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The Economy-wide Effects of Mandating Private Retirement Incomes

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Abstract

This paper investigates the economy-wide effects of mandating private (employment-related) pensions. It draws on the Australian experience with its Superannuation Guarantee legislation which mandates contributions to private retirement (superannuation) accounts. Our key objective is to quantify the long-run implications of alternative mandatory superannuation contribution rates for household economic decisions over the life cycle, household welfare, and macroeconomic and fiscal aggregates. To that end, we develop a stochastic, overlapping generations (OLG) model with labor choice and endogenous retirement, which distinguishes between (*i*) ordinary private (liquid) assets and (*ii*) superannuation (illiquid) assets. The benchmark model is calibrated to the Australian economy, fitted to Australian demographic, household survey and macroeconomic data, and accounting for a detailed representation of Australia's government policy, including its mandatory superannuation system. The model is then applied to simulate the effects of alternative mandatory superannuation contribution rates, with a specific focus on the counterfactual of a legislated future rate of 12% of gross wages. Based on the model simulations, we show that in the long run, this increased mandate generates larger average household wealth, output and consumption per capita and (rational) household welfare across income distribution.

Keywords: Private Pension, Social Security, Income Taxation, Labor Supply, Endogenous Retirement, Stochastic General Equilibrium

JEL Classification: J32, H55, H31, J22, J26, C68

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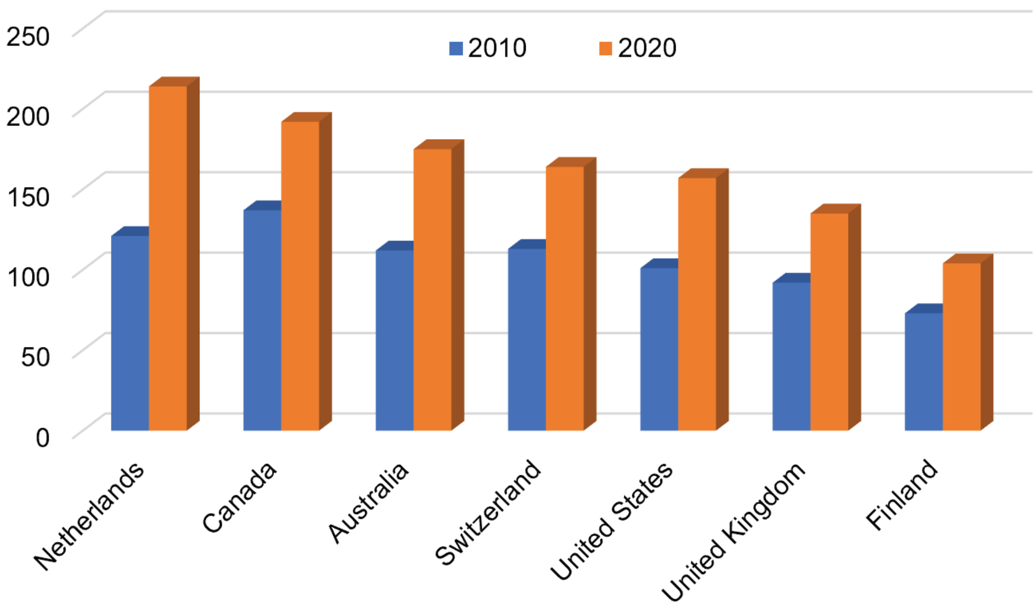
1 Introduction

Population ageing is placing an increasing burden on the funding of age pensions and social security around the world. In response, many governments, particularly in developed countries, have reformed their pension systems – cutting spending on public pensions and increasing their reliance on private fully funded pension pillars (OECD 2019, 2021; Willis Towers Watson 2021). As indicated in Figure 1, private pension assets in developed countries (those with the largest private pension funds globally) have increased significantly over the last decade.

Figure 1: Private pension assets as a percentage of GDP



Source: Global Pension Assets Study by Willis Towers Watson (2021).

The focus of this paper is on Australia, where superannuation (private retirement savings/pension) assets have more than doubled over the last decade to about 175% of GDP in 2020 (Willis Towers Watson 2021), with projections indicating substantial future increases in superannuation assets (to more than triple) by the middle of this century (see Chomik et al. 2018). The increases have been (and will be) driven by mandatory superannuation contributions required under the Superannuation Guarantee (SG) legislation (which has already been in operation for three decades). When introduced in 1992, the mandatory SG rate was set at 3% of gross wages. Since then, the rate has been gradually increased to the current rate of 10% and will increase further up to a legislated rate of 12% by 2025-26. The mandatory superannuation scheme covers about 95% of Australian employees who benefit from concessional tax rates on superannuation contributions and fund investment earnings at 15% and about 7%, respectively.[1] Given its concessional tax treatment, this private pension pillar interacts with Australia's progressive income taxation. It also interacts with the public age pension since private pension assets at older age are subject to means testing which determines the eligibility and amount of the public age pension.

The Australian pension system has been consistently ranked among the best pension systems in the world (e.g., see the Mercer Global Pension Index by Mercer 2021). As seen in Figure 1, Australia ranked third in terms of ratio of pension assets to GDP in 2020 (in local currency) and at the current asset growth rate it will soon overtake Canada in second place (according to Willis Towers Watson 2021).[2] Australia's public pension system is fiscally sustainable, with the public pension expenditure less than 3% of GDP (Australian Government, 2018), which is much lower compared most other developed countries (see OECD, 2019). This is largely due to the superannuation mandate and the above-mentioned interactions of private retirement savings with a means-tested public pension and income taxation. Nevertheless, the key features of the superannuation scheme have been subject to recent debate in Australia, with many commentators and experts on retirement incomes questioning whether the mandatory SG rate should further increase to the legislated 12% or not. Recently, the Australian Treasury conducted the Retirement Income Review (Treasury 2020), which received almost 300 submissions and many different recommendations for changes to the SG rate.

This paper investigates the economy-wide effects of the superannuation mandate, quantifying the implications of alternative mandatory SG rates for household economic decisions over the life cycle, for their welfare, and macroeconomic implications. Both policy counterfactuals with either lower or higher SG rates are examined. However, the main focus is on the counterfactual of the legislated (future) 12% SG rate for which we also provide sensitivity to alternative economic and policy assumptions.

In order to undertake this quantitative analysis, we develop a computable overlapping generations (OLG) model with labor choice and endogenous retirement that distinguishes between ordinary private (liquid) assets and superannuation (illiquid) assets. The model builds on the seminal computational OLG model developed by Auerbach and Kotlikoff (1987), which has been modified for Australian pension and fiscal policy analysis by Kudrna and Woodland (2013) and Kudrna et al. (2022). The model developed for the analysis of mandatory superannuation in this paper has been extended in a number of directions that we see as essential for the current policy analysis. These extensions include: the stochastic labor productivity; bequest motive; and greater details of the Australian government policy.[3]

[1] In relation to superannuation policy rules, this paper mostly draws on Chomik et al. (2018) who provide other specific details.

[2] Note that (smaller economies of) Denmark and Iceland, which are not included in Willis Towers Watson (2021), also have larger pension assets as a percentage of GDP than Australia (see OECD 2021).

[3] The model can be augmented to incorporate the tax and public pension policy in other developed countries such as that in the US, with a less progressive tax schedule and employment linked PAYG social security pensions. We provide some hypothesis for the effects of mandated private pensions in such a framework in the sensitivity analysis section.

Our simulation approach is as follows. First, the benchmark model is calibrated to the Australian economy (pre-COVID-19), fitted to recent Australian demographic, household survey and macroeconomic data. The model accounts for a detailed representation of Australia's government policy, including its progressive income taxation, means-tested age pension, and mandatory superannuation. The model is then applied to examine the macroeconomic and distributional impacts of changes to the mandatory SG rate and superannuation tax concessions, with specific implications reported for the labor market, capital accumulation and savings and the final goods market, as well as the impacts on households' economic behaviour over the life cycle. Importantly, the model is applied to study the welfare impacts on different cohorts and skill types of households.

Based on the model simulations, increased SG rates would generate larger household wealth, output or real GDP, consumption per capita and welfare on average and across skills. For example, a counterfactual economy with the legislated 12% SG rate would in the long run see an increase in total household wealth (by 12.2%), output or real GDP (by 5.5%), consumption (by 3.7%) and average welfare (by 0.75%). In contrast, under the hypothetical counterfactual with no superannuation mandate, household wealth would be 20.7% lower (compared to the benchmark economy). We show that these long-run results are due to: (*i*) the direct behavioral effects, with the increased mandate leading to higher superannuation asset accumulation and overall household wealth, generating increased self-funding at older age (and retirement income substitution away from public means-tested age pensions); and (*ii*) indirect effects, including general equilibrium adjustments in factor prices (e.g., with an increased effective wage rate under the higher SG rate policy), changes in budget-equilibrating instruments (e.g., with lower consumption taxes under higher SG rates) and bequest redistributions (with larger bequests under higher SG rates). These effects together with the publicly stipulated tax and pension rules specific to Australia – progressivity of its personal income tax schedule, superannuation tax concessions as well as its public age pension that is non-contributory and means-tested – "collectively" drive the positive macroeconomic and welfare effects of the higher superannuation contribution rate in the long run.

Existing literature There is a large body of literature studying social security and old age pension reforms, using large-scale OLG models. Examples of recent papers with applications to different countries include: Kitao (2014), McGrattan and Prescott (2017) and Hosseini and Shourideh (2019) for the US; Kitao (2015) and Braun and Joines (2015) for Japan; and Kudrna et al. (2022) for Australia. Note that these papers studied policies of partial or full privatisation of social security pensions (with increased self-financing of retirement consumption), but did not model any private pension mandate (and instead assumed voluntary savings taxed as ordinary income but that are liquid, able to be used at any year for funding consumption). We model both public and (publicly stipulated) private pensions in great detail.

There is also a growing body of literature studying funded private pensions (using OLG models), which examines the introduction of voluntary (or mandatory) retirement savings accounts with a preferential tax treatment. These retirement accounts are important instruments for retirement savings in many countries (as depicted in Figure 1) and their economic implications have been studied, for example, by Imrohoroglu et al. (1998), Gomes et al. (2009), Nishiyama (2011), Ho (2017) and Lin et al. (2021) for the US; Fehr et al. (2008) and Fehr and Kindermann (2010) for Germany; Kitao (2015) for Japan; and Kudrna and Woodland (2013, 2018) for Australia. Common findings are that these tax-favored accounts have positive effects on capital accumulation and welfare, which depend on the assumed behavior of economic agents (rational vs. myopic agents), and the specific designs of these private pension schemes and their funding. However, little is known about the economic effects of private pension mandates. We contribute to the literature by providing a quantitative analysis of the established forced-savings pillar in Australia (with one of the world's largest private pension assets), examining the economy-wide effects of the superannuation mandate in a framework that captures interactions of funded pensions with income taxation and means-tested age pensions.

This paper is connected to studies on the economic effects of Australia's superannuation. As discussed, we extend the early OLG analysis of mandatory superannuation carried out by Kudrna and Woodland (2013, 2018) and Creedy and Guest (2008) by accounting for the stochastic labor productivity, bequest motive and greater government policy details, including progressive income taxation, means-tested age pension and mandatory superannuation. Including stochastic labor productivity (generating uncertain earnings) and intended bequests into the model introduces additional two saving motives (i.e., precautionary saving and bequest motives), compared to the deterministic models developed for Australia by Kudrna and Woodland (2013) and Kudrna et al. (2022) which feature only one motive to save, i.e., for retirement consumption.

There is also a growing body of empirical literature studying tax-favored superannuation in Australia. For example, early studies by Connolly and Kohler (2004) and Connolly (2007), using time series or household survey data, show positive impacts of compulsory superannuation on total assets and household savings. A recent paper by Longmuir (2021) provides an empirical analysis of household wealth between 2002 and 2018 in Australia, also capturing mandatory superannuation. Longmuir shows that household retirement wealth has increased significantly, partly due to considerable gains in superannuation accounts, driven by mandatory contributions. His paper also finds evidence for behavioral responsiveness from the interaction between superannuation and means-tested age pensions. Using Australian tax register data, Chan et al. (2022) show significant income and labor supply responses to tax-favoured superannuation contributions (specifically to changes in the annual caps on these contributions). The findings of this empirical literature are supported by our OLG model, which not only accounts for saving and labor supply responses to mandatory superannuation (and its interaction with the public age pension and progressive income taxation) but also for general equilibrium effects.

The rest of the paper is structured as follows. In the next section, we provide a detailed description of the OLG model. In Section 3, we present the details of the calibration of the benchmark economy to Australian macro-level and micro-level data. In Section 4, we present and discuss the economy-wide effects of alternative mandatory SG rates, with results for household life cycle variables as well as the macroeconomic and welfare effects provided. Section 5 considers several robustness checks by altering various model assumptions, e.g., to alternative market structure with alternative household preferences, constant factor prices, alternative government budget-equilibrating policy instruments, and alternative tax and public pension policy rules. The final section provides key conclusions and points to future research.

2 The model

In this section, we develop a general equilibrium overlapping generations (OLG) model with endogenous labor and retirement and where households face labor income and lifespan uncertainty. The model consists of a household sector with overlapping generations of heterogenous households, profit-maximising firms, and a government sector with detailed policy settings. We start by providing a brief overview of the key features of the model, highlighting the importance of this type of economic model for tax and pension policy analysis. We then describe the demographic structure of the model and the distributional measure of households, provide an algebraic description of each of the sectors and define the steady state equilibrium of the model.

2.1 Key features of the model

The stochastic OLG model – developed in this paper to analyse the economic-wide impacts of superannuation mandate – captures the economic behavior of individuals over the life cycle. It also provides macroeconomic and fiscal implications by aggregating across individuals and sectors. This type of macroeconomic model has been used extensively for studying taxation and social security (and private pensions) in developed countries (as indicated in the abovementioned existing literature). Our model incorporates the following features:

- expected lifecycle utility maximization with endogenous labor supply, retirement, consumption and saving (in both liquid assets and illiquid superannuation assets);
- multiple generations aged from 20 to 99 years, with each generation represented by 3 heterogeneous skilled types of households (distinguished by educational attainment or skill type);
- mortality risk, with mortality differentials among the three skilled types (following Kudrna et al. (2022));
- labor income risk, with stochastic labor productivity (following AR(1) process), differentiated by skill type and estimated from the Household, Income and Labor Dynamics in Australia (HILDA) surveys (see Summerfield et al. (2019) for details about HILDA);

- both intended and accidental bequests, with intended bequests modelled as a luxury good (De Nardi, 2004);
- detailed representation of the tax and retirement income policies in Australia, including mandatory superannuation, means-tested age pension and progressive income taxation;
- dynamic general equilibrium model structure capturing the interactions between the household sector, the production sector and government policy.

