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Krzysztof Makarski, Joanna Tyrowicz,
Magda Malec

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Institute for Labour Law and Industrial Relations in the
European Union (IAAEU)
54296 Trier
www.iaaeu.de

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Krzysztof Makarski
FAME|GRAPE, NBP,
Warsaw School of Economics

Joanna Tyrowicz†
FAME|GRAPE, IAAEU, IZA
University of Warsaw

Magda Malec
FAME|GRAPE,
Warsaw School of Economics

March 2019

Abstract

Many countries consider rising fertility through pro-family policies as a solution to the fiscal pressure stemming from longevity. However, an increased number of births implies immediate private costs and only delayed public benefits of younger and larger population. We propose using an overlapping generations model with a rich family structure to quantify the effects of simulated increases to the birth rates. We analyze the overall macroeconomic and welfare effects of these simulated paths relative to status quo. We also study the distribution of these effects across cohorts and study the sensitivity of the final effects to the assumed target value and path of increased fertility. Since our study tries to quantify the possible effects of pro-natalistic policies, we focus of public costs and benefits of having children. We find that fiscal effects are positive, but short of the natalistic expenditures in many countries. The sign and the size of both welfare and fiscal effects depend on the patterns of increased fertility.

Key words: fertility, welfare, natalistic policies, overlapping generations model

JEL Codes: H55, E17, C60 C68, E21, D63

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†Corresponding author: j.tyrowicz@grape.org.pl.

1 Introduction

In a recent overview, Olivetti and Petrongolo (2017) argue that, in developed economies, the previous century of family policies facilitated female labor force participation, but had typically negligible causal effects on fertility rates (e.g. Baizan et al. 2016, Rossin-Slater 2018, the efficiency of natalistic policies differ between countries). Child care availability and parental leave, raise fertility mostly at the intensive margin (e.g Dehejia and Lleras-Muney 2004, Del Boca et al. 2009, Lalive and Zweimueller 2009, Rindfuss et al. 2010, Havnes and Mogstad 2011, Bauernschuster et al. 2015). Meanwhile, direct financial transfers appear to raise fertility, but at a high cost. Drago et al. (2011) finds that the average cost of an additional child in Australia amounts to roughly 130 thousand Australian dollars (studies for other countries comprise Milligan 2005, Brewer et al. 2012, Frejka and Zakharov 2013, Laroque and Salanie 2014, Garganta et al. 2017, among others).[1] Given the high costs and relatively low efficiency, one may ponder about the welfare and long-run macroeconomic effects of these policy interventions. Using historical life-cycle paths for many countries around the world, Lee et al. (2014) argue, that for some countries fertility of roughly 1.6 does not have to be a cause for a concern. However, this result does not account for potential general equilibrium effects from population dynamics and is mainly driven by the pension system viability. While the individual level (microeconomic) literature can evaluate the cost of one "additional" child born, for example, little has been done to estimate the macroeconomic and the aggregate welfare effects of this rise in fertility. Our aim is to contribute to filling this gap.

The costs of family policies are immediate, whereas macroeconomic benefits are delayed. Hence, structural modelling is indispensable. Moreover, child bearing and rearing consist of both private costs for parents as well as public costs covered by society, the benefits of a larger future working population can only be internalized through general equilibrium effects (e.g. lower taxes or higher pension benefits to the retirees, higher output due to higher employment, see the classical discussion by Easterlin 1975). Since the short run effects of policies and the anticipation of long run effects of changed fertility are likely to encourage general equilibrium adjustments, the overall direction of these adjustments is an empirical question that can only be answered with a general equilibrium tool.

We propose an overlapping generations model in which we simulate the effects of fertility increase. We analyze a variety of fertility scenarios and we obtain the estimates for the present value of the increased fertility in terms of fiscal gains. We also measure welfare effects of increased fertility from the point of view of society. Our study builds on some earlier work utilizing macroeconomic simulations on micro-foundations to evaluate the effects of demographic processes on economic outcomes. Werding (2014) provides a conceptual overview of the costs and benefits of having children from an economic perspective. Hock and Weil (2012) show that longevity may imply higher endogenous fertility in the long run.

In the study of Taiwan, Liao (2011) provides an account of the macroeconomic adjustments in a rapidly growing economy with endogenously declining aggregate fertility, but does not

[1] Many of the natalistic policies have objectives unrelated to long-term population trends: disease spread (Khan et al. 2016), reproductive health (Régnier-Loilier and Vignoli 2011, Ahmed et al. 2012, Bongaarts and Sobotka 2012, Bratti and Tatsiramos 2011, Casterline and Han 2017), contraception and family planning (Dereuddre et al. 2016, Singh et al. 2017), etc.

compare various fertility scenarios. Also analyzing the case of Taiwan, Sánchez-Romero (2013) accounts for the role of *previous* demographic developments, but this study focuses on the effects on output rather than on the fiscal effects. Georges and Seçkin (2016) give an account of possible macroeconomic outcomes for Turkey if, instead of central path, an optimistic scenario of population growth occurred. However, this study looks at aggregate change in the population size rather than family and fertility *per se*. Momota (2016), Fehr et al. (2017) and Ludwig and Reiter (2010) provide models with family structure and exogenous fertility. Models with family structure accentuate the relevance of the assumption about the type of fertility adjustment: families having more children (intensive margin) vs. more families having children (extensive margin). For example, the capital stock seems to exhibit a non-linear, U-shaped relationship with the share of mothers in the economy, i.e. the extensive margin of fertility (Momota 2016). However, Momota (2016) has a highly stylized 3-period model, while the interest of Ludwig and Reiter (2010), Fehr et al. (2017) lies in the old-age insurance provided within family. As a consequence, they do not elaborate the fertility scenarios, nor the consequences of changed fertility.

In light of this literature, we develop a model to study the macroeconomic and welfare effects of fertility changes. Our model allows providing an estimate of how much could be spent in order to achieve certain fertility targets without detriment to long-term aggregate fiscal stability and individual welfare. Throughout the study, we remain agnostic about the relationship between natalistic policy and fertility increase: fertility scenarios are exogenous[2], whereas our objective is to judge how much can be spent in fiscal terms to net out the present value of the increased fertility. We also provide an evaluation of the accompanying public component of the welfare effects. If majority of costs and benefits of children are private, there is little room for policy. In order to discuss room for policy, one should measure societal rather than private cost and benefits of higher fertility in terms of welfare. Our approach to measuring welfare achieves just that.

Relative to the literature, our paper offers several important innovations. First, we provide direct identification of the costs and benefits of higher fertility. To this end, building on Fehr et al. (2017), we implement a family structure into an overlapping generations general equilibrium model of an economy. We quantify the cost and benefits or changing fertility rate both in terms of welfare and fiscal effects. An important caveat for our results is that we exclude the direct utility of children ("love for children") from our model. We do this because we focus on the fiscally relevant angles of natalistic policy argument in evaluating the welfare effect (see also Cremer et al. 2006, where children do not affect welfare *per se*). A standard approach in economic analysis usually is to identify an external effect of some phenomena to justify policy support for it. Therefore, in our study we focus mostly on the costs and benefits that cannot be internalized by households. If the cost of having children is foregone consumption of parents and benefit is providing parents with a child that they 'love' then, their decision on number of children is optimal from the point of view of society and there is no point in pro-natalistic

[2]There is also a growing body of literature with endogenous fertility, e.g. Liao (2011), Ludwig et al. (2012), Hock and Weil (2012). However, for the objective of this paper, endogenizing fertility would not be an advantageous model setup. The model results would depend crucially on the assumed response of the households to the family policies, which would have to be stylized and sensitive to the assumed parameters.

policies. Whereas, in reality, raising children exhibits certain economies of scale, i.e. the average cost of raising a child declines in the number of children in a family. There are also externalities – childless individuals may benefit from a higher number of adults in the future despite bearing no immediate costs. Our focus in this study is on evaluating the strength of this channel.

Second, we analyze a variety of fertility increases, starting with incremental increases of the birth rates, up to levels equivalent to the population replacement rates. We also analyze a number of scenarios between these boundaries. While it may be unrealistic to assume that low fertility, advanced economies are likely to observe fertility of 2.1 any time soon, the inclusion of high fertility scenarios allows us to address the potential nonlinearities between the fertility and the fiscal and welfare effects. Notably, in scientific and policy debate the replacement rate is often considered a silver bullet: once replacement fertility rates are restored, fiscal stance is expected to return to balance, also yielding superior welfare outcomes.

Third, a change in fertility rate may occur because of adjustments at the extensive margin (more families have children at all) or at the intensive margin (families with children have more of them). Both the costs and the benefits of increased number of births depend on the proportion between the intensive and extensive margin adjustments, which is highly uncertain and may depend on the given policy instrument employed. To avoid arbitrariness at this stage of the model, we adopt a fairly novel approach, i.e. provide evaluation from a wide variety of simulated fertility paths to a given target fertility, separately for intensive and extensive margin adjustments. Hence, we obtain a distribution of welfare and macroeconomic variables, conditional on the distribution of children across families. This approach yields a sensitivity analysis of our findings, also providing conceptual "confidence intervals" for the simulated macroeconomic and welfare effects.

While the method we propose is universal, any applied OLG model needs to be calibrated to a specific economy. Our study is calibrated to the case of Poland. This case is interesting for two reasons. First, the country has a rapidly aging and declining population, due to pronounced and permanent decline in fertility between 1970s and 1990s, accompanied by increasing life expectancy. Hence, it is a convenient case to observe relatively larger fiscal and welfare effects than would have been the case for a country with positive population growth and stable age structure. Second, it has a defined contribution pension system, which makes it fiscally viable even in the light of the declining and aging population. While declining labor force is likely to yield low pensions, a rise in fertility will not only increase the tax base (fiscal effects), but will also imply directly an increase in pension benefits, thus raising welfare. Again, these effects should be larger than in the case of an economy with a defined benefit system, where majority of the welfare effects would come from the fiscal adjustments and no direct effect of population size on welfare could be expected.

We offer several novel findings. First, we show that even a 30% increase in fertility rate is associated with very moderate aggregate fiscal and welfare effects. Indeed, for small increases of fertility, the aggregate fiscal effects are often negative, gradually increasing to positive values in the case of greater rises in the birth rates. However, even for the target fertility rate in excess of 2.0, the fiscal effects are positive in the long run only in the extensive scenarios, allowing in total an approximately 2% rise in government expenditure. This is the actual size of the potential fiscal space from large increases in fertility. Given that not a single advanced economy which experienced fertility decline subsequently observed fertility rates returning to replacement rates despite much higher expenditure, one should be wary about the actual economic efficiency of natalistic policies. We also show that the adjustments which reduce childlessness yield lower fiscal gains (or higher fiscal losses) than the intensive margin adjustments in the birth rate. We discuss in detail the nature and sensitivity of these fiscal adjustments and their policy implications.

As to the welfare effects, they are much more sensitive to fertility than the fiscal effects. Indeed, for a given target rate in fertility, the welfare effects may vary between positive and negative, depending on how the change in fertility is translated to the family structure of the population. Large sensitivity of the sign is associated with almost negligible magnitude of these effects: they range from -0.1% of lifetime consumption to 0.04%. For comparison, the magnitude is roughly 20 times smaller than the welfare effects of the business cycle over the lifetime or that of pension system reforms. We discuss in detail the sources of these changes and how they can be influenced by economic policy.

This paper is structured as follows. First, we present the model in section 2 and the demographic projection in section 3. In section 4, we analyze the results of the simulations along with the sensitivity analysis. The paper is concluded by policy recommendations.

