits decreased by 6%

Notes: studies investigate the long-run impact of fertility variations on public finances, using simulations with overlapping-generations models; *pp* = percentage points; *pp GDP* = percentage points of GDP; *TFR* = total fertility rate; *SSC* = social security contribution rate; impacts in 40 to 100 years, depending on the study; Attanasio et al. (2007) uses a model with two regions, a developed North and a developing South; fertility shock reduced to + 0.25 child per woman after 50 years in Attanasio et al. (2007); TFR increase in 50 rather than 100 years in Braun and Joines (2015); fertility shock applied during years 1 to 25 in Coeurdacier et al. (2014); Population growth dropping from + 0.85% to - 0.3% in Hirte (2002).

Study	Location	Fertility shock	Output/capita impact
Attanasio et al. (2007)	North	+ 0.5 child per woman	- 6%
Fehr et al. (2008)	US	+ 0.2 child per woman	+ 0.8%
Fehr et al. (2008)	Europe	- 0.4 child per woman	- 1.8%
Fehr et al. (2008)	Japan	- 0.6 child per woman	- 2.9%
Krueger and Ludwig (2007)	US	UN projected increase	- 0.3%
Kudrna et al. (2015)	Australia	+ 0.2 child per woman	- 2.2%

Notes: studies investigate the long-run impact of fertility variations on output, using simulations with overlapping-generations models; impacts in 40 to 100 years, depending on the study; Attanasio et al. (2007) uses a model with two regions, a developed North and a developing South; fertility shock reduced to + 0.25 child per woman after 50 years in Attanasio et al. (2007).

Table 6: Simulation findings from the literature, impact of fertility on output

In that case, the link between pension payments and working history is looser. Here too, the benefits of higher fertility may be underestimated, leading to negative output impacts.

The same arguments may explain why Kudrna et al. (2015) also find a negative impact of higher fertility on output. Indeed, the study models the pension system in a fashion close to the Australian reality, where there are no public earnings-related pillar but a large, means-tested flat pillar[22]. For low-income households, the pension payment is flat and entirely unrelated to the earnings history. The link between pension payments and working history is thus, on average, fairly loose.

The previous discussion also implies that the finding from Fehr et al. (2008), a positive link between fertility and long-run output per capita, is more robust than the opposite findings from the other studies reported in table 6, for countries where pension payments are closely tied to working histories. Fehr et al. (2008) indeed considers endogenous labor supply and pensions with both flat and earnings-related payments. This conclusion is also consistent with the empirical study Hondroyiannis and Papapetrou (2005), which finds a positive link between fertility and long-run output per capita for some European countries between 1960 and 1998, but not all (which is sometimes statistically significant, sometimes not).

6 Concluding remarks

The simulations show that all 14 European countries in my sample would derive welfare and public finance gains from higher fertility, over the long run. The amounts of the gains vary by country, but only little. On average for instance, the financial deficit of public pay-as-you-go pensions would be cut by 27% in 50 years, in spite of population aging, if one woman out of five had one more child in her lifetime. By contrast, the long-run macroeconomics impacts differ. On average, GDP per capita would increase by 0.7 percentage points in 50 years. The gain would exceed 1.0 percentage points in

[22]The means-tested pillar accounts for close to 3% of GDP in their model, to be compared to average public expenditures of 12% of GDP in the European Union.

5 countries and be smaller than 0.3 percentage points in 6 countries. For one country, Sweden, higher fertility would lead to a *drop* in GDP per capita, of close to 1.0 percentage points.

These results are consistent with the literature, which always find long-run public finance benefits with higher fertility, while the impacts on output per capita differ.

I also find that GDP per capita would increase in Sweden to the same extent as in Germany if Sweden had the same population structure, the same population aging, the same age-productivity profile and the same public pension system as in Germany. These channels thus have an important influence on the link between fertility and output.

From a policy standpoint, my analysis confirms that an increase in fertility can help aging countries to finance their increasingly costly public pension systems. Fertility-promoting policies may also be associated with pension designs with tight links between earnings histories and pension payments. Higher fertility indeed would generate a larger relative increase in labor supply if the pension system had strong labor supply incentives.

The paper showed that the macroeconomic gains from higher fertility would be lower, even possibly negative, with steep age-productivity profiles, slow aging populations and pension systems with a loose link between earnings' histories and pension payments. All of these channels had been identified in the literature. Additional channels have not been considered, but could. For instance, future research could investigate the impact of capital market integration on public finances and output, when fertility is increased. Krueger and Ludwig (2007) indeed show that the benefits from higher fertility can be larger when capital markets are integrated.

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A Appendix: theoretical macroeconomic impacts

In their four-period overlapping-generations model, Pestieau and Ponthiere (2017) show that the output per young worker decreases immediately after an increase of fertility. This appendix extends their analysis to the immediate impact on output per capita.

