Growing Old Gracefully: Fiscal policy for an ageing society

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Abstract

The Italian population is shrinking and ageing. The old-age dependency ratio is projected to rise considerably over the coming decades from 33.7% in 2015 to 61.2% in 2060. While the Monti’s government of 2011-13 has introduced some measures to address these issues, debt sustainability projections from the European Commission point to significant pressure on Italy’s public finances in the medium-term.

In this paper, we evaluate the macroeconomic and intergenerational impact of realistic demographic trends in Italy with an overlapping generations model, OG-ITA, which is heavily inspired by the open-source model for the United States, OG-USA. Key features of the model include an overlapping generations structure that considers individuals of ages 21 to 100, who are split into seven income-earning ability types. By integrating microeconomic data and simulations from the EUROMOD microsimulation model into the overlapping generations macro model, we can address the dynamic effects of fiscal policies that would counteract the fiscal challenges of ageing populations.

The effects of demographic change are obtained solving the OG-ITA model with demographic projections and comparing the equilibrium outcomes to those found when solving the same model with fixed (as of 2015) rates of population growth. We furthermore simulate pension reforms, including raising the age at which one receives a public pension. The results confirm the desirability of combining tax and pension reforms to address the challenges of ageing societies, particularly in the case of Italy. The simulations demonstrate the balance between supporting growth and prosperity over the short run and avoiding excessive burdens for the future.

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1. Introduction

Demographic change is an impending challenge for many European countries. Across much of the continent, populations are becoming smaller and older. Italy is an example of this trend and faces increased challenges in terms of its old-age dependency ratio. In line with Eurostat (2018), the old-age dependency ratio is projected to rise considerably over the coming decades; from 33.7% in 2015 to 61.2% in 2060. The demographic trend alone puts significant pressure on the workforce to provide for the elderly. Furthermore, Italy is saddled with one of the highest public debt-to-GDP ratios in the EU of around 130 percent. While the Italian government has introduced some measures to tackle these issues, especially those undertaken during the Monti government of 2011-13, debt sustainability projections from the European Commission (2018) point to significant pressure on Italy's public finances in the medium-term.

This paper models the approaching demographic change in an overlapping generations model, OG-ITA. This is a new model heavily inspired by the open-source model for the United States, OG-USA (see DeBacker et al., 2017b). In brief, the salient features of OG-ITA include the detailed representation of households, which are split into 80 adult generations and 7 income-earning ability types. Households receive utility from consumption and leaving bequests, and disutility from labour. Households optimise over their lifetime choosing how much to participate in the labour force, for which they receive earnings dependent on their ability type. They also then decide how much to consume and to save, where savings enables future consumption and bequests. Parameters affecting the disutility of labour supply are calibrated using the data on hours worked and EUROMOD microsimulation model. We match the labour elasticities estimated using micro-data, to the more aggregated individual agents of our OLG model, producing our labour supply curve. To produce realistic consumption profiles, our model parameters have been calibrated to closely reproduce the actual wealth and bequests distributions in Italy. Firms maximise profits generated from the production of a single good. Investment is determined by the availability of savings and by the demand for capital in the production function.

The effects of demographic change are obtained by first solving a standard version of the model with demographic projections and comparing the equilibrium results with those found by solving the model with fixed (as of 2015) rates of population growth. The consequent budget deficit due to the ageing population is balanced first by raising tax rates. We compare the effects of raising labour tax, consumption tax and capital income tax on macroeconomic outcomes and on the distributional impacts in terms of both income and age. We furthermore simulate pension reforms, including raising the age at which one receives a public pension. The results confirm the desirability of combining tax and pension reforms to address the challenges of ageing societies, particularly in the case of Italy. The simulations demonstrate the balance between supporting growth and prosperity over the short run and avoiding excessive burdens for the future.

The paper is structured as follows. Section 2 explains the construction of the realistic demographic projections in some detail, which are the crucial inputs into the model. Section 3 provides an overview of the full overlapping generations model, highlighting the key equations. Section 4 presents the simulations and results, showing how the demographic projections impact on the wider macro economy. Section 5 concludes as well as introduces the work currently underway to extend the model to the analysis of pensions.
2. Demographic Projections

Population dynamics are driven by three interacting rates of change. First, the fertility rate is the number of live births per member of the population for each age. Second, the mortality rate is the number of deaths per member of the population for each age. And third, the net immigration rate is the immigrants less emigrants per member of the population for each age.

We begin with Eurostat population data for Italy for 2015 and proceed to introduce three possible demographic projection scenarios: (i) a naïve projection, that assumes the current population structure will remain indefinitely, (ii) projections that assume that the current fertility, mortality and net immigration rates will continue into the future (constant rates projection), and (iii) projections that update fertility, mortality and net immigration rates in line with baseline Eurostat (2018) projections (updated rates projection). In order for the final model to solve, one must fix the demographic dynamics at some point in the future. We introduce updates from the Eurostat projections only as far as 2060 and then keep them constant, as this is our main period of interest and estimates beyond this point become less significant due to the uncertainty of the predictions.

2.1. Calculating demographic dynamics

In order to generate the demographic projections, the following equations are employed. The first equation shows the generation of new-borns, $\omega_{1,t+1}$, which is determined by the fertility rate for each age, $f_{s,t}$, plus the immigration rate of under 1 year olds, $i_{1,t}$. The second equation is for the rest of the population, which has a probability of dying, the mortality rate, $\rho_{s,t}$, which varies by age, plus the net immigration rate, $i_{s+1,t}$.

\[
\omega_{1,t+1} = \sum_{s=1}^{E+S} f_{s,t} \omega_{s,t} + i_{1,t} \omega_{1,t} \quad \forall \ t \quad (1)
\]

\[
\omega_{s+1,t+1} = (1 - \rho_{s,t}) \omega_{s,t} + i_{s+1,t} \omega_{s+1,t} \quad \forall \ t \quad (2)
\]

To solve for the steady-state and the transition path of the stationary population distribution, we write the stationary population dynamic equations in their matrix representation, where $\Omega$ represents the stationarised transition matrix incorporating the fertility, mortality and net immigration rates.

\[
\bar{\omega}_{t+1} = \frac{1}{1+g_{n,t+1}} \Omega \bar{\omega}_t \quad \forall \ t \quad (3)
\]

The stationary steady-state population distribution $\bar{\omega}$ is the eigenvector $\omega$ with eigenvalue $(1 + g_{n})$ of the matrix $\Omega$ that satisfies the following version of the above equation:

\[
(1 + g_{n}) \bar{\omega} = \Omega \bar{\omega} \quad (4)
\]

---

5 As we do not model males and females separately, we convert the fertility rate for women into a fertility rate for the total population.

6 For modelling reasons, the immigrants and emigrants are assumed to be identical to the existing population of the same age, with the same dispersion of income-earning abilities. This would be an interesting assumption to relax in the future.

