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Facing Demographic Challenges:
Pension Cuts or Tax Hikes

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Abstract

In this paper, we investigate two fiscal policy options to mitigate fiscal pressure arising from ageing of the Australian population: pension cuts or tax hikes. Using a computable overlapping generations model, we find that while both policy options achieve the same fiscal goal, the macroeconomic and welfare outcomes differ significantly. Future generations prefer pension cuts, whereas current generations prefer tax hikes to finance government spending commitments. Interestingly, taxing consumption or income results in opposing macroeconomic and welfare effects. Increases in the consumption tax rate have positive effects on labour supply, domestic assets and output (similar to pension cuts), but reduce the welfare of low income households most. Conversely, increases in progressive income or payroll taxes have negative effects on the economy but reduce the welfare of low income households least. Our results highlight the intra- and inter-generational conflicts of interest and political constraints when implementing any structural fiscal reforms.

Keywords: demographic transition, fiscal policy, welfare, overlapping generations.

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1 Introduction

Developed countries around the world are experiencing ageing of their populations arising from changes in fertility and mortality. In Australia, population ageing will accelerate in the next few decades, driven partly by falling fertility rates in the past and partly by projected mortality improvements in the future. Although almost all developed countries need to deal with similar fiscal issues associated with ageing demographics, the problems facing Australia are quite different. The Australian population will increase significantly in size due mainly to high net migration inflows. Ageing while growing fast due to migration is a distinct feature of the demographic trend in Australia over the next 50 years.

Such changes in the age structure and size of Australia's population will place increasing demands on the government in terms of financing old-age related spending on health, aged care and pensions. Fiscal reform will inevitably form part of the overall policy response to demographic change, but formulating an optimal policy response requires a rigorous economic analysis of how much adjustment is needed and what will be the consequences. Increased knowledge of the impacts of different fiscal reforms designed in response to population ageing in Australia will not only be of benefit in informing Australian fiscal policy but will also give an insight into fiscal policy analyses of other ageing economies. The main purpose of this paper is to quantify the macroeconomic and distributional welfare effects of two fiscal adjustments to mitigate fiscal pressure arising from population ageing in Australia - pension cuts and tax hikes.

To that end, we construct a small open economy version of computable, overlapping generations (OLG) models based on Auerbach and Kotlikoff (1987) with non-stationary demographic structures. This class of models has been used by many researchers worldwide to analyse the economic effects of population ageing (see, for example, Fehr (2000), Nishiyama (2004), Kotlikoff *et al.* (2007) and Fehr *et al.*, 2008). Specifically, our model consists of overlapping households and the production, government and foreign sectors. Since rising fiscal costs are due not only to pensions but also to other age-related spending, our model embodies a rich fiscal structure with public expenditures on health care, aged care, the means tested age pension as well as on education and family benefits. In addition, we use a demographic model to account for future developments in the age structure and size of Australia's population.

We discipline our benchmark economy to match key Australian macroeconomic aggregates

and demographic structure in 2012 and to approximate the lifecycle behavior of Australian households, including labour supply, labour earnings and pension payments. The model is then applied to conduct policy experiments.

First, using the demographic projections derived from our demographic model, we quantify the fiscal costs of demographic transition. Note that we maintain our assumptions about the policy environment to focus on endogenous responses of households, firms and the government to the exogenously-presumed changes in the demographic structure of the population. Our simulation results indicate that demographic shift in Australia with increasing (decreasing) population shares of the elderly (working cohorts) has significant implications for the future government budget position through changes in both taxation revenues and expenditures. Similarly to Kudrna *et al.* (2013), we find (*i*) significant changes in the tax base with a shift from labour income to assets income and consumption and (*ii*) substantial increases in age-related spending on health care, aged care and the age pension, with a resulting fiscal gap of over 2.5 percentage points of GDP in 2050, increasing to over 4.5 percentage points of GDP by 2100.

Next, we examine the macroeconomic and welfare effects of the following two fiscal reform options to respond to demographic shift: (*i*) a cut to government spending by reducing pension benefits and (*ii*) an increase in taxation revenues through adjusting either consumption or progressive income or payroll taxes. We find that while the two fiscal reform options achieve the same goal of reducing the fiscal burden of population ageing, their macroeconomic and welfare outcomes differ greatly. In terms of the welfare effects, we find that young and future generations prefer pension cuts, but currently older and middle-age generations prefer to finance the fiscal burden though tax hikes. Furthermore, higher income households would prefer pension cuts as the age pension is not an important source of retirement income for them, whereas lower income types would prefer tax hikes with increases in progressive income tax rates. Interestingly, the indirect and regressive consumption tax hikes have opposing effects on macroeconomic aggregates and welfare across skill types to those obtained from the income tax hikes. We show that the required increases in the consumption tax rate result in positive effects on per capita labour supply, assets and output, but reduce the welfare of low income households most. Conversely, the increases in progressive income or payroll taxes result in negative effects on output but reduce the welfare of poor households least.

Finally, we analyse the consequences of a mix of pension cuts and tax hikes. Given that the examined pension cuts alone only partially reduce the fiscal pressure, we allow either the consumption or payroll tax rates to adjust to close the fiscal gap. The results for these two experiments indicate that each tax rate initially declines due to pension cuts, but this is shown to reverse after 2030, with the payroll tax in particular rising significantly to fund the increases in age-related spending. Similarly to the effects of tax hikes alone, pension cuts combined with adjustments in consumption (payroll) taxes have positive (negative) long run effects on the economy. Furthermore, welfare losses to future generations from increased payroll taxes are more than double of those resulting from consumption tax adjustments. The comparison of these two experiments indicates that the mix of pension cuts and labor income tax hike has some advantages by 2030. However, the mix of pension cuts and consumption tax hikes is a dominant policy option beyond 2030.