I allow the age-productivity profile to be either downward-sloping or upward-sloping and restrict the analysis to populations with constant or increasing sizes. I find that output per capita rises if the fertility increase is moderate and the age-productivity profile has a moderate slope, but that output per capita declines if the fertility increase is large or the profile very steep. Specifically and using the same notation as Pestieau and Ponthiere (2017), output per capita increases if and only if

$$\alpha < \frac{1 + \frac{2\pi}{n} - n^2}{2n + 1 - \frac{\pi}{n^2}},$$

where n is the fertility rate (denoting by N_t the size of a cohort, $N_{t+1} = nN_t$, with $n \geq 1$), where $\pi \leq 1$ is the survival probability into the retirement period and where α is the relative productivity of old workers compared to young workers.

The intuition for the result is the following. The addition of new, young workers has two effects. Adding a worker, whatever its productivity, always increases output and thus has a positive impact on output per capita, as the number of retirees is constant immediately after the fertility increase. However, adding a worker can also have a negative impact on output per capita, if the worker has a much lower productivity than average: the production increases a little only and the population count more. If the second effect dominates, output per capita declines. This will be the case when the age-productivity profile is very steep ($\alpha > RHS$). The first effect will on the other hand dominate if the age-productivity profile is not too steep ($\alpha < RHS$). Then, output per capita will increase. In short, when the age-productivity profile is very steep, the added production does not compensate for the strong reduction of average productivity.

I continue with a brief overview of the model in Pestieau and Ponthiere (2017), notation details and then the proof for the result.

Households live four periods in their life, childhood, labor as a young worker, labor as an old worker and retirement. Survival into the last period is uncertain. Children have no economic weight. Labor is provided inelastically (and normalized to one), fertility is exogenous and there is no pension system. Households choose savings in the second and third periods of their life to maximize lifetime utility. Production uses capital as well as labor and is represented by a production function which is homogeneous of degree 1.

The size of a cohort is denoted by N_t and the fertility rate by n, so $N_{t+1} = nN_t$. The total population size is equal to $\overline{N}_t = N_t + N_{t-1} + N_{t-2} + \pi N_{t-3}$, where $\pi \leq 1$ denotes the survival probability into the retirement period. I restrict the analysis to non-shrinking populations, so $n \geq 1$. Relative to a young worker, the productivity of an older worker is $\alpha \geq 0$. The total labor supply, in efficiency terms, is thus $L_t = N_{t-1} + \alpha N_{t-2}$. The parameter α is influenced both by the learning need of young workers (pushing α up) and by skill losses of old workers (pushing α down). Guided by a policy discussion in

Belgium, Pestieau and Ponthiere (2017) can restrict their analysis to $\alpha \leq 1$. I do not impose this restriction and will take values from microdata for quantitative analyses with a large-scale version of the model. The capital stock is denoted by K_t and the production function by $F(K, L)$.

Because F is homogeneous of degree 1, output per capita is equal to $F\left(K/\overline{N}, L/\overline{N}\right)$. Immediately after an increase of fertility n, output per capita will increase if and only if $L/\overline{N}$ increases, because savings and thus capital adjustments are sluggish. Using the population dynamics, the effective labor supply is equal to $L_t = N_{t-2}(n+\alpha)$ and the total population to $\overline{N}_t = N_{t-2}\left(n^2+n+1+\frac{\pi}{n}\right)$. Effective labor supply per capita is thus equal to $L/\overline{N} = (n+\alpha) / \left(n^2+n+1+\frac{\pi}{n}\right)$. Because

$$\frac{\partial}{\partial n}\frac{L_t}{\overline{N}_t} = \left(\frac{1}{n^2+n+1+\frac{\pi}{n}}\right)^2 \left[\left(n^2+n+1+\frac{\pi}{n}\right) - (n+\alpha)\left(2n+1-\frac{\pi}{n^2}\right)\right],$$

effective labor supply per capita increases with a fertility increase if and only if the square bracket in this expression is positive, that is, if and only if,

$$\frac{1+2\frac{\pi}{n}-n^2}{2n+1-\frac{\pi}{n^2}} > \alpha.$$

B Appendix: calibration approach

The calibration of the large-scale model is standard. Consensual empirical estimates from the literature are taken, when available. For other parameters, household-level datasets are used. The model is calibrated and benchmarked to values averaged between 2010 and 2015, to remove business cycle fluctuations. The outcome of the calibration and its evaluation are provided in appendix C.

Starting with *demographics*, the country-specific skill distribution is derived from the European Union Labour Force Survey (EU-LFS). Initial, country-specific fertility and age-dependent mortality rates are defined so that the age structure in the model replicates the age distribution reported by Eurostat. The baseline fertility and mortality rates are then changed over time to match the demographic projections from Eurostat (2018).