7 Note: for the steady state solution, both equations are stationarised by dividing by $(1 + g_{n,t+1})$. 
2.2. Demographic projections

We consider three scenarios for demographic projections. The first we call the naïve projection, by which we mean that population dynamics are not considered and one imagines that the current population profile will persist into the future. The second, the constant rates projection, imagines that the fertility, mortality and immigration rates are steady at their 2015 values (Eurostat 2018). The third, the updated rates projection, changes the fertility, mortality and immigration rates in line with Eurostat (2018) baseline projections from 2015 to 2060, and then kept constant.

The first 100 years of population profiles for each of the three projections are shown in Figure 1 a, b, c below. In each figure, the far wall to the right traces the current (2015) population. The movement forward and to the left traces the population evolution over time. The current population peak is between approximately ages 40 to 50. In the naïve projection, this peak remains, however in the more realistic scenarios, this cohort ages and passes away. Later generations have steadily lower populations, until after 100 years, shown at the front of the figure on the left, one sees the relatively smooth projection for the lower population profile for 2115. In both the constant rates and updated rates projections, total population shrinks markedly, though it is shown that the constant rates imply a sharper population decline.

Figure 1: Population dynamics 2015 to 2115

a) Naïve projection (constant population)  

b) Constant rates projection (rates fixed at 2015 values)  

c) Updated rates projection (rates updated until 2060)  

Source: Authors’ calculations
The fertility, mortality, and immigration rates that generate the above figures are shown in Figure 2. The values for the fertility, mortality and immigration rates in 2015 and 2060 are shown. In the naïve projection, the 2015 values are taken for fertility and mortality, and the immigration rates are adjusted to keep population constant (the naïve immigration rates are shown in Appendix 7.1). In the updated rates projection, the rates begin at 2015 levels and are then updated year-by-year until 2060 after which they are kept constant.

Under the Eurostat (2018) projections, fertility rates are predicted to rise somewhat until 2060, though this higher level is still below replacement fertility. Mortality is predicted to fall between 2015 and 2060. Note that in the model, we do not allow lifetimes to exceed 100 years, and therefore impose a mortality rate of 1 on 99 year olds. Immigration rates are generally predicted to rise, with a similar profile to the current one with higher immigration rates by those of teen age and in their 20s and 30s.

Figure 2: Fertility rates, immigration rates and mortality rates in 2015 & Projections 2060

a) Fertility rates

![Fertility rates graph]

b) Mortality rates

![Mortality rates graph]
Figure 3 compares the population projections. The figure shows the number of people by age 0 to 100 in each of the three different demographic scenarios. The blue line represents 2015 and is the same under all projections, since this represents the actual population distribution in 2015. Under the naïve projection, this distribution is constant in all years. The green and red lines show the population distributions in 2060 and 2100, respectively, under the assumption that 2015 fertility, mortality, and immigration rates remain constant into the future. The light blue and purple lines show the population distributions in 2060 and 2100 given the Eurostat (2018) projects, which entail higher fertility rates and are currently observed. By 2100, the higher population is even more pronounced with Eurostat (2018) projections (the purple line) substantially above the projected population under the assumption of fixed fertility, mortality, and immigration rates (the red line). Note again that the increase is more pronounced for the younger ages, and that a substantial overall population decline relative to 2015 is still projected.

Source: own compilation based on Eurostat (2018)
3. Modelling Methodology

The utility of OLG models for evaluating the dynamics of economic policies trace back to the work of Allais (1947), Samuelson (1958) and Diamond (1965). A major step forward in the use of applied, computable OLG models came with the publication of Dynamic Fiscal Policy (Auerbach and Kotlikoff, 1987), which made full use of the newly available computing power to solve more complex and detailed models. Most applied OLG models used today still recognise the Auerbach-Kotlikoff model as an important aspect of their heritage, despite the fact that such models have been extended and expanded across many dimensions since then (see Gorry and Hassett, 2013, for an overview of the impact of the Auerbach-Kotlikoff model and Diamond and Zodrow, 2013 for an overview of tax policy analysis using overlapping generations models).

OLG models have been used in pension reform analysis (see e.g. Fehr (2000), Börsch-Supan, Ludwig and Winter (2006), Auerbach, Lee (2011), Agudo and García (2011), Auerbach et al. (2016), among many others). There are also a number of papers studying the macroeconomic and intergenerational effects of demographic change with the OLG model (see e.g. Fehr et al. (2008), Fehr et al. (2013), Börsch-Supan, Klaus Härtl, and Alexander Ludwig (2014), Nishiyama (2015), Georges et al. (2016), Catalano and Pezzolla (2016) among others). Fehr (2016) provides the review of CGE models application to study social security reforms.

Although OLG models have been frequently used for policy analysis, those using calibrations based on micro data remain uncommon. OG-ITA, heavily inspired by the open-source model for the United States, OG-USA (see DeBacker et al., 2017b), is one of the examples of such models. In what follows, we present the main structure of the OG-ITA model.

3.1 Households

The OG-ITA model we have developed accounts for households maximizing their lifetime utility and making consumption, savings and labour supply decisions based on their expectations. The most remarkable characteristic degrees of heterogeneity incorporated. Model agents differ across age, earnings ability, and preferences over bequests. This allows the model to capture the richness of the cross-sectional and intergenerational distributions over income, wealth, labour supply and other endogenous variables. An economic unit in the model is the household, who face mortality risk, but who may live up to a maximum age. These derive utility from leaving intentional and unintentional bequests to their descendants. They are forward looking and optimize their life time utility choosing consumption, labour supply and savings in every period. Mortality risk is the only source of uncertainty in the model. On this regard, we have included realistic demographics parameters that represent mortality rates, fertility rates, and immigration rates. Taken together, these imply a population distribution that evolves over time according to the law of motion implied by these rates. In OG-ITA, we model households instead of individuals in order to avoid issues as gender, marital status or children. Furthermore, household often offer a better approximate to the tax filing units from administrative and survey data.

3.1.1 Households lifetime earnings profiles

Among households in OG-ITA, we model both age heterogeneity and within-age earnings ability heterogeneity. We use this ability, or productivity, heterogeneity to generate the distribution of income observed in the data.
Differences among workers' productivity in terms of ability is one of the key dimensions of heterogeneity to model in a micro-founded macroeconomic model. We characterize heterogeneity in earnings ability as exogenous lifecycle-profiles of earnings ability that vary across model agents. One can think about these earnings abilities as the number of effective labour units an agent supplies per hour of work. In OG-ITA, households' total labour income is determined by product of the equilibrium wage rate, the effective labour units per hour of work, and the quantity of labour the agent choses to supply. The effective labour units per hour of work, or individual ability, \( e_{j,s} \) vary across \( j \), the index of the ability type or path of the individual, and \( s \), the age of the individual.

\[
x_{j,s,t} \equiv w_t e_{j,s,t} n_{j,s,t} \quad \forall j, t \text{ and } E + 1 \leq s \leq E + S
\]

In this specification, \( w_t \) is an equilibrium wage representing a payment per effective labour unit and is common across all workers. Individual quantity of labour supply is \( n_{j,s,t} \), and the number of effective labour units per hour of labour supply, \( e_{j,s} \), yield the total supply of effective labour units from the household.