Related literature. Our paper is related to a growing literature that calculates the fiscal costs of population ageing and examines the implications of fiscal reforms to mitigate these costs. Attanasio *et al.* (2006) build a multi-regional world model focusing on the effects of demographic trends across regions. Imrohoroglu and Kitao (2009) study the effects of social security reforms in the U.S. Diaz-Gimenez and Diaz-Saavedra (2009) simulate a reform to raise the retirement age, using a model calibrated to the Spanish economy. Hansen and Imrohoroglu (2013), using a standard representative agent growth model, calculate the size of the Japanese fiscal burden, which they define as additional taxes required to maintain the promised levels of per capita public pensions and health services. Imrohoroglu *et al.* (2013) build a model based on micro-data to estimate the fiscal costs of population ageing in Japan. Kitao (2014) uses a computable OLG model to examine the effects of four pension reform options to achieve a fiscal balance for the U.S. social security system. We follow a similar approach, but build a dynamic, general equilibrium OLG model with a detailed description of fiscal policy to estimate fiscal costs of population ageing in Australia. We also consider a broader plan for fiscal reforms, allowing the government to adjust not only pension benefits but also taxes to finance the fiscal deficit caused by population ageing. By comparing the implications of these two fiscal reform options, we highlight that they result in different macroeconomic and welfare outcomes.

Braun and Joines (2014) and Kitao (2015) use a similar approach to analyse the fiscal cost

of population ageing in Japan, while Nishiyama (2013) similarly analyzes ageing in the U.S. It is important to notice that the population ageing problems facing Australia are quite different from Japan and other advanced economies. That is, net migration inflows to Australia are relatively high, so that the size of the Australian population will double while ageing is accelerated. In contrast, Japan's population is declining. Moreover, Australia's fiscal setting is different, with its means-tested age pension and limited payroll taxes. Understanding the consequences of population ageing in that special Australian context will have important implications for policy analyses of other ageing economies that plan reliance on their migration policies to mitigate the fiscal costs of ageing.

We also contribute directly to the literature on the economic and fiscal implications of population ageing in Australia. The Australian Government (2010, 2015) and Productivity Commission (2013) also quantify the fiscal challenges caused by demographic shift. However, neither of these reports in their projections take direct account of behavioural responses to population ageing, which are an important component of our methodology. In addition, the 2015 Intergenerational Report (Australian Government, 2015), which includes the effects of the proposed policy changes on the government budget, provides little guidance on who bears the costs of these policy changes. The analyses of population ageing by Guest and McDonald (2001, 2002) and Guest (2006) uses a Ramsey model of optimal savings with no inter-generational heterogeneity among households. Kulish *et al.* (2010) apply an OLG model to study the macroeconomic effects of changes in fertility and longevity, but they do not analyse the fiscal effects of demographic change. While fiscal effects are analysed by Kudrna *et al.* (2013), they abstract from the policy reforms required to finance the budgetary costs arising from population ageing, which are the focus of our paper.

The paper is structured as follows. In Section 2 we set up a dynamic, general equilibrium model. Section 3 provides details on the calibration of our model to the Australian economy, while Section 4 contains the discussion on the effects of demographic transition. In Section 5, we examine a range of policy experiments to mitigate the fiscal costs of population ageing, with the results presented in terms of macroeconomic and welfare implications. Section 6 offers some conclusions and the Appendix describes the computational method.

2 Model

In this section, we formulate a small open economy OLG model. It is a general equilibrium model that comprises overlapping generations of heterogeneous households, a perfectly competitive representative firm, and a government sector with essentials of the Australian tax and pension policy settings.

2.1 Demographics

The model economy is populated by overlapping generations of households. In every time period t, there are 101 generations aged 0 to 100 years ($j = 0, .., J = 100$). We assume that only adult households aged 21 years and over make economic decisions. Denoting $N_{j,t}$ as the size of a cohort of age j in time t, the total population is a sum of all cohorts alive in period t as $P_t = \sum_{j=0}^{J} N_{j,t}$. The cohort share of the entire population at any point in time t is given by $\phi_{j,t} = \frac{N_{j,t}}{P_t}$. The population dynamics depend on the evolution of age-specific fertility, mortality and net immigration rates. The assumptions for these vital rates and the constructed demographic scenarios are discussed in detail in the next section on calibration.

2.2 Endowments

Agents are born with a specific skill (or income) type that determines their labor productivity over the lifecycle. Let i denote an individual's skill type and let there be I types of skill. The skill type is predetermined and unchanged over the life span. Let μ^i be a measure of each skill type.

In each period of life, agents are endowed with 1 unit of time that has labor efficiency (or working ability) denoted by e_j^i. Note that the efficiency unit e_j^i is skill- and age-dependent but time-invariant. According to this specification, agents have working abilities that change over their lifecycle. The quantity of agent's effective labor is $h_{j,t}^i = \left(1 - l_{j.t}^i\right) e_j^i$, where $l_{j.t}^i$ is leisure and $\left(1 - l_{j,t}^i\right)$ is labor supply of i type household at age j in time period t.

The skill (income) types of households also differ by pre-determined family benefits, $fb_{j,t}^i$, which are higher for lower income types of households compared to higher income types.

2.3 Preferences

All agents have identical lifetime preferences over consumption, $c_{j,t}^i \geq 0$, and leisure, $l_{j,t}^i$, where leisure time is constrained by $0 \leq l_{j,t}^i \leq 1$. Preferences are given by the expected inter-temporal utility function, which for generation j of skill type i who begins economic life at date t is expressed as

$$E\left[\sum_{j=21}^{J} \beta^{(j-21)} S_{j,s} \frac{u\left(c_{j,s}^i, l_{j,s}^i\right)^{1-1/\gamma}}{1-1/\gamma}\right], \tag{1}$$

where the subscript s is defined as $s = j+t-21$, γ is the inter-temporal elasticity of substitution, β is a constant discount factor and the term $S_{j,s}$ denotes unconditional age-dependent survival rates.

2.4 Technology

The production sector consists of a large number of perfectly competitive firms, which is formally equivalent to one aggregate representative producer that maximizes profits. The production technology of this firm is given by a constant returns to scale production function

$$Y_t = A \cdot F\left(K_t, L_t\right), \tag{2}$$

where K_t is the input of capital, L_t is the input of effective labor services (human capital) and A is the total factor productivity, which we assume to be constant. Capital formation is subject to the adjustment costs (see the next section for details).