Continuing with *production*, the specification of the production function, which exhibits capital-skill complementarity with three types of labor (low, medium and high skills), is an extension of the production function from Krusell et al. (2000), which also exhibits capital-skill complementarity but with two types of labor (low and high skills). Elasticity parameters are derived from Krusell et al. (2000) and the remaining production parameters are defined to match output, the marginal product of capital and income shares by production input. The private capital depreciation rate is set to match the capital/output ratio. Private capital stock estimates are taken from the OECD Structural Analysis (STAN) database. These estimates include tangible assets and new intangible assets but neither residential capital nor military expenditures.

Switching to *labor markets*, age-dependent productivity profiles are obtained from Mincer wage regressions using survey microdata, namely the European Union Statistics on Income and Living Conditions (EU-SILC). Labor supply elasticities vary by skill groups and differ for participation and hours decisions, but are identical across countries. Conservative values are taken from the discussion in Immervoll et al. (2007). Other parameters of labor disutility functions (shift parameters) are set to match the average participation rates, unemployment rates and working hours, which are computed for each age and skill groups from the EU-LFS and EU-SILC surveys.

Regarding parameters on *savings*, the interest rate is set at 3%, consistent with the macroeconomic literature. The intertemporal elasticity of substitution is set at 0.4, which lies in the medium range of estimates from the empirical literature. Intervivo transfer parameters are defined to match life-cycle consumption profiles computed from Eurostat data. The trade balance is taken from OECD Annual National Accounts.

Social security parameters are derived as follows. Pensions benefits are set to match the pension replacement rates, provided by the OECD Pensions at a Glance documentation, and the aggregate pension expenditures, provided in the OECD Annual National Accounts. Unemployment insurance replacement rates are computed from the EU-SILC dataset. Social security contributions, and remaining social security benefits, are computed as for income tax rates, presented below. Other parameters related to institutions are taken from the European Commission's Mutual Information System on Social Protection (MISSOC) database.

Finishing with *public finance*, the information on public debt comes from OECD Annual National Accounts. Labor income taxes, social security contributions and social security benefits are set to match the averages by age and skill classes computed from the EU-SILC, the OECD Tax-Benefit model and the MISSOC database. The OECD Tax-Benefit model, which provides tax and social security information for representative family circumstances in OECD countries, is used to impute missing tax and benefit data from the EU-SILC.

C Appendix: calibration values and model outcomes

Tables 7 and 8 provide calibration values for the main parameters as well as calibration outcomes. The model performance can be evaluated along two dimensions.

The value for some variables is not calibrated but an outcome of the calibration process. These variables are indicated with a star in tables 7 and 8 . When compared to benchmark values, they allow for a first evaluation of the model and the calibration performance.

The second evaluation consists in comparing the predictions of the model to the predictions of analogous models, applying a population aging shock. 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 Europe for the different models.

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 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). 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	
	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	
Med skills share (%)	65.6		37.2		75.9		55.7		42.0		21.8		44.7	
High skills share (%)	18.2		33.4		15.5		21.4		34.3		29.7		37.3	
*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
Production														
Exo. productivity growth (%)	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	
*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
*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
Labor Markets														
Average participation rate (%)	64.7		60.8		66.3		64.3		68.9		65.5		66.3	
Average unemployment rate (%)	5.5		8.4		7.0		6.2		4.6		10.8		7.3	
Average retirement age	59.4		59.6		61.2		60.6		62.7		61.1		62.4	
*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
*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
Savings														
Annual interest rate (%)	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	
Trade balance/GDP (%)	0.70		2.67		-0.05		2.77		1.92		-1.91		3.01	
*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
Social Security														
Net pension replac. rate - low skills	0.85		0.60		0.86		0.47		1.17		0.98		0.74	
Net pension replac. rate - med skills	0.79		0.57		0.62		0.48		1.04		0.92		0.72	
Net pension replac. rate - high skills	0.62		0.42		0.47		0.43		0.90		0.81		0.66	
Net UI replacement rate - low skills	0.48		0.41		0.34		0.46		0.53		0.24		0.49	
Net UI replacement rate - med skills	0.39		0.37		0.34		0.36		0.50		0.21		0.46	
Net UI replacement rate - high skills	0.31		0.27		0.24		0.34		0.40		0.17		0.33	
Pension expenditure/GDP (%)	13.8		12.1		8.2		10.1		14.9		12.2		13.4	
Health and LTC expenditure/GDP (%)	8.9		8.2		6.7		8.8		9.3		6.6		8.3	
Public Finance														
Public debt/GDP (%)	78.7		100.4		46.7		87.6		55.1		64.5		57.5	
Avg labor tax rate - low skills (%)	10.1		17.1		4.5		9.2		30.3		11.4		18.9	
Avg labor tax rate - med skills (%)	17.0		21.7		6.7		13.5		33.6		15.0		20.7	
Avg labor tax rate - high skills (%)	23.8		28.5		10.1		19.0		38.2		20.6		27.5	
Average SSC employee rate (%)	15.6		9.5		10.0		14.6		8.9		6.5		5.7	
Average SSC firm rate (%)	26.0		21.7		30.9		14.5		12.0		30.5		19.8	
Average SSC retiree rate (%)	4.7		2.8		0.0		7.6		0.0		0.0		1.4	
*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
*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