We calibrate the deterministic ability paths such that each lifetime income group, \( j \), has a different life-cycle profile of earnings. The distribution on income and wealth are often focal components of heterogeneous agent macroeconomic models. As such, we use a calibration of deterministic lifetime ability paths which is an adaptation from DeBacker et al. (2017a) that can represent earners in the top 1% of the distribution of lifetime income. Piketty and Saez (2003) show that income and wealth attributable to these households has shown the greatest growth in recent decades and this group often accounts for a significant source of income tax revenue.

We employ survey data from Banca d'Italia in our calibration of these lifecycle profiles of earnings ability. The data set is the "Archivio storico dell'Indagine sui bilanci delle famiglie italiane, 1977-2014".\(^8\) The Banca d'Italia data does not provide hourly wages. To obtain them we exploit the following information: number of worked months in a year, yearly earnings from labour income (including non-monetary benefits), and number of hours worked on average in a working week. We consider both full and part-time workers. We assume 46 out of 52 weeks worked for a full-time employee in a year. The nominal wages are then converted to real wages using annual consumer price indexes (CPIs), expressed relative to the reference year (2010=100). Then, our measure of hourly real wage \( W \) is obtained as:

\[
W = \text{earnings} / ( \text{worked_hours} \times \text{worked_months} \times 46/52 \times \text{CPI/100} )
\]

Since hourly earnings vary over the lifecycle, we wish assign individuals to one of our \( J \) earnings ability types based on their potential earnings over their lifetime. Since we do not observe earnings over a full lifetime for households in our data, we use the following methodology to identify ability groups based on lifetime income. First, we divide the data into six age brackets: 20 to 30, 31 to 40, 41 to 50, 51 to 60, 61 to 70, and 70 to 80. Within each bracket individuals were ranked according to their mean hourly wage. Individuals are then assigned to ability groups based on their positioning within the assigned bracket: ability group 1 if in the 24% percentile, 2 if in 25-49%, 3 if 50-69%, 4 if...

\(^8\) We employed version 9.1 (July 2017). Data and the related documentation were downloaded in January 2017, in Stata file format, from the URL: https://www.bancaditalia.it/statistiche/tematiche/indagini-famiglie-imprese/bilanci-famiglie/index.html. To transform monetary amounts from nominal to real values we employed seasonally unadjusted consumer price indexes (CPIs) downloaded from the St. Luis FRED (https://fred.stlouisfed.org).
70-79%, 5 if 80-89%, 6 if 90-99%, and finally 7 if 99-100%. For each of these 7 ability groups we then obtain a panel dataset by year and individual, where the age and the hourly wage of the person is observed. Separately for each ability group, we run panel fixed-effects regressions to derive the relation between age and hourly wage, according to the following cubic regression model:

$$\log(w_{i,t}) = \alpha_i + \beta_1\text{age}_{i,t} + \beta_2\text{age}_{i,t}^2 + \beta_3\text{age}_{i,t}^3 + \epsilon_{i,t}$$

The coefficients obtained from estimating this regression model are used to predict new values for each household in the data at every age, even if the individual was not in the data at that age. Because there are few individuals above age 80 in the data, our data series were further extended up to age 100 by linearly extrapolating new wages, assuming that the hourly wage at age 100 is equal to the hourly wage at 80 divided by 1.5. Finally, in order to have differentiable curves for each ability type, the data was smoothed using a "lowess" function with a 0.3 bandwidth.

Figure 4 shows a calibration for the seven deterministic lifetime ability paths of $e_{i,s}$ corresponding to each group of hourly earnings percentiles.

![Figure 4: Exogenous life cycle income ability paths $\log(e_{i,s})$ with $S = 80$ and $J = 7$](image)

Source: Author’s calculations using data from Banca d’Italia

Our calibration allows for each lifetime income group to have different life-cycle profile of earnings. This helps us match the distributions of income and wealth observed in the data. Matching these distributions is key aspect of our model and adds important relevance to the distributional analyses it provides.

### 3.1.2 Households bequests’ calibration

The last term in Equation (10) (see below) incorporates a warm-glow bequest motive in which individuals value having savings to bequeath to the next generation. The term $X^b_j$ is the utility weight on bequest. This weight varies by lifetime income group, $j$, influencing the marginal utility of bequests, $b_{j,s+1,t+1}$ relative to the other arguments in the period utility function. Allowing the $X^b_j$ scale parameter on the warm glow bequest motive vary by lifetime income group is critical for matching the distribution of wealth. Since there is no income uncertainty in the model there is no precautionary savings. Thus savings decisions are driven by incentives to smooth consumption over time given the hump-shaped earnings profiles and to satisfy bequest motives Thus, calibrating the $X^b_j$ for each income group $j$ allows us to capture, in a reduced form way, some of the characteristics that individual income risk provides.
To calibrate $x^n_j$ we choose 7 values $\{x^n_j\}_{j=1}^7$ to match nine moments from the data. These moments include the share of wealth held by each of the following percentile groups in the wealth distribution: 0-24%, 25-49%, 50-69%, 70-79%, 80-89%, 90-99%, and 99-100%, the Gini coefficient from the wealth distribution, and the variance of log wealth. This is done by minimizing the sum of squared percent deviations between average steady-state wealth values in our baseline model and the corresponding values from the data.

Because agents face mortality risk, and because of the functional form for the warm glow bequest motive, they prefer to hold some savings for bequest at each age, in the chance they die before the next period. Including this term is essential to generating the skewed distribution of wealth that exists in the data.

Equation (9) highlights how these bequests are distributed to other model agents. The term $BQ_t$ represents total bequests from individuals who died at the end of period $t$-1. We assume that bequests are distributed evenly across all ages to those in the same lifetime income group. Given available data, it is difficult to precisely calibrate the distribution of bequests from the data, both across income types $j$ and across ages $s$. We find that this assumption helps to reproduce the empirical distribution of wealth, where wealth is highly concentrated at the top.