These features of the model allow us to examine the economy-wide effects (of funded private pensions and their interactions with public pensions and progressive income taxation), including: (*i*) impacts on labor supply and saving and retirement decisions of households over their life cycle; (*ii*) distributional welfare effects for different skilled types of households (intra-generational) and different generations (inter-generational); and (*iii*) the macroeconomic effects on labor, capital and goods markets and the fiscal implications for the government budget. The focus of our analysis in this paper is on the long-run implications of mandatory superannuation, examining alternative mandatory SG rates.

2.2 Demographics and distributional measure of households

The model economy is populated by overlapping generations of heterogeneous households with age from 1 to J. The model also distinguishes between the pension access age j_R and the retirement (from workforce) age $j_{\overline{R}}$ (with $j_{\overline{R}} > j_R$). By endogenous retirement, we mean that we do *not* force households to retire when reaching the pension access age.[4] When entering the model at $j = 1$, each household is assigned a permanent skill type $i \in \mathcal{I} = \{1, ., I\}$ according to the probability distribution ϖ_i. The model assumes a stationary demographic structure, with a constant population growth rate n and lifespan uncertainty given by age- and skill-specific survival probabilities $\psi_{j,i}$ – conditional probabilities of surviving from age $j-1$ to age j with $\psi_{1,i} = 1$ and $\psi_{J+1,i} = 0$, also distinguished by skill type i.

The individual state vector is defined as:

$$z = (j, i, a_j, s_j, \eta_j) \in \mathcal{Z} = \mathcal{J} \times I \times \mathcal{A} \times \mathcal{S} \times \mathcal{E}$$

where $a_j \in \mathcal{A} = [0, \infty]$ denotes liquid ordinary assets held at the beginning of age $j \in \mathcal{J} = \{1, .., J\}$. These assets are set to zero at $j = 1$ and restricted throughout the whole life cycle to be non-negative, i.e., $a_j \geq 0$. During $j < j_{\overline{R}}$, households receive labor productivity shocks $\eta_j \in \mathcal{E}$ and during $j < j_R$, they also accumulate superannuation assets $s_j \in \mathcal{S} = [0, \infty]$, which is preserved in the superannuation fund for $j < j_R$. The productivity shocks follow a skill-specific finite-state Markov process. Therefore, households know their current productivity levels at the beginning of each j, but have to take expectations about next period productivities.

[4] Note that exogenous retirement has been used as a common assumption in this type of models (see e.g. Hosseini and Shourideh 2019).

Consequently, the initial distributional measure of households at age $j = 1$ depends on the initial distribution skills and productivity shocks. Let $X(z_j)$ be the corresponding cumulated measure to $\phi(z_j)$, so that

$$\int_{\mathcal{I}\times\mathcal{E}} \mathrm{d}X(z_1) = 1 \qquad \text{with} \quad z_1 = (1, i, 0, 0, \eta_1) \tag{1}$$

must hold, since we normalized the cohort size of newborns to equal one. Let $\mathbf{1}_{k=x}$ be an indicator function that returns 1 if $k = x$ and 0 if $k \neq x$. Then, the law of motion for the measure of households at age j follows

$$\phi(z_{j+1}) = \frac{\psi_{j+1}}{1+n} \int_{\mathcal{Z}} \mathbf{1}_{a_{j+1}=a_{j+1}(z)} \times \mathbf{1}_{s_{j+1}=s_{j+1}(z)} \times \pi(\eta_{j+1}|\eta_j)\mathrm{d}X(z_j), \tag{2}$$

where $\pi(\cdot)$ denotes the transition probabilities for labor productivity of workers from one period to the next.

Note that in the model description provided below, the state index z is omitted and agents are only distinguished according to their age j.

2.3 Household sector

Preferences Households have preferences over streams of consumption c_j and leisure l_j as well as from leaving bequests upon death.[5] The expected discounted lifetime utility function is given by

$$E\left[\sum_{j=1}^{J} \beta^{j-1} \left(\prod_{o=1}^{j} \psi_{o,i}\right) \left\{u(c_j, l_j) + \beta(1-\psi_{j+1,i})\mathcal{B}(\bar{b}_{j+1})\right\}\right], \tag{3}$$

where the annual utility takes the standard Cobb-Douglas functional form of

$$u(c,l) = \frac{\left(\left(\frac{c}{\mu}\right)^{\nu} l^{1-\nu}\right)^{1-\sigma}}{1-\sigma},$$

and the bequest function is given by

$$\mathcal{B}(\bar{b}) = q_1 \left[1 + \frac{\bar{b}}{q_2}\right]^{1-\sigma_b}.$$

The utility function parameters include the subjective discount factor, β, the Cobb-Douglas consumption share parameter denoted by ν, the coefficient of relative risk aversion σ and the consumption equivalence parameter μ (which is age-specific and based on Kaas et al. (2021)

[5] In this subsection, we will omit the state index z for every variable, and so households are only distinguished according to their age j.

and Nishyiama and Smetters (2005)).[6] Note that future $u(c,l)$ is also discounted by age- and skill-specific survival rates, $\psi_{j,i}$. The specification of the bequest motive follows De Nardi (2004), with the term q_1 reflecting the parent's concern about leaving bequests, q_2 measuring the extent to which a bequest is a luxury good and σ_b governing the relative risk aversion for the bequest. Agents derive utility from bequests equal to total assets (consisting of liquid (ordinary private) and illiquid (superannuation) assets, i.e. $\overline{b}_{j+1} = a_{j+1} + s_{j+1}$)) left by those agents who do not survive to $j+1$.

Labor earnings and budget constraint Agents start working at age $j = 1$ and in each period $j < j_{\overline{R}}$, they receive an endowment of productive efficiency supplied to the labor market at the wage rate w. It is assumed that labor productivity is a function of a deterministic age–profile of earnings (per hour worked) e_j and a transitory component η_j. The latter evolves stochastically over time and is assumed to have an AR(1) autoregressive structure:

$$\eta_j = \rho\eta_{j-1} + \epsilon_j \quad \text{with} \quad \epsilon_j \sim N\left(0, \sigma_\epsilon^2\right) \quad \text{and } \eta_0 = 0, \tag{4}$$

where ρ is the persistence parameter and ϵ_j is the innovation of the process. The idiosyncratic innovation term ϵ_j is normally distributed with mean zero and variance, σ_ϵ^2. Note that labor productivity is also skill-specific.

Labor supply is endogenous at the intensive as well as extensive margins, given by $ls_j = 1 - l_j$, with the time endowment normalized to one.[7] Given the market wage rate, labor productivity and hours worked, households' gross labor income le_j then can be derived as

$$le_j = \begin{cases} w \cdot e_j \cdot \exp\left[\eta_j\right] ls_j, & \text{if } \; j < j_{\overline{R}} \\ 0, & \text{if } \; j \geq j_{\overline{R}} \end{cases}.$$

Households aged $j < j_R$ receive government social transfer payments st_j and (skill-specific) bequests b_j.[8] Those aged $j < j_R$ also make mandatory superannuation contributions sc_j.[9] Older households aged $j \geq j_R$ can continue working (if aged $j < j_{\overline{R}}$), but they receive withdrawals

[6] In the sensitivity analysis, we consider alternative preference structures as in Conesa et al. (2009). Note that they also assumed the Cobb-Douglas preferences (non-separable in consumption and leisure) in the main analysis but abstracted from any bequest motives. We also consider a separable annual utility function as one of the robustness checks.

[7] Assuming 15 non-sleeping hours per day and therefore 105 hours of the time endowment per week, one could simply derive weekly hours worked.

[8] Bequests are assumed to be received by households aged 45 to 64 (when most households receive inheritances in Australia, see e.g. Wood et al. 2019), at equal skill-specific amounts, as defined below (when describing the steady state equilibrium).

[9] We assume that mandatory superannuation contributions are made directly by households in our model (rather than by the representative producer or their employers as under the SG legislation). However, irrespective of who pays the contributions, the effects of the policy changes investigated by this model (with profit-maximizing producers) would be identical. In Australia, there is empirical evidence, showing that the incidence of mandatory superannuation is born largely by workers (e.g., see Breuning and Sobeck 2020).

from their private pension fund sp_j and may receive (means-tested) age pension income ap_j. All households are subject to a consumption tax with the flat rate τ^c and progressive income taxation $T(\cdot)$, while superannuation taxes only apply to those $j < j_R$ and are concessional compared to $T(\cdot)$.[10] The households' periodic budget constraint (with liquid assets at the beginning of $j+1$ denoted by a_{j+1}) can then be expressed as

$$\begin{aligned} a_{j+1} = (1+r)a_j + (le_j - sc_j) + b_j + st_j \\ + ap_j + sp_j - T(\cdot) - (1+\tau^c)c_j, \end{aligned} \tag{5}$$

with the right-hand side including the asset income ra_j, labor earnings net of superannuation contributions $le_j - sc_j$, bequest receipts b_j, social transfers st_j (for those $j < j_R$), public and private pensions ap_j and sp_j (for those $j \geq j_R$) less progressive income tax $T(\cdot)$ and consumption expenditure $(1+\tau^c)c_j$.

2.4 Production sector

The production sector is characterized by a representative producer, representing a large number of perfectly-competitive, profit-maximizing firms. The representative firm demands capital K and effective labor L on perfectly competitive factor markets to produce a single output good according to the Cobb-Douglas production technology:

$$Y = \kappa K^\alpha L^{1-\alpha}, \tag{6}$$

where α denotes the capital share in production and κ is the productivity constant. Capital is rented from households at a riskless rate and depreciates at the depreciation rate δ. Firms pay corporate taxes $T_k = \tau^k[Y - wL - \delta K]$, where the corporate tax rate τ^k is applied to the output net of the labor cost and capital depreciation. Factor prices are determined competitively by marginal productivity conditions[11]:

$$w = (1-\alpha)\left(\frac{K}{L}\right)^\alpha, \tag{7}$$

$$r = (1-\tau^k)\left[\alpha\left(\frac{L}{K}\right)^{1-\alpha} - \delta\right]. \tag{8}$$

[10] The tax and pension policy settings are discussed further in the subsection below on the government sector.

[11] Note that in the sensitivity analysis section, we also consider partial equilibrium effects of alternative mandatory superannuation rates, assuming a small open economy (SOE) framework, where the domestic interest rate is exogenous and set to the world interest rate ($r = r^w$). Assuming SOE, a policy change would have no impact on the factor prices – neither domestic interest rate nor wage rate, unless r^w or any production parameter is changed.

2.5 Government sector

The government is responsible for collecting revenues from taxes on household income, consumption and superannuation as well as corporate income, in order to pay for its general consumption and transfer payments. It is also responsible for regulating the pension system. We incorporate the main features of the two publicly-stipulated pillars of Australia's retirement income policy – the means-tested public age pension and the mandatory private superannuation scheme. The modeling of fiscal and pension policies is described in more detail below, starting with the modeling of mandatory superannuation (which is the main focus of this paper).[12]

Mandatory superannuation Australia's major employment-related pension pillar is represented by mandatory, privately-managed retirement savings accounts, which are based on defined contributions and regulated by the government under the legislation known as the Superannuation Guarantee (SG).

The model assumes that mandatory superannuation contributions sc_j are made by households aged $j < j_R$, up to a legislated cap (see below). The contributions, net of the contribution tax sct_j, are added to the stock of superannuation assets s_j, which earns investment income at the after-tax interest rate, $(1-\tau^r)\,r$. Superannuation assets are assumed to be preserved in the fund until households reach the access age j_R. For those aged $j \geq j_R$, we assume the (age-specific) draw-down fraction of the superannuation (private pension) balance denoted by ζ_j, which determines their withdrawals from the fund $sp_j = \zeta_j(1+r)s_j$ that are included in the household budget constraint (5). The superannuation asset accumulation and decumulation (with superannuation assets at the beginning of $j+1$ denoted by s_{j+1}) can be expressed as

$$s_{j+1} = \begin{cases} (1+(1-\tau^r)\,r)s_j + sc_j - sct_j, & \text{if } \; j < j_R \\ (1-\zeta_j)(1+r)s_j, & \text{if } \; j \geq j_R \end{cases}, \tag{9}$$

where r is the interest rate and τ^r denotes the fund earnings tax rate. The mandatory superannuation contributions sc_j are made at the SG rate τ^p from labor earnings, but they are capped at $\overline{sc}$ (reflecting the policy rule of the cap on concessional contributions), i.e., $sc_j = \min\left[\tau^p l e_j; \overline{sc}\right]$. Finally, the superannuation contribution tax sct_j, with the concessional tax rate τ^s, is imposed on mandatory contributions sc_j only by those with earnings above the tax-free threshold $y_{\min}$ (which reflects the policy of superannuation co-contributions that effectively removes the contribution tax for low-income individuals, $sct_j = 0$), i.e., $sct_j = \tau^s sc_j$, iif $le_j > y_{\min}$.[13]

Public age pension The publicly-managed "safety net" pillar of the Australian pension system is represented by a non-contributory, means-tested age pension, financed through general

[12] More details on Australia's tax and pension systems (and the modeling) are provided in Appendix A.

[13] Note that all superannuation taxes are only imposed in the accumulation phase and we allow for some progressivity in the taxation of superannuation contributions, sct_j (approximating the Australian superannuation tax rules).

taxation revenues.

The age pension ap_j is paid to households of the access age ($j \geq j_R$) provided that they satisfy the means test. In the model, we only consider the income test, but we calibrate its parameters to closely approximate the distribution of the pension-age eligible population with respect to their age pension payments (with more details provided in the next section on the model calibration).