2.5 Government

Mandatory retirement savings. The Australian pre-funded private pension scheme, which is stipulated by the government, is called the Superannuation Guarantee. It mandates employers to make contributions into employees' superannuation accounts. Accordingly, the representative producer in our model is required to pay these contributions for working households at the after-tax contribution rate, $(1-\tau^s)\,cr$, from their gross labour income, $w_t e_j^i(1 - l_{j,t}^i)$, into the superannuation fund. The contributions are added to superannuation assets, $sa_{j,t}^i$, which earn investment income at the after-tax interest rate, $(1-\tau^r)\,r_t$. The superannuation assets

accumulation during $j \leq J_{sa}$ can be expressed as

$$sa_{j,t}^i = [1 + (1 - \tau) r_t] sa_{j-1,t-1}^i + [(1 - \tau^s) cr] w_t e_j^i (1 - l_{j,t}^i),\qquad(3)$$

where τ^r is the earnings tax rate, τ^s denotes the contribution tax rate, cr is the mandatory contribution rate, r_t is the domestic interest rate and w_t is the market wage rate. The stock of superannuation assets accumulates in the fund until age J_{sa}, when the accumulation ceases and households receive lump-sum payouts, expressed as

$$sa_{j=J_{sa},t}^i = \sum_{j=21}^{J_{sa}} \left(\prod_{s=21}^{j} [1 + (1 - \tau^r)r_{t-s}] \right) [(1 - \tau^s) cr] w_t e_j^i \left(1 - l_{j,t}^i \right).$$

We further assume that working households aged $j > J_{sa}$ are paid mandatory contributions directly into their private assets account, denoted by $sp_{j>J_{sa},t}^i$ in household's budget constraint.

Means-tested public pension. The Australian public pension system consists of some distinct features: (i) the age pension is means-tested and so not every retiree receives it; (ii) the age pension payments form part of the government budget expenditure, so that there is no social security tax to collect revenue from the current working population. That is, the age pension is non-contributory, funded through general tax revenues and means tested.

The government pays the age pension to households from age J_{ap}, with the amount of pension benefits being subjected to the income test. Let $ap_{j,t}^i$ denote the age pension benefit, which is defined by

$$ap_{j,t}^i = \max \left\{ \min \left\{ P^{\max}, P^{\max} - \theta \left(\widehat{y}_{j,t}^i - IT \right) \right\}, 0 \right\}, \text{ with } j \geq J_{ap},\qquad(4)$$

where $P^{\max}$ is the legislated maximum pension paid to pensioners with the assessable income, $\widehat{y}_{j,t}^i$, not greater than the income free threshold, IT. For pensioners with $\widehat{y}_{j,t}^i > IT$, the pension paid is reduced at the income taper rate, θ, for every dollar of the assessable income above the threshold, becoming zero for those with $\widehat{y}_{j,t}^i \geq IT + P^{\max}/\theta$. The assessable income includes interest income and half of labour earnings. Note that the means-tested age pension is a component of social transfer payments (TR_t), included in the overall government budget that we describe next.

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Fiscal policy. The government collects consumption and income (progressive income, superannuation and payroll) taxes from individuals and corporate taxes from firms, Tax_t, in order to finance government final consumption expenditures, G_t, interest and principal payments on its debt, $(1 + r_t) D_t$, and government transfer payments to households TR_t.[1] The government also issues new debt, D_{t+1}, to finance fiscal deficits. The government budget constraint is given by

$$D_{t+1} + Tax_t = G_t + (1 + r_t) D_t + TR_t. \tag{5}$$

2.6 Foreign sector

We employ a small open economy specification as this description fits best the Australian economy. Hence, the domestic interest rate is exogenous and equal to the world interest rate, $r_t = r$. When domestic savings fall short of the value of domestic capital, foreign capital will be employed, which adds to foreign debt. Denoting the net foreign debt as FD_t at the beginning of period t, the international budget constraint can be expressed as

$$FD_{t+1} - FD_t = TB_t - rFD_t, \tag{6}$$

where the left-hand side of (6) represents capital flows and the right-hand side gives the current account comprising the trade balance, TB_t, and the interest payments on net foreign debt, rFD_t.

2.7 Household's problem

The household's problem is to choose a sequence of consumption and leisure quantities to maximize the expected lifetime utility given by

$$\max_{c^i_{j,t}, l^i_{j,t}} E \left[\sum_{j=21}^{J} \beta^{(j-21)} S_{j,t} \frac{u\left(c^i_{j,t}, l^i_{j,t}\right)^{1-1/\gamma}}{1 - 1/\gamma} \right]$$

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[1]We will specify all items of government expenditures and transfers in our calibration section.

subject to a lifetime budget constraint that can be expressed as period by period asset accumulations

$$a_{j,t}^i + (1+\tau^c)\, c_{j,t}^i \;=\; (1+r_t)\, a_{j-1,t-1}^i + (1-\tau^l) w_t e_j^i (1-l_{j,t}^i)$$
$$+ ap_{j,t}^i + sa_{j=J_{sa},t}^i + sp_{j>J_{sa},t}^i + fb_{j,t}^i + b_{j,t}^i - t(y_{j,t}^i). \qquad (7)$$

The left hand side of (7) includes the asset holdings at the end of age j, $a_{j,t}^i$, and consumption expenditures, $(1+\tau^c)\, c_{j,t}^i$. The right-hand side includes the asset holdings at age $j-1$, $a_{j-1,t-1}^i$, interest income, $r_t a_{j-1,t-1}^i$, labour earnings, $w_t e_j^i (1-l_{j,t}^i)$, superannuation payouts denoted by $sa_{j=J_{sa},t}^i$ and $sp_{j>J_{sa},t}^i$, family benefits, $fb_{j,t}^i$, bequest receipts, $b_{j,t}^i$, and the progressive income taxes, $t(y_{j,t}^i)$. Households pay a consumption tax at the rate of τ^c, a payroll tax at the rate of τ^l and a progressive income tax from their taxable income, $y_{j,t}^i$, that comprises labour earnings net of the payroll tax, interest income and the age pension. The labour supply is required to be non-negative, $1 - l_{j,t}^i \geq 0$, which implies that leisure, $l_{j,t}$, cannot exceed available time endowment, which is normalised to one. Note that when $l_{j,t}^i = 1$, the household does not work.