### 3.1.3 Labour supply calibration

In order to calibrate the utility weight on the disutility of labour, $X^n_s$, we use a method of moment estimator. To do this, we begin with the first order condition on the household’s choice of labour supply:

$$w(c_s)^{-\sigma} = X^n_s \left( \frac{b}{\mu} \right) \left( \frac{n_s}{\tau} \right)^{v-1} \left[ 1 - \left( \frac{n_s}{\tau} \right)^v \right]^{1-\nu} \forall s \quad (5),$$

where $w$ is gross wage (in units of consumption that a worker is paid for each unit of labour supplied), $c_s$ is consumption of individual of age $s$, $\frac{n_s}{\tau}$ is hours worked as a percentage of total time endowment of individual of age $s$, $\sigma$ is coefficient of risk aversion (the inverse of the intertemporal elasticity of substitution), $X^n_s$ is a scale parameter that influences the relative disutility of labour to the utility of consumption. The parameters $b$ and $v$ are parameters of an elliptical utility function for labour as described in Evans and Phillips (2018). The values for $b$ and $v$ are found by matching the marginal utility from the elliptical utility function to the marginal utility from a constant Frisch elasticity utility function, where the Frisch elasticity is calibrated based on econometric studies of the Frisch elasticity.

In order to identify $X^n_s$ we have to reformulate the above equation as:

$$X^n_s = \frac{w(c_s)^{-\sigma}}{\left( \frac{b}{\mu} \right) \left( \frac{n_s}{\tau} \right)^{v-1} \left[ 1 - \left( \frac{n_s}{\tau} \right)^v \right]^{1-\nu}} \quad (6).$$

Consumption and wages in the above equation are given in consumption units (consumption is the numeraire good). To determine the value of $X^n_s$, which is found from an equation corresponding to Equation (6), but where consumption and wages are defined in data units, we use data on average gross wage, average consumption by individuals of age $s$, and data on average hours worked. The data on average gross wage and on average hours worked are the EU-SILC data.\(^9\) Since the EU-SILC...
data do not contain detailed information on consumption and expenditures, these have been imputed based on the information from the Household Budget Surveys being matched to EU-SILC data through estimated Engel curves. Note that the $X^n_s$ will be measured in data units that may not directly correspond to the model consumption units $X^n_s$ is measured in. Wage is defined as gross hourly wage from the discrete choice labour supply model (being one of the extensions to the EUROMOD microsimulation model) multiplied by the assumed total time endowment of 4000 hours per year. We find $c_s$ form the data by averaging over annual consumption for all individuals of age $s$ in our data for years 2008, 2010, 2012, and 2014. Similarly, we find $n_s$ by averaging hours worked over all individuals of age $s$. Over the years 2008, 2010, 2012, and 2014. To express annual hours worked as a percentage of total time endowment we assume 4000 hours per year as total time endowment.

In order to account for the differences between the model units (i.e. consumption units) and data units (i.e. thousands of EUR) the scaling factor has been introduced for determining the steady-state variables in the model. The relation between parameter $X^n_s$ (in model units) and parameter $\bar{X}^n_s$ (in data units) is as follows:

$$X^n_s = \bar{X}^n_s \left( \text{factor}^{(s-1)} \right) \quad (7).$$

Thus, by estimating $\bar{X}^n_s$ using the data on wages, consumption, and labour supply, one can determine model parameters up to a scale. That scale is function of the model scale parameter, \text{factor}.

### 3.1.4 Budget Constraint and optimality conditions

The household lifetime optimization problem consist on choosing consumption $c_{j,s,t}$, labour supply $n_{j,s,t}$ and savings $b_{j,s+1,t+1}$ in every period of life to maximize expected discounted lifetime utility:

$$\max \left\{ (c_{j,s,t}), \left(n_{j,s,t}, b_{j,s+1,t+1} \right) \right\} \sum_{s=1}^{S} \beta^{s-1} \left[ \prod_{t=E+1}^{T} \left( 1 - \rho_u \right) \right] u(c_{j,s,t+s-1}, n_{j,s,t+s-1}, b_{j,s+1,t+s} ) \quad (8)$$

where $\beta^{s-1}$ is a discount factor, $\rho_u$ is mortality rate and $u(\cdot)$ is households’ period utility function.

This is subject to budget constraints and upper-bound and lower-bound constraints. We impose the Inada condition whereby consumption is always strictly positive in equilibrium. The budget constraint for the age-$s$ household in lifetime income group $j$ at time $t$ can be defined as:

$$c_{j,s,t} + b_{j,s+1,t+1} = (1 + r_t)b_{j,s,t} + w_t e_{j,s,t} n_{j,s,t} + \frac{BQ_t}{\lambda_j \omega_{j,t}} + \frac{TR_t}{\lambda_j \omega_{j,t}} - T_{s,t} \forall j,t \text{ and } s \geq E + 1, \quad (9)$$

where $b_{j,E+1,t} = 0, \forall j,t$ and $s$ is the age of households; $c_{j,s,t}$ is households consumption, $b_{j,s+1,t+1}$ is savings for the next period, $r_t$ is the interest rate in the current period, $b_{j,s,t}$ is current wealth (savings from last period), $w_t$ is the wage, and $n_{j,s,t}$ is labour supply. $\zeta_{j,s}$ is the share of total bequests $BQ_t$ that go to the age-$s$ and income group-$j$ household.

Households become economically active at $s = E+1$ and they live until to $E+S$. In making the optimal decisions households choose lifetime consumption $\{c_{j,s,t+s-1}\}_{s=1}^{S}$, $\{n_{j,s,t+s-1}\}_{s=1}^{S}$, $\{b_{j,s+1,t+s-1}\}_{s=1}^{S}$. Consequently, their period utility function can be defined as follows:

$$u(c_{j,s,t}, n_{j,s,t}, b_{j,s+1,t+1}) \equiv \left( \frac{c_{j,s,t}}{1-\sigma} \right)^{1-\sigma} + e^{\gamma(1-\sigma)} X^n_s \left( b \left( 1 - \frac{\left(n_{j,s,t}\right)^{1}}{l} \right)^{\frac{1}{\sigma}} \right) + X^n_s \rho_s \left( b_{j,s+1,t+1} \right)^{1-\sigma-1} \quad \forall j,t, \quad (10)$$

$E + 1 \leq s \leq E + S$, where $g_s$ is productivity growth rate, all remaining variables are defined as before.
\[
\begin{align*}
\text{The first term to the right is a constant relative risk aversion (CRRA) utility function of consumption. The second term is the elliptical disutility of labour described where } X^b_j \text{ adjusts the disutility of labour supply relative to consumption and can vary by age } s. \text{ This is very helpful for calibrating the model to match labour market moments. This parameter needs to be multiplied by } e^{g_j (1-\sigma)} \text{ because both consumption } c_{j,s,t} \text{ and savings } b_{j,s+1,t+1} \text{ are growing at the rate of technological progress. Additionally, it keeps the relative utility values of consumption, labour supply, and savings in the same units. The final term in the utility function refers to bequests and it is a CRRA utility of savings, discounted by the mortality rate } \rho. \text{ Intuitively, it captures the utility that households get if they don’t live in the next period with probability } \rho. \text{ It is a utility of savings beyond its usual benefit of allowing for more consumption in the next period. This utility of bequests also has constant } X^b_j \text{ which adjusts the utility of bequests relative to consumption and can vary by lifetime income group } j. 
\end{align*}
\]