The income test works as follows. The legislated maximum age pension benefit $\overline{p}$ is paid to age-eligible households provided that their assessable income $\widehat{y}_j$ is not greater than the given pension income threshold $\widehat{y}_{\min}$. If $\widehat{y} > \widehat{y}_{\min}$, ap_j gets reduced at the taper rate θ (for every dollar of $\widehat{y} > \widehat{y}_{\min}$ until $ap = 0$). The age pension benefit then can be expressed as

$$ap_j = \begin{cases} 0, & \text{for } j < j_R \\ \max\left\{\min\left\{\overline{p}, \overline{p} - \theta\left(\widehat{y}_j - \widehat{y}_{\min}\right)\right\}, 0\right\}, & \text{for } \ j \geq j_R \end{cases}, \tag{10}$$

where the assessable income $\widehat{y}_j = y_j + 0.5le_j$ includes the deemed income and half of labor earnings (which reflects the policy rule of preferential means testing of employment income). The deemed income y_j is derived from the total assets – sum of private ordinary and superannuation assets $ta_j = a_j + s_j$, as $y_j = 0.04(ta_j - \min\left[ta_j; a_{min}\right]) + 0.025 \min\left[ta_j; a_{min}\right]$, with the deeming rates of return of 4% and 2.5% p.a. applied above and below the asset (for deeming) threshold a_{min}.[14,15]

The total expenditure of the public pension program is given by $P_A = \sum_{j \geq j_R}^{J} \int_{\mathcal{X}} ap(z) \mathrm{d}X(z)$.

Social transfers The government also runs a social transfer program that pays social transfers st_j to households aged $j < j_R$.[16] The total social transfer expenditure (excluding the age pension) is given by $ST = \sum_{j=1}^{j_R - 1} \int_{\mathcal{X}} st(z) \mathrm{d}X(z)$.

Taxes The government collects taxes to finance its spending programs. Specifically, it collects taxes from households – taxing their income, consumption and superannuation as well as from firms taxing their (taxable) corporate income. The model incorporates the progressive income taxation and flat tax rates on the other revenue sources.

[14] As in Kudrna et al. (2022), we do not model housing directly, but in order to closely target actual income tax revenues and age pension expenditures, we calculate the age-specific fraction of owner occupied housing on total net worth from ABS (2019e). It is further assumed that the interest income generated by that fraction of assets is exempt from personal income taxation and the age pension means test.

[15] Further note that under the counterfactuals examined in Section 5, these deeming rates follow the changes in the reported endogenous interest rate exactly. This reflects the current rules for the income test and deeming rates. However, as mentioned, in Australia there are two tests – an income and an asset test – and with declining interest rates, it is the asset test that now binds for most age pensioners. In the sensitivity check, we model this by assuming that the pension deeming rates are kept constant (as in the benchmark).

[16] Drawing on the Australian social security programs for the unemployed, families with children and those with disability, the age profiles of the sum of these benefits are estimated for the three skill types, using the HILDA survey data. Further details are provided in the calibration section.

The households' taxable income $\tilde{y}_j$ is taxed under the 2017-18 progressive income tax schedule $T(\tilde{y}_j)$. The taxable income includes gross labor earnings, net of mandatory superannuation contributions $le_j - sc_j$, returns on liquid ordinary private assets ra_j and the age pension ap_j, i.e.,

$$\tilde{y}_j = (le_j - sc_j) + ra_j + ap_j. \tag{11}$$

The government total tax revenue, TR, consists of revenues from different taxation sources: household progressive income tax, T^Y, consumption tax, T^C, (concessional) superannuation taxes, T^S, as well as corporate tax paid by firms, T^K. The government tax receipts can be expressed as

$$\begin{aligned}
T^Y &= \int_{\mathcal{Z}} T(\tilde{y}(z))\mathrm{d}X(z), \\
T^C &= \tau^c \int_{\mathcal{Z}} c(z)\mathrm{d}X(z), \\
T^S &= \textstyle\sum_{j=1}^{j_R-1} \displaystyle\int_{\mathcal{X}} [sct(z) + \tau^r rs(z)]\mathrm{d}X(z), \\
T^K &= \tau^k[Y - wL - \delta K].
\end{aligned} \tag{12}$$

Budget balance The government collects taxes from households and firms (with total tax revenue TR), in order to finance general government expenditure G, transfer payments $P_A + ST$, as well as interest payments on its debt. In the steady state, the government budget constraint becomes

$$TR = G + P_A + ST + (r - n)B_G, \tag{13}$$

where B_G denotes net government debt.

In the benchmark steady state equilibrium, we specify the debt-to-output ratio b_y and let public consumption G balance the government budget. We also use five adjustment parameters (f_{ap}, f_{st}, f_i, f_c, f_k) calculated to match observed ratios of the given expenditure or tax revenue to output. These adjustment parameters alter the effective (tax or transfer) rates, with f_{ap}, f_{st}, f_i and f_c being included in the households' optimisation problem and f_k in the firms' marginal productivity of capital condition.[17]

Under all the counterfactual policy experiments examined in Section 5, B_G and G and all the adjustment parameters (f_{ap}, f_{st}, f_i, f_c, f_k) are kept at their benchmark levels and we adjust the consumption tax rate τ^c to balance the government budget in (13).

[17] For example, $\tau^c = \overline{\tau}^c f_c$ in the household budget constraint (5) and consumption tax revenue (12) is the effective consumption tax rate – a product of the statutory rate and the consumption tax adjustment parameter targeting the observed consumption tax revenue to GDP ratio. Similarly, the age pension benefit ap_j needs to be scaled by f_{ap}, which is calibrated to match the observed pension expenditure to GDP ratio.

2.6 Equilibrium

Given the government fiscal and pension policy, a stationary recursive equilibrium is a set of value functions $\{V(z_j)\}_{j=1}^J$, household decision rules $\{c_j(z_j), l_j(z_j), a_{j+1}(z_j), s_{j+1}(z_j)\}_{j=1}^J$, distribution of bequests $\{b(z_j)\}_{j=1}^J$, and time-invariant measure of households $\{\phi(z_j)\}_{j=1}^J$ such that the following conditions are satisfied:

1. households make optimal consumption/saving and leisure/labor decisions by maximizing (3) subject to the household budget constraint (5), the borrowing constraint $a_j \geq 0$, time constraint $l_j \leq 1$ and the non-negativity constraint on consumption and leisure;

2. the domestic interest and wage rates are determined according to (7) and (8);

3. the aggregation holds

$$\begin{aligned} L &= \int_{\mathcal{Z}} e_j \cdot \exp[\eta_j]\, l s_j \mathrm{d}X(z_j), \\ C &= \int_{\mathcal{Z}} c(z_j)\mathrm{d}X(z_j), \\ A &= \int_{\mathcal{Z}} a(z_j)\mathrm{d}X(z_j), \\ S &= \int_{\mathcal{Z}} s(z_j)\mathrm{d}X(z_j); \end{aligned}$$

4. let $\mathbf{1}_{k=x}$ be an indicator function that returns 1 if $k = x$ and 0 if $k \neq x$. Then the law of motion for the measure of households at age j follows

$$\phi(z_{j+1}) = \frac{\psi_{j+1}}{1+n} \int_{\mathcal{Z}} \mathbf{1}_{a_{j+1}=a_{j+1}(z)} \times \mathbf{1}_{s_{j+1}=s_{j+1}(z)} \times \pi(\eta_{j+1}|\eta_j)\mathrm{d}X(z_j);$$

5. bequests satisfy

$$\int_{\mathcal{Z}} b(z_j)dX(z_j) = \int_{\mathcal{Z}} (1-\psi_{j+1})\big[(1+r)(a_{j+1}(z_j) + s_{j+1}(z_j))\big]\mathrm{d}X(z_j);$$

6. the government budget (13) (with given B_G/Y) is balanced by choosing G (only in the benchmark equilibrium);

7. the capital market clears

$$K = A + S - B_G; \tag{14}$$

8. the goods market clears[18]

$$Y = C + (n+\delta)K + G. \tag{15}$$

[18] Note that in the SOE framework with the exogenous domestic interest rate, the capital stock K is determined from (8) and the capital market clears with net foreign debt set to $B_F = A + S - (K + B_G)$. The (steady state) goods market clearance then becomes $Y = C + (n+\delta)K + G + (n-r)B_F$. As mentioned, in the sensitivity

3 Calibration

The benchmark economy of our stochastic OLG model is assumed to be in a stationary steady state equilibrium. We calibrate this benchmark steady state equilibrium model to Australia, utilising macro-level and fiscal policy data averaged over 5 years ending in June 2018, as well as micro-level data from the HILDA surveys conducted between 2001 and 2018 (see Summerfield et al. (2019) for details on the HILDA surveys).

In this section, we first provide and discuss our parameter choices for the benchmark model, starting with the values of demographic, household and production parameters displayed in Table 1, and then the values of the government policy parameters reported in that subsection. We then provide a discussion of the benchmark solution and how it compares to macroeconomic and fiscal data.

Table 1: Key parameter values of benchmark model

Definition	Value	Source
Demographics		
Survival probabilities	See the text	ABS (2019a)
Population growth rate (p.a.)	1.6% p.a.	Calibrated[a]
Skill distribution	[0.19, 0.50, 0.31]	HILDA18
Household preferences		
Intertemporal elasticity of subs.	0.5	Kudrna et al. (2021)
Ordinary consumption share	[0.36, 0.37, 0.38]	Calibrated[b]
Time discount factor	0.973	Calibrated[c]
Bequest motive parameters	See the text	Cho and Sane (2013)
Labor productivity		
Deterministic age-wage function	See the text	HILDA18
AR(1) correlation	0.95	Freestone (2018)
Transitory variance	0.017	Freestone (2018)
Production sector		
Capital share	0.4	Calibrated[d]
Capital depreciation rate (p.a.)	7%	Calibrated[e]
Production constant	1.6	Calibrated[f]

Notes: [a]To target old-age dependency ratio; [b]to target average hours worked (also by skill type); [c]to target capital output ratio (K/Y); [d]to target interest rate; [e]to target investment rate (I/K); [f]to target wage rate that is normalized to one.

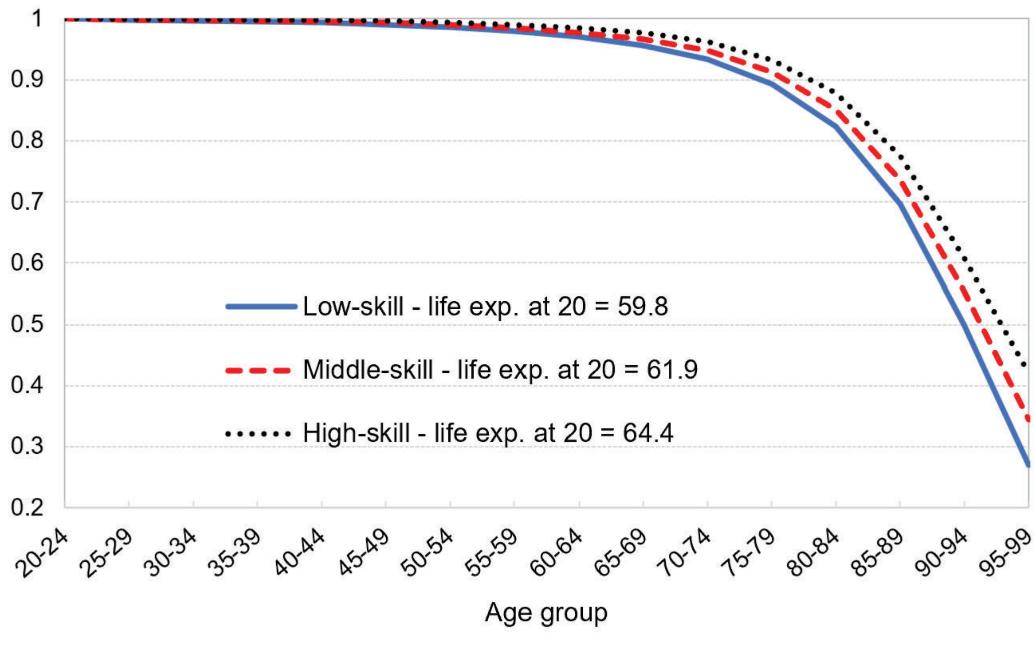
analysis section, one of the robustness checks examines the effects of alternative mandatory superannuation under this SOE market structure with constant factor prices.

3.1 Demographic structure

The model's time period is 5 years. Agents start life at age 20 (representing the age group 20-24) or model age $j = 1$ and can live up to the age of 99 years ($J = 16$) (representing age group 95-99). Hence, the model is populated with 16 age groups (20-24,..,95-99) of agents. We assume that households become eligible for age and superannuation pensions at age 65 (representing age group 65-69) ($j_R = 10$) and that they are forced to retire at age 85 (representing age group 85-89) ($j_{\overline{R}} = 14$).

The model assumes a stationary demographic structure with age- and skill-specific survival probabilities $\psi_{j,i}$ and a population growth rate n that jointly determine the sizes of different age cohorts. The age-specific survival probabilities for the middle-skill type $\psi_{j,i=2}$ are derived from the 2016-18 Australian life tables (ABS 2019a) as averages for male and female survival probabilities from age 20 to 100 and adjusted for the 5-year age groups.[19] These survival rates (for $j > 1$) are scaled down and up for low-skill and high-skill households, respectively, in order to match the life expectancy gap of 4.6 years (between low- and high-skill at age 20), as estimated for Australia by Clarke and Leigh (2011). The conditional survival probabilities $\psi_{j,i}$ and implied life expectancies by skill type used in the model are depicted in Figure 2.

Figure 2: Conditional survival probabilities by skill type



We calibrate the population growth rate to approximate the old-age dependency ratio of 0.26 in 2018 (ABS 2019b).[20] As shown in Table 1, the value for annual population growth rate

[19] The three skill types of individuals and the skill distribution are discussed in detail below in the subsection on skills and labor productivity.

[20] The old-age dependency ratio is defined here as the ratio of the population aged 65 and over to the population aged 20 to 64.

is $n = 1.6\%$, which closely matches the population growth rate in 2018. Our model also closely replicates the life expectancy targets derived from ABS (2019a), with the model-generated (average) life expectancy at age 20 and 65 being 62.3 and 20.2 years, respectively.

3.2 Household preferences

We adopt Cobb-Douglass non-separable preferences (in consumption and leisure), which are standard in the related social security literature. We apply a similar approach to calibrating household preferences, as in Kudrna et al (2021). We set the risk aversion parameter $\sigma = 2$. The value of the discount factor $\beta = 0.973$ is calibrated for the model to match the capital to output ratio of 3.3 (as other macro targets, averaged over the last 5 years ending in June 2018 (ABS 2019c)).