2 The model

We develop a general equilibrium overlapping generations model in the spirit of Auerbach and Kotlikoff (1987), as described in detail in Appendix A. As is typical in such frameworks, households make decisions on consumption, labor supply and savings to optimize life-time utility. While making their decisions, they take into account their cohort specific mortality rates.[3] Individuals derive utility from leisure and consumption, guided by the parameter defining their preference for leisure over working. This parameter is calibrated to match the labor supply observed in the data. The intra-temporal choice between leisure and labor supply determines the life-time path of earned income. Additionally, households may save and can either invest in physical capital or government bonds, which pay interest. This inter-temporal choice allows for the accumulation of assets over the working period to finance consumption in old age. The choice between contemporaneous consumption and delayed consumption (i.e. consumption and savings) is guided by the time preference parameter, which is calibrated to match the interest rates observed in the economy. The details of the consumer modeling are described in Appendix A.1.

The economy has a production sector. As is typical in such frameworks, our model has technological progress which augments labor productivity. Firms in the model employ labor and use capital to produce output, consumed by the households. The details of the producer section are described in Appendix A.2.

The economy has also government, which collects taxes and provides pension benefits to the retirees. The government taxes consumption as well as the income of labor and capital (see details of calibration in section 2.2). The government uses these proceeds to finance government

[3] We also introduce longevity: households from a given birth cohort live longer than older birth cohorts. The longevity is modeled according to the demographic projection.

expenditure as well as to service the public debt. Public debt is held constant throughout the simulation, in terms of share in per capita GDP. The details of the government budget constraints are described in Appendix A.4. The government also operates a defined contribution pension system, financed on a pay-as-you-go basis: it collects the contributions (on gross wages) and contemporaneously pays out the benefits to the retirees. The contributions and the pensions alike are indexed with the payroll growth rate, i.e. they depend on the labor supply and on wages. The pensions are an annuity from the contributions over the working years. The details of the pension system are described in Appendix A.3.

This fairly standard model is enriched to include families. Households consist of two types of agents: a primary care-giver has lower labor endowment if the household has children. Following the empirical evidence, if there are children in a given household, the labor supply of a primary care-giver is temporarily reduced, to reflect the asymmetric nature of the costs of child bearing and rearing (e.g. Attanasio et al. 2015, Erosa et al. 2016, Adda et al. 2017).[4] Given the number of children in the household, the individual consumption of the adults in the household is also adjusted to reflect the equivalence scales. From now on, for simplicity, we refer to primary care givers as PCG and the other adult in the household as SCG. To keep the model tractable, households are formed when agents are young and the number of children is the main characteristic which distinguishes households of a given birth cohort from one another (see also Ludwig and Reiter 2010, Fehr et al. 2017). A household may have zero, one, two or three children. We describe the details of fertility scenarios in section 3.

2.1 Fiscal and welfare effects – mechanisms

When the population grows, the government may observe an increasing tax base. This higher tax base may be used to finance some government programs. We make no assumptions on how this *additional* government revenue is spent and how it affects household utility, instead, we distribute its equivalent in the form of a lump sum transfer to all the living households. We use these *additional* tax proceeds as the measure of the fiscal effect of increased fertility. We use the utility of the households, including the one they derive from the lump sum transfer, to measure the welfare effects of the increased fertility. Note that there are many ways that this extra revenue can be spent. It is entirely possible that a government could find a highly productive way of employing these resources to the benefit of the agents. Indeed, those benefits could outweigh the welfare costs we demonstrate. With changed fertility, economic conditions also change: higher labor supply due to a larger population affects the relative price of labor and capital. The net effect of higher labor supply and changed wages affects the rate of pension benefits indexation. These general equilibrium effects also influence the utility of the households in the scenario of increased fertility, relative to the baseline scenario of unchanged fertility. We give the exact formulae of the fiscal and welfare measure in Appendix A.6.

Notably, our setting takes the conservative view that children yield no direct utility – an argument referred to by the literature as "love for children" (see Cremer et al. 2006, Ludwig and Reiter 2010). If children yield direct utility, increasing fertility implies a trivial direct

[4] In the interest of clarity and tractability, we abstract from the quantity-quality problem formulated in the literature on fertility, e.g. Baudin (2011).

increase in welfare. Our modeling is conservative approach, which has an additional advantage of yielding novel insights. Namely, we measure two components of welfare effects: the change in the nature of the world in which the households live and the change of the composition of the individual household types. The net effect of these two can be positive or negative and thus remains an empirical question. Since these two effects are likely to operate in the opposite direction – children constitute an externality – it may also be that the observed net effect on welfare are negligible.

2.2 Model calibration

The demographic calibration replicates the demographic evolution of Polish population over the period 1964-2014. We have the same birth cohort size at every age and the same number of births as well as cohort-specific mortality as was observed in the data until 2014. We use this 50 years period to construct the population at the moment, when we begin simulating the alternative fertility paths. The economic calibration replicates micro- and macroeconomic features of the Polish economy in 2014. This implies that the model is effectively calibrated along the path: we seek parameters that allow economy to arrive at a state consistent with the data in 2014, conditional on the data-driven demographic evolution from the period 1964-2014. Table A.1 reports the central parameters of the model.

Production function The path of the TFP growth is in line with the projections of European Commission AWG Aging Report. It was constructed under the assumption that poorer members of the EU will continue to catch up until around 2060 when productivity in all countries will be slowly converging towards the value of 1.0% per annum.

The capital share of income is assumed at the standard $\alpha = 0.33$ level, and the annual depreciation d rate is calibrated to yield a GDP investment share at the level of 21%, which is the average investment rate over the past two decades in Poland.

Taxes and the government The share of government expenditure in GDP is assumed to be constant, in the steady states as well as along the transition, at the level of 20% of GDP *per capita*. This implies an increase in government expenditure in absolute terms, i.e. every additionally born person receives the same education, health care, etc.

The initial debt to GDP ratio is set to 60%, corresponding to the data. We set the capital income tax rate at the *de iure* level of 10% as there are no exemptions. The labor income tax τ_l is set at 6.8%, which matches the rate of revenues from this tax as a share of GDP (on average over the past two decades). The social security contribution rate is calibrated to replicate the resulting pensions to GDP ratio of 7%. The consumption tax rate is residual.

Preferences The leisure preference parameter ϕ is set to 0.28, which is calibrated to replicate the labor market participation rate of 56.8 in 2014, as reported by the Polish Labor Force Survey. To translate household consumption into the consumption realized by the adult family members we use scaling parameters in order to replicate the equivalence scale used. Note that even in childless households, there are scale effects of the second adult. Using the formula from equation (A.2), we find that the parameters of the household consumption replicate the values of the equivalence scaling factors, which are consistent with values in the earlier literature (e.g. Fehr et al. 2017). We calibrate the time preference parameter to replicate the interest rate of app. 6.5% in the initial steady state, consistent with the data and literature. [5]

The full account of the calibrated parameters is reported in Table A.1.

3 Demographics

In the model, the initial population structure is matched to replicate the data covering 1964-2014. We describe below procedures employed to obtain the initial population structure. Subsequently, we utilize the mortality rates as projected by the Central Statistical Office until 2060 and stable thereafter. We also use the fertility projected by CSO as our baseline scenario. Fertility projections by the CSO are in terms of total fertility rate, whereas our model structure operates in terms of the completed fertility rate (or, otherwise put, with the total number of children born to a given birth cohort). We explain below the procedure to replicate the demographic projections of the CSO in terms of the structure of our model.

[Table 1 about here.]

Our model starts from the number of children born in every year. Applying the mortality rates, the model would be able to reconstruct the size of each age group in every year. However, annual cohort-specific mortality data are not readily available beyond 1964. Moreover, the legacy of the World War II, 1968 and subsequent waves of emigration and return migration confound the regular, age specific mortality patterns with other population flows if one wanted to use the size of each birth cohort to recover the mortality rates. Moreover, household structure in terms of the number of children is only available for the recent years. Prior to 1990, the data may be recovered from the census, hence at low frequency.

Given these constraints, we simplify the population in the initial steady state in the following manner. We obtain the fertility data for the period 1964-2014. We obtain the age-specific mortality rates for the period 1964-2014. For simplicity, we assume flat TFR for 2006-2014 period to eliminate short run fluctuations which caused computational issues to our algorithms. The flat TFR for 2006-2014 is assumed at the level averaged over the actual TFRs measured in this period. Under the assumption that averaged fertility rates generated the population in the initial steady state, we obtain the input for our model about the household structure in terms of the number of children born across households over the period 2006-2014. We define s_i $\forall_i \in \{0, 1, 2, 3+\}$ to denote the share of households with zero, one, two and three or more children, respectively. Similar to TFR, also these shares are assumed flat over the period 2006-2014 for computational reasons. The flat shares match exactly the averages in the data.

Note that the population is not stationary in the initial steady state. Neither is there a replacement of subsequent cohorts. In fact, we calibrate the model to reflect the $TFR = 1.44$, see Figure A.1. Table 1 summarizes the assumptions in the model and the fit between the model and the actual population structure.

[5] See also Nishiyama and Smetters (2007). The average real annual rate of return at the level of 7.5% was achieved by the open pension funds with a balanced portfolio strategy in the period 1999-2009.

Mortality The mortality projections start with the Eurostat projections. Mortality gradually declines for the subsequent birth cohorts, reflecting longevity. For simplicity, we assume unified mortality rates for both types of adults. Since in our model, for the purpose of tractability, parents cannot die until they complete child rearing, we adapt the initial age structure of the mortality rates: the probability of death is reduced to 0 prior to children leaving the household and is proportionally higher thereafter. This adaptation of the mortality tables is of negligible importance already in mid 1980s and our adjustment is lowering with the time, see Figure A.2.

Fertility The fertility projections are published in terms of total fertility rate, which is a year specific measure of the number of children born in a given period relative to women within certain age brackets. In our model, the population is obtained using the completed fertility for each birth cohort. Hence, we utilize the age specific fertility from the data to recalculate the completed fertility from the total fertility rates for the initial year of our simulation. We assume a stable relationship between total and completed fertility. This assumption may easily be relaxed in our setup, depending on the scenario of interest.

Once the projection is reformulated in terms of completed fertility rather than TFR, it is straightforward to obtain the size of each birth cohort at time t, born to mothers born at time $t-20$. The annual increase in the size of the cohort is the population growth measure we utilize in our model.

Changes in fertility paths (simulation scenarios) We depict two types of the scenarios: the baseline scenario and the raised fertility scenarios. In the baseline scenario we utilize the *status quo* demographic projection provided by the Central Statistical Office of Poland. This projection provides the number of births until 2060. We convert the number of births to the fertility rate in our model. We assume that the economy converges to the last value in the projection in the long run. This assumption is only needed for computational purposes (in order to obtain a transition path, we need to provide an end point for this path). In the raised fertility scenarios, we allow the fertility in the model to deviate from the baseline scenario of the demographic projection. Implicitly, we assume that this deviation is a consequence of some tacit change in family related policy and evaluate the macroeconomic (fiscal) and welfare effects.