### 3.1.5 Households expectations

The 2S first order conditions for every type of household that characterize its S optimal labour supply decisions \( \{n_{j,s,t+s-1}\}_{s=1}^{S} \) and S optimal savings decisions \( \{b_{j,s+1,t+s}\}_{s=1}^{S} \) are the following:

\[
\left( w_t e_{j,s} - \frac{\partial r_{s,t}}{\partial n_{s,t}} \right) (c_{j,s,t})^{-\sigma} = e^{\gamma_j (1-\sigma)} X^b_j \left( \frac{n_{j,s,t}}{r_t} \right)^{\sigma-1} \left[ 1 - \left( \frac{n_{j,s,t}}{r_t} \right) \right]^{\frac{1-\sigma}{\sigma}} \tag{11}
\]

\[
(c_{j,s,t})^{-\sigma} = X^b_j \rho_s (b_{j,s+1,t+1})^{-\sigma} + 
\beta (1 - \rho_s) \left( 1 + r_{t+1} - \frac{\partial r_{s+1,t+1}}{\partial b_{j,s+1,t+1}} \right) (c_{j,s+1,t+1})^{-\sigma} \tag{12}
\]

\[
(c_{j,E+S,t})^{-\sigma} = X^b_j \rho_s (b_{j,E+S+1,t+1})^{-\sigma} \forall j, t \tag{13}
\]

where \( \frac{\partial r_{s,t}}{\partial n_{s,t}} \) is marginal tax rate on labour, \( \frac{\partial r_{s+1,t+1}}{\partial b_{j,s+1,t+1}} \) is the marginal tax rate on capital, all the remaining variables and parameters are defined as before.

The household budget constraint that binds in all S periods is the following:

\[
c_{j,s,t} + b_{j,s+1,t+1} = (1 + r_t) b_{j,s,t} + w_t e_{j,s} n_{j,s,t} + TR_t - T_{s,t}. \tag{14}
\]

where \( TR_t \) are transfers that households receive and \( T_{s,t} \) is total amount of taxes they pay.

### 3.2 Firms

The representative firm maximizes static profits by means of a Cobb-Douglas production function of capital and labour:

\[
Y_t = F(K_t, L_t) \equiv Z_t (K_t)^\gamma + (e^{\gamma_j L_t})^{1-\gamma} \forall t \tag{15}
\]

where \( Y_t \) is total output, \( K_t \) is capital stock, \( L_t \) is labour input to production, \( \gamma \) is capital share in income, \( Z_t \) is total factor productivity that can be time dependent, and \( g_j \) is the rate of labour augmenting technological progress (constant productivity growth).
The profit function of the representative firm can be written as:

$$PR_t = F(K_t, L_t) - w_tL_t - (r_t + \delta)K_t \quad \forall t \quad (16)$$

where $PR_t$ are firm’s profits, $\delta$ is the period depreciation rate, all the remaining variables are defined as before.

Gross income for the firms is given by the production function $F(K_t, L_t)$ because we have normalized the price of the consumption good to 1. Labour costs to the firm are $w_tL_t$, and capital costs are $(r_t + \delta)K_t$.

The first derivative of profits respect to labour and capital is equal to their corresponding optimal demands:

$$w_t = e^{\eta y_Z} (1 - \gamma) y_t e^{\eta y_Z L_t} \quad \forall t \quad (17)$$

$$r_t = Z_t Y Z - \delta \quad \forall t. \quad (18)$$

### 3.3 Government

The government takes in tax revenues and uses those revenues to finance transfers, $TR_t = \sum s=1 ^2 tr_{s,t}$. The transfers are distributed lump-sum to all agents, thus $tr = \frac{TR_t}{s} \forall s$. The taxes on labour and capital at this stage of model development are linear functions of labour and capital income. The average for all households marginal tax rates on labour and capital income as well as the effective tax rate have been calculated based on the output from the EUROMOD microsimulation model. In the current version of the model we assume that government budget is balanced every period.

#### 3.3.1 Non-linear tax functions

An important feature of the model is the capability to model income taxes as a function of both labour and capital income. In this way we consider the interactions existing between the two types of income taxation, for example due to means-tested benefits or substitutions between sources of income (e.g. entrepreneurs shifting income to the lower-tax type between business income and labour or self-employed income). Our tax functions can be written as:

$$Tax Liability = f(Labour Income, Capital Income, Age, Year)$$

The tax functions are estimated on output from the EUROMOD microsimulation model. Our approach to estimating marginal tax rate functions follows the methodology of DeBacker et al. (2017b). We fit the parameterized functional form to our microsimulation data in order to obtain a smooth and well-behaved representation of the real world tax code that can be used in the overlapping generations model. Tax liabilities and marginal tax rates also enter in the function estimation and are computed, separately for labour and capital income.

Figure 1 shows scatter plots of effective tax rates (ETR), marginal tax rates on labour income (MTRx) and capital income (MTRY) simulated using the EUROMODmodel, each plotted as a function of labour income and capital income (averaged for ages 20-99) in the base year 2015. Labour and capital income are truncated at 500,000 EUR in the plots in order to see more clearly the shape of the data in spite of the long right tail of the income distribution. Although there is noise in the data,
Effective tax rates are found to be generally increasing in both labour and capital income at a decreasing rate (from some slightly negative level to an asymptote around 40 percent).

Figure 1: Scatterplot of labour income, capital income and effective tax rate (ETR) from EUROMOD simulations (2015)

\[
\tau(x, y) = [\tau(x) + shift_x]^\phi [\tau(y) + shift_y]^{1-\phi} + shift
\]

where

\[
\tau(x) \equiv (max_x - min_x) \left( \frac{Ax^2 + Bx}{Ax^2 + Bx + 1} \right) + min_x
\]

and

\[
\tau(y) \equiv (max_y - min_y) \left( \frac{Cx^2 + Dx}{Cx^2 + Dx + 1} \right) + min_y
\]

where \( A, B, C, D, max_x, max_y, shift_x, shift_y > 0 \) and \( \phi \in [0, 1] \)

and \( max_x > min_x \) and \( max_y > min_y \)

In the above equation, we are allowing \( \tau(x, y) \) to represent the effective tax rate functions. The total tax liability function is simply the effective tax rate function times total income. This functional form for tax rates delivers flexible parametric functions that can fit tax rate data shown in Figure 1. The function can be re-estimated under policy reforms to give an appropriate simulation based on microsimulated output. Appropriately, these functional forms are monotonically increasing in both
labour income $x$ and capital income $y$. The 12 parameters of our tax functional form are summarised in Table 1.