The consumption share parameter in the periodic utility ν_i is skill-specific. We set the value for the middle-skill type to $\nu_{i=2} = 0.37$, for the model to approximate average work hours of 0.32 (of the time endowment normalised to one) (ABS 2019d). For the low-skill and high-skill type, the value is reduced to 0.36 and is increased to 0.38, respectively. This is to better match their labor supply, which is smaller for low-skill and higher for high-skill than average hours worked, particularly at older ages (based on HILDA1-18 waves).

We follow a similar approach to Kaas et al. (2021) and Nishyiama and Smetters (2005) in incorporating the consumption equivalence into the periodic utility. In relation to deriving the parameter values (over the life cycle), we use the OECD-modified equivalence scale and ABS (2019e) data, setting $\mu_j = (1, 1.4, 1.9, 1.75, 1.65, 1.56)$ for broader age groups (20-24, 25-34, 35-44, 45-54, 55-64, 65+).

The bequest function parameterisation follows De Nardi (2004) and Cho and Sane (2013), with the parameters set to $q_1 = -9$, $q_2 = 11.6$ and $\sigma_b = 1.5$.[21]

3.3 Skills and labor productivity

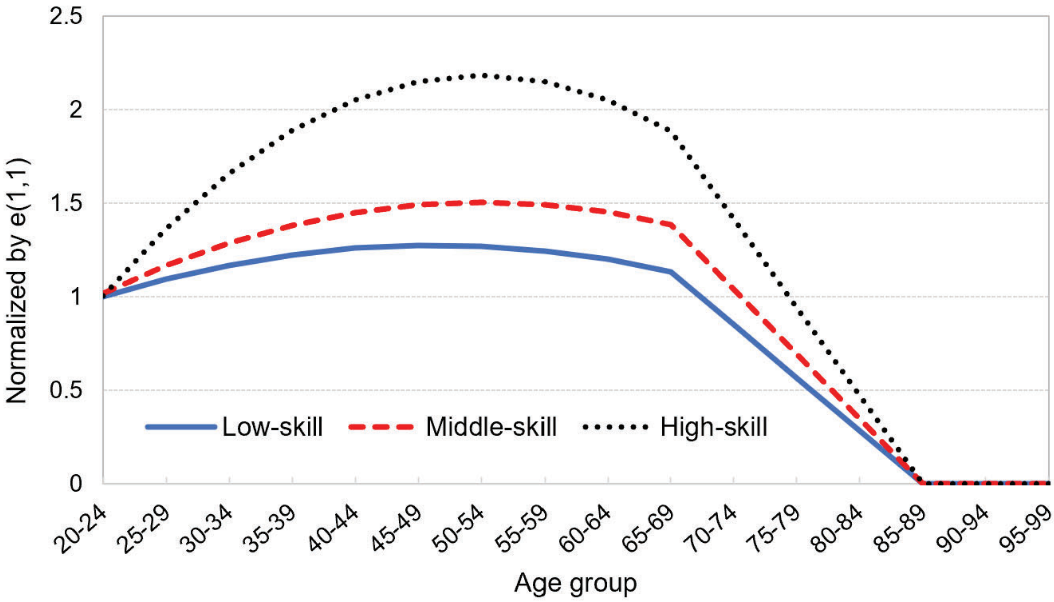
Individuals are assigned to three skill types based on the highest level of education they attained – *low*-skilled (with less than 12 years of schooling), *middle*-skilled (12 years of schooling and above but less than a completed bachelor's degree), and *high*-skilled households (with a completed bachelor's degree and above). The initial probability distribution for the three skill types (reflecting low-, middle- and high-skilled households) is derived from HILDA18 using employed individuals (both males and females) aged 20 to 64 years for the three skill types in the 18 survey waves released in years 2001 to 2018, setting $\varpi_i = (0.193, 0.502, 0.305)$.

The three skill types each have a different labor productivity, which is a function of a deterministic age-profile and a transitory component assumed to follow an AR(1) process. The

[21] In the sensitivity analysis, we consider alternative preference structures as in Conesa et al. (2009), with increased σ and no bequest motive. We also consider an alternative periodic utility function that is separable in consumption and leisure as one of the robustness checks.

estimates for the deterministic age profile $e_{j,i}$ (a quadratic wage equation including both age and age-squared) are skill-specific and derived from HILDA18. The profiles for each of the three skill types (normalised by the labor productivity of low-skill at age 20 $e_{1,1}$) are plotted in Figure 3. Note that for those aged 65 and over, we assume that their labor productivity declines linearly, reaching zero at $j_{\overline{R}}$ (as in Kudrna et al. (2022)). In relation to incorporating stochastic labor productivity, we follow Conesa et al. (2009) and Fehr et al. (2013), with the autocorrelation and variance terms of the AR(1) process in (4) derived from Freestone (2018).[22]

Figure 3: Labor probabilities (wage per hour) by skill type



3.4 Production sector

The production function in (6) takes the Cobb-Douglas functional form, which is standard in other related literature (e.g., see Hosseini and Shourideh 2019). We calibrate the values of capital share $\alpha = 0.4$ and the depreciation rate of the capital stock $\delta = 0.07$ p.a. to approximate the investment rate ($I/K = 0.077$) and the gross investment to output ratio ($I/Y = 0.25$). The wage rate, w, is normalized to one by calibrating the value of the productivity constant $\varrho = 1.46$. As discussed, we use the Australian national account data as 5-year averages ending in 2018 (ABS 2019c). The domestic interest rate is set to $r = 4.4\%$ p.a. (similar values were used in Australian-based OLG models by Kudrna et al. (2019, 2022) and also by Hosseini and Shourideh (2019) for the US).

[22] One of the sensitivity checks of the long-run results applies a model with increased labor earnings uncertainty (by doubling the variance term of labor productivity for each skill type).

3.5 Government sector

This section provides the details for the policy rules and parameters of the Australian tax and pension systems, with the parameter values reported in Table 2. We follow the same policy order as in the model section, starting with mandatory superannuation.

Table 2: Calibration of government policy in benchmark model

Definition	Value	Source
Superannuation		
Mandatory SG rate	7%	Calibrated[a]
Contribution tax rate	15%	Data
Fund earnings tax rate (effective)	7%	Data
Public pension		
Maximum pension	0.34y	Data
Means test disregard	0.18y	Calibrated[b]
Taper rate	0.9	Calibrated[c]
Social transfers		
Age- and skill-specific transfers	See the text	HILDA18
Taxes		
Personal income tax	See the text	Data
Statutory corporate tax rate	30%	Data
Statutory cons. tax rate (GST)	10%	Data
Fiscal adjustment parameters (scalars)[d]		
Public age pension	0.81	Calibrated
Social transfers	0.9	Calibrated
Personal income tax	0.9	Calibrated
Corporate tax	0.75	Calibrated
Consumption tax	1.04	Calibrated

Notes: [a]To target superannuation assets to GDP ratio; [b]to target the share of full age pensioners; [c]to target the share of self-funded seniors; [d]these scalars are calculated to target the given government expenditure or tax revenue to GDP ratio.

Mandatory superannuation We focus on the mandatory Superannuation Guarantee scheme that was legislated in 1992. It mandates employers to make contributions on behalf of their employees, at the SG rate of 3% of gross wages initially (in 1992), increasing to the current 10% and then to the legislated 12% by 2025. In the benchmark model, we assume mandatory contributions (made by working households aged < 65) at the SG rate of $\tau^p = 7\%$ (which is approximately the average SG rate over the period 1992-2018 and approximates the superannuation assets of 150% of GDP, taken from Chomik et al. (2018) for 2018).[23] The mandatory

[23] Note that under more recent estimates by Willis Towers Watson (2021), Australia's superannuation assets are already at 175% of GDP.

contributions are made by households up to a contribution cap of $\overline{sc} = 0.3\overline{y}$.

The superannuation taxes on mandatory contributions and fund earnings are made during the superannuation assets accumulation ($j < j_R$), with the tax rates set to $\tau^s = 15\%$ and $\tau^r = 7\%$, respectively.[24] We also assume that low income individuals with earnings below the income tax free threshold ($y_{min} = 0.3\overline{y}$) do not pay any contribution tax (reflecting the policy of super co-contributions).

The superannuation assets cannot be accessed prior to the superannuation access age $j_R = 10$ (representing age group 65-69). Individuals aged $j \geq j_R$ are paid their accumulated superannuation savings at the assumed age-specific fractions ζ_j of their superannuation balance, with $\zeta_j = (0.25, 0.35, 0.5, 1)$ for age groups (65-69, 70-74, 75-79, 80+).[25] Based on the current legislation, these drawdowns are tax-free.

Public pension Households become eligible for the public pension ap_j at the same eligibility age as for superannuation payouts, $j_R = 10$ (representing the age group 65-69). The pension benefit is means-tested, subject to the calibrated income test in the model. The income test includes the maximum pension benefit $\bar{p}$ (which applies to single pensioners $\bar{p} = 0.34\overline{y}$), the income threshold (or disregard) $\widehat{y}_{\text{min}}$ (up to which $\bar{p}$ is payable) and the taper θ (at which $\bar{p}$ reduces for every dollar of the assessable income above the threshold $\widehat{y} > \widehat{y}_{\text{min}}$. The assessable income $\widehat{y}$ consists of the deemed income $\widehat{y}$ (derived from financial assets) and half of labor earnings (for working households).[26] As for the deemed income, there are two deeming rates of 4% p.a. and 2.5% p.a. above and below the asset (for deeming) threshold $a_{min} = 0.7\overline{y}$ (applicable to single pensioners). For the deeming rates and threshold we use pension policy data from 2016 (when the pension access age was 65). Importantly, the income disregard and the taper are calibrated to approximate the share of those on full (maximum) pension and those on no pension (i.e., self-funded seniors), respectively, with $\widehat{y}_{\text{min}} = 0.18\overline{y}$ and $\theta = 0.9$ in our benchmark model (which closely match the distribution by age pension payments as shown in Table 4).[27] Finally, we scale the pension benefits ap_j (and also the maximum pension $\bar{p}$) by the adjustment factor $f_{ap} = 0.81$ that is calculated so that the model matches the observed pension expenditure (including both age and service pensions) to output ratio $P_A/Y = 0.029$.[28],[29]

[24] Note that τ^r is the effective fund's earnings tax, with the value set as in Kudrna and Woodland (2013) and Kudrna et al. (2021).

[25] In one of the sensitivity checks in the next section, we consider an alternative lump-sum payout at $j = j_{\overline{R}}$ (with $\zeta_j = 1$ at that age).

[26] In terms of preferential means testing of labor earnings, we follow Kudrna et al (2022). Alternatively, we could incorporate the maximum earnings that are to be exempted from the income test, as in Kudrna (2016).

[27] By calibrating these parameters, we effectively combine the actual income and asset test into one - the means test in (10).

[28] Scaling down the pension benefit reflects the model use of the maximum pension rate for single pensioners, which is higher than the maximum pension for each of the pensioner couple.

[29] Note that all the calibration fiscal targets (including the one for the pension expenditure here) are 5-year averages ending in June 2018, derived from budget papers over the period (Australian Government, 2018).

Social transfers The model incorporates social transfer payments paid by the government to households aged $j < j_R$ and targeted to those on lower incomes. These payments aim to capture transfer payments to the unemployed, families with children and the disabled (such as Newstart Allowance, various family benefits and the Disability Support Pension). We estimate the transfer age-profile for each skill type using HILDA18 and scale these transfer profiles for the model to match the observed expenditure on these social transfers to output ratio $ST/Y = 0.054$.

Taxes The model consists of the following four sources of total tax revenue: personal income taxes, superannuation taxes, corporate taxes and consumption taxes. As mentioned, the (personal) income tax base (11) includes labor earnings (net of mandatory contributions), asset income and the public age pension, and it is subject to progressive taxation. We use the Australian 2017-18 personal income tax schedule with five tax brackets and marginal tax rates (increased by the Medicare levy of 2%).[30] We scale the income tax payable by $f_i = 0.90$ to match $T^Y/Y = 0.114$.[31]

Other tax revenues are collected from superannuation, corporate (or firms' taxable income) and consumption taxes. As discussed above, the tax rates on superannuation contributions and fund earnings are set to $\tau^s = 0.15$ and $\tau^r = 0.07$ (i.e., effective tax rate on superannuation fund earnings during the accumulation stage). The corporation and consumption tax rates in Table 2 are effective rates – the products of their statutory rates ($\overline{\overline{\tau}}^k = 0.3$ and $\overline{\overline{\tau}}^c = 0.1$) and the respective adjustment factors. As with the household income taxation, we calculate adjustment factors for these taxes ($f_k = 0.75$ and $f_c = 1.04$) to match the ratios of the given revenue to output ($T^K/Y = 0.046$ and $T^C/Y = 0.062$). In the benchmark economy, we also fix the government net debt at the observed ratio to output $b_y = 0.2$ and calculate government consumption ($G = 0.15Y$) to balance the government budget specified in (13).

3.6 Benchmark solution and comparison with data

The benchmark solution is obtained by numerically solving the model for the initial steady state equilibrium, with the parameters and the government policy settings specified above. The computation method follows the Gauss-Seidel procedure of Auerbach and Kotlikoff (1987), which for stochastic OLG models is explained in great detail by Fehr and Kindermann (2018). We start with a guess for aggregate variables, bequests distribution and exogenous policy parameters. Then, we compute the factor prices and the individual decision rules and value functions.[32]

[30] In Australia, the Medicare levy is used to fund some of the costs of Australia's public health system known as Medicare.

[31] One could think of this scalar as the proportion of income that is not taxable (e.g., due to various tax deductions or exemptions).

[32] Note that in this paper, the model assumes discrete labor-leisure choices, assuming 11 equally spaced grid points for labor, ranging from 0 to 0.5 (of the time endowment).

The latter involves the discretization of the state space. Next, we obtain the distribution of households and aggregate assets and government consumption (or the consumption tax rate under policy counterfactuals examined in the next section) that balances government budgets (and the five policy adjustment parameters, targeting the ratios of the given tax revenue or government expenditure to output). This information allows us to update the initial guesses. The procedure is repeated until the initial guesses and the resulting values for capital, labor, bequests and endogenous taxes have sufficiently converged.

In this subsection, we first present and discuss model-generated life-cycle solutions for the main variables of households. These implications then drive the macroeconomic and fiscal solutions, which we discuss next. In this regard, we provide a detailed comparison of the model generated and actual macro and budgetary implications, also including distributions of the retired population in relation to their public pension receipts.