Table 7: Model parameter values, outcomes and benchmark data, part 1

	FR		IT		NL		PL		SE		SK		UK	
	Mod	Data	Mod	Data	Mod	Data	Mod	Data	Mod	Data	Mod	Data	Mod	Data
Demographics														
Low skills share (%)	29.6		45.7		26.6		12.0		19.3		9.1		25.4	
Med skills share (%)	41.7		39.8		40.6		66.8		47.6		75.2		41.2	
High skills share (%)	28.7		14.5		32.8		21.2		33.0		15.8		33.4	
*Old age dependency ratio (%)	30.1	27.9	33.9	32.8	27.9	25.9	24.4	20.5	30.7	30.2	21.9	18.7	27.7	26.6
Production														
Exo. productivity growth (%)	1.21		1.21		1.21		1.21		1.21		1.21		1.21	
Capital/Output	3.2		3.5		3.5		3.0		2.6		4.5		2.5	
*Capital depreciation rate (%)	5.7	3.9	5.5	3.9	5.2	3.9	6.7	4.8	6.8	4.6	5.4	5.2	6.3	3.8
*Labor revenue share (%)	67.8	68.6	68.1	68.6	69.6	68.8	69.8	54.6	74.3	65.1	61.0	52.5	74.1	69.6
Labor Markets														
Average participation rate (%)	64.4		59.5		66.7		60.5		71.5		64.7		66.3	
Average unemployment rate (%)	9.8		7.7		4.0		13.8		6.5		14.4		5.0	
Average retirement age	60.2		59.8		61.6		59.4		64.1		58.0		62.1	
*Net earnings low vs med skills	0.78	0.92	0.85	0.85	0.83	0.86	0.73	0.74	0.89	0.92	0.75	0.76	0.81	0.81
*Net earnings high vs med skills	1.51	1.41	1.17	1.39	1.33	1.41	1.80	1.67	1.20	1.22	1.37	1.30	1.36	1.39
Savings														
Annual interest rate (%)	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	
Trade balance/GDP (%)	0.01		0.53		4.48		-2.54		3.81		-3.43		-0.94	
*Consumption/Output (%)	55.0	55.0	53.4	60.0	49.9	46.0	59.5	62.0	44.5	45.0	57.5	57.0	61.9	65.0
Social Security														
Net pension replac. rate - low skills	0.90		0.75		0.63		0.65		0.76		0.51		0.58	
Net pension replac. rate - med skills	0.92		0.77		0.62		0.58		0.75		0.52		0.41	
Net pension replac. rate - high skills	0.83		0.75		0.61		0.50		0.73		0.48		0.26	
Net UI replacement rate - low skills	0.41		0.11		0.57		0.09		0.37		0.18		0.12	
Net UI replacement rate - med skills	0.42		0.10		0.64		0.09		0.38		0.21		0.09	
Net UI replacement rate - high skills	0.35		0.09		0.45		0.05		0.29		0.22		0.06	
Pension expenditure/GDP (%)	15.0		15.6		12.3		11.2		11.7		8.6		7.7	
Health and LTC expenditure/GDP (%)	9.5		8.0		9.6		4.7		10.2		6.5		9.3	
Public Finance														
Public debt/GDP (%)	93.3		126.4		70.9		61.4		49.5		44.1		81.8	
Avg labor tax rate - low skills (%)	12.8		13.0		4.5		11.5		19.4		4.3		11.9	
Avg labor tax rate - med skills (%)	13.9		18.7		9.0		13.3		21.7		6.1		15.1	
Avg labor tax rate - high skills (%)	16.0		24.7		20.5		15.4		26.6		9.5		19.8	
Average SSC employee rate (%)	13.6		7.5		14.9		8.4		6.1		8.9		6.0	
Average SSC firm rate (%)	35.9		25.3		23.3		11.3		32.7		23.4		7.9	
Average SSC retiree rate (%)	1.0		0.0		10.8		0.0		0.0		0.0		0.0	
*Average consumption tax rate (%)	19.1	18.2	18.7	16.2	22.7	21.8	21.3	19.3	24.9	26.3	18.6	16.1	15.6	14.7
*Tax ratio/GDP (%)	48.1	42.9	40.9	42.9	41.9	38.7	33.5	31.7	48.0	45.5	28.4	28.3	37.4	34.9

Table 8: Model parameter values, outcomes and benchmark data, part 2