Given the versatility of our approach, one could imagine evaluating effects of any specific change in fertility, but only some of those possible scenarios are plausible. Frejka and Gietel-Basten (2016) provide an overview of the fertility and family policies in Poland, as well as the rest of the Central and Eastern Europe, arguing that the decline in fertility observed in these countries is partly a fault of deficient welfare states, unable to provide necessary public services. Hence, it appears plausible that, with a substantial change in policy, some increase in fertility is possible. We use evidence from previous episodes of fertility change from other countries to formulate scenarios of interest. For example, generous policies in Russia implied a 30% spike of TFR in only few years, but negligible permanent effects (Frejka and Zakharov 2013). Some positive fertility effects of pro-natalistic policies were also observed in Australia (Sinclair et al. 2012), Austria (Lalive and Zweimueller 2009) and Norway (Rindfuss et al. 2010). By contrast, in Canada (Milligan 2005) and Argentina (Garganta et al. 2017), costly policies observed almost no change in TFR. The Netherlands, meanwhile, observed a surprisingly high increase in the so-called "catching up" fertility, despite programs targeting this specific type of procreative patterns (Fokkema et al. 2008). Given these insights, we analyze small increases in fertility (as reflecting the low effects scenarios) and medium increases in fertility (as reflecting the gradual increase in fertility in the Netherlands). For the sake of argument, we also include the scenario of fertility rates securing population replacement.

Family structure of the population The combination of households with zero, one, two and three or more children has to change to allow for a change in completed fertility. Indeed, for any change in the fertility, there is an infinite number of combinations between the types of families. The literature has emphasized the relevance of the intensive margin adjustment and small effects for the extensive margin. For example in Germany, the provision of child care facilities had noticeable effects for families with children, who increased fertility, but no effects for families without children (Bauernschuster et al. 2015). There is a rich body of literature on childlessness, arguing that trends in childlessness are even less persistent and predictable than the trends in fertility in the short and medium run, whereas in the long run, the share of household with no children has been increasing over the past several decades and may continue to do so (e.g. a volume by Inhorn and Van Balen 2002). Moreover, some policies may address specifically the "first child" (e.g. first child bonus in Australia), whereas others may encourage families to have more children (e.g. child income support for families with two or more children in Poland). Clearly, any decision about the change in the family structure of the economy is arbitrary.

To limit the scope of arbitrariness, we propose a simulation approach. Given the lack of clear empirical suggestions and policy relevance, we will analyze both intensive and extensive scenarios of fertility change. For a given target increase in fertility, we consider two paths. First, we assume that the proportion of childless households remains unchanged and adjust the share of 2 and 3+ children households to match the target fertility rate. We assume their ratio to one another to be constant. We call this the intensive scenario. Second, we assume that the proportion of childless households declines and adjust the share of 1, 2 and 3+ households to match the fertility rate, assuming their ratio to one another is constant. We call this the extensive scenario. We then randomly simulate paths for each of the plausible fertility rates: 100 paths for intensive scenarios and 100 paths for an extensive scenario for each plausible target fertility rate. See Appendix D for details of the simulation procedure.

4 Results

In the baseline scenario, the fertility rate is assumed to continue at 1.44. In the scenarios of increased fertility, we compare the fiscal and the welfare effects for the alternative target fertility rates. We first portray, in Figure 1, the relationship between the fertility rise and the fiscal and welfare effects. We consider intensive and extensive scenarios as separate, to show the potential boundaries on the measurement of the fiscal and welfare effects.

Recall that the increased fertility may result in an immediate fiscal cost in the form of lower labor force participation. Unless adjustments in labor supply of the secondary care givers or wages fully compensate for this labor force decline, labor tax revenue are bound to decline.

Naturally, lower labor supply pushes wages up, partly offsetting the effects of reduced labor supply in the government and household budgets. As the new generations enter the labor force, gains arise in fiscal terms, as the additional number of workers pays labor taxes and the additional number of consumers pays consumption taxes. At the same time, larger labor supply drives the wages down in relative terms, due to labor being relatively more abundant in this economy. The net effect of these two opposite processes remains an empirical question and is likely to depend on the size and the character of the fertility increase. Our measure of the fiscal effects yields the net outcome in terms of the revenues raised by the government, controlling for the commensurate increase in government expenditure (recall that, in our model, government expenditure is constant in *per capita* terms, hence rising population will imply larger government expenditure; we describe in detail in Appendix A.6 the method obtaining this measure).

The welfare effects answer if the households populating our model prefer to live in the *status quo* economy of unchanged fertility or in the economy with raised fertility. Raised fertility will yield direct increase in utility due to higher pensions. The direct cost comes from lower consumption by the adults, since consumption of children needs to be provided for. There is also an indirect source of welfare effects: a change in wage due to different labor supply in the economy. The measurement of the net effect of these processes is described in detail in Appendix A.6.

[Figure 1 about here.]

Admittedly, the effects in Figure 1 are small. Fertility increase generates fiscal gains in net terms, reaching up to 2.5% of the total government budget for fertility target of 2.1 in the extensive scenario and slightly short of 2% in the intensive scenario, see the left panel of Figure 1. For small increases in fertility, the difference between the intensive and extensive scenarios is negligible, due to small overall effects. In the case of the intensive scenarios, the fiscal gains are about 25% smaller than in the case of the extensive scenarios, which stems from the fact that the decline in labor supply by primary care givers is, to a large extent, offset by the higher labor supply of the other adult. This increase in the labor supply of the adult with unconstrained labor supply comes largely from the income effect: a larger number of children imposes more decline in consumption for the adults. Consumption smoothing necessitates increasing labor supply to compensate the decline in consumption. The extensive scenarios – which by construction imply larger negative direct effects for the labor supply of the primary care givers – result in effectively larger boosts to wages, making the initial adjustments somewhat less fiscally costly than in the case of the intensive scenarios. We depict the behavior of aggregate wages, interest rates and capital in Appendix C.

Notably, the welfare effects are of low magnitude and negative, falling short of 0.002% of lifetime consumption even for a significant fertility increase. The main reason behind this result is the decline in wages in response to a larger supply of labor.[6] Note that welfare effects measure the change in utility with probabilities of having $1, 2, ..., 3+$ kids unchanged. So in a sense, it

[6]Admittedly, this effect could be a consequence of the assumed functional form for the production function. With a Cobb-Douglas production function, the labor share – the share of output that goes to labor – is bound to be constant. With a different functional form, increased supply of labor could affect labor and capital shares in the economy, partially offsetting the decline in wages. However, although a different functional form of the production function could reduce the size of the wage channel, it would not change the size of the overall welfare

is the average change of welfare for a household between the baseline scenario and the scenario of increased fertility. But, when we measure this effect we abstract from both private benefits and private costs of having children.

The results depicted in Figure 1 are fairly universal in a sense that the patterns are preserved even if the fertility rate prior to the simulated increase is not 1.44, see Figure A.4 in Appendix E. We analyzed an extreme case of the low fertility environment taking 1.2 as the baseline value (similar to Singapore or Korea) as well as baseline of 1.7, (which characterizes some advanced European economies, e.g. in Denmark, Finland or the Netherlands). The patterns, scale and direction of fiscal and welfare changes remain the same, see Figure A.4a and Figure A.4b. Note that in this sensitivity check we do not re-calibrate the economies to gauge the pure effects of the baseline fertility rates on the final results. Hence, any comparison needs to be made with caution because these simulations, in essence, share the same parameters, but refer to different simulated economies, even in the baseline (see Figure A.5).

The results reported in Figure 1 could mask the large role of the composition effects. Namely, for each increase in fertility, as reported in that figure, we had to make an assumption concerning the type of adjustment: how many childless households from the baseline scenario will have a child in a raised fertility scenario, analogously for households with children. Our setup – in order to replicate the features of the real world – is susceptible to those assumptions, as the costs of raised fertility will depend crucially on the change in the household structure. Depending on the exact pattern of fertility increase, the welfare effects are also likely to differ. To this end, we perform a series of systematic sensitivity analyses. We choose two specific target fertility rates in the increased fertility scenario and analyze the role of the composition effects by simulating various paths of reaching that given target fertility. In the simulations, we follow the intensive or the extensive adjustments, described earlier, but allow the ratios to vary. The details are described in Appendix D.

The target levels for the completed fertility were based on the literature. Notably, many of the studies find moderate increase in fertility in response to natalistic policies, usually short of 10%. Hence, the first target is to reach 1.5 completed fertility over the simulation horizon, starting from 1.4. However, in some selected cases, the fertility increased by as much as 30% (e.g. the changes in reproductive patterns in the Netherlands since 1970s). Commensurate increase of fertility in the case of our simulation implies a target rate of 1.9, starting from 1.4. Indeed, among low fertility advanced economies, larger increases were not observed. Yet, 1.9 target fertility rate implies that the population continues to shrink, only at a lower rate. To also include a scenario of eventually stationary population, with a stable replacement, we also include a simulation with 2.1 target fertility rate. For each targeted value and for each type of the scenario, we simulate 100 possible paths. Hence, in total we run the estimations for 600 patterns of fertility increase. These simulations provide a sense of confidence in one given simulation path, i.e. they permit to answer computationally if a selected composition of changes in fertility is likely to yield outlying fiscal and welfare effects, or are all compositions of changes

effects: they would be small, even for substantial changes in fertility. To address this point, we analyzed the case of the constant elasticity of substitution (CES) production function, which permits the endogenous change in the labor share and capital share in response to the changes in relative abundance of the production factors. Despite allowing this more flexible functional form, the conclusions remain qualitatively the same. The detailed results are available upon request.

in fertility delivering roughly the same ballpark of the results. The results are portrayed in Figures 2 and 3.

[Figure 2 about here.]

[Figure 3 about here.]

The sensitivity analysis portrayed in Figure 2 reveals that the size of the fiscal effect depends to a large extent on the change of the fertility patterns, not solely the fertility rate. The reason for this dispersion is predominantly the share of childless households that start having children. Indeed, the results are highly compressed for the intensive margin scenarios. The higher target fertility rates, naturally, result in higher fiscal effects, but the dispersion of the results remains similarly large. Given the displayed distributions, it is challenging to predict accurately the overall fiscal effects of any natalistic policy intervention even for one given predetermined target fertility rate. If one may not forecast the fiscal effects, but one follows the objective of implementing only positive net present value policies, it may be rather difficult to determine the potential natalistic policy spending even if it were to be effective in raising fertility.

In terms of welfare, here too the intensive margin scenarios are compressed, yielding effectively indistinguishable welfare levels. They are negligibly positive for the below replacement fertility and negative for the 2.1 fertility scenario. However, the extensive scenarios display negative values for welfare effects for the small and medium increases in fertility, as well. These negative effects are small, not exceeding 0.0025% of lifetime consumption. One way to think about these results is that even with very small direct utility of having children, the world with raised fertility would be preferable, because it would easily outweigh the negative values derived from the general equilibrium effects evaluated in the model.

Our results also shed some light on the discrepancies in the empirical literature struggling to *causally* attribute the effects of policy to fertility outcomes. Observing the histograms of the fiscal and welfare effects reveals that indeed the composition of the increased fertility is of paramount importance for low changes in fertility (as majority of the cases analyzed in the empirical literature). Notably, the differences between the various extensive scenarios as well as the intensive scenario revealed by Figure 2 show that the welfare may be both positive and negative in the case of 1.5 scenarios. If taken at a face value, our results argue that some agents may find it optimal not to respond to natalist policies due to unfavorable general equilibrium effects, in particular if these policies encourage extensive adjustments. Also, the benefits of potential intensive adjustments are not high, hence inattention could be a rational response to these policies.

Finally, we also present the time distribution of the gains and losses due to the increased fertility, as portrayed in Figure 3. In the early years of demographic change, a larger number of children is related to only small fiscal effects: adjustments in labor supply and wages roughly compensate each other, combined with increased consumption. As the "additional" children become adult and start contributing to the economy, the fiscal gains surface. They are larger in the case of extensive scenarios, due to the fact that there are increasing returns to the number of children, as calibrated by the equivalence scale. Once the economy adjusts to the new population growth rate (and the implied adjustment in prices and taxes), the fiscal effects stabilize at negative and small levels, relative to the baseline scenario of lower fertility. This it due to the fact that a larger number of children implies a larger social cost of raising them. The fiscal effects can be universally positive in the long run only in the case of high fertility extensive scenarios (bottom right panel of Figure 3).