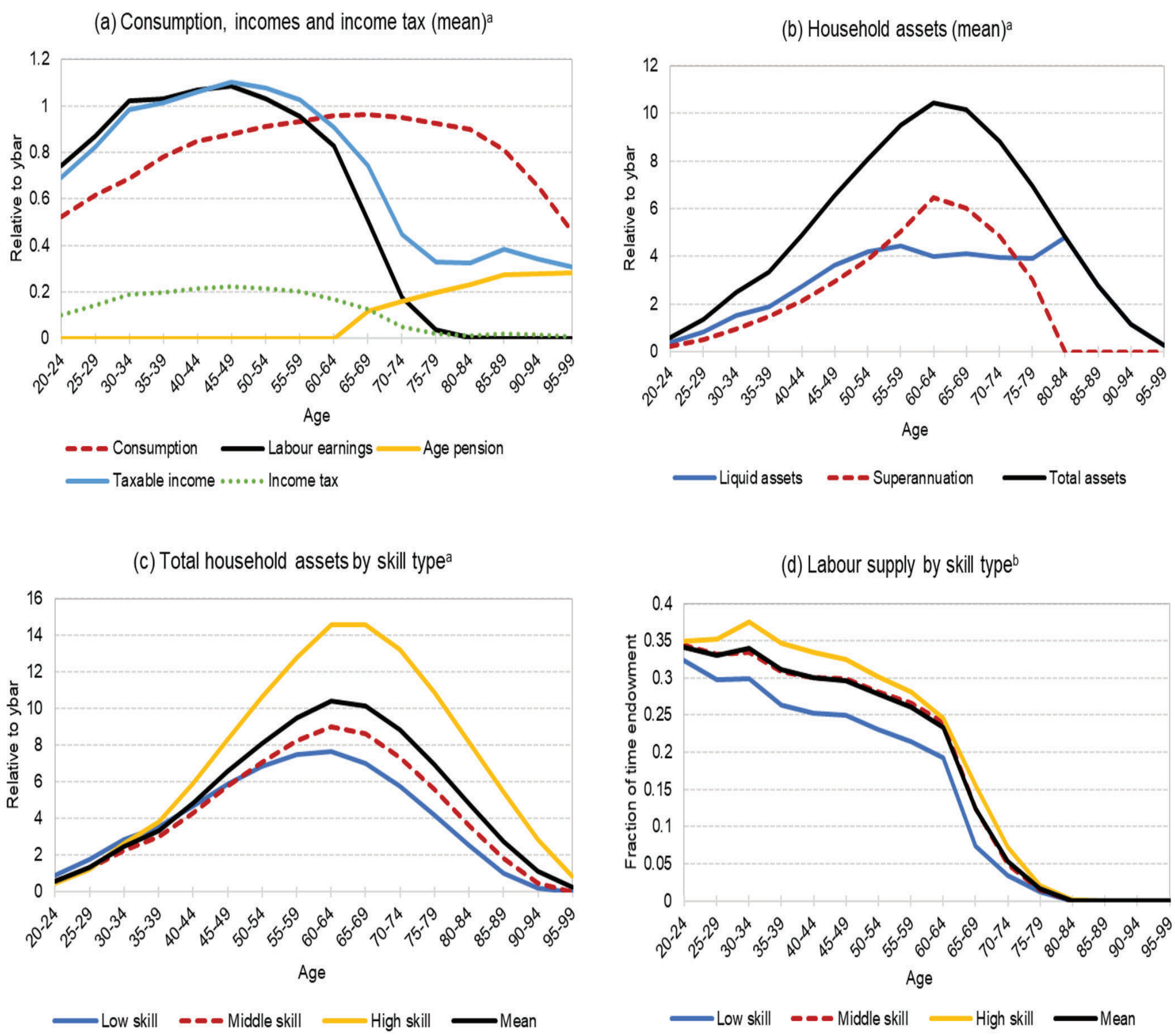
Life cycle solutions The main life cycle solutions are plotted in Figure 4, which include 4(a) consumption, incomes and income taxes, 4(b) household assets (mean), 4(c) total assets by skill type, and 4(d) labor supply by skill type. Apart from labor supply, which is presented as the fraction of normalized time endowment (with assumed 105 non-sleeping hours per week or 5,460 hours p.a.), all other variables are expressed as a fraction of economy-wide average labor earnings (≈A$64,000 derived from ABS (2019d) for 2018).

As shown in Figure 4, consumption, earnings, incomes, taxes, total assets and labor supply have standard hump-shapes, driven by stochastic labor productivities and (with age-declining) survival productivities and also, importantly, by government policy. Note that during younger ages, the individual taxable income is (on average) below the labor earnings, because of the deduction of concessional mandatory contributions into their private superannuation accounts. On average, households at older ages pay very low income taxes and their public pension benefits increase with age (as seen in Figure 4(a)) due to means testing.

The household assets and total assets in Figures 4(b) and 4(c), respectively, are reported for the holdings at the end of each age group. As discussed, we assume the superannuation assets to be preserved in the fund until the access age j_R, with households aged 65-69 and above drawing a given fraction of their private pension balance as a payout made into liquid private assets. This assumption determines the asset composition for those $j \geq j_R$.[33] In Figures 4(c) and 4(d), we document the difference in the total asset holdings and labor supply (hours worked), respectively, by skill type.

[33] In Section 5, we also consider alternative payouts of superannuation savings, which alter the asset composition at older ages.

Figure 4: Benchmark solutions for consumption, incomes, assets and labour supply over life cycle



Notes: [a]Relative to benchmark economy-wide average earnings (ybar=A$64,000 p.a.); [b]Fraction of annual time endowment (=5,460 hours).

Macroeconomic and fiscal solutions The macroeconomic and fiscal solutions with the Australian data comparison are reported in Table 3, with most selected variables expressed as a percentage of GDP. The comparison with the data reveals that our benchmark model effectively matches Australian macroeconomic and budgetary data. As pointed out, in the benchmark model we assume no net export (and net foreign assets) so that we can examine the closed economy effects with general equilibrium adjustments in factor prices – wage and interest rates. We use the 7% SG rate to approximate the observed superannuation assets to GDP ratio. Note that the superannuation assets in the accumulation stage ($j < j_R$) equals about 140% of GDP (not displayed). As shown, our model matches exactly many of the fiscal targets (government expenditures and tax revenues) by utilising the discussed fiscal adjustment parameters. Note that as for the consumption taxes, we target the revenue from overall consumption taxation (including the GST), and the target for pension expenditure includes both the age and service pensions (which are subject to the same means testing rules).

Table 3: Benchmark macroeconomic and fiscal solutions and targets*

Variable	Model	Target[a]
Expenditures on GDP		
Consumption	74.3	75.2
Private consumption	59.3	56.9
Government consumption	15.1	18.3
Gross investment	25.6	25.3
Net export	0.0	-0.6
Capital markets		
Capital stock	330.9	329.5
Government (net) debt	20.0	20.0
Household wealth	351.5	
Superannuation assets	160.8	150[b]
Interest rate p.a. (%)	4.4	
Government policy[c]		
Income tax revenue	11.4	11.4
Superannuation tax revenue	0.9	0.6
Corporate tax revenue	4.6	4.6
Consumption tax revenue	6.2	6.2
Effective cons. tax rate (%)	10.5	
Public pension benefits	2.9	2.9
Social welfare benefits[d]	4.5	4.5
Interest on gov. net debt	1.0	
Mandatory SG rate (%)[e]	7.0	
Distribution of those aged 65+ (%)[f]		
No age pension	23.8	25.0
Full age pension	44.4	43.5
Part age pension	31.8	31.5

Notes: *% of GDP, if not stated otherwise; [a]targets derived from ABS (2019c) as 5-year average ending in June 2018; [b]taken from Chomik et al. (2018); [c]targets derived from Australian Government (2018) as 5-year average ending in June 2018; [d]paid to those aged younger than 65 (include unemployment, disability and family benefits); [e]calibrated to approximate superannuation asset to GDP; [f]based on DSS (2016) demographic data for June 2016.

As discussed, we calibrate the pension means test to approximate the distribution of households aged 65 years and over (of age pension age) in relation to age pension payments, with the comparison based on DSS (2016) data (also provided in Table 3). As for the calibration targets of this distribution, we first use the ABS (2019b) population data and DSS (2016) demographic data for 2016 to derive the proportion of self-funded seniors.[34] We then derive the proportions of those on full and part pension, based on DSS data.

4 Quantitative analysis

In this section, we report on the long-run economic effects of alternative mandatory SG contribution rates. Specifically, we consider the following counterfactuals with alternative mandates via the SG rate set to $\tau^p = 0\%$, 3%, 12% or 15% of gross wages, with the results compared to the benchmark model with $SG = 7\%$. Hence, relative to benchmark model, we consider two counterfactuals with lower and higher SG rates. As already pointed out, the $SG = 12\%$ counterfactual has been legislated (with the increased rate applicable after 2024, whereas all the other counterfactuals are hypothetical (in the Australian context). The focus is on the legislated future 12% SG rate, with the other counterfactuals of (*i*) the $SG = 0\%$ environment, matching the key features of the Australian economy more than three decades ago before the SG legislation), and (*ii*) the $SG = 15\%$ counterfactual to demonstrate if higher SG rates would be preferable in the long run.

Under each policy counterfactual, the government budget is balanced by adjusting the (effective) consumption tax rate, with government consumption and government debt (and all the fiscal adjustment parameters or scalars) kept at their benchmark levels. As mentioned, in addition to the assumed budget balancing tax rate, the model accounts for general equilibrium effects via changing factor prices and for redistributions of bequests, which all generate feedback (or indirect) effects on household life cycle behavior. Below, we start with key life cycle implications (in our model capturing both direct and indirect behavioral effects of alternative contribution mandates) and then proceed to aggregate effects (of the examined changes in the SG rate).

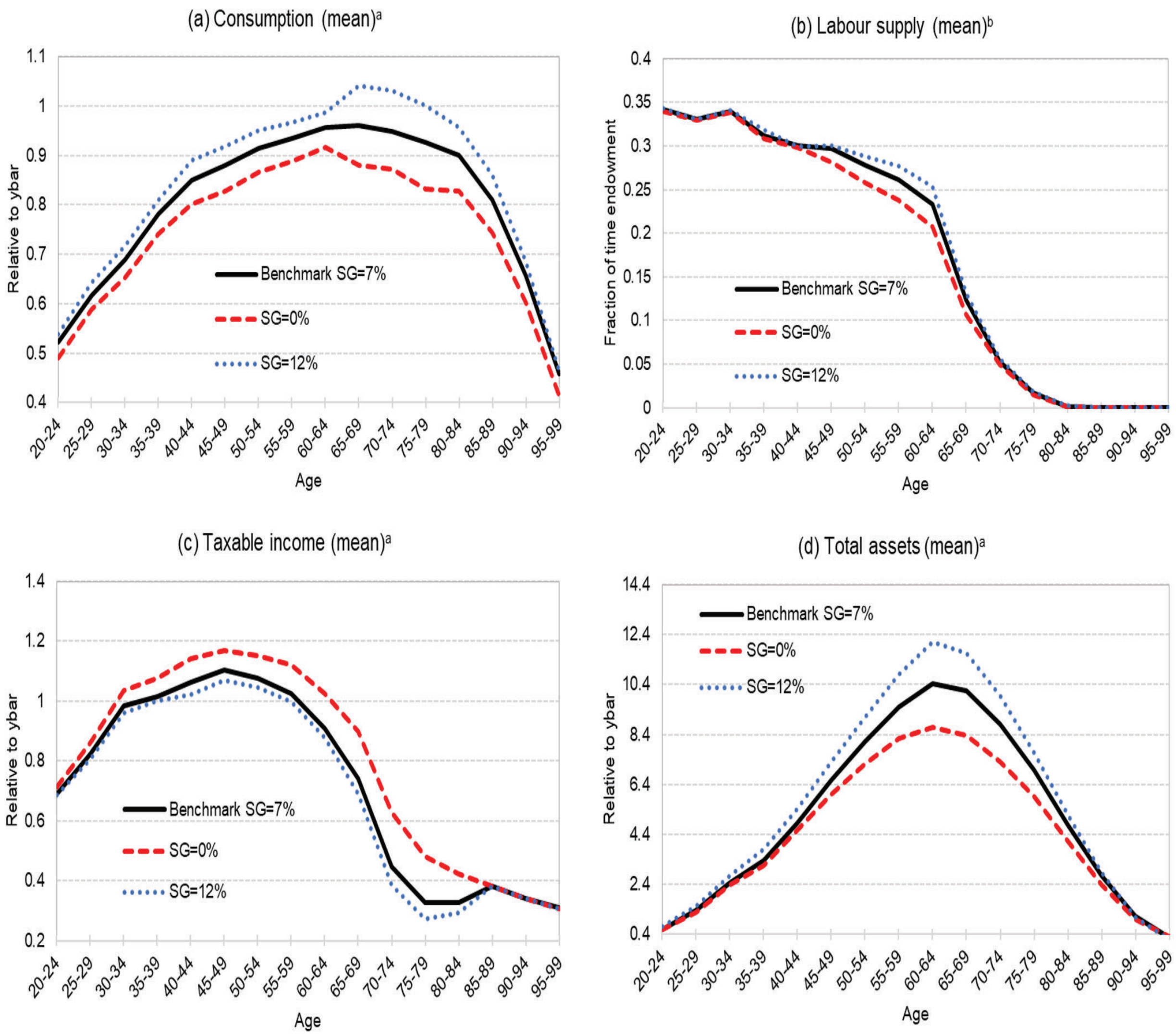
4.1 Behavioral life cycle effects

The life cycle implications of the SG rate alternatives (in this subsection demonstrated by setting the mandatory SG rate to 0% or the legislated future 12%) (on average, across the three skill types) are plotted in Figure 5 for: 5(a) household consumption (household expenditure net of the consumption tax), 5(b) labor supply (hours worked as a fraction of time endowment – $5,460$ hour per year or 105 hours per week), 5(c) the income tax base (i.e., taxable income defined in (11) of Section 2) and 5(d) total household assets (including both liquid assets and illiquid superannuation). All the variables are expressed as the mean values (by age group), with the monetary variables (e.g., net consumption expenditure) also expressed relative to the economy-wide average labor earnings ($\overline{y}$ ≈A$64,000 p.a.). Note that we used the benchmark

[34] This is about 30% of the age-eligible population, but we target 25% since not all age-eligible population would satisfy the minimum residency eligibility for the age pension.

value of $\overline{y}$ in Figures 5(a), 5(c) and 5(d), in order to compare across the SG rate alternatives.[35]

Figure 5: Behavioural life cycle effects of alternative SG rates in long run



Notes: [a]Relative to benchmark economy-wide average earnings (ybar=A$64,000 p.a.); [b]Fraction of annual time endowment (=5,460 hours).