**Table 1: Description of tax rate function parameters**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A$</td>
<td>Coefficient on squared labour income term $x^2$ in $\tau(x)$</td>
</tr>
<tr>
<td>$B$</td>
<td>Coefficient on labour income term $x$ in $\tau(x)$</td>
</tr>
<tr>
<td>$C$</td>
<td>Coefficient on squared capital income term $y^2$ in $\tau(y)$</td>
</tr>
<tr>
<td>$D$</td>
<td>Coefficient on capital income term $y$ in $\tau(y)$</td>
</tr>
<tr>
<td>$max_x$</td>
<td>Maximum tax rate on labour income $x$ given $y = 0$</td>
</tr>
<tr>
<td>$min_x$</td>
<td>Minimum tax rate on labour income $x$ given $y = 0$</td>
</tr>
<tr>
<td>$max_y$</td>
<td>Maximum tax rate on capital income $y$ given $x = 0$</td>
</tr>
<tr>
<td>$min_y$</td>
<td>Minimum tax rate on capital income $y$ given $x = 0$</td>
</tr>
<tr>
<td>$shift_x$</td>
<td>$shift &gt;</td>
</tr>
<tr>
<td>$shift_y$</td>
<td>$shift &gt;</td>
</tr>
<tr>
<td>$shift$</td>
<td>$shift$ (can be negative) allows for support of $\tau(x, y)$ to include negative tax rates</td>
</tr>
<tr>
<td>$\phi$</td>
<td>Cobb-Douglas share parameter between 0 and 1</td>
</tr>
</tbody>
</table>

Source: DeBacker et al. (2018b)

We estimate the functions based on all observations from EUROMOD output for Italy for our base year of 2015. We use a genetic solve algorithm\textsuperscript{11} to find the least absolute distances between the estimated function and the data points. The results are shown in Figure 2.

\textsuperscript{10} As DeBacker et al. (2018) point out, while it does limit the potential tax systems to which one could apply our methodology, tax policies that do not satisfy this monotonicity assumption would result in non-convex budget sets, consequently they would require non-standard general equilibrium model solution methods and would not guarantee a unique equilibrium.

\textsuperscript{11} We use “differential evolution” from theSciPy suite of optimisers.
The estimated effective tax function is shown against the actual EUROMOD output (reproduced from Figure 1). The estimated function surfaces are based on the 2015 law and pooling together observations for individuals of all ages between 21 and 80. As tax variables are endogenous in the EUROMOD model, the estimated parameters and the corresponding function surface change whenever any of the many policy levers in the microsimulation model that generate the tax rate data are adjusted.

### 3.3.2 Further work – unbalanced government budget

We are currently working on the version of the model with government balance that need not be balanced every period (i.e. an unbalanced government budget). To this end, let $D_t$ denote the stock of government debt at time $t$ and $R_t$ denote total government tax revenue. Thus we write the government budget constraint as:

$$D_{t+1} + R_t = (1 + r_t)D_t + G_t + TR_t \quad (19)$$

Revenues are given as a sum of corporate income tax revenue ($\tau_c(Y_t - w_tL_t) - \tau_c \delta K_t$) and individual income tax revenue ($\sum_{s=1}^{S} \sum_{j=1}^{J} \tau_t w_{t,j} n_{s,t} + \sum_{s=2}^{S} \tau_t r_t b_{s,t}$):

$$R_t = \tau_c(Y_t - w_tL_t) - \tau_c \delta K_t + \sum_{s=1}^{S} \sum_{j=1}^{J} \tau_t w_{t,j} n_{s,t} + \sum_{s=2}^{S} \tau_t r_t b_{s,t} \quad (20)$$

To close the government budget we can alter for example the path of government spending in order to hit a target debt to GDP ratio in the steady-state.
3.4 Market clearance

The labour market, the capital market, and the goods market must clear in OG-ITA. According to the Walras’ Law, it is enough with two of three clearing conditions. In the model, we ignore the goods market clearing condition. The labour market clearing requires that aggregate labour demand \( L \), measured in efficiency units equal the sum of household efficiency labour supplied \( e_{j,s} n_{j,s,t} \).

\[
L_t = \sum_{s=E+1}^{E+S} \sum_{j=1}^{J} \omega_{s,t} \lambda_j e_{j,s} n_{j,s,t} \quad \forall t \tag{21}
\]

In the capital market clearing aggregate capital demand equal the sum of capital savings and investment by households:

\[
K_t = \sum_{s=E+1}^{E+S+1} \sum_{j=1}^{J} \omega_{s-1,t-1} \lambda_j b_{j,s,t} + i_s \omega_{s,t-1} \lambda_j b_{j,s,t} \quad \forall t \tag{22}
\]

And aggregate consumption \( C_t \) is defined as the sum of all household consumptions, and aggregate investment:

\[
Y_t = C_t + K_{t+1} - \left( \sum_{s=E+2}^{E+S+1} \sum_{j=1}^{J} i_s \omega_{s,t} \lambda_j b_{j,s,t+1} \right) - (1 - \delta) K_t \quad \forall t \tag{23}
\]

where \( C_t = \sum_{s=E+1}^{E+S} \sum_{j=1}^{J} \omega_{s,t} \lambda_j c_{j,s,t} \)

Note that the extra terms with the immigration rate \( i_t \) in the capital market clearing equation and the resource constraint accounts for the assumption that age-s immigrants in period \( t \) bring with them (or take with them in the case of out-migration) the same amount of capital as their domestic counterparts of the same age.

4. Simulations and results

We define the following simulations, which serve highlight the impact of demographics and public pension policy. For more details on the demographic simulations, see Section 2.

An additional feature of the simulations here is to introduce a highly stylised tax and transfer system, which shows some of the challenges of maintaining a public pension system with a changing demography. Individuals pay an income tax at 28% of labour income and 17.5% of capital income. This revenue is then redistributed to all individuals according to the following rule: (i) those up to retirement age receive a basic amount, and (ii) those above retirement age receive a different, larger amount. This stylised transfer system reflects the idea that government provides some universal services for all individuals (the basic amount) and also provides a universal public pension above a certain age. In the baseline, we set this age to 62, which is the current retirement age in Italy. We define three simulation scenarios to be compared with a baseline one as follows:

- **BASELINE**: Our baseline assumed a constant population, which we refer to as the naïve projection, because it replicates a myopic projection that the future will be the same as the present. The retirement age is kept at age 62. Retirees receives the average Italian old-age transfer on the top of a lump-sum amount being transferred to everybody that can be thought of as individuals’ share in government expenditures on goods and services. The idea of having this artificial baseline scenario was to determine the “pure” demographic impact onto the Italian economy.
• **PENSION REFORM (RETIREMENT AGE RISE):** Demography defined as in the baseline scenario. The retirement age is increased to the age of 70.

• **DEMOGRAPHIC CHANGE (UPDATED DEMOGRAPHIC RATES):** The rates for fertility, mortality and net immigration are in line with the Eurostat’s (2018) baseline projections fixed. The retirement age is kept at age 62. Average transfers to both retired and non-retired individuals are kept at their baseline levels.