The results are in general consistent with the earlier literature (e.g. Ludwig and Reiter 2010, Sánchez-Romero 2013). Increased fertility generates important direct fiscal effects already when the "new" children are born, not only when they come to the labor market, which implies that policies subsidizing higher fertility need to be cautiously designed and require strong commitment. We also provide insights regarding the role of the family structure. Momota (2016) and Fehr et al. (2017) argue that the actual combination of extensive and intensive margin increase in fertility may be relevant for the economy, but the focus of these studies is placed elsewhere in a sense that they do not inform about the fiscal nor welfare effects of the raised fertility. We show that the actual composition of the intensive paths is of minor importance: the results are relatively robust for a given target rate both in fiscal and in welfare terms. However, once we allow for extensive margin adjustments as well, increased fertility may in fact imply negative fiscal effects for a range of modest fertility increases. For a larger increase in fertility, extensive margin scenarios imply negative welfare effects due to the fact that a fairly large number of adults in households experience a reduction in welfare due to lower consumption and a smaller labor endowment. This finding may help to explain why different empirical studies find opposite effects of fertility on labor supply, economic well-being, etc.: depending on the actual adjustment path in fertility, the results for households may be positive or negative and in either case, likely to remain negligible. Given how much more randomness is observed in empirical data, type 2 errors are very likely despite best methodological efforts.

5 Conclusions

In his overview of the economic approaches to fertility, Werding (2014) gives an intuition as to why increased fertility – although possibly socially desirable – economically may impose some costs as well. Earlier literature has typically analyzed the effectiveness of public policy instruments – including fiscal instruments – on increasing fertility (e.g. Baizan et al. 2016, Rossin-Slater 2018). There is also abundant literature on the link between pension system viability and demographic trends (Liao 2011, Ludwig et al. 2012, Hock and Weil 2012). However, quantification of the intuitions summarized by Werding (2014) has, so far, been largely missing from the literature. Lee et al. (2014) present evaluations from demographic simulations, but their models have no adjustment at the household level. To this end, we develop a micro-founded model with a rich family structure to evaluate the macroeconomic and welfare effects of fertility changes, providing an estimate of how much may be spent in order to achieve certain fertility targets, without detriment to long-term aggregate welfare.

In our setting, when a larger number of children are born, the immediate reaction is a decline in labor supply (due to the lower labor endowment associated with the need to provide care) and a decline in the consumption of the adults (due to non-zero consumption of the "new" children). The decline in the labor supply necessitates wage adjustments (and thus interest rates). The exact magnitude of these costs depends crucially on the extent to which larger fertility is associated with an intensive margin adjustment (households with children have more of them) and the extent to which they are associated with an extensive margin adjustment (households without children start having them). This discrepancy owes to the fact that we allow for economies of scale in child rearing, which is in concordance with a large number of empirical regularities (e.g. the use of the equivalence scales, see also Fehr et al. 2017, and references therein). On the side of the benefits, an increased number of adults, as children grow older and start participating in the labor market, raises the output of the economy as well as increasing the size of the tax base. By consequence, when population is growing – relative to the baseline of unchanged fertility – fiscal gains emerge. Once the society stabilizes at a new demographic structure, a larger number of people *per se* implies fiscal costs, as many public policies are fixed *per capita*, which reflects the empirical regularity that bigger populations typically have bigger governments (bigger in aggregate terms, stable in *per capita* terms). Summarizing, in the long run, a larger population need not be fiscally less costly in aggregate terms. This combined with the fact that private costs are immediate, whereas gains appear with delay and via general equilibrium effects, implies that computing a fiscal net present value of increased fertility requires a rigorous model.

Admittedly, all the identified aggregate effects are small. In fact, if natalistic policies result in an increase in fertility in the range of up to 30% they are likely to bring about fiscal loss in the long run. A relatively high increase in fertility from 1.4 to 1.9 creates a permanent fiscal surplus in the aggregate terms of 1-1.5% of the total government budget, which is much less than the budget of natalistic policies in many countries (e.g. Poland currently spends over 8% of the total government budget on child benefits alone; additionally, there are expenditures related to health during pregnancy and child-rearing, institutionalized care programs and tax credit for families with 2 or more children). Moreover, intensive margin scenarios have the lowest yield in the range of the fiscal effects, which implies that, in the case of policies encouraging larger families rather than more families, the net fiscal effect is less likely to be positive.

We model the immediate cost of children as a reduction in labor endowment. This way of modeling is not a value statement, however. Indeed, whether the care is provided within a household by a primary care giver, by two adults in the household or by institutionalized care, less labor can be used in the directly productive sector of the economy. Our model is indifferent between the scenario of shared care (the two adults sharing the caring time equally) and the scenario of care specialization (all care time is provided by primary care giver). The primary care giver and the other adult are the same in terms of productivity, mortality and preferences. Naturally, one possibly interesting avenue for further research would consist of analyzing the direct link between the reduction in the time endowment and the fiscal cost of raising children, as the two are likely to exhibit a trade off: higher fiscal costs of raising children could be associated with a lower reduction in time endowment and thus lower decline in fiscal revenues when a larger number of children is born in the economy.

In our model, the effects of increased fertility in the pension system characterized mostly by a higher indexation of contributions and pensions. Hence, the retired households receive higher pension benefits than they would have received if fertility continued at the *status quo*. This is a direct source of welfare gain, which appears to be outweighed by the direct effect of children on adult consumption as well as a decline in wages. Since, in our setting, the society begins and ends with a self-stabilizing defined contribution scheme, the system itself is not generating fiscal effects with increased fertility. However, in the case of defined benefit schemes with fixed contribution rates, raised fertility would improve solvency of pension systems, therefore increasing the fiscal effects of raised fertility. Measuring this effect in the case of a defined benefit system is an interesting extension for the future.

Another feature that could be of interest to scholars in the future is the extent to which the adjustment of population growth rate could be substituted by alternative channels, for example by faster technological progress. In this model we use the European Commission forecast of the TFP growth rate, which assumes convergence for the whole of Europe to 1.1% per annum. A increase in the TFP growth rate, commensurate to the modeled increased fertility, would necessitate the TFP to increase at 1.4% per annum for the scenario of target fertility at 1.5 and 2.6% for the target fertility at 1.9. While the former seems feasible in a sense that, in the past, the TFP in Europe grew on average at rates in excess of 1.4%, the long-term average TFP growth at 2.6% does not seem attainable in practice. Given these limitations, one could and should also consider a mix of policies, which combines investment in faster technological progress and fosters fertility. Relative to the results presented in this paper, such combined policies are likely to boost the fiscal gains, while reducing the welfare losses.

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A The theoretical model – full derivation

A.1 Consumers

The economy is populated by agents forming κ classes of households with a differentiated household structure, but preferences drawn from the same function family. Households consist of two adults, the class of the household κ denotes the number of children to be born and raised in that household: $\kappa = 0, 1, 2, 3$. Agents live for $j = 1, 2..., J$ periods facing a time and age specific mortality rate. Agents have no bequest motive, but since survival rates after the age of $j = 40$ at time t – i.e. $\pi_{j>40,t}$ – are lower than one, in each period t, a certain fraction of subcohort (κ, j) leaves unintended bequests, which are distributed within their subcohort. Hence, the subcohort (κ, j) is identified by the year of birth, by the number of children to be raised and characterized by survival probabilities, same for all agents born in a given year.

Until adult ($j \leq 20$), agents live in the household of type κ to which they were born at time $t - j$. After reaching adulthood at $j = 21$, agents form a new household and observe the realization of κ i.e. how many children are born in their household.[7] Once born, agents do not die until they reach the age of $j = 40$ (children are raised). This assumption has no large bearing on the model, as it is equivalent to the alternative convention in the literature that when the household head dies, the household is dissolved and the surviving dependent offspring are borne by a different household of the same type (Sánchez-Romero 2013, Fehr et al. 2017).

After reaching adulthood, at each point in time t a family of age j with κ number of children purchases on the market $c_{\kappa,j,t}$ and allocates hours of work to primary and secondary care givers (PCG and SCG). We denote by $l^*_{\kappa,j,t}$ the labor supply of the primary care given and by $l_{\kappa,j,t}$ the labor supply of the other adult in the household. Throughout the text we follow the convention that the asterix denotes the allocation for PCG in the household. We assume collective decision making within a household, which means that households maximize the weighted sum of utility of both adults in the household.[8] Consequently, assuming equal weights, the utility of a household at age $j \geq 21$ with κ number of children in period t is as follows:

$$U_{\kappa,j,t} = \sum_{s=0}^{J-j} \beta^s \frac{\pi_{j+s,t+s}}{\pi_{j,t}} [u_{j+s}(\tilde{c}_{\kappa,j+s,t+s}, l_{\kappa,j+s,t+s}) + u^*_{j+s}(\tilde{c}_{\kappa,j+s,t+s}, l^*_{\kappa,j+s,t+s})] \tag{A.1}$$

where β denotes the discount factor and $\tilde{c}_{\kappa,j,t}$ denotes individual consumption per household member obtained from purchasing $c_{\kappa,j,t}$ consumption units on the market.

Individual consumption for each adult in a household depends on the number of children in this household and can be defined as follows:

$$\tilde{c}_{\kappa,j,t} = \begin{cases} \frac{1}{(2+\vartheta(\kappa))^{\varpi}} c_{\kappa,j,t}, & \text{for } 21 \leq j < 41 \\ \frac{1}{2} c_{\kappa,j,t}, & \text{for } j \geq 41 \end{cases} \tag{A.2}$$

[7] This assumption is without the loss of generality, as the model does not address the link between the timing of the first-born and the final number of children.

[8] With such assumption, weights for both adults may be equal or display a disparity (e.g. Gray 1998, Agarwal 1997).

where $\vartheta(\kappa)$ is a scaling parameter factor which adjusts consumption for the number of children and ϖ determines the economies of scale in the household. These economies of scale reflect the fact that e.g. nutrition of a household with 1 children is more than half as costly as nutrition as a household with 3 children.