First, we consider the future economy with the legislated 12% SG rate, with the main focus on the results depicted by the blue dotted lines. The results show increased life cycle consumption, particularly at older ages and significantly increased total assets over the life cycle, compared to the benchmark economy with 7% SG rate (black line). Labor supply (in Figure 5(b)) is also higher at mature and older ages, prior to the eligibility for the superannuation payouts. This is because of reduced distortions from the lower income tax base (see the blue dotted line in Figure 5(c)), that is subject to progressive income taxation.

[35]Note that (as we will discuss in the next subsection) there are significant macroeconomic impacts of the SG rate alterations in the long run, to some extent also altering the average earnings (with the results showing higher average earnings in the economy with the 12% SG rate).

In contrast, in the hypothetical economy with the 0% SG rate (with no superannuation mandate), households would consume less, and average household wealth would be significantly lower (while paying higher income taxes) over the entire life cycle and particularly at older age, as depicted in Figures 5(a) and 5(d) by the red dashed lines. To a large extent, this counterfactual economy resembles the Australian economy prior to the introduction of the SG legislation (in the 1980s, the average earnings and household wealth in real terms where significantly lower compared the current economy).

As pointed out above, these life cycle results are due to direct behavioral impacts of alternative SG mandates (with higher rates generating larger household wealth and consumption at older ages) as well as indirect effects from adjustments in factor prices, the bequest redistribution and the budget-equilibrating tax rate (which will be discussed below).

4.2 Macroeconomic, welfare and fiscal effects

In this subsection, we present the macroeconomic, fiscal and welfare implications of the four counterfactuals (with the SG rate reduced to 0% and 3%, and increased to 12% and 15% of gross wages). The macroeconomic implications are reported in Table 4 as percentage (long-run steady state) changes in selected variables under each counterfactual relative to the benchmark model with SG=7% of gross wages. The long-run welfare effects, also in Table 4, are presented as the % changes in the expected lifetime utility (given by (3) in the model section) relative to the benchmark model. The fiscal effects are reported in Table 5, with most fiscal variables expressed as a percentage of the benchmark GDP.[36] Table 5 also includes the distribution of the age-eligible population for public means tested age pension (in the model those aged 65+), showing the percentage of those on no, full and part age pension under the benchmark model and each SG rate counterfactual.

[36] Note that since the benchmark model closely matches the Australian economy (and its current GDP), the fiscal results presented as a % of benchmark (current) GDP could be easily converted into dollar amounts.

Table 4: Macroeconomic and welfare effects of alternative SG rates in long run*

Variable	Mandatory SG rate set to			
	0%	3%	12%	15%
Effective labor	-3.58	-1.82	0.60	1.16
Wage rate	-8.20	-4.40	4.90	8.20
Labor earnings[a]	-11.57	-6.20	5.37	9.30
Output (GDP)	-11.39	-6.16	5.49	9.53
Private consumption	-9.74	-5.04	3.72	6.21
Capital stock	-21.74	-12.18	13.13	23.06
Household wealth	-20.72	-11.62	12.15	21.60
Liquid private assets	46.15	24.58	-29.07	-40.81
Superannuation assets	-100.00	-54.52	61.01	95.56
Interest rate (p.p.)	1.05	0.55	-0.54	-0.89
Welfare effects[b]				
Average	-2.30	-1.09	0.75	1.21
Low skill	-1.87	-0.88	0.61	1.02
High skill	-2.57	-1.22	0.84	1.34

Notes: *% changes relative to benchmark (with SG=7%), if not stated otherwise; [a]Economy-wide average earnings (A$64,000 p.a. in benchmark), [b]% change in lifetime utility level relative to benchmark.

Table 5: Fiscal effects of alternative mandatory SG rates in long run*

Variable	Benchmark	Alternative mandatory SG rate set to			
	SG=7%	0%	3%	12%	15%
Total tax revenue	23.1	26.6	24.9	21.6	20.7
Total (personal) income	12.3	13.5	12.8	11.7	11.4
Progressive income	11.4	13.5	12.4	10.3	9.8
Superannuation	0.9	0.0	0.4	1.4	1.7
Company profits	4.6	5.1	4.9	4.3	4.0
Total consumption	6.2	8.0	7.2	5.7	5.2
Consumption tax rate[a] (p.p.)	10.5	2.8	1.5	-0.7	-1.4
Age pension expenditure	2.9	3.5	3.3	2.6	2.4
Distribution of those aged 65+ (%)[b]					
No age pension	23.8	15.6	19.0	28.0	29.5
Full age pension	44.4	47.5	49.2	40.3	40.4
Part age pension	31.8	37.0	31.9	31.8	30.1

Notes: *Expressed as a % of benchmark GDP, if not stated otherwise; [a]Consumption tax rate assumed to balance government budget, expressed in % under benchmark and as percentage point (p.p.) difference from benchmark under alternative SG rates; [b]% of those 65+ on no, full or part age pension.

Macroeconomic effects The qualitatively opposite macroeconomic effects are shown in Table 4 for the increased SG rates (e.g., to the legislated future 12%), compared to lower SG rates (such as the hypothetical removal of mandatory superannuation with $SG = 0\%$). First, there are opposite general equilibrium effects, with the increased SG rates leading to capital deepening (a higher capital-labor ratio) that causes the wage rate to increase and the interest rate to decline.[37] The former causes effective labor (labor supply in efficiency unit) to increase (generating higher (economy-wide) average labor earnings), while the reduced interest rate increases investment demand, which in turn leads to a larger capital stock. These two inputs to production generate higher output or real GDP under the examined higher SG rate counterfactuals.[38] Second, there are opposing effects on macroeconomic aggregates (as a result of the above). For example, in the economy with $SG = 12\%$, total household wealth increases by 12.2% (since increased superannuation assets more than offset reduced liquid ordinary private assets), real GDP increases by 5.5% and consumption increases by 3.7% in the long run, compared to the benchmark with $SG = 7\%$. In contrast, under the hypothetical $SG = 0\%$ counterfactual, household total wealth, consumption and labor earnings per capita would decline by 20.7%, 9.7% and 11.6% respectively, in the long run.

Fiscal effects As mentioned, under each counterfactual, government consumption and net debt are kept constant, while the government budget is balanced by adjusting the consumption tax rate. The fiscal effects presented in Table 5 as a percentage of the benchmark GDP show that higher (lower) SG rates reduce (increase) the size of the government budget in terms of total tax revenue, with all tax revenue sources (i.e., total (personal plus superannuation) income, corporation and consumption tax revenues) being lower (higher) under higher (lower) SG rates. Note that the consumption tax rate (which is assumed to balance the government budget) is adjusted down under higher SG rates, e.g., reduced by 0.7 percentage points to about 9.8% (from 10.5% in the benchmark). This is despite the increased tax expenditure (due to the increased mandatory SG rate of 12%) by about 0.6% of the benchmark GDP.[39] The budget

[37] Note that mandatory superannuation (and specifically the legislated increase in the mandatory SG rate) has been frequently criticized due to a reduction in take-home wages (or growth in take-home wages). In Table 4, we report the effects on the (gross) wage rate (normalized to one in the benchmark model), which increases under higher SG rate counterfactuals. One could report the effects on the wage rate net of the mandatory SG rate (i.e., relative to $w - \tau^p = 0.93$ in the benchmark model). Note that in a partial equilibrium model (i.e., small open economy framework with constant factor prices), any increase in the SG rate would be fully offset by a corresponding reduction in the net wage rate. In the present general equilibrium (closed economy) framework, we could show that this negative effect (of a higher SG rate) on the take home wage rate (i.e., the wage rate net of the SG rate but before income taxation) would be mitigated in the long run.

[38] The numerical results derived from this closed economy model with endogenous factor prices provide an upper (lower) bound for the effect of the increased SG rate on output (household wealth). In the sensitivity analysis section, we consider an alternative market structure - the small open economy framework with exogenous factor prices (and the capital and goods markets balanced by changes in foreign assets and next export). In that framework with constant factor prices, the effect of a higher SG rate on output (assets) should be at its lower (upper) bound. It should be noted that about 50% of superannuation assets are invested domestically (Willis Towers Watson 2021) and so the actual impacts of an increased SG rate on output, household wealth (and other variables) would be somewhere in the middle of the results derived from these two market structures – closed economy (in the section) and small open economy (outlined in the next section).

[39] We calculate the tax expenditure due to mandatory superannuation by using the total personal income tax revenue (including the superannuation tax revenue) under each counterfactual relative to that in the benchmark. For example, for the counterfactual $SG = 12\%$ the tax expenditure goes up by $12.3 - 11.7 = 0.6\%$ of benchmark GDP.

equilibrating tax adjustments are due to: (*i*) changes in the interest rate (directly impacting interest payments on government debt) and (*ii*) changes in the public pension expenditure.

As shown in Table 5, mandatory superannuation interacts with the public age pension because of the means testing. Higher (lower) mandatory SG rates generate larger (smaller) assets at older ages, which cause the pension expenditure to decline (increase) in the long run. For example, in the economy with no superannuation mandate, the public pension expenditure would increase by $\approx$ 22% to 3.54% of benchmark GDP, driven by the reduced proportion of self-funded seniors (receiving no age pension) at 15.6% of the age-eligible population (compared to 23.8% in the benchmark). In contrast, in an economy with the future 12% SG rate, the public pension expenditure declines by $\approx$ 12% to 2.58% of benchmark GDP, with the proportion of self-funded seniors up by 4.2 percentage points compared to the benchmark solution.

Welfare effects The welfare effects are reported in Table 4 on average (averaged across all skill types) and for low- and high-skill types. We simply calculate the value of the lifetime utility function in (3) under each counterfactual and express the welfare effects as a percentage change relative to the benchmark value.[40]

As indicated in the lower part of Table 4, increasing (reducing) the superannuation mandate improves (worsens) the average welfare in the long run, with larger welfare gains (losses) for high skill types, compared to low skill types. Specifically, eliminating mandatory superannuation (with $SG = 0\%$) would reduce the average welfare by 2.3% in the long run, with a welfare loss of 2.57% attained by high skill households (relative to the benchmark economy with $SG = 7\%$). Under the counterfactual economy with the increased future 12% SG rate, future born households will gain in welfare, on average by 0.75%, as well as across the skill distribution, with gains to low skill (high school dropouts) by 0.61% and to high skill (college graduates) by 0.84%. As shown in the last column of Table 4, increasing the SG rate to 15% of gross wages would further improve the long-run welfare, on average by 1.21%. In fact, the model generates a much higher optimal SG rate in the long run under the benchmark preferences as well as under alternative preferences (see Appendix B for more details).

However, optimal policy should not be judged on the long run effects only. In the case of our analysis, it needs to be pointed out that although higher mandatory SG rates benefit future born generations (in the long run), they are likely to generate short-run welfare losses for the current elderly households. These households (while not impacted directly by the increased mandate) would face indirect effects through lower interest rates (and therefore reduced returns on their asset holdings) and higher consumption taxes in the short run (financing increased tax expenditure due to higher (tax-favored) superannuation). Since (welfare losses of) these elderly households would need to be compensated, very high mandatory SG rates are less likely to be

[40] One could think of these percentage changes in the value functions as equivalent variations measuring the proportional percentage increase/decrease in consumption and leisure for each household needed in the benchmark model to produce the realized lifetime utility under each counterfactual. This would hold exactly for household preferences with $\gamma = 0.5$ and no bequest motive.

optimal over the transition path.

Summary In this section, we have examined long-run economy-wide effects of the superannuation mandate (under which working individuals have to contribute into their retirement accounts, thus funding their income at older ages). We have shown that the counterfactual economy without any mandate ($SG = 0\%$) would look much worse than with the current mandate ($SG = 7\%$ approximating average SG rate since the legislation introduction in 1992), e.g., households would be on average over 20% poorer in terms of net wealth. In contrast, our model with rational agents provides strong support for the superannuation mandate (and for the increased future $SG = 12\%$), showing that the Australian economy with this higher (future) mandate will see significantly higher average household wealth, labor supply, capital stock, output and consumption, as well as household welfare.

Next, we provide the sensitivity results to explain what drives these positive effects of the superannuation mandate (increased to 12% of gross wages).

5 Sensitivity analysis

This section provides the sensitivity analysis of the long-run results (reported above for the $SG = 12\%$ counterfactual) of several modifications of the model, in relation to both its economic features as well as the policy side of the model. The objective is to identify the key drivers of the positive effects of increasing the mandatory superannuation contribution rate to 12%.

We consider the following modifications of the model: (*i*) market structure (small open economy with constant factor prices, showing the importance of general equilibrium effects when comapred to the benchmark model); (*ii*) government budget balancing policy instrument (either government consumption (with no impact on household behavior) or income tax adjustments); (*iii*) bequest redistribution (bequest fully taxed, hence part of the government budget with no inheritances by households); (*iv*) progressivity of income tax schedule and superannuation tax concessions (to study the long-run effects under an economy with a 30% proportional tax cut, and then under an economy with no superannuation tax concessions); (*v*) age pension means test (removal of the link between superannuation (private pensions) and public age pension by switching to universal age pension, paid to all age-eligible households); (*vi*) superannuation payouts (lump sum payouts at age 65, rather than gradual withdrawals as in the previous section); (*vii*) earnings uncertainty (increased (doubled) variance of the stochastic component of the estimated labor productivity); and (*viii*) sum of (*i*) – (*v*). In Appendix B, we also discuss the sensitivity of the results for alternative SG mandates under alternative preferences (of rational agents), drawing on Conesa et al. (2009).

Note that only simulations (*i*) and (*ii*) use the same benchmark model as in the previous section. The other sensitivity checks require the benchmark model to be re-calibrated, but we only recalibrate productivity constant (to normalize the benchmark wage rate) and adjust government consumption (with the same tax schedule in the benchmark model used in the previous main section and given in Appendix A). Although the utility levels across these modified benchmarks are not exactly the same as in the benchmark model calibrated in Section 3, they are similar, and thus a comparison of the long-run effects of the increased SG rate to 12% (from 7%) under these model modifications can be made, relative to the results reported in Section 4.