2.8 Firm's problem

The producer maximizes the present value of all future profit payments discounted at the world interest rate, r, subject to the capital accumulation equation, as described by

$$\max_{\{K_t,\ L_t,\ I_t\}} \ \sum_{t=0}^{\infty} \frac{1}{(1+r)^t} \left[\left(1 - \tau_t^f\right) (Y_t - C(I_t, K_t) - I_t - (1+cr) w_t L_t) \right] \qquad (8)$$
$$\text{s.t.} \qquad K_{t+1} = I_t + (1-\delta)\, K_t,$$

where τ_t^f denotes the effective corporation tax rate, δ is the capital depreciation rate and $C(I_t, K_t)$ represents adjustment costs, which are assumed to be quadratic in net investment, I_t.

The first-order necessary conditions from the profit maximization problem (8) may be solved for the producer's inter-temporal demands for labour, capital and investment and the Lagrange multiplier, q_t, (also representing the market price for capital), given the time profile for wage rate, w_t, and the interest rate, r.

2.9 Competitive equilibrium

Given government policy settings for the taxation and pension systems, the demographic struc-
ture and the world interest rate, a steady state competitive equilibrium is such that

(a) households make optimal consumption and leisure decisions by solving the utility maxi-
mization problem in (7);

(b) the representative firm chooses labour and capital inputs to solve the profit maximization
problem in (8);

(c) the current account is balanced and foreign debt, FD_t, is freely adjusted so that $r_t = r^w$,
where r^w is the world interest rate;

(d) the labour, capital and goods markets clear

$$
\begin{aligned}
L_t &= \sum_{i \in I} \mu^i \sum_{j \in J} e_j^i (1 - l_{j,t}^i) N_{j,t}, \\
q_t K_t &= \sum_{i \in I} \mu^i \sum_{j \in J} a_{j-1,t-1}^i N_{j,t} - FD_t, \\
Y_t &= \sum_{i \in I} \mu^i \sum_{j \in J} c_{j,t}^i N_{j,t} + I_t + G_t + TB_t,
\end{aligned} \tag{9}
$$

where μ^i gives intra-generational shares and $N_{j,t}$ is the size of cohort age j at time t.

(e) the government budget constraint (5) is satisfied.

(f) the skill-specific bequest transfer is equal to the total amount of assets within each skill
type left by the deceased agents, $B_t^i = \sum_{j \in J} d_{j,t} a_{j,t}^i \phi_{j,t}$, where the term $d_{j,t}$ denotes the
age-specific mortality rates and $\phi_{j,t}$ denotes the cohort shares.[2]

3   Calibration

We start our calculations by computing the benchmark economy that targets key Australian
macroeconomic data averaged over 5 year period ending in June 2012. Hence, the year 2012

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[2]We follow Gokhale *et al.* (2001) by assuming that all inter-generational transfers are accidental and, hence,
that there are no planned bequests. We further assume that accidental bequests are equally redistributed to
surviving households of the same income type aged between 45 and 65 years, reflecting intergenerational transfers
from parents to children.

is assumed to be the base year for our economic calculations. While some model parameters are calibrated, other parameters are either taken from related literature or match actual policy settings in 2012. Demographics and values assigned to the model parameters that are reported in Table 1 are discussed in detail below.

Insert Table 1 here

3.1   Demographics

The population dynamics in our model are driven by the sex-specific and age-dependent fertility, mortality and immigration rates. Even though we do not formally distinguish between sexes, we model the influences of sex-related factors on the dynamics of population ageing. That is, we assume that a cohort of age j in time t consists of male individuals $\left(N_{j,t}^m\right)$ and female individuals $\left(N_{j,t}^f\right)$, so that $N_{j,t} = N_{j,t}^m + N_{j,t}^f$. The size of each gender-specific cohort evolves over time. In each year t, the number of persons of gender g $(g = m, f)$ at age j, $N_{j,t}^g$, is recursively given by

$$N_{j,t}^g = \begin{cases} \left(1 - d_{j,t}^g\right) N_{j-1,t-1}^g + M_{j,t}^g, & \text{for } j > 0, \\ \omega^g \sum\limits_{j=15}^{49} N_{j,t}^f f_{j,t}, & \text{for } j = 0, \end{cases}$$

where the term $\left(1 - d_{j,t}^g\right) N_{j-1,t-1}^g$ denotes the last year's survivors, $d_{j,t}^g$ is the sex-specific mortality rate and $M_{j,t}^g$ denotes the number of net immigrants at age j in year t. The number of newborn males and females, $N_{0,t}^g$, is a function of age-specific fertility rates $f_{j,t}$ of females aged between 15 and 49 years in year t, with the terms ω^m and ω^f defining the birth shares of male and female newborns.[3]

The assumptions for the three age-specific demographic rates are taken from the Productivity Commission's (2013) medium population projection scenario. Figure 1 shows these age-specific rates in 2012 (actual rates) and in a future year from which the given vital rates are assumed to remain constant. The Productivity Commission (2013) further assumes (i) the total fertility rate (sum of the age-specific fertility rates, $f_{j,t}$) to decrease from 1.89 in 2012 to 1.85 babies per woman by 2027; (ii) annual net immigration (sum of age-specific net immigration, $M_{j,t}$) to

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[3]This description of the population dynamics is based on Fehr and Habermann (2006). Similarly to Kotlikoff *et al.* (2007) and Fehr and Habermann (2006), our economic model does not distinguish between immigrants and the native population on the household side, meaning that the economic behaviour of immigrants is exactly the same as of the native-born households.

decline from 236,700 people in 2012 to 180,000 people by 2018; and (*iii*) the constant decline in mortality rates to generate life expectancy at birth that increases from 80 years in 2012 to 89.1 years by 2060 for males and from 84 years in 2012 to 91.4 years by 2060 for females.