Total time endowment is normalized to one for SCG and childless PCG. For PCG of type $\kappa = 1, 2, 3$ time endowment is reduced by child bearing and rearing $\forall_j \leq 40: \ \varphi(\kappa) > 0$, where $\varphi(\kappa) > 0$ denotes the fraction of time devoted to caring. Once children reach adulthood, PCG in each type of household have total time endowment normalized to one. Agents work until $j \geq \bar{J}$, when they retire. The instantaneous utility function for agents in a household is defined as follows:

$$
\begin{aligned}
\text{SCG in age} \quad j < \bar{J}: & \qquad u_j(\tilde{c}_{\kappa,j,t}, l_{\kappa,j,t}) = \log \tilde{c}_{\kappa,j,t} + \phi \log(1 - l_{\kappa,j,t}) \\
\text{PCG in age} \quad j < 41: & \qquad u^*_j(\tilde{c}_{\kappa,j,t}, l^*_{\kappa,j,t}) = \log \tilde{c}_{\kappa,j,t} + \phi \log(1 - l^*_{\kappa,j,t} - \varphi(\kappa)) \\
\text{PCG in age} \quad 41 \leq j < \bar{J}: & \qquad u^*_j(\tilde{c}_{\kappa,j,t}, l^*_{\kappa,j,t}) = \log \tilde{c}_{\kappa,j,t} + \phi \log(1 - l^*_{\kappa,j,t}) \\
\text{SCG in age} \quad j \geq \bar{J}: & \qquad u_j(\tilde{c}_{\kappa,j,t}, l_{\kappa,j,t}) = \log \tilde{c}_{\kappa,j,t} \\
\text{PCG in age} \quad j \geq \bar{J}: & \qquad u^*_j(\tilde{c}_{\kappa,j,t}, l^*_{\kappa,j,t}) = \log \tilde{c}_{\kappa,j,t}
\end{aligned}
\tag{A.3}
$$

Households maximize utility, subject to the budget constraint, which consists of (net) earned income, interest on savings, pension benefits and (net) social transfers. Earned income $w_t l_{\kappa,j,t}$ is subject to labor income tax τ_l. Agents pay mandatory social security contributions τ. Labor income tax is also levied on pension benefits. Households can accumulate assets, $a_{\kappa,j,t}$ denotes assets per adult in household, which earn interest r_t. Interest earned is subject to capital income tax τ_k. Households of subcohort $\{\kappa, j\}$ receive unintended bequests $beq_{\kappa,j,t}$ and pay lump sum tax Υ_t equal for all subcohorts (and used to close the model in t, can be negative in which case it becomes subsidy). Once a member of a households retires she or he receives a pension $b^*_{\kappa,j,t}$ (for the primary care giver) and $b_{\kappa,j,t}$ (for the other adult). Hence, the budget constraint of household type κ at age j in time t is given by:

$$
\begin{aligned}
(1+\tau_c)c_{\kappa,j,t} + a_{\kappa,j+1,t+1} \quad = \quad & (1-\tau-\tau_l)w_{j,t}l_{\kappa,j,t} + (1-\tau-\tau_l)w_{j,t}l^*_{\kappa,j,t} \\
& + (1 + r_t(1-\tau_k))\, a_{\kappa,j,t} \\
& + (1-\tau_l)b_{\kappa,j,t} + (1-\tau_l)b^*_{\kappa,j,t} \\
& + beq_{\kappa,j,t} + \Upsilon_t
\end{aligned}
\tag{A.4}
$$

where τ_c denotes a consumption tax.

A.2 Production

Perfectly competitive producers supply a composite final good with the Cobb-Douglas production function $Y_t = K_t^{\alpha}(z_t L_t)^{1-\alpha}$ that features labor augmenting exogenous technological progress denoted as $\gamma_{t+1} = z_{t+1}/z_t$. By K_t and L_t we denote the capital and labor, respectively.

The maximization problem of the firm yields the following standard equations

$$r_t = \alpha K_t^{\alpha-1}(z_t L_t)^{1-\alpha} - d \tag{A.5}$$

$$w_t = (1-\alpha)K_t^{\alpha} z_t^{1-\alpha} L_t^{-\alpha} \tag{A.6}$$

where d denotes the depreciation rate of capital.

A.3 Pension system

We consider a pay-as-you-go defined contribution system with a mandatory contribution rate τ. The DC pension system collects contributions and uses them to fund the contemporaneous benefit, but pays out pensions computed on the basis of an annuity. During the working period, agents accumulate contributions:

$$f_{\kappa,j,t} \quad = \quad (1+r_t^I)f_{\kappa,j-1,t-1} + \tau w_t l_{\kappa,j,t}, \tag{A.7}$$

which are converted to an annuity at retirement according to:

$$b_{\kappa,\bar{J},t} \quad = \quad \frac{f_{\kappa,\bar{J},t}}{\sum_{s=0}^{J-\bar{J}} \frac{\pi_{\bar{J}+s,t+s}}{\pi_{\bar{J},t}}} \qquad \text{and} \qquad \forall_{j>\bar{J}} \;\; b_{\kappa,j,t} = (1+r_t^I)b_{\kappa,j-1,t-1}. \tag{A.8}$$

where $1+r_t^I = w_{t+1}L_{t+1}/w_t L_t$ denotes the rate of the payroll growth. The benefits are indexed annually with payroll growth. Without the loss of generality for the model findings, survival rates are common to PCG and SCG throughout (a relevant fraction of a household survives, with a shared pension benefit). In childless households, contributions and thus pension benefits of both adults will be equal. In households with children, primary care givers work less temporarily, hence contributing less to the pension system.

The DC system is by construction balanced in the sense that each cohort collects exactly the contributions it accumulated. However, some individuals die before reaching the retirement age, and hence before their accumulated funds are converted to an annuity, following equation (A.8). Government balances the pension system.

$$subsidy_t = \tau w_t L_t - B_t \tag{A.9}$$

B_t denotes the aggregate pension benefits, i.e. $B_t = \sum_{j=\bar{J}}^{J} \sum_{\kappa=0}^{3} N_{\kappa,j,t}(b_{\kappa,j,t} + b^*_{\kappa,j,t})$. The $subsidy_t$ enters directly into the government budget constraint.

A.4 The government

The government collects taxes: τ_l on labor, τ_k on capital and τ_c on consumption. A fixed share of GDP is spent every year on unproductive yet necessary consumption $G_t = g \cdot Y_t$, where g is a calibrated parameter. Given that the government is indebted, it also services the outstanding debt. Total tax revenues T_t is then given by:

$$T_t = \tau_l(1-\tau)w_tL_t + \tau_lB_t + \tau_{c_t}C_t + \tau_kr_tA_t \quad (A.10)$$

$$T_t = G_t + subsidy_t + r_tD_t - (D_{t+1} - D_t) \quad (A.11)$$

where C_t and A_t denotes aggregate consumption $C_t = \sum_{j=21}^{J}\sum_{\kappa=0}^{3} N_{\kappa,j,t}c_{\kappa,j,t}$ and aggregate assets $A_t = \sum_{j=21}^{J}\sum_{\kappa=0}^{3} N_{\kappa,j,t}a_{\kappa,j,t}$. In the initial steady state and in the final steady state, public debt D_t is kept constant as a share of GDP throughout the simulation. We calibrate g in the steady state to match the government expenditures/GDP ratio to the data. Henceforth, on the transition path, the value of G is held fixed in *per capita* terms. The consumption tax rate adjust to satisfy equations (A.10) and (A.11).

A.5 Market clearing, equilibrium and model solving

In the equilibrium the goods market clearing condition is defined as

$$C_t + G_t + K_{t+1} = Y_t + (1-d)K_t. \quad (A.12)$$

Labor market clearing condition yields

$$L_t = \sum_{j=21}^{\bar{J}-1}\sum_{\kappa=0}^{3} N_{\kappa,j,t}(l_{\kappa,j,t} + l^*_{\kappa,j,t}), \quad (A.13)$$

Finally, capital market clearing condition is

$$K_{t+1} = \sum_{j=21}^{J}\sum_{\kappa=0}^{3} N_{\kappa,t,j}a_{\kappa,t+1,j+1} - D_{t+1} \quad (A.14)$$

A perfectly competitive equilibrium is an individual allocation $\{((c_{\kappa,j,t}, a_{\kappa,j,t}, l_{\kappa,j,t}, l^*_{\kappa,j,t})_{j=21}^{J})_{\kappa=0}^{3}\}_{t=1}^{\infty}$, aggregate quantities $\{K_t, Y_t, L_t\}_{t=1}^{\infty}$ and prices $\{w_t, r_t\}_{t=1}^{\infty}$ such that:

- for all t, for all κ, $\{(c_{\kappa,j+s,t+s}, a_{\kappa,j+s,t+s}, l_{\kappa,j+s,t+s}, l^*_{\kappa,j+s,t+s})\}_{s=0}^{J-j}$ solves the problem of a family of age j in period t with κ children, given prices and government policies;
- prices are given by eq. (A.5) and (A.6);
- government badget given by eq. (A.11) is satisfied.
- markets clear, i.e. eq. (A.12)-(A.14) are satisfied.

The solution procedure follows the Gauss-Seidel method. In the steady states, we start with guesses on capital which are enough to compute aggregates in the economy. Perfectly foresighted households take them as given and solve their maximization problem. Aggregated variables are employed to produce a new guess for the output in the next iteration. The procedure is repeated until the difference between the initial aggregate capital and the capital aggregated from household savings is numerical, i.e. 10^{-8}.

Along the transition path, we produce a path of guessed aggregate variables based on the results of the initial and final steady states. The solution procedure is then analogous to the one used to compute the steady states. The model is solved multiple times. First, the baseline scenario is computed keeping fertility rate constant, with the value as in the first steady state. Second, the model is solved for every simulation scenario of changes in the fertility, as described in detail in Section 3.

A.6 Measuring fiscal and welfare effects of fertility changes

In the baseline scenario we keep fertility constant at the level from the initial steady state. To measure the welfare and fiscal fiscal effects of e.g. higher fertility we propose the following. Define by Υ_t the surplus in the government budget (deficit, if negative) due to the fertility change:

$$\Upsilon_t = G_t + subsidy_t + r_t D_{t-1} - D_t - \tau_l(1-\tau)w_t L_t - \tau_l B_t - \bar{\tau}_{c_t} C_t - \tau_k r_t S_t \tag{A.15}$$

where $\bar{\tau}_{c_t}$ is the consumption tax rate, kept on the transition path at the levels from the baseline scenario. In the reform scenario we consider alternative paths of fertility increase. For illustrative purposes (e.g. Figure 1) we portray this fiscal change as as a percent of government expenditure rather than in absolute terms. Then, the measure of contemporaneous fiscal effects of changed fertility may be expressed as $\lambda_t = \Upsilon_t / G_t$ and the aggregate fiscal effects can be expressed as the ratio of discounted to period 1 net changes in fiscal balance to the discounted value of government expenditures in the baseline scenario

$$\lambda = \frac{\sum_{t=1}^{\infty} \left(\Upsilon_t \prod_{s=1}^{t} \frac{1}{(1+r_s)} \right)}{\sum_{t=1}^{\infty} \left(G_t \prod_{s=1}^{t} \frac{1}{(1+r_s)} \right)} \tag{A.16}$$

The increased fertility is operationalized in equation (A.16) by ν_t, which denotes the growth rate in the number of children born, year-on-year.

The definition λ in equation (A.16) has several important advantages. First, it allows us to capture the actual difference in the fiscal balance due to the increased fertility; once prices and the quantities adjust to the new population (the net effect of all changes expressed in the net surplus of the government budget). It also accounts for the general equilibrium effects. Second, it may be conveniently expressed in terms of the total government budget, hence being an intuitive measure of how much could, in principle, be spent on a given change in fertility in permanent terms. Finally, it encompasses the total (social) effects of changed fertility.

In addition to the fiscal measure, we also propose using a welfare-based measure. Here, the unit of observation is the household and the metric is the utility. For each household, we compute utility in the baseline scenario of stable fertility and in the alternative scenario of increased fertility. We express the welfare effect as a consumption equivalent, i.e. we check is a percentage of baseline scenario consumption that agents within each type of household would be willing to give up or receive in order to be indifferent in terms of consumption between baseline and fertility change scenario. In order to express the utility in comparable terms, we discount it at the beginning of period $j = 21$, i.e. before the veil of ignorance about the number of children is lifted. For a household at age $j = 21$ in period t with a utility function U given by (A.1), the consumption equivalent is given by:

$$X_t = \exp\left(\frac{\sum_{\kappa=0}^{3} \Pr(\kappa)(U^F_{\kappa,21,t} - U^B_{\kappa,21,t})}{\sum_{s=0}^{J-21} \delta^s \frac{\pi_{21+s,t+s}}{\pi_{21,t}}}\right) - 1 \tag{A.17}$$

and in case of agents of age higher than $j > 21$ at the moment of policy change

$$X_j = \exp\left(\frac{\sum_{\kappa=0}^{3} \Pr(\kappa)(U^F_{\kappa,j,t} - U^B_{\kappa,j,t})}{\sum_{s=0}^{J-j} \delta^s \frac{\pi_{j+s,t+s}}{\pi_{j,t}}}\right) - 1 \tag{A.18}$$

In this expression, $U^B_{\kappa,j,t}$ and $U^F_{\kappa,j,t}$ refer to the utility of the agent of age j entering the labor market at period t in baseline and increased fertility scenario, respectively. $\Pr(\kappa)$ denotes probability of having κ kids. For, the purpose of this welfare measure this probability is taken from the baseline scenario, below we explain why.