• **PENSION REFORM WITH DEMOGRAPHIC CHANGE (UPDATED DEMOGRAPHIC RATES and RETIREMENT AGE RISE):** This simulation has the same demography as **DEMOGRAPHIC CHANGE** scenario. However, the retirement age rises to 70. The transfer to non-retired individuals is kept at the baseline levels, and the remaining amount is transferred to retirees.

Since for the moment we keep the balanced government budget assumption, there is no fiscal deficit in the model. In simulation scenarios these assumption is being maintained by (labour) tax adjustments. In the further version of the paper the balanced government budget assumption will be relaxed and the implications of pension reforms for public debt and long-term fiscal sustainability could be analysed.

In the remaining part of this section we describe the results for individuals distinguished by age and income group of the three simulations that are compared to the BASELINE: i) **DEMOGRAPHIC CHANGE**, ii) **PENSION REFORM** and iii) **PENSION REFORM WITH DEMOGRAPHIC CHANGE**.

On Figure 5 below dynamic solution for the baseline scenario is presented for labour supply, consumption, savings and tax revenues. Since our OLG model is multidimensional in order to present readable 3-D graphs we have to fix one dimension. Hence, we only present here the results for the forth ability group. As can be seen from the graphs, labour supply is hump-shaped with young and elderly generations working less and prime-aged individuals working more. Consumption is growing with age until age 80 then it starts declining. Savings are having double hump-shaped profile over the life cycle with the second pick coming at the retirement age (62) when individual is receiving an additional lump-sum transfer. Tax revenues (on personal income from labour and capital) pattern over a life cycle is a combination of labour supply and savings patterns.
Figure 5: Baseline scenario (fourth ability group)

a) labour supply

b) consumption

c) savings
Before analysing the consequences of the pension reform, we wanted first to examine the pure demographic impact (DEMOGRAPHIC CHANGE scenario). To this end, we ran a scenario with actual fertility, immigration and mortality rates up to year 2060, in line with the Eurostat’s (2018) baseline projections, and compared it against the (constant population) baseline scenario. Actual demographic trends result in a smaller population decline than in the constant population baseline. In Figure 6 the scenario with Eurostat’s demographic trends (DEMOGRAPHIC CHANGE scenario) is compared against the (constant population) baseline scenario. The seven workforce participation profiles are shown for each of the seven ability income-earning types representing, namely the lowest 25 percentiles, the next 25, the next 20, the next 10, the next 10, the next 9 and the top 1 percent (see Section 3 for details on ability types). Although it cannot be seen from the graphs presented here the lower earners in our OLG model have higher aggregate labour force participation. Looking at the labour force participation from age perspective, it peaks between around age 30 and age 60, before declining to very low levels in retirement years.\(^\text{12}\)

As is apparent from Figure 6, panel a), lower population decreases labour force participation,\(^\text{13}\) especially for younger workers (until age 50). Labour force participation increases slightly for elderly, but since there are far fewer labour force participants in these age groups, total aggregate labour supply falls (by 12.1\%). The driver of the labour force participation effect is the wage level. The lower population leads to a 3.5\% higher wage level as labour is less abundant relative to capital. Therefore the marginal utility of consumption matches the marginal disutility of labour at a lower labour force participation level. Under the lower population scenario (i.e. the one with actual demographic trends), consumption is significantly lower, especially for elderly. Aggregate steady-state consumption loss in the updated rates scenario (actual Eurostat trends) is equal to 7.6\% with respect to the constant population scenario and the aggregate steady-state income loss is equal to 9.1\%. Higher savings of elderly until age 70 followed by lower savings of the most elderly drive greater tax revenues followed by lower tax revenues respectively for these age groups. By an assumption of the government budget being balanced every period, aggregate lump-sum transfer to individuals is equal to total tax revenues. Since tax revenues on average fall, so does aggregate transfer to households.

\(^\text{12}\) Note that the number of individuals aged above 90 (marked as 70+ in the figure) is very small, so we are only mildly concerned with the uptick in labour force participation.

\(^\text{13}\) Labour supply in the OG-ITA is expressed as percentage of total time endowment, that is why its changes versus the baseline scenario are presented here in percentage points.
Here for the sake of brevity only long-run (steady state) effects have been discussed. In the Appendix on Figure 7.2.1 time paths of deviations of labour supply, consumption, savings and tax revenues are presented.

Figure 6: Impact of demography (actual demographic trends versus constant population)

- a) labour supply – difference (in pp.) wrt baseline
- b) consumption – percent changes wrt baseline
- c) savings – percent changes wrt baseline
- d) tax revenues – percent changes wrt baseline

Source: Authors’ calculations

In what follows the results of raising the retirement age from 62 to 70 are discussed (PENSION REFORM scenario). The abovementioned pension reform increases transfers to individuals at retirement age. Since this is a perfect foresight model, agents at the pre-retirement age react increasing savings (and slightly consumption) as compared with the baseline scenario. As can be seen in Figure 7 the reform increases labour supply of the young and prime-aged people (by around 1 pp. for young and by up to 6 pp. for elderly workers).

Younger generations (of age 21 to 35) and especially prime-aged workers increase their labour supply. Analysing the effects of the reform by different income groups, we can see that the lower the income group is, the bigger effect is of the reform for this group. Quite intuitively, as a result of the pension reform long-term welfare as measured by consumption is increased. Long-term aggregate consumption is greater by 10% than it would be in the absence of the reform. Long-term aggregate income is greater by 10.9% after the increase of the retirement age with aggregate capital stock being higher by 13.7% and aggregate labour supply being higher by 9% than before the reform. Tax revenues follow savings’ pattern. Since government budget is balanced every period total transfers all households receive must equal total taxes paid by all households.

Here only long-run (steady state) effects have been discussed. In the Appendix on Figure 7.2.2 time paths of deviations of labour supply, consumption, savings and tax revenues are presented.
Figure 7: Effects of the increase of the retirement age from 62 to 70 (constant population)

a) labour supply – difference (in pp.) wrt baseline

b) consumption – percent changes wrt baseline

c) savings – percent changes wrt baseline

d) tax revenues – percent changes wrt baseline

Source: Authors’ calculations

The third scenario, PENSION REFORM WITH DEMOGRAPHIC CHANGE, combines the first two scenarios, allowing us to investigate interaction effects. The steady-state results for individuals over their life cycles with the distinction of income groups are presented in Figure 8. Demographic change affects consumption, savings and tax revenues. It reduces increases of consumption and savings for those age groups that are experiencing positive effects as well as limits decreases of consumption and savings for those age groups that are experiencing negative effects. Labour supply increase is reduced under demographic change as compared to the scenario with base year (i.e. of 2015) demographic patterns.