Insert Figure 1 here

Since our economic framework does not distinguish between sexes, we use average mortality rates between males and females in the utility function to determine effective rates of discount and also to calculate accidental bequests. The intra-generational cohorts shares, μ^i, are set to 0.2 for each skill or income type, based on the quintiles used by ABS (2012a).

3.2 Endowments

The time endowment that households allocate between leisure and labour supply is normalised to one. Households are also endowed with the efficiency or earnings ability, e_j^i, that is age- and skill-dependent. We consider five skill or income types of households (i.e., the lowest, second, third, fourth and highest quintiles). The age- and skill-specific earnings ability, which is the age profile of the full wage earned with all time endowment allocated to work, is based on the econometric estimates of the lifetime wage function for males with 12 years of schooling by Reilly *et al.* (2005). Using their estimates and ABS (2012a) data to derive income distribution shift parameters, we construct the lifecycle profiles of efficiency units for each skill type to approximately replicate the private income distribution in Australia.[4]

The five skill types are also distinguished by their exogenously given social transfer payments (excluding the age pension). These pre-determined payments from the government allow us to also match social welfare and gross total income for each income quintile, and are discussed in more detail in the subsection on government parameterization.

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[4]Note that the earnings ability after age 65 is assumed to decline at a constant rate, reaching zero at age 90 for each skill type, as Reilly *et al.* consider only workers aged 15-65.

3.3 Preferences

Our choices of the annual utility and of the parameter values are standard in the related literature. The per-period utility function takes the constant elasticity of substitution (CES) form

$$u(c, l) = \left[c^{(1-1/\rho)} + \alpha l^{(1-1/\rho)} \right]^{1/(1-1/\rho)}, \tag{10}$$

where the intra-temporal elasticity of substitution, ρ, is set to 0.9 and the value for the leisure distribution parameter, α, is 1.5, as in Auerbach and Kotlikoff (1987). The remaining parameters in the lifetime utility (1) are the inter-temporal elasticity of substitution, $\gamma = 0.35$, and the subjective discount factor, $\beta = 0.98$, whose value is set to generate the capital output ratio $\frac{K}{Y}$ of 3 (ABS, 2012b).

3.4 Technology

The technology is described by the CES production function

$$F(K_t, L_t) = \kappa \left[\varepsilon K_t^{(1-1/\sigma)} + (1-\varepsilon) L_t^{(1-1/\sigma)} \right]^{[1/(1-1/\sigma)]}, \tag{11}$$

where the technology constant, $\kappa = 0.88$, is calibrated to reproduce the market wage rate, w, which is normalised to one in 2012. The elasticity of substitution in production, $\sigma = 0.87$, and the capital intensity parameter, $\varepsilon = 0.45$, are calibrated via the producer's first order conditions to match the interest rate and national account data for factor shares. The capital stock depreciates at rate $\delta = 0.07$, which is set to target the investment rate $\frac{I}{K}$ of 0.09 (ABS, 2012b). Following Fehr *et al.* (2008), the adjustment cost function is assumed to be quadratic in net investment and given by

$$C(I_t, K_t) = 0.5\psi I_t^2 / K_t, \tag{12}$$

with the adjustment cost parameter, $\psi = 2.27$, calibrated such that the adjustment costs account for about 10 percent of investment in 2012.[5]

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[5]Note that the chosen values for production function parameters result in a steady state q-value (i.e., the price of capital) of 1.15, which is very close to an equilibrium q-value of 1.13 found in the empirical study by Oliner *et al.* (1995).

3.5 Government

Tax revenues. The government total tax revenue, Tax_t, consists of tax revenues from taxing household taxable income, Tax_t^Y, and consumption, Tax_t^C, payroll, Tax_t^L, superannuation, Tax_t^S, and from imposing corporate taxes, Tax_t^F. Specifically, these government tax revenues are given by

$$
\begin{aligned}
Tax_t^Y &= \sum_{i \in I} \mu^i \sum_{j=21}^{J} t(y_{j,t}^i) N_{j,t}, \\
Tax_t^C &= \sum_{i \in I} \mu^i \sum_{j=21}^{J} \tau_t^c c_{j,t}^i N_{j,t}, \\
Tax_t^L &= \sum_{i \in I} \mu^i \sum_{j=21}^{J} \tau_t^l w_t e_j^i (1 - l_{j,t}^i) N_{j,t}, \\
Tax_t^S &= \sum_{i \in I} \mu^i \sum_{j=21}^{J} \left[\tau^s cr \cdot w_t e_j^i (1 - l_{j,t}^i) + \tau^r rsa_{j-1,t-1}^i \right] N_{j,t}, \\
Tax_t^F &= \tau_t^f (Y_t - \delta q_t K_t - (1 + cr) w_t L_t).
\end{aligned}
$$

The statutory rates for the consumption, payroll, corporation and superannuation taxes are reported in Table 1. The income taxes (imposed on taxable income consisting of labour earnings net of the payroll tax, investment income and the age pension) are progressive and we use a differentiable approximation function of the 2010-11 Australian personal income tax schedule.[6]

Age-specific government expenditures. The average age-specific public expenditures on health care, hc_j, aged care, ac_j, education, edu_j, and family benefits, FB_j, which are exogenous in our model, are plotted in Figure 2. Note that the age-profiles of public health care, aged care and education expenditures are taken from Productivity Commission (2013), while the age-profile of family benefits is derived from the 2010 HILDA survey. As mentioned, family benefits are further disaggregated so that they also differ across the five household types, $fb_j^i = \lambda^i FB_j$. The parameter, λ^i, is calculated to match the share of social welfare in gross total income for each income quintile in 2012 (ABS, 2012a).

Insert Figure 2 here

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[6]Note that the approximated income tax function used in the model is very similar to the actual personal income tax schedule. The function, the estimation procedure and the comparison with the actual income tax schedule are available from the authors.