In general there are two channels through which increased fertility can affect welfare. The first channel is private cost and benefits related to a change in expected the number of children a given household will have. This effect is uninteresting from the point of view of our study since we focus on the effects of changed fertility for the society. The second channel evaluates the general equilibrium effect of increased fertility, which by contrast, is at the core of the research question. The general equilibrium effects associated with increased fertility are: changed wages, interest rates, pension benefits and the government transfers. In a sense, it allows to answer whether an individual, regardless of the number of children to raise, prefers living in a *status quo* world of unchanged fertility or in the world with changed fertility. Our computation strategy does just that. When we compute the difference between the expected utility in the baseline scenario and the expected utility in the raised fertility scenario for an agent we keep the probabilities of having $0, 1, 2$, and $3+$ kids the same (from the baseline scenario). Therefore, we take into account only the general equilibrium effects and we are able to put aside both private benefits and private costs of having children. In order to evaluate the total welfare over all the subsequent birth cohorts, we need to take into account possibly positive and negative consumption equivalents of the subsequent cohorts, in present value terms of the first year of the model This is denoted by:

$$X = \frac{\sum_{j=22}^{J} \left(\sum_{s=0}^{J-j} \sum_{\kappa=0}^{3} X_j c_{\kappa,j+s,1+s} N_{\kappa,j+s,1+s} \prod_{i=1}^{s} \frac{1}{1+r_i} \right)}{\sum_{t=1}^{\infty} \left(C_t \prod_{i=1}^{t} \frac{1}{(1+r_i)} \right)} + \\ + \frac{\sum_{t=1}^{\infty} \left(\sum_{j=21}^{J} \sum_{\kappa=0}^{3} X_{t-j+21} c_{\kappa,j,t} N_{\kappa,j,t} \prod_{i=1}^{t+j-21} \frac{1}{1+r_i} \right)}{\sum_{t=1}^{\infty} \left(C_t \prod_{i=1}^{t} \frac{1}{(1+r_i)} \right)} \tag{A.19}$$

$X > 0$ means that the fertility increase improves welfare, i.e. after compensation of the potential losses, we still have some surplus generated by the change.

B Calibration

Figure A.1: Calibrating completed fertility in the model to the data

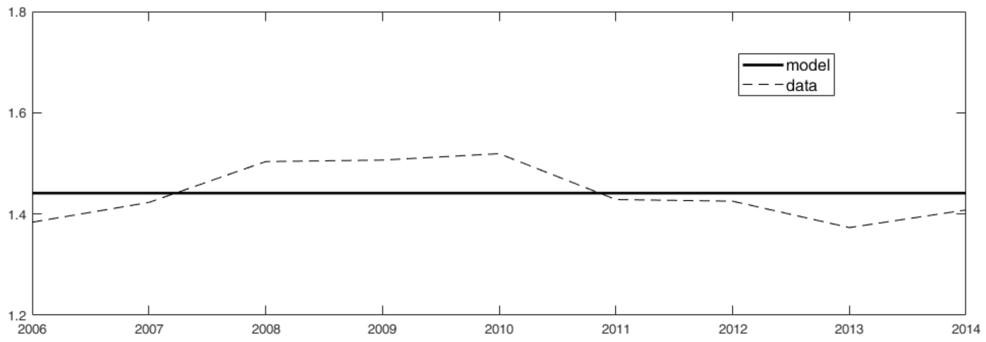


Figure A.2: Survival rates: comparison between data and model at initial steady state

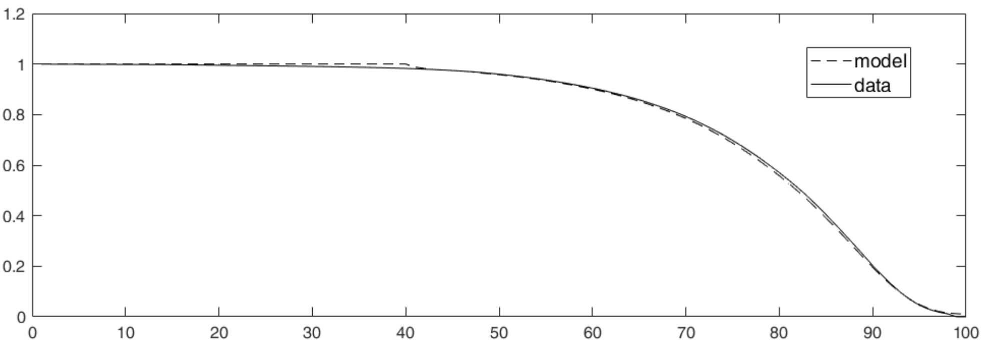


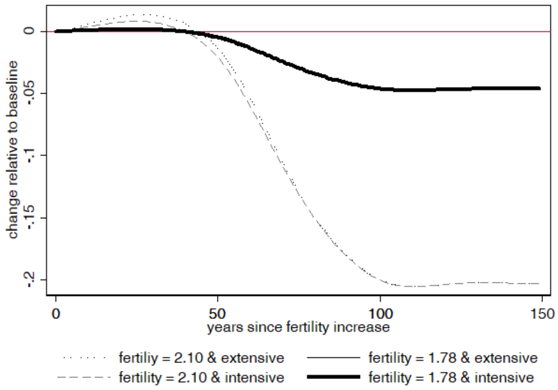
Table A.1: Economic parameters calibration

Macroeconomic parameters		Calibration	Target	Data	Model
d	one year depreciation rate	0.14	investment rate	21%	21%
τ_l	labor tax	0.065	revenue as % of GDP	4.5%	4.5%
τ	social security contribution	0.12	benefits as % of GDP	7%	7%
Preference parameters					
ϕ	preference for leisure	0.28	average hours	56.8%	56.8%
δ	discounting rate	0.97	interest rate	6.5%	6.5%
ϖ	consumption scaling factor	0.51	equivalence scale	0.7	
$\vartheta(\kappa)$	children scaling factor	$\{0.31, 0.27, 0.23\}$	equivalence scale	$\{0.65, 0.62, 0.6\}$	

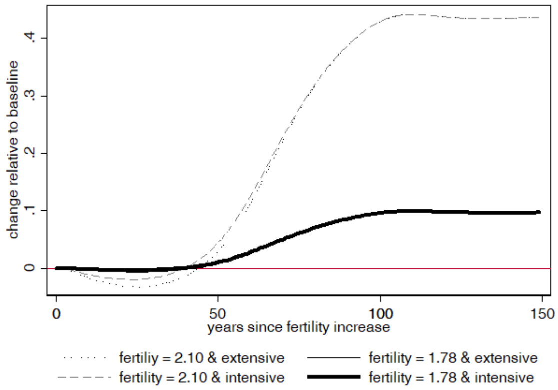
Note: OECD equivalence scales adopted. Average hours based on OECD, averaged for 2000-2010, computed as share of hours worked in the economy over the hours available, 16 hours a day, 250 days a year. Interest rate calibrated to the real net rate of return reported by the investment rate, averaged over 2000-2010. Investment rate based on national accounts data, averaged over the analogous period. The labor tax, consumption tax and social security contribution calibration matched to national accounts, averaged for 2005-2015.

C Macroeconomic effects

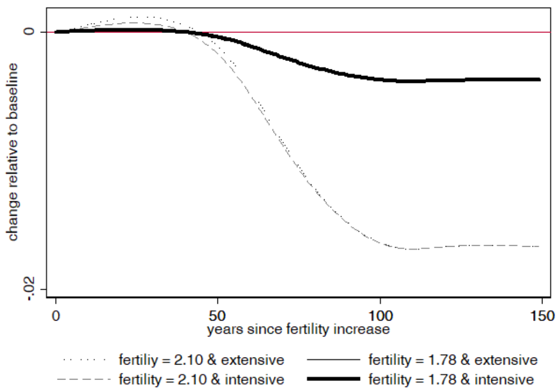
(a) Capital



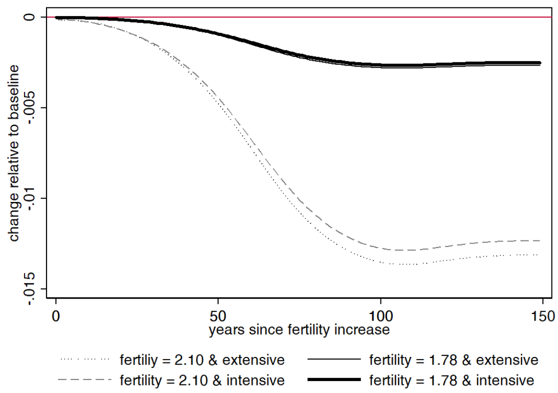
(b) Interest rate



(c) Wage



(d) Tax revenues



Note: the red line denotes 0 deviation relative to the baseline, for convenience.

D Demographic simulations

Following the notation from the earlier sections, denote by s_0, s_1, s_2 and s_3 the share of households without children, with one child, with two children and with three or more children, respectively. For all simulation scenarios, it holds that:

$$\begin{aligned} s_0 + s_1 + s_2 + s_3 &= 1 \\ s_0 + s_1 + 2s_2 + 3.5s_3 &= \text{completed fertility (CFR)} \end{aligned}$$

Denote for all scenarios:

$$s_1 + s_2 + s_3 = a \quad \text{and} \quad s_1 + 2s_2 + 3.5s_3 = b \quad \text{and} \quad \frac{s_3}{s_2} = c \quad \text{and} \quad \frac{s_1}{s_2} = d$$

Intensive margin adjustment is the type of change in fertility that keeps the s_0 unchanged from the initial calibration (data) and adjusts the share of households with 1 or more children accordingly. We do the following:

$$s_1 + (1+c)s_2 = a \quad \text{and} \quad s_2 = \frac{b-a}{2.5c+1}.$$

For higher target values of CFRs, a shift between s_1 and s_2 as described above is insufficient. We denote this value by a^* and from then on we keep constant last share of s_1 and adjust s_2 and s_3 according to:

$$s_3 = a^* - s_2 \quad \text{and} \quad 2s_2 + 3.5(a^* - s_2) = b^* \quad \text{and} \quad s_2 = \frac{3.5a^* - b^*}{1.5}.$$

Extensive margin adjustment is the type of change in fertility where we reduce the share of households without children (s_0). This is obtained following:

$$ds_2 + 2s_2 + 3.5cs_2 = b \quad \text{and} \quad s_2 = \frac{b}{(d+2+3.5c)}.$$

Simulations In order to derive different household ratios for a given target CFR, we relax one assumption in the system of equations described above. We draw s_1 randomly from a range of feasible values, this stochastic share of 1 child households is denoted by s_1^*. In the case of the intensive margin adjustments we follow:

$$s_2 = a - s_1^* - s_3 \quad \text{and} \quad s_1^* + 2(a - s_1^* - s_3) + 3.5s_3 = b \quad \text{and} \quad s_3 = \frac{(b + s_1^* - 2a)}{1.5}.$$