Table 6 presents the long-run macroeconomic and welfare effects of the increased mandatory contribution rate to 12% under all these modifications. These effects can be compared to the main results discussed in Section 4 (here called and labelled in Table 6 as "baseline"). Below, we provide a brief discussion of the results for each model modification.

(i) Market structure In this modification of the model, we abstract from general equilibrium effects of the increased SG rate on factor prices derived from the closed economy model in Section 4. Instead, we assume a small open economy framework with an exogenous interest rate (and wage rate), with foreign assets and net export balancing the capital and goods markets. As indicated, under the SOE economy, the (gross) wage and interest rates remain constant (as in the benchmark model). Comparing the results in columns 2 and 1 of Table 6, households accumulate larger household wealth but lower consumption and labor supply relative to the baseline effects for the 12% SG rate (as in Section 4). As mentioned, the closed economy (CE) market structure provides the results for output (household wealth) at their upper (lower) bound. The opposite is the case for these macro effects under the SOE economy (where the interest rate would not decline in the counterfactual economy with the higher SG rate).

As for the welfare effects, under the SOE framework, with the average welfare increases by 0.51% (compared to 0.75% for the baseline effect under the CE framework). The difference is due to the increased (gross) wage rate under the CE framework with the 12% SG rate, which also generates a consumption tax cut. In contrast, under the SOE framework, the consumption tax rate would need to increase to balance the government budget (see in Table 6 the SOE column).

Table 6: Macroeconomic and welfare effects of the 12% SG rate under alternative model specifications in long run*

Variable	Baseline[a]	(i)	(ii)		(iii)	(iv)		(v)	(vi)	(vii)	(viii)
		(SOE)[i]	(G)[iia]	(fi)[iib]	(G+b)[iii]	(T(y))[iva]	(T^S)[ivb]	(Taper)[v]	(Payout)[vi]	(Risk)[vii]	(Sum)[viii]
Effective labour	0.60	-2.07	0.63	2.57	1.90	0.69	-0.83	1.11	0.88	2.29	-2.11
Wage rate	4.90	0.00	4.80	5.80	5.50	4.30	5.80	4.40	4.80	4.50	0.00
Output (GDP)	5.49	-2.04	5.51	8.54	7.47	5.10	4.99	5.64	5.68	7.01	-1.89
Private consumption	3.72	3.34	3.02	6.74	3.90	3.22	2.56	3.85	3.92	5.22	-2.43
Capital stock	13.13	-1.96	13.12	17.96	16.21	11.97	14.19	12.71	13.15	14.35	-1.57
Household wealth	12.15	29.69	12.23	17.02	15.27	11.19	13.01	12.32	12.26	15.01	31.64
Liquid private assets	-29.07	-4.29	-29.00	-21.60	-26.26	-26.70	-36.67	-25.21	-13.98	-21.23	-6.49
Superannuation assets	61.01	69.97	61.10	62.79	61.93	63.29	56.61	63.40	64.86	65.66	65.36
Interest rate (p.p.)	-0.54	0.00	-0.54	-0.64	-0.62	-0.47	-0.63	-0.49	-0.54	-0.51	0.00
Pension expenditure	-5.81	-10.32	-5.81	-7.10	-8.28	-5.59	-5.23	0.00	-2.58	-6.37	0.00
Cons. tax rate (p.p.)[b]	-0.73	0.51	0.00	0.00	0.00	-0.87	-2.23	-0.58	-0.78	-1.56	0.00
Welfare effects											
- Average	0.75	0.51	0.52	1.23	0.48	0.61	0.66	0.63	0.74	0.76	-1.94
- Low skill	0.61	0.52	0.39	0.92	0.28	0.56	0.66	0.52	0.63	0.64	-1.64
- High skill	0.84	0.54	0.61	1.54	0.66	0.66	0.67	0.68	0.80	0.85	-2.14

Notes: *% changes relative to benchmark equilibrium, if not stated otherwise; [a]Baseline results for the increased 12% SG rate in main Section 4; [i]Small open economy market structure abstracting from general equilibrium effects on factor prices; [iib]Government consumption balancing gov. budget; [iib]Income tax adjustment balancing gov.budget; [iii]Bequest fully taxed and iia; [iva]Scaling the tax schedule down by 30%; [ivb]Removal of all superannuation tax concessions; [v]Setting pension taper to zero (universal pension to all age-eligible households); [vi]Superannuation lump sum payout at age 65; [vii]Increased earnings uncertainty (doubling the variance of labor productivity); [viii]Modification with (i), (iia), (iii), (ivb) and (v); [b]Balancing gov.budget (except for (iia), (iib), (iii)).

(ii) Budget-equilibrating policy instrument In this subsection, we consider two alternative budget-balancing policy instruments: (*iia*) government consumption (with no impact on household behavior in our model) and (*iib*) income tax adjustment scaling the income tax schedule. As shown in column 3 and 4 of Table 6, the consumption tax rate is kept at the benchmark level (so the change in τ^c is zero).

First, focusing on (*iia*), the macroeconomic effects are very similar (to the baseline) but the welfare effects are smaller, with average welfare effects at 0.52% (compared to 0.75% for the baseline). Second, the results for (*iib*) show that the income tax adjustment (i.e., the income tax cut balancing the government budget) is to be preferred to the consumption tax cut under the baseline results in terms of both higher macroeconomic and welfare effects. In the long run, the choice for budget equilibrating tax policy is shown to impact the results of the higher superannuation rate quantitatively, but not qualitatively (same sign of the changes in columns 3 and 4 as for the baseline effects in column 1 of Table 6).

(iii) Bequest redistribution We now consider an economy that fully taxes bequests, which are no longer received by the households but are a revenue component of the government budget. We further assume that the government budget is balanced by adjusting government consumption, both in the benchmark and the counterfactual economy with the increased 12% SG rate (combining the change in bequest receipts with (*iia*) above). As seen, in the counterfactual economy with no redistribution of bequests (to younger cohorts), effective labor, household assets and output are larger than the baseline results, but the welfare gains (on average and by skill type) are smaller. The latter is due to relatively smaller consumption when households are young and middle aged.

(iv) Income tax schedule and superannuation tax concessions Under this modification, we consider income tax changes to: (*iva*) the progressive income tax schedule (modelling a 30% proportional tax cut by scaling the progressive income tax schedule by $0.3 \cdot f_i$) and (*ivb*) superannuation tax concessions (removing all tax concessions with $\tau^s = \tau^r = 0$, but both superannuation contributions and fund earnings included in the income tax base and fully taxable under $T(\tilde{y}_j)$). As mentioned above, in each case (as with all other modifications that will follow) we need to recalibrate the benchmark solutions (with 7% SG rate).[41]

In the economy with lower income taxes (under (*iva*)), the benefits of an increased SG rate in terms of welfare effects are lower, but still increase by 0.61% on average. As expected, high skill households experience a greater drop in their welfare gain (compared to the baseline result) under this tax policy modification of the model.

In the economy with no superannuation tax concessions (both mandatory contributions and fund earnings included in the income tax base) under (*ivb*), the welfare effects are similar to those in (*iva*), with the drop in welfare gains to high skill more significant. Note that Note that the

[41] Note that the utility levels are similar across all these benchmarks, allowing for a comparison across the policy modifications (in this subsection and those that follow).

difference in welfare effects is very low between low- and high-skill types in column 6 of Table 6. Since these superannuation contributions (and withdrawals) are mandated, the increased mandatory SG rate leads to higher total tax revenues which allow for a greater consumption tax cut (with positive impact on household welfare) in the long run.

As above, lowering income tax rates or removing superannuation tax concessions reduces the welfare gains from the increased SG rate, but only marginally.

(v) Age pension means test We now remove the means testing of the age pension by setting the taper rate (at which the pension benefits were withdrawn in Section 4) to zero. Under this modification, there are no longer three groups of the elderly population. Instead, all elderly are now paid a universal pension ($\overline{p}$) for ages $j \geq j_R$. Hence, this modification removes any interaction of mandatory superannuation with the public age pension (as is the case of social security pension systems in many other developed countries that are not means tested, with benefits independent of asset holdings).

As indicated in column 7 of Table 6, the pension expenditure does not change as a result of the increased SG rate. Although this modification removes the saving disincentive (due to the means test) with effective labor up (compared to the baseline effects), the welfare gains from increased SG rate are lower (on average up by 0.63%, compared to 0.75% for the baseline). We show that this is due to relative declines in net consumption of young and working households (and leisure at older age) in the economy with universal pensions, relative to the baseline results.

(vi) Superannuation payout In this subsection, we consider an alternative superannuation payout by assuming that all households withdraw their superannuation funds at age 65 $j = j_R$ as a lump sum. In column 8 of Table 6, welfare results show only a small decline in welfare relative to the baseline effects. On the one hand, under this modification, households pay higher taxes at older ages (as there is no tax-favored superannuation past j_R). On the other hand, since we assume that only a proportion of ordinary private assets are subject to the pension means test (while all superannuation assets are assessed), the increased SG rate generates a smaller decline in pension expenditure, with higher public pension payments. These effects seem to offset each other, with only marginal changes in welfare gains compared to the baseline results with gradual withdrawals of superannuation funds at older ages.[42]

(vii) Earnings uncertainty We also consider changes to earnings uncertainty by doubling the value for the variance for labor productivity (for each skill type). In this economy, the average wealth increases as households save more for precautionary reasons.[43] Interestingly, as

[42] It needs to be pointed out that in Section 4, we assume quite high withdrawal rates ζ_j (with the lump sum paid out at age 85 and no superannaution after that age). In Australia, there are required, with-age increasing minimum withdrawal rates that are lower than the ones we assumed. These minimum withdrawals could be studied as another policy modification. Or one could allow households to choose optimal drawdowns subject to these minimum withdrawal rates (which would be more complex to program).

[43] Increased earnings uncertainty reduces the size of the superannuation offset (i.e., decline in liquid assets).

a result of the increased superannuation mandate, the average household welfare also increases (but only very marginally), compared to the baseline effects. Note that in the economy with a greater earnings risk, the higher SG rate generates a smaller reduction in liquid assets (because of precautionary savings) and significantly higher labor supply. It should be pointed out that welfare effects under a different uncertainty are not as clear cut. We have also run a model modification halving the variance term (not shown), which also generated higher welfare gains compared to the baseline effects (in fact, higher than those reported in column 9 of Table 6).

(viii) Combined modification and summary Finally, we combine several alternative features of the model discussed above into (*viii*) the sum of (*i*), (*iia*), (*iii*), (*ivb*) and (*v*), with the long run results of the increased 12% rate depicted in the last column of Table 6. As shown, under this combined model modification, the increased SG rate counterfactual generates lower effective labor, output and consumption per capita, comparted to the baseline results. It also has negative effects on household long-run welfare (and that also holds for a CE framework).

In this section, we have examined long-run economy-wide effects of increasing the mandatory superannuation rate to 12% (from 7%) under several modifications of the model (described in Section 2 and calibrated in Section 3). We have shown that the baseline effects (discussed in Section 4) are due to: (*i*) general equilibrium effects through adjustments in factor prices (switched off under SOE alternative), (*ii*) the choice of budget-equilibrating policy adjustments, (*iii*) bequest redistributions but also to (*iv*) − (*v*) income tax and public pension features (such as income tax schedule, superannuation tax concessions and the means testing of public pensions) and (to a small extent in our model), (*vi*) superannuation withdrawals. Increased earnings risk (in (*vii*)) reduces the superannuation offset from the increased SG rate (due to a precautionary saving motive), with insignificant change in baseline welfare results. However, none of these model modifications (alone) alters the sign of welfare effects from the (legislated future) increased SG rate, with the "lowest" average welfare gains of 0.48% under the no bequest redistribution and of 0.51% under the SOE modification (compared to the 0.75% gain under the baseline results in Section 4).

Based on these sensitivity checks, one can also hypothesize about potential effects of private pension mandates under alternative tax and pension designs common in other developed countries such as the USA. As indicated in Fehr et al. (2021), the US income tax schedule features lower marginal tax rates (compared to Australia) and the US social security benefits are pay-as-you-go financed (with the 12.4% payroll tax), linked to former earnings and not means-tested (with public pension benefits higher than in Australia, particularly for higher skill types). These government policy features are likely to mitigate positive effects of the private pension mandates (obtained in this paper for Australia). We leave this extension to the US policy for future research.

6 Conclusions

This paper has examined the long-run economy-wide effects of the superannuation mandate – the mandatory contribution rate at which working individuals must contribute to their retirement accounts for the purpose of funding their retirement incomes. We have developed a stochastic OLG model with endogenous retirement, liquid ordinary private and illiquid private pension assets (that is calibrated to the Australian economy with a benchmark 7% contribution rate mandated under the Superannuation Guarantee (SG) legislation, averaged over the period from the legislation's introduction in 1992 to 2018) to quantify the behavioral life cycle, macroeconomic and welfare effects of alternative mandatory rates in the long run. We have shown that higher (lower) mandatory rates generate significantly larger (lower) average household wealth, output and consumption per capita and household welfare in the long run. More specifically, the key findings are that: (a) the future economy with the increased 12% SG rate (legislated to apply after 2024), output, private consumption, and total household assets are all significantly larger (e.g., average household net wealth increases by over 12% in the long run), compared to the current benchmark economy; while (b) in the hypothetical economy with no superannuation mandate, average household wealth and consumption per capita would reduce by over 20% and almost 10%, respectively. The legislated future 12% SG rate is shown to increase household assets and consumption, particularly at older ages, making more elderly fully self-funded (hence substitution away from the means tested public age pension). Importantly, in the economy with the 12% SG rate, the welfare of future generations would be significantly higher, both on average as well as across the skill distribution (with welfare gains by both low- and high-skill types of households).

In this paper, we have contributed to the so far very limited literature, studying the mandated superannuation (private pension) reforms in a general equilibrium OLG economy. The model developed here extends the Australian-calibrated models in Kudrna and Woodland (2013, 2018) and Kudrna et al. (2022), to incorporate the stochastic labor productivity, bequest motive and greater details of the government policy with respect to mandatory superannuation, means-tested public pensions and progressive income taxation. We have also provided the sensitivity analysis to explain key drivers of the positive macroeconomic and welfare effects derived from the increased superannuation mandate. We show that general equilibrium effects via changes to factor prices, the choice of budget-equilibrating policy instruments, marginal income tax rates and superannuation tax concessions, as well as the public pension means test and the type of superannuation payouts (collectively) drive these effects, but individually, each of these economic and policy features do not change the results qualitatively.