Government consumption. The final government consumption, G_t, consists of expenditures on education, health care, aged care and government purchases of other goods and services. The government purchases of other goods and services are non-age related expenditures that are expressed in per capita terms and denoted as $\overline{G}_t$. The government's final consumption expenditures can be expressed as

$$G_t = \overline{G}_t \cdot P_t + \sum_{i \in \varrho} \mu^i \sum_{j=0}^{20} edu_j N_{j,t} + \sum_{i \in \varrho} \mu^i \sum_{j=0}^{J} hc_j N_{j,t} + \sum_{i \in \varrho} \mu^i \sum_{j=65}^{J} ac_j N_{j,t}. \tag{13}$$

Note that the average age-specific expenditures on education, edu_j, (which are spent on children aged 0 to 20 years), health care, hc_j, and aged care, ac_j, are assumed to be constant over time.

Government transfers. There are two government transfer programs: age pension payments and family benefits. The age pension payments, $ap_{j,t}^i$, are endogenous in the model and are received only by eligible households aged 65 years and over that satisfy the means test. The values for the age pension parameters (i.e., the maximum pension rate, $P^{\max}$, the income threshold, IT, and the income taper rate, θ) and for the superannuation parameters (i.e., mandatory contribution rate, cr, contribution and fund's investment tax rates, τ^s and τ^r) match the actual values in 2012. The age- and time-specific family benefits, $fb_{j,t}^i$, are assumed to be exogenous and received by households between ages 21 and 60 years.[7] The total transfer payments are

$$TR_t = \sum_{i \in \varrho} \mu^i \sum_{j=65}^{J} ap_{j,t}^i N_{j,t} + \sum_{i \in \varrho} \mu^i \sum_{j=21}^{60} fb_{j,t}^i N_{j,t}. \tag{14}$$

Adjustments parameters. We match the exact sizes of government items expressed in percent of GDP in 2012 by using adjustment parameters for each of government expenditures and for each of tax revenues. We calculate these parameters to match the composition of government spending based on the data from ABS (2013a, 2013b). Table 2 reports the values of these calibrated parameters together with the calibrated targets.

Insert Table 2 here

Note that the optimization problems faced by households and firms and the government budget constraint with all the tax revenues and expenditures described algebraically above

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[7] We assume that the aggregate spending on family benefits also depends on the changes in the ratio of children (0-20) to adults (21-60) that is set to one in 2012.

would need to be adjusted so that each tax rate and transfer payment are multiplied by the corresponding adjustment parameter. For example, given the pension adjustment parameter is 0.89, the pension benefits, $ap^i_{j,t}$, in (14) and in the household's budget constraint (7) are scaled down for each income quintile, reflecting the use of the maximum pension for single pensioners (whereas a lower pension is paid to many couples in Australia).[8]

Finally, we assume a balanced government budget with no government debt, that is, $\Delta D(t) = rD(t) = 0$ in Equation (5). Although the consolidated Australian government budget was in a deficit of about 3 percent of GDP in 2012 and net government debt was 10.6 percent of GDP in the same year, the Australian government is committed to balanced budgets in the future.

3.6 Foreign sector

The small open economy framework that we use implies that the domestic interest rate is exogenous and equal to the world interest rate. The world interest rate, r^w, is assumed to be 5 percent. We also set the equilibrium condition for the capital market such that 81 percent of the domestic capital stock come from household savings, with the remaining 19 percent funded through net foreign debt. This reflects the net foreign ownership of about 19 percent of Australia's capital stock (i.e., $\frac{FD}{K} = 0.19$), averaged over five years ending in June 2012 (ABS, 2012b).

3.7 Benchmark solution and performance

The benchmark solution is obtained by numerically solving the model for the artificial steady state (as in Fehr, 2000), using the parameters and the policy settings specified earlier. In this subsection, we report the benchmark solution for the base year of 2012 and provide a comparison with the actual data at both the household and aggregate levels. The computational technique

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[8]The progressive income tax is also scaled down, as the model does not account for any tax offsets available mainly for lower income earners. Given the superannuation adjustment parameter, the effective superannuation tax rates are lower than the statutory ones as the superannuation guarantee system is fully mature in our model, whereas it has yet to achieve full maturity in Australia. The effective consumption tax rate (i.e., the product of the statutory GST rate of 10 percent and the consumption adjustment parameter) equals 14.5 percent, generating the tax revenue that includes not only the GST revenue but also receipts from other indirect taxes. In Australia, the payroll taxes are collected by state governments from businesses with payroll exceeding a certain threshold. The tax rate and the threshold differ across the states. The model assumes the payroll tax to be imposed on household's labour income at the statutory rate of 5.45 percent (i.e., the NSW payroll tax rate). We abstract from any threshold and so the effective rate of 2.6 percent is to match the observed payroll tax revenue to GDP ratio.

and the software used to solve for the base year and the demographic transitions are discussed in the Appendix.

The lifecycle profiles for labour supply, labour earnings and age pension payments of three selected skill types – the lowest, third and highest income quintiles are depicted by Figure 3. Both the labour supply and earnings profiles for each income quintile exhibit the standard hump shapes, rising at early ages with increasing labour productivity and then declining. According to Figure 3c, the lowest quintile gets the full (or maximum) pension from age 65 onwards, while the third quintile receives a part age pension at early age pension ages and households in the highest quintile do not receive any pension until age 76 due to the means test. Importantly, the model-generated profiles averaged across the five income groups are shown to approximate fairly well average cross-sectional data derived from the 2010 HILDA data set based on a survey of Australian households (Wooden *et al.*, 2002).[9]

<center>Insert Figure 3 here</center>

The benchmark solution for key macroeconomic ratios and household net income variables is presented in Table 3, which also provides a comparison with Australian data taken from ABS (2012b, 2013c) and reported as averages over the five-year period of 2008-12. As shown, the distribution of net income and the Gini coefficient measured in net income match closely the ABS (2013c) data. Similarly, the results for the components of aggregate demand reveal that the model replicates the Australian economy fairly well.[10] The positive trade balance generated by the model, which has been negative in Australia for some time, is due to the targeted negative foreign assets position and our assumption of dynamic efficiency with the exogenous interest rate greater than the rate of population growth.