In the case of the extensive margin adjustment we follow:

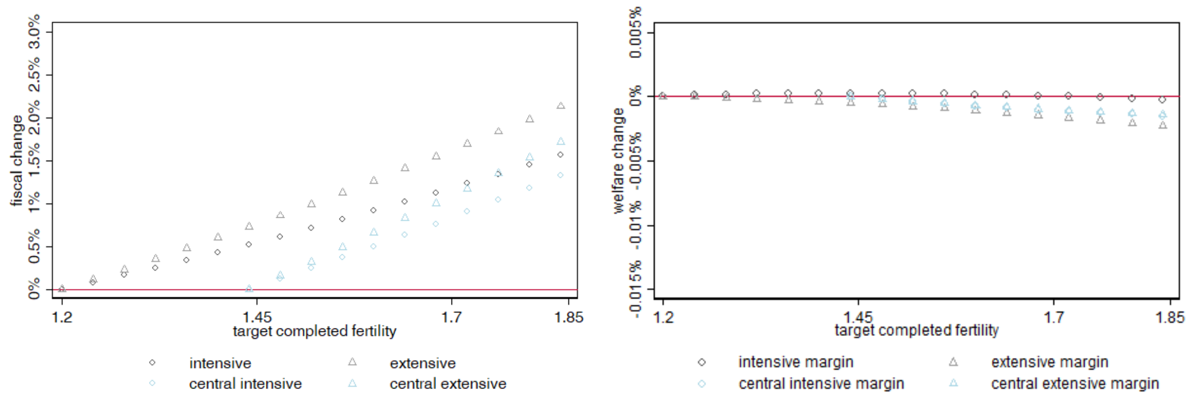
$$s_0 + s_1^* + s_2 + s_3 = 1 \quad \text{and} \quad 2s_2 + 3.5s_3 = b - s_1^* \quad \text{and} \quad s_2 = \frac{(b - s_1^*)}{(2+3.5c)}$$

E Sensitivity of the results to the starting value of fertility

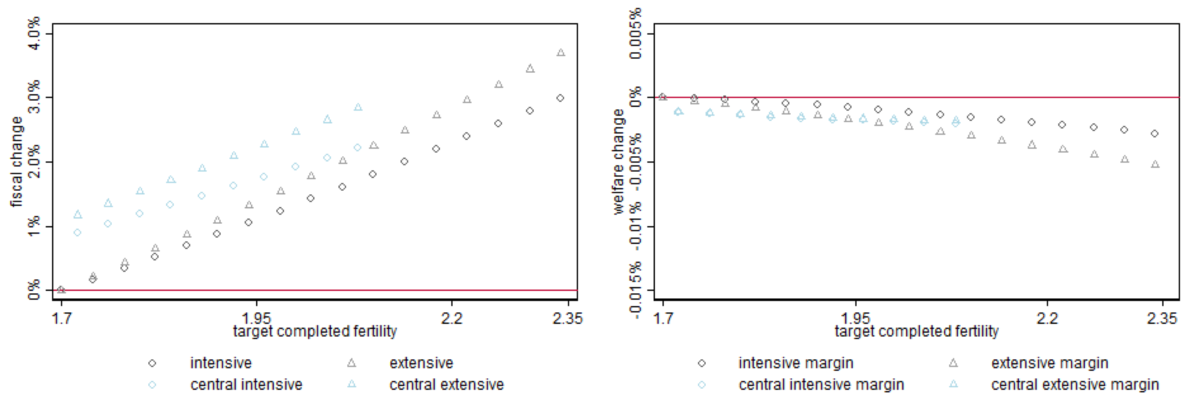
This section replicates the results portrayed in Figure 1 taking alternative assumptions about the starting value of fertility. Namely, we keep economy unchanged, but instead of taking 1.44 as the starting and baseline value, we repeat the simulations for 1.2 as the starting value and 1.7 as the starting value. This experiment is intended to verify if the patterns uncovered in Figure 1are a consequence of the initial fertility calibration.

Figure A.4: Replication of Figure 1 for alternative assumptions about fertility rate prior to the simulated increase

(a) fertility rate prior to the simulated increase: 1.20



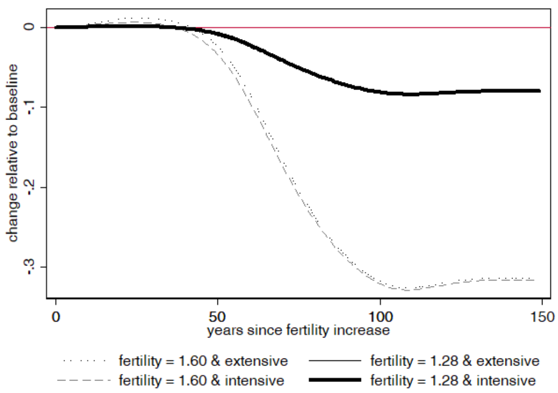
(b) fertility rate prior to the simulated increase: 1.70



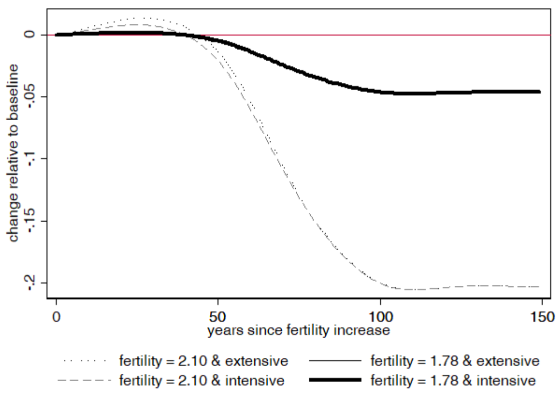
Note: This Figure replicates the results from Figure 1 for alternative assumptions about fertility rate prior to the simulated increase. The blue marks denote the baseline simulation, as depicted in Figure 1. The calibrated macroeconomic and microeconomic parameters remain unchanged. Mortality rates remain the same as in the main simulation, depicted in Figure 1, hence in the simulations depicted here, population structure differs: population experiences a faster decline in the case of Figure A.4a and a slower decline in the case of Figure A.4b. The left figure depicts the net fiscal effect of the reform, as expressed by λ in equation (A.16), in percent of government expenditure. The right figure depicts the general equilibrium welfare effect as discussed in Appendix A.6, expressed in percent of lifetime consumption. The raised fertility is translated as a proportional increase in the share of households with 1, 2 or more children and a proportional decline in the share of childless households.

Figure A.5: Replication of Figures A.3a - A.3d for alternative assumptions about fertility rate prior to the simulated increase

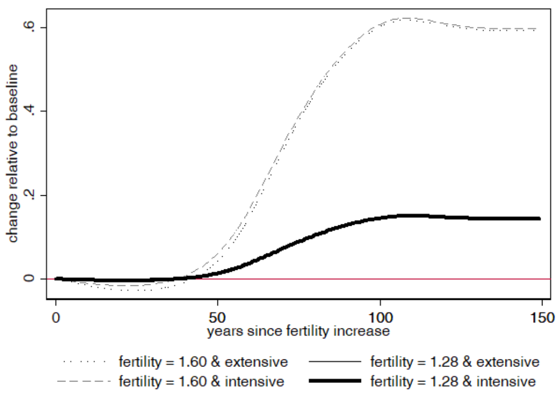
(a) Capital, fertility prior to simulation: 1.2



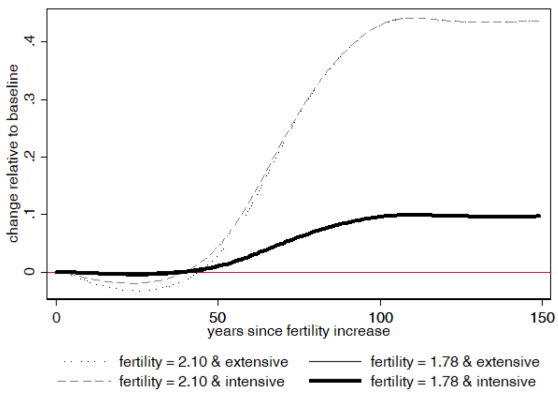
(b) Capital, fertility prior to simulation: 1.7



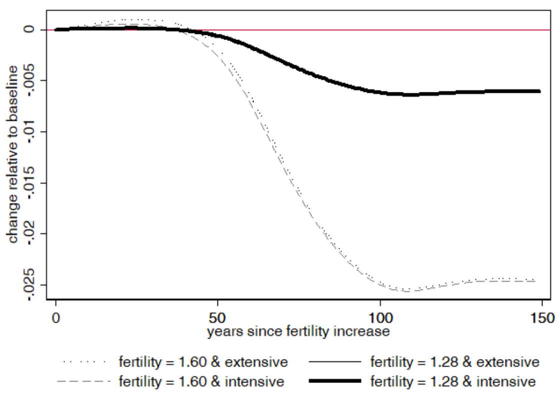
(c) Interest rate, fertility prior to simulation: 1.2



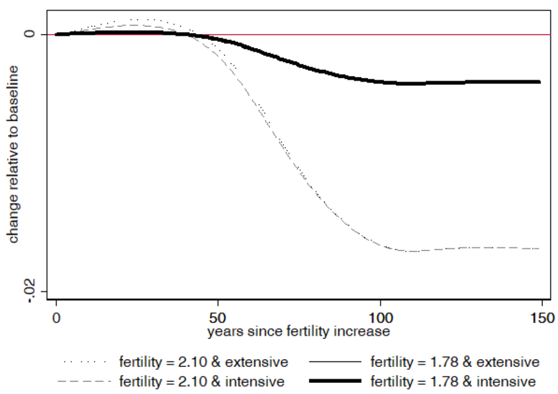
(d) Interest rate, fertility prior to simulation: 1.7



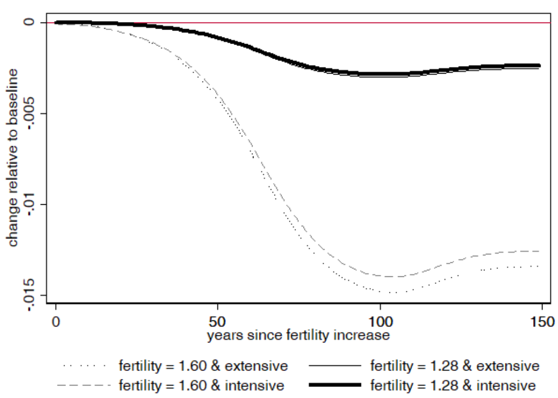
(e) Wage, fertility prior to simulation: 1.2



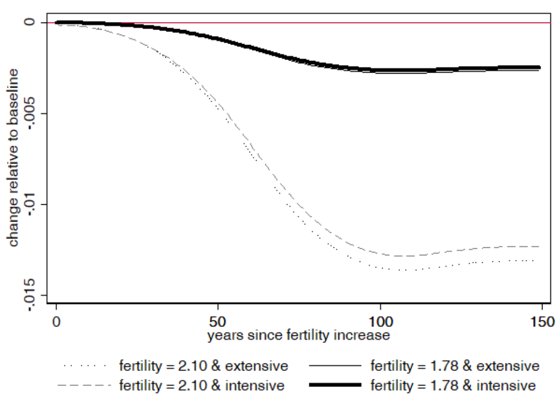
(f) Wage, fertility prior to simulation: 1.7