Any modelling analysis such as that employed here is subject to qualifications and limitations. First, in this paper we abstract from voluntary superannuation contributions (i.e., households do not have the choice to contribute more than the mandate (up to the cap) into their retirement accounts) and we also mandate superannuation withdrawals. Allowing for voluntary superannuation contributions (in a rational agent framework) is expected to reduce the positive effects derived from the increased mandate in this paper. Second, we have used an OLG model with rational agents only. An interesting exercise would be to study the economic effects of the increased mandatory contribution rate in an OLG model populated by agents that do not behave rationally and instead have self-control preferences (used, e.g., by Kumru and Thanopoulos (2011) for the US social security analysis). The expectation here is that in such a model (with some or all myopic households), the welfare effects of the superannuation mandate will further improve (with the mandate correcting for myopic behavior). Third, we abstract from the effects of private pensions on tenure choice and housing assets. One would expect that higher mandatory superannuation contribution rates would reduce homeownership (as they would lower disposable income to fund the housing deposit or down payment). However, Fehr et al. (2021), using a German-calibrated OLG model with tenure choice (but inelastic labor and exogenous retirement) find only a marginal impact of the introduction of mandated private pensions on the average homeownership ratio. We leave these extensions of the present analysis to future research.

7 References

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8 Appendix

In this appendix, we provide more details about Australia's tax and public pension systems and additional results for the sensitivity analysis.

A. Australia's tax and pension system

Australia's tax and transfer system In Australia, the government collects by far the most revenue from taxing household income, derived from earnings (and public pensions) but also capital income. Most government transfers, however, are means-tested, targeted to those in need. The tax and transfer system is highly progressive, which is not just because of the income tax schedule (given below) but also the progressivity of government transfer payments. Corporate taxation is high compared to other developed countries (with a statutory rate of 30% for large companies). Indirect consumption taxes are low compared to many European countries (with the effective consumption tax rate of about 10% (including all indirect taxes) and only about 7% effective GST rate in Australia). In the model, we therefore assume the consumption tax instrument to balance the government budget.

Below, we provide more details about the progressive income tax schedule in Australia. The Australian progressive personal income tax schedule with the tax base $\widetilde{y}$ (which includes labor earnings (net of mandatory superannuation contributions), capital income and public pension) can be expressed (with all tax amounts and income thresholds in A\$ for 2017-18) as:

$$T18(\widetilde{y}) = \begin{cases} 0 & \text{if} \quad \widetilde{y} \leq \$18,200 \\ 0.19\,(\widetilde{y} - \$18,200) & \text{if} \quad \$18,200 < \widetilde{y} \leq \$37,000 \\ \$3,572 + 0.325\,(\widetilde{y} - \$37,000) & \text{if} \quad \$37,000 < \widetilde{y} \leq \$90,000 \\ \$20,797 + 0.37\,(\widetilde{y} - \$90,000) & \text{if} \quad \$90,000 < \widetilde{y} \leq \$180,000 \\ \$54,097 + 0.45\,(\widetilde{y} - \$180,000) & \text{if} \quad \widetilde{y} > \$180,000 \end{cases}.$$

In the model, we index the income thresholds to the annual average earnings of about \$64,000 in 2018 (ABS 2019f), with the income tax schedule expressed as follows[44]:

$$T18(\widetilde{y}) = \begin{cases} 0 & \text{if} \quad \widetilde{y} \leq 0.28\overline{y} \\ 0.19\,(\widetilde{y} - 0.28\overline{y}) & \text{if} \quad 0.28\overline{y} < \widetilde{y} \leq 0.58\overline{y} \\ 0.056\overline{y} + 0.325\,(\widetilde{y} - 0.58\overline{y}) & \text{if} \quad 0.58\overline{y} < \widetilde{y} \leq 1.4\overline{y} \\ 0.325\overline{y} + 0.37\,(\widetilde{y} - 1.4\overline{y}) & \text{if} \quad 1.4\overline{y} < \widetilde{y} \leq 2.8\overline{y} \\ 0.845\overline{y} + 0.45\,(\widetilde{y} - 2.8\overline{y}) & \text{if} \quad \widetilde{y} > 2.8\overline{y} \end{cases}.$$

Although Australia collects higher revenue from income taxes than e.g. the US or Germany (as shown in Fehr et al. 2021), there is no payroll tax collected to finance public pensions in Australia. Therefore, overall taxation of labor is lower in Australia than in many other

[44] Note that we adjust the tax schedule to incorporate the Medicare levy of 2% to any non-zero marginal tax rate. For example, the top marginal tax rate becomes 47%.

developed countries. For example, in Germany, the overall marginal tax rates on labor (under progressive personal income taxation) would need to also feature the payroll tax financing PAYG pensions. In that case, its top marginal tax rate is well over 50%.

Australia's public pension Whereas most developed countries rely on their PAYG social insurance systems that provide the elderly with defined benefit pensions financed by payroll taxes on workers, in Australia the public age pension is non-contributory and means-tested with a modest maximum pension benefit. As indicated in Kudrna et al (2022), the age pension has the following distinct features: (*i*) pension benefits are dependent on economic status (assets and/or income) and targeted to the age-eligible population with limited private financial resources/means; (*ii*) pension coverage is not universal in that some affluent retirees are covered by this public pension system; (*iii*) pension benefits are independent of individuals' contribution/working history; and (*iv*) the tax financing instrument is not restricted to the payroll tax revenue collected from the current working population. Note that the pension benefit is affluence-tested with about 75% eligible for some payment, and with 45% (of the age-eligible population) receiving the maximum benefit (that is modest at about 30% of average earnings).

As for the means test, there are two tests – an income and an asset test, with the test resulting in a lower pension benefit applied (i.e., binding test). Each test involves (*i*) the maximum benefit (that depends on household unit and homeownership status); (*ii*) the (income and asset) disregard (up to which the maximum benefit is paid); and (*iii*) the (income and asset) taper (at which the pension benefit is reduced if the private resource (income and asset) exceeds the disregard. The actual interactions between the income and asset tests are complex (e.g., implying non-linear taper by assessable income and assets). In the model, we approximate these complex interactions by employing the calibrated income test (capturing mainly the retirement assets/incomes and only partly earnings at older age). As shown in Section 3, our benchmark model closely matches the observed distribution of the age-eligible population for the age pension and the total pension expenditure (at $< 3\%$ of GDP, which us low compared to other developed countries (see OECD 2019)).

Australia's superannuation In Australia, the second pension pillar is based on a (publicly stipulated but private) defined contribution system known as mandatory superannuation. It is an employment-related pension system represented by mandatory, privately-managed retirement saving accounts, which are based on defined contributions and regulated by the government under the legislation known as the Superannuation Guarantee (SG). Australia has over 30 years of experience with mandating private retirement savings. The legislation was initially introduced in 1992 with the 3% SG contribution rate. The SG rate is currently at 10%, increasing to the legislated 12% rate in the financial year of 2025-26 and beyond. Table A.1 reports the SG rates since 1992. This implies that the superannuation system is still in a transition. In the model, we calibrate the mandatory SG contribution rate to approximate the current size of the superannuation system (the benchmark SG rate is 7% approximating the average SG rate in the period of 1992-2017).

Table A.1: Mandatory SG rate (% of gross wages)

Year/Period	Small employers	Large employers
1992	3	4
1993	3	5
1994	4	5
1995	5	6
1996-97	6	6
1998-99	7	7
2000-01	8	8
2002-13	9	9
2014	9.25	9.25
2015-21	9.5	9.5
2022	10	10
2023	10.5	10.5
2024	11	11
2025	11.5	11.5
2026+	12	12

Source: Australian Taxation Office (ATO)

Note that Australia's third pension pillar includes voluntary superannuation that receives smaller tax concessions and is also illiquid until reaching the preservation age. In fact, Australians often have only one superannuation account which collects all (mandatory and voluntary) contributions. In the model, we abstract from modeling voluntary contributions (of the household choice) since (on average) these are insignificant (only relevant for higher skill types at mature ages), with the mandate (minimum contributions) as the main driving force behind significant increases in superannuation assets in Australia (in the past and projected over the next 40 years).

Importantly, superannuation assets are subject to the public age pension means test, with higher private retirement assets reducing dependence on the public age pension and public pension expenditure. It also interacts with the progressive personal income taxation. The superannuation taxes on contributions and fund earnings are highly concessional – basically flat rates at 15% on contributions and (effective) 7% on fund earnings (compared to the top marginal tax rate of 47%, including the Medicare levy). This concessional tax treatment generates the so-called superannuation tax expenditure – the income tax revenue forgone from taxing superannuation income at lower rates (see Chomik and Piggott (2018) for details on calculating such tax expenditures). Our model simulations show that this expenditure increases with the increased SG rate. However, our comprehensive framework (capturing behavioral, budgetary, and general equilibrium effects) shows that higher SG rates may, in fact, allow for a consumption tax cut (assumed to balance the government budget). This is because of increased labor supply and earnings and reduced age pension expenditure in the long run as a result of the increased superannuation mandate.

How does Australia's superannuation scheme compare to private pension systems in other developed countries? For example, in the US, its private pension system is well developed, based on individual retirement accounts (IRAs) with main (employment-related) 401k plans that are also tax-favored. Although the US government does not mandate contributions (to these accounts), many employment schemes are using behavioral economics and finance features to replicate the mandate, such as auto-enrollments and contribution rate escalations (e.g., see Beshears et al. 2009). In our model with rational agents, we provide strong support for mandating retirement savings, but the positive effects would be mitigated under public policy settings with less progressive income taxation and public pensions (independent of private retirement resources, including private pensions).

B. Additional results for sensitivity analysis

This appendix provides additional sensitivity checks of the long-run results to alternative household preferences. As for the alternative parameterization and specification of household preferences, we follow Conesa et al. (2009) by removing the bequest motive and assuming (*i*) non-separable preferences (in consumption and leisure), and (*ii*) separable preferences. Under each modification, we fully re-calibrate the model for the new initial steady state to match all the targets of the benchmark model described in Section 3. Note that this is different to the sensitivity checks in Section 5 where we have not re-calibrated the new benchmarks fully (i.e., the discount factor was unchanged while here in the model without the bequest motive and with alternative preferences, it is re-calibrated to match the benchmark K/Y). Below, we first provide the notation for these alternative preferences and then discuss the long-run results.

Following Conesa et al. (2009), we assume that households have preferences over streams of consumption c_j and leisure l_j, where the expected discounted lifetime utility function is given by

$$E\left[\sum_{j=1}^{J}\beta^{j-1}\left(\prod_{o=1}^{j}\psi_{o,i}\right)u(c_j,l_j)\right],$$

where the annual utility is either $u(i)$ non-separable of Cobb-Douglas functional form

$$u(c,l)=\frac{\left(c^{\nu}l^{1-\nu}\right)^{1-\sigma}}{1-\sigma},$$

or $u(ii)$ separable in consumption and leisure and given by

$$u(c,l)=\frac{c^{1-\sigma_1}}{1-\sigma_1}+\chi\frac{l^{1-\sigma_2}}{1-\sigma_2}.$$

As in Conesa et al. (2009), in the former case $u(i)$, σ is set to 4 and ν to 0.37 (that is now the same for each skill type, targeting average hours), both determining the coefficient of relative risk aversion in consumption as $\sigma\nu + 1- \nu$; and in the latter case $u(ii)$, we set $\sigma_1 = 2$, $\sigma_2 = 3$ and $\chi = 2.5$ (to match average hours). Under each modification, the subjective discount factor, β, is recalibrated to match the benchmark K/Y. Note that under these alternative preferences, we also abstract from the consumption equivalence parameter (denoted μ in (3) of the model section).

As indicated in each case above, we fully re-calibrate the initial steady state solution and then study the effects of the increased future 12% SG rate in these alternative preference frameworks. We also provide the long-run effects of a higher SG rate at which the average household long run welfare peaks, as shown in Table B.1. For comparison, in Table B.1, we also include the baseline results (discussed in the main quantitative section of the paper). Note that since household preferences differ across the three initial steady states, the welfare effects can only be compared within each model.

Table B.1: Long run effects of higher SG rates under alternative utility assumptions*

Variable	Increased 12% SG rate			Optimal long run SG rate[a]		
	Baseline	u(i)	u(ii)	Baseline	u(i)	u(ii)
Effective labour	0.60	0.84	-0.07	2.20	2.33	-1.24
Wage rate	4.90	5.30	4.80	26.80	19.40	21.10
Output (GDP)	5.49	6.23	4.78	29.68	22.26	19.77
Private consumption	3.72	3.92	2.73	13.89	10.98	6.64
Capital stock	13.13	15.21	12.85	84.02	61.40	61.97
Household wealth	12.15	14.79	11.52	79.25	58.63	57.85
Liquid private assets	-29.07	-20.79	-25.58	-68.82	-54.73	-64.97
Superannuation assets	61.01	61.79	62.15	254.77	208.39	225.48
Interest rate (p.p.)	-0.54	-0.60	-0.54	-2.47	-1.91	-2.04
Pension expenditure	-5.81	-5.88	-1.37	-4.52	-7.19	1.37
Cons. tax rate (p.p.)[b]	-0.73	-1.05	-0.20	-3.04	-2.41	-0.17
Welfare effects						
- Average	0.75	2.23	0.95	2.40	5.78	2.28
- Low skill	0.61	2.08	0.97	2.16	5.70	2.46
- High skill	0.84	2.31	0.95	2.57	5.79	2.16

Notes: *% changes relative to benchmark equilibrium under each model, with baseline results as in Section 4 and u(i) and u(ii) denoting the effects under two alternative household preferences; [a]Here we calculate the optimal SG rate under which average welfare peaks in long run - 30% for baseline model, 25% for u(i) and 27% for u(ii); [b]Balancing the government budget.

A key finding observed from Table B.1 is that qualitatively, the effects of the increased SG rate are the same across the three models with alternative preferences (except for the effects on effective labor, which under $u(ii)$ declines). The optimal long run SG rate is high, ranging from

25% to 30%. However, as discussed, allowing for the transition path is expected to generate short-run welfare losses to the current elderly, not directly impacted by higher mandates (as they no longer accumulate superannuation) but expected to face increased consumption taxes (due to a higher superannuation tax expenditure) and lower rates of return on their assets. Since these households would need to be compensated, very high SG rates (optimal in the long run) are unlikely to be optimal over the transition path. We leave this transition path analysis to future research.