<center>Insert Table 3 here</center>

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[9] As already discussed, our model abstracts from bequest motives, requiring households to completely exhaust their savings, if they survive until the assumed maximum age of 100 years. Hence, the model underestimates average asset holdings at older ages.

[10] Note that, given the calibrated adjustment parameters, each of the model-generated tax revenues and government expenditures match exactly the actual data expressed in percent of GDP.

<center>20</center>

4 Quantifying the effects of demographic transition

We now use the model specified in Section 2, fitted with demographic projections described below, to examine fiscal costs of demographic transition. We first present key population statistics of the baseline demographic transition and then discuss the implications of this demographic transition for the main macroeconomic and fiscal aggregates.

4.1 Demographic projections

The starting point of our population projections is the age structure of the Australian population (i.e., actual cohort sizes) in 2012. We then use the future fertility, survival and net immigration rates assumed in the Productivity Commission's (2013) medium population projection scenario (see Section 3 above for details) to generate the future cohort sizes and cohort shares in the total population over the next 100 years.[11]

The key population statistics for this demographic transition path are provided in Table 4, which shows that by 2050 a) the total population increases to over 35 million, b) the old-age dependency ratio exceeds 37 percent, and c) the total dependency ratio (that includes the youth dependency ratio) increases above 65 percent. Furthermore, the proportion of 65+ year olds in the population will increase from 14 percent in 2012 to over 22 percent in 2050, demonstrating an ageing trend in Australia's population.

<div align="center">Insert Table 4 here</div>

This baseline demographic transition path with the changes in the cohort shares and sizes is used our economic model to simulate the implications for key macroeconomic aggregates and for the budgetary situation of the government. These aggregate effects are driven to a large extent directly by the demographic changes (i.e., future changes in the age structure of the population briefly described above), but also to some extent by behavioural responses of households to these demographic changes. Since it takes several hundred years to reach a new steady state in our model, we only focus on the effects along the transition up to 2100.

The macroeconomic and fiscal effects that are presented below also assume that the gov-

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[11]In fact, the transition period spans the future until 2300. In addition to the demographic projection period from 2013 to 2100 for which the results are presented, there is the adjustment period from 2101 to 2200 (to reach a stable population) and the additional 100 year period from 2201 to 2300 for the model reach a final steady state.

ernment budget is balanced each year by adjustments in non-age related expenditures. The required cuts in these non-age related expenditures to finance expected increases in age-related government spending will give us a measure of the total fiscal cost or burden due entirely to the future changes in the population structure in Australia.[12]

4.2   Macroeconomic effects

The simulation results of the baseline demographic transition for the key macroeconomic variables are provided in Table 5. The effects are reported as percentage changes in the selected per capita variables relative to their benchmark values in 2012.

Insert Table 5 here

Starting with the effects on labour supply, our results show an initial increase in per capita labour of 3.04 percent by 2015, as the working population work longer hours to respond to unanticipated improvements in mortality rates and longevity. However, in the medium and long terms, direct demographic effects with smaller shares of the working-age population cause per capita labour supply to decline 7.51 percent by 2050 and 11.63 percent by 2100. The labour supply effects are negatively correlated with the implications for the wage rate, which is somewhat higher for most of the transition path, due to capital deepening. Notice that the effects on the wage rate are small in our open economy framework with the exogenous interest rate.

The effects on domestic total assets are significantly positive. Table 5 shows that domestic total assets are 35.4 percent higher in 2050 and almost 40 percent in 2100 relative to the base year of our calculations in 2012. Both the direct demographic effects with an increasing proportion of the elderly holding large assets and indirect behavioural effects with increased lifecycle savings are behind these aggregate increases in domestic assets.[13] In contrast, the domestic capital stock decreases over the transition (due predominantly to reduced per capita labour supply, which to large extent determines the implications for other production variables), implying that the

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[12]Note that households in our framework are not affected by this government budget balance assumption.

[13]Note that the effects of population ageing on domestic assets or wealth resulting from the simulations by Kotlikoff *et al.* (2007) for the US and Fehr *et al.* (2008) for Europe and Japan are much smaller or even negative. The key difference is the presence of distortive payroll taxes, which are high in these countries and need to be increased further to finance growing old-age related government spending programs. Our model includes a payroll tax rate, which only collects 5 percent of the total tax revenues and is unchanged over the transition (as the other tax rates).

increase in domestic assets is used to reduce net foreign debt. As found in related literature (Fehr *et al.*, 2008), we observe declining asset prices as the population ages. The effects on average consumption are mostly positive, with per capita consumption increasing by 3.70 percent in 2050 relative to its 2012 value. However, the increases in per capita consumption (the largest expenditure on GDP) are not large enough to prevent the economy from contracting, with a decrease of 6.7 percent in GDP per capita by 2050. The implications for national product or GNP, which includes interest payments on foreign debt, are positive compared to GDP because of large decreases in foreign debt.[14]

4.3 Fiscal effects

Table 6 reports the fiscal implications of the baseline demographic transition as percentage changes in government tax revenues and expenditures (all measured in per capita terms) relative to their benchmark values in 2012. The results for the government tax revenues show an increase of 2.16 percent in the total tax revenues by 2050. More interestingly, the projected demographic changes lead to a structural change in tax revenues, with a shift in the tax base from labour earnings to asset incomes and consumption. Hence, the tax revenue from payroll taxes declines significantly, while the consumption tax revenue improves during the demographic transition.

<center>Insert Table 6 here</center>

On the expenditure side of the government budget, old-age expenditures are shown to increase significantly due to a growing proportion of older cohorts in the population, causing the overall age-related spending to increase by 40 percent (to over 22 percent of GDP) by 2050. In particular, our results (that only account for the effects of the changes in demographic factors) indicate that the increases in health care, aged care and pension expenditures in 2050, relative to 2012, are 27.3, 111.85 and 47.6 percent, respectively.