(g) Tax revenues, fertility prior to simulation: 1.2



(h) Tax revenues, fertility prior to simulation: 1.7



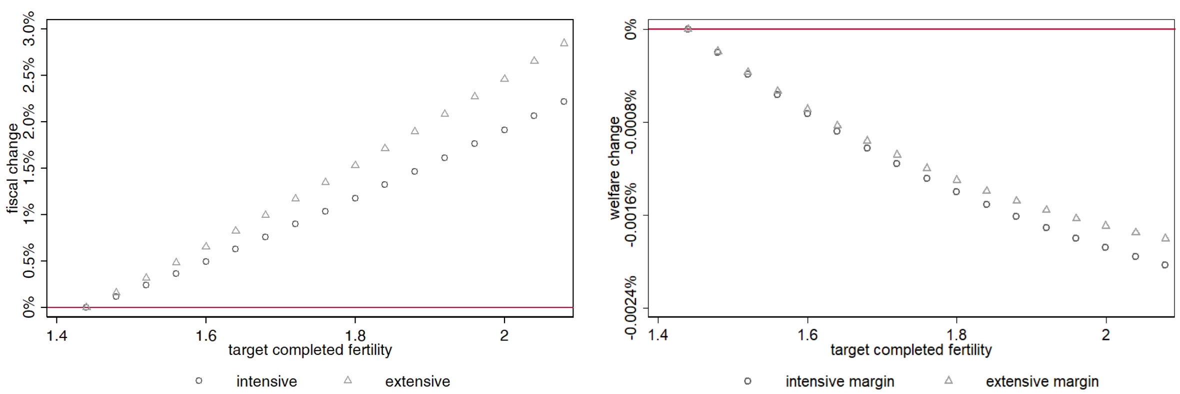
F Tables and Figures

Table 1: Calibration of the population in the initial steady state

	Data	Model
Fertility (TFR)	1.44	1.44
Share of cohorts at $j < 21$	0.23	0.28
Share of cohorts at $20 < j < 41$	0.31	0.31
Share of cohorts at $j \geq \bar{J}$	0.18	0.16
Life expectancy at $j = 1$	73.47	73.83
Life expectancy at $j = \bar{J}$	15.41	15.42
Proportion of		
childless women	0.36	0.36
women with 1 child	0.16	0.16
women with 2 children	0.28	0.28
women with 3+ children	0.20	0.20

Note: Data on fertility relate to total fertility, which we recover from the model to match the CSO forecasts. The model effectively operates with completed fertility for simulations, but in the model recovering TFR from CFR is immediate. The proportions of household size reported in this table relate to completed fertility (measured as realized fertility for women aged 45 years or older, data averaged over 2006-2014. Shares of age groups based on population structure data, averaged over 2006-2014. Data from Eurostat.

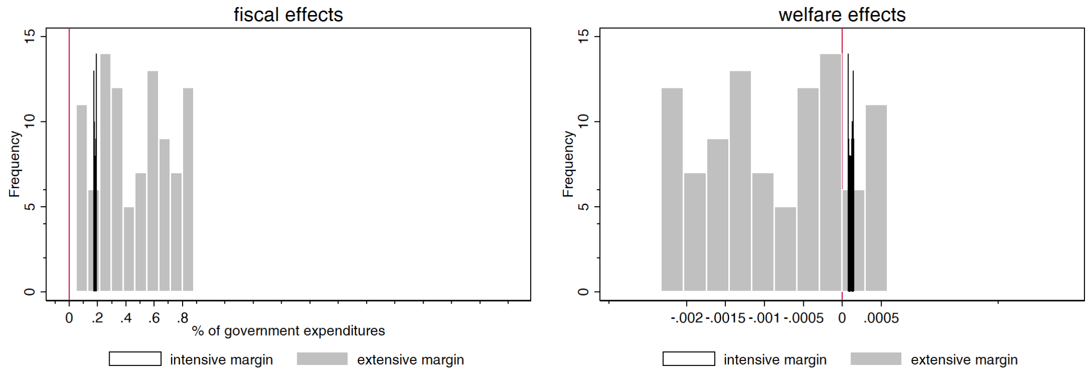
Figure 1: Evaluating the macroeconomic and welfare effects



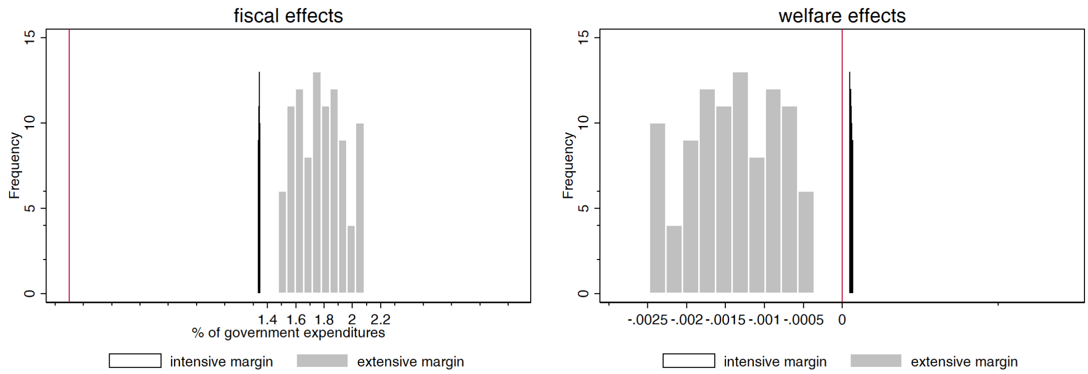
Note: The left figure depicts the net fiscal effect of the reform, i.e. a fiscal gain relative to the baseline scenario of the unchanged fertility. The measurement of the fiscal gain, as expressed by λ in equation (A.16), in percent of the total government budget is described in Appendix A.6. The right figure depicts the general equilibrium welfare effect as discussed in Appendix A.6, expressed in percent of lifetime consumption. The raised fertility is translated as a proportional increase in the share of households with 1, 2 or more children and a proportional decline in the share of childless households.

Figure 2: Sensitivity analysis of the macroeconomic and welfare effects

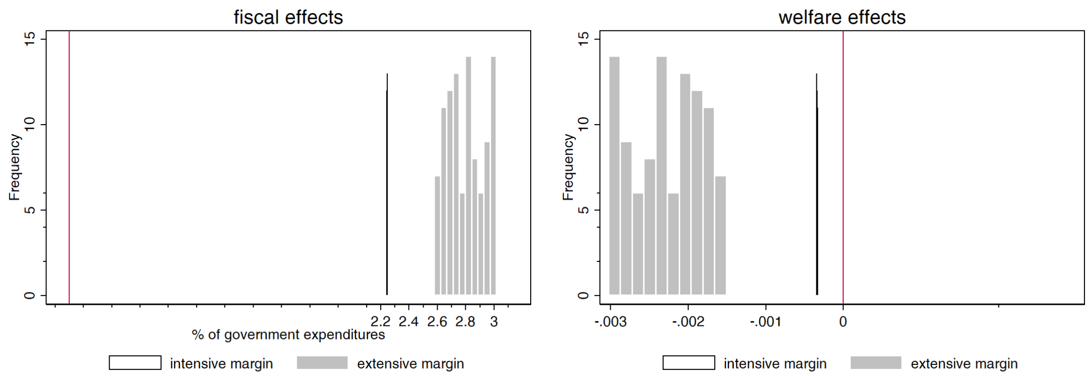
(a) target completed fertility 1.5



(b) target completed fertility 1.9



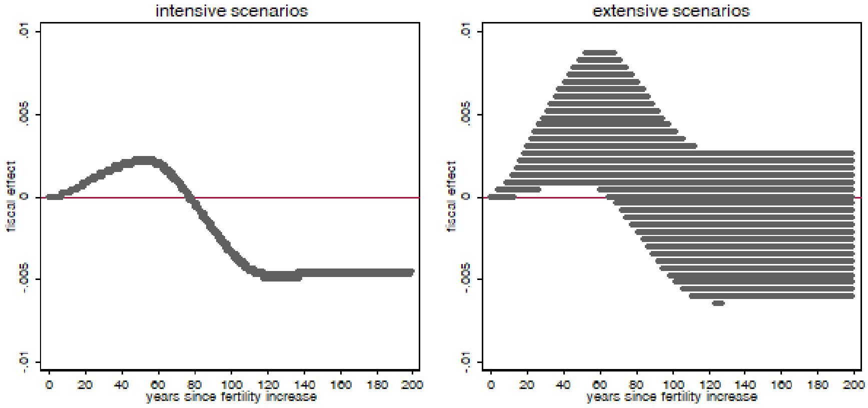
(c) target completed fertility 2.1



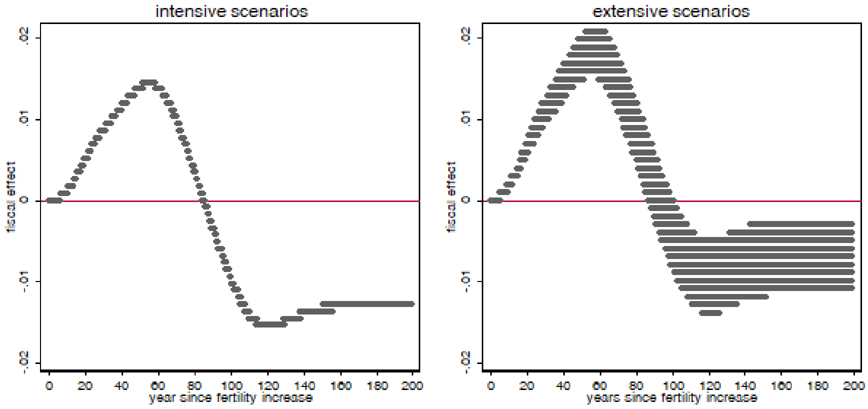
Note: In each of the three panels, the left figure depicts the fiscal effects, i.e. λ, as defined by equation (A.16), in percent total government expenditure, whereas the right panel the welfare effects, as discussed in Appendix A.6, expressed in percent of lifetime consumption. The figures plot the density of a given implied fiscal/welfare effect from the 100 simulations for each target fertility rate in extensive scenarios and the 100 simulations for each target fertility rate in intensive scenarios. We set each histogram to display 10 bins (10 simulations in each bin).

Figure 3: Distribution of the fiscal effects over time

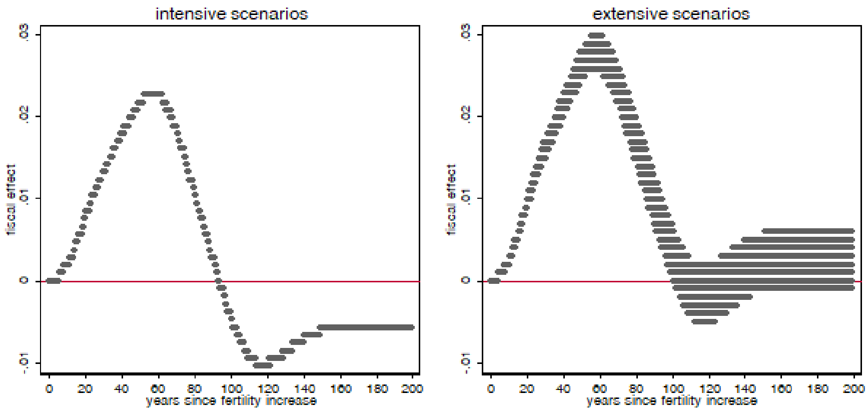
(a) target completed fertility 1.50



(b) target completed fertility 1.85



(c) target completed fertility 2.08



Note: The figure depicts the λ, as defined by equation (A.16), in percent of total government expenditure. The left panel displays the intensive demographic scenarios, whereas the right panel displays the extensive scenarios, see Appendix D for details. The figure contains the domain of outcomes of all the simulated scenarios for each point in time, but does not denote the density of those values.

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