All in all, presence of the demographic change is counterbalancing the positive impact of the pension reform on the long-term welfare. Aggregate long-term consumption in the pension reform scenario combined with actual demographic trends is lower by 3.0% as compared with the baseline scenario. Aggregate income is lower by 4.5% with aggregate capital being slightly higher by 0.4% and aggregate labour being lower by 7.7% as compared to the baseline scenario.

In the Appendix on Figure 7.2.3 time paths of deviations of labour supply, consumption, savings and tax revenues are presented in addition to the just discussed long-term (steady state) effects.
Figure 8: Combined effect of the increase of the retirement age from 62 to 68 and the demographic change

- a) labour supply – difference (in pp.) wrt baseline
- b) consumption – percent changes wrt baseline
- c) savings – percent changes wrt baseline
- d) tax revenues – percent changes wrt baseline

Source: Authors’ calculations

Table 1 summarises the impact of the scenarios on macroeconomic indicators. Generally, demographic change is reducing to a great extent positive effects of the retirement age increase that would occur in the absence of demographic change. Pension reform alone causes an increase in aggregate consumption (welfare) and production, but combined with the demographic change results in fall of aggregate consumption and production.

To further show that fiscal policy is greatly affected by demographic trends in Figure 9 we present old-age pension transfer as well as total (PIT) tax revenues as a percentage of GDP for the baseline and the three simulations scenarios. What is apparent from the graphs is that in the presence of the demographic change pension reform results in both tax revenues and old-age pension transfers being lower than they would be in the absence of this change. Relaxation of the assumption that government budget is balanced every period would enable to examine how pension reform and demographic change affects budget deficit. This is left for further work.
Table 1: Macroeconomic indicators (scenarios vs baseline, percentage or percentage points change)

<table>
<thead>
<tr>
<th>Pension reform (retire age 70)</th>
<th>Demographic change (actual demographic trends)</th>
<th>Pension reform &amp; demographic change (retire age 70; actual demographic trends)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest rate</td>
<td>-0.5 pp.</td>
<td>-1.0 pp.</td>
</tr>
<tr>
<td>Wage</td>
<td>1.7%</td>
<td>3.5%</td>
</tr>
<tr>
<td>Total consumption</td>
<td>10.0%</td>
<td>-7.6%</td>
</tr>
<tr>
<td>Labour supply</td>
<td>9.0%</td>
<td>-12.1%</td>
</tr>
<tr>
<td>Capital stock</td>
<td>13.7%</td>
<td>-4.3%</td>
</tr>
<tr>
<td>Production</td>
<td>10.9%</td>
<td>-9.1%</td>
</tr>
<tr>
<td>Total bequests</td>
<td>-4.6%</td>
<td>12.5%</td>
</tr>
<tr>
<td>Total transfer</td>
<td>10.6%</td>
<td>-9.7%</td>
</tr>
</tbody>
</table>

Source: Authors’ calculations

Figure 9: Combined effect of the increase of the retirement age from 62 to 68 and the demographic change

a) old-age pension transfers as a percentage of GDP

![Chart a)](chart_a.png)

b) total (PIT) tax revenues as a percentage of GDP

![Chart b)](chart_b.png)

Source: Authors’ calculations
5. Conclusions and Future Developments

We have investigated the relevance of demographic trends for an exemplary pension reform scenario. We have compared two possible demographic trends both of which show a declining population. The first supposes that current demographic trends are maintained and the second uses updated demographic dynamics through to 2060, which in particular increases the fertility rates and reduces the mortality rates relative to the fixed scenario. Then we ran pension reform simulation of raising the retirement age in Italy from 62 to 70.

The overlapping generations model structure allows us to trace the impact on different age groups. What emerges from the model is that those in mid-career (from around age 45, depending on the ability type) would choose to work more hours in the actual Eurostat (2018) demographic scenario than in the constant population scenario with lower population growth, reaching a peak in the early 50s before declining. This generates additional earnings which are initially are saved, and later both consumption and savings rise. Indeed we show that consumption would be expected to increase especially for those between the ages of 50 and 90 (with the fairly small number of people over 90 showing a decline). We are also able to distinguish between the optimal paths for different income-earning ability types. For example, the top one percent of income earners shows the highest responses to labour market changes, first increasing their labour market participation the most from approximately ages 45 to 60, and then restricting it the most in later ages.

The results of the pension reform simulation showed that total welfare and income of the Italian economy as a result of the retirement age increase would rise and that the greatest beneficiaries of this reform in the long run would be younger generations. Since households in our OLG model are heterogeneous by age and income groups we were able to analyse the simulation scenarios by heterogeneous households’ groups.

Current work focuses on developing the model to accurately model public and private pension provision in Italy. Also this will address funding of additional pension expenditures through different tax types, with the intention of comparing the burden-sharing impact of raising labour taxes compared with consumption taxes. We will investigate the extent to which a trade-off between efficiency and equity is observed. The overlapping generations structure will consider the impacts that pension provision has on labour market decisions and address the policy options available given the projected population implosion. We will also address policies to address the debt-to-GDP ratio, so as to investigate the impact of reducing this ratio over different time horizons. We are also working on representing marginal and effective tax rates as non-linear functions of capital and labour incomes, thus enabling us to approximate with the OLG macro model the complexity and richness of microeconomic data. Importantly for this analysis, we are developing the model to allow for unbalanced government budgets, so as to incorporate public deficits and debt evolution into the analysis.
6. References


7. Appendix

7.1. Immigration rates for constant population
The naïve immigration rates are shown in comparison to the 2015 and 2060 values. These were calculated to maintain population constant for all ages. As shown in Figure A1, the values for the ages need to be both positive and negative, and for some ages have a large absolute value.

Figure A1: Population dynamics 2015 to 2115

Source: Authors’ calculations

7.2. Results over the time path

Figure 7.2.1: Impact of demography (actual demographic trends versus constant population)

a) labour supply – percent changes wrt baseline

Time periods

Ages 20 - 99
b) consumption – percent changes wrt baseline

![Graph showing consumption changes]

Ages 20 - 99

---

c) savings – percent changes wrt baseline

![Graph showing savings changes]

Ages 20 - 99
d) tax revenues – percent changes wrt baseline

Source: Authors’ calculations
Figure 7.2.2: Effects of the increase of the retirement age from 62 to 70 (constant population)

a) labour supply – difference (in pp.) wrt baseline

b) consumption – percent changes wrt baseline
c) savings – percent changes wrt baseline

Ages 20 - 99

Time periods

32

d) tax revenues – percent changes wrt baseline

Ages 20 - 99

Time periods
Figure 7.2.3: Combined effect of the increase of the retirement age from 62 to 70 and the demographic change

a) labour supply – difference (in pp.) wrt baseline

b) consumption – percent changes wrt baseline
c) savings – percent changes wrt baseline

Source: Authors’ calculations

---

d) tax revenues – percent changes wrt baseline

Source: Authors’ calculations