We find significant fiscal costs due to population ageing, with the other (non-age related) government expenditure needing to decline by 31.7 percent by 2050 and by almost 60 percent by 2100 to close the fiscal gap. As shown in Figure 4 depicting government expenditures expressed in percent of GDP, the other expenditures decrease by over 2 percentage points of GDP to 5.5

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[14]Our interest is in the effects of population ageing on per capita variable. Note that all aggregate variables increase significantly over the transition path due to high net immigration resulting in a growing total population.

percent of GDP in 2050 and by additional 2 percentage points of GDP to 3.56 percent of GDP in 2100.

<div align="center">Insert Figure 4 here</div>

5 Quantifying the effects of fiscal reforms

We now relax the fiscal rule in which the government adjusts the non-age related expenditure and examine other fiscal adjustments to finance some or all of the fiscal costs of population ageing that we documented above for the baseline demographic scenario. The fiscal policy reforms include (i) pension cuts, (ii) tax hikes and (iii) a mix of pension cuts and tax hikes. The objective is to study the consequences of these fiscal reforms for the economy and welfare of households.

5.1 Fiscal reform 1: Pension cuts

We start with an experiment in which the government implements several changes in the age pension policy settings to cut pension benefits and thus to limit future growth in overall pension expenditures. Since cutting pension benefits is not sufficient to cover the increased fiscal cost of all aged related expenditures, we adjust the non-age related expenditure to maintain a balanced government budget.

We consider the following policy changes: (i) a higher pension access age, (ii) a reduced maximum pension and (iii) an increased taper rate of the pension means test. It is further assumed that each of these policy changes representing a pension cut is implemented gradually in two steps, following the gradual increases in the age pension access age legislated in 2010. We closely match this legislation by increasing the age pension access age from 65 years to 66 years in 2018 (for cohorts aged between 59 and 56 years in 2012) and to 67 years in 2023 (for generations aged 55 years and younger in 2012). The second policy change assumes a 5 percent hypothetical cut in the maximum pension in 2018, with an additional 5 percent cut in 2023. The third policy change is implemented by raising the income taper from the current rate of 0.5 to 0.625 in 2018, with a further increase to 0.75 in 2023.[15]

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[15] Notice that in the algebraic description of the age pension benefit in (4), the age pension access age, J_{ap}, the maximum pension benefit, P^{max}, and the income taper rate, θ, become time-dependent, increased initially in

We first present and discuss the macroeconomic and welfare effects of the aggregate pension cut, containing all three aforementioned changes in the current pension policy rules. We then report on the effects of each of the components of the assumed aggregate pension cut.

Aggregate pension cut. The macroeconomic implications of all three pension policy changes (labeled as the aggregate pension cut) in Table 7 are reported as percentage changes in the main per capita variables relative to the effects obtained from the baseline demographic transition. The displayed improvements in other (non-age related) expenditures give the reduction in the fiscal gap (or costs). As a result of the aggregate pension cut, the non-age related expenditures increase 30 percent by 2050 and over 50 percent by 2100 relative to the baseline demographic effects. However, notice that these budget-equilibrating expenditures are still significantly lower along the demographic transition than they were in the base year of 2012. Furthermore, the reduced age pension expenditures (over 30 percent by 2050) contribute only a 6.35 percent decrease in overall age-related government expenditures. Hence, the cuts in age pension payments alone cannot fully eliminate the fiscal costs of population ageing, driven to a large extent by projected increases in other old-age related public spending such as on health and aged care programs.

Insert Table 7 here

The fiscal gap narrows not only because of lower age-related government spending but also due to increased taxation revenues. It is well known that public pensions may reduce lifecycle labour supply and savings as they act as substitute for private income in retirement. The simulated pension cuts provide an incentive for households to work and save more over the lifecycle. Table 7 shows the increase in per capita labour supply and domestic total assets by 2050 of 1.19 percent and 5.71 percent, respectively. As households work longer hours and save more, their labour earnings and investment income increase, generating higher revenues from progressive income and payroll taxes.

The pension cuts have also positive effects on GDP per capita, driven by higher labour supply. The effects on per capita consumption, however, are negative and more significant in the short run as consumption of some older households with reduced pension benefits declines.

The distributional (both inter- and intra-generational) welfare effects of the aggregate pen-

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2018 and then in 2023.

sion cut are displayed in Figure 5. The effects are depicted for income quintiles and average welfare as a function of generation's age at the time of the pension reform announcement in 2012.[16] Following Auerbach and Kotlikoff (1987, p.87), the calculation of welfare effects is based on the concept of standard equivalent variation, which, for a particular generation, measures the proportional percentage change in consumption and leisure needed in the benchmark scenario (i.e., baseline demographic transition) to produce the remaining utility under the policy change (i.e., baseline demographic transition with the aggregate pension cut).

Insert Figure 5 here

The inter-generational effects on average welfare across the income quintiles depicted by the dotted line in Figure 4 indicate that older and middle age generations experience particularly large welfare losses. The losses for these generations are caused by the cuts in their future pension payments phased in after 2018, which have negative implications for their consumption. The effects on average welfare of future adult generations (i.e., those aged 20 years and younger at the time of the reform announcement) are still negative, but the losses are significantly smaller in comparison with those attained by older and middle age cohorts. Although these future generations face the same changes in the pension policy settings, they have the whole lifecycle to adjust their behaviour in terms of labour supply and savings to these policy changes.[17]

The results across different skill types highlight that lower income types attain significantly greater welfare losses than higher income types. For these lower income households, the age pension represents by far the main source of retirement income and, in particular, the 10 percent reduction in the maximum pension and the higher pension access age policy lead to large decreases in their life cycle consumption. As shown in Figure 5, there are two significant reductions in welfare of the lowest and second quintiles aged 59 and 55 years at the time of the reform announcement. These are the first generations affected by the higher pension ages of 66 and 67, respectively. As mentioned, future adult generations of all income types adjust their life cycle behaviour by accumulating large private savings to fund retirement consumption, thus, to a some extent, limiting the negative welfare effects of pension cuts. The welfare losses for

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[16] Recall that the oldest generations in our model are aged 100 years and the youngest adult generations are aged 21 years, with all younger generations than 21 years of age assumed to enter the economic model in the succeeding years of the demographic transition (i.e., future adult generations).

[17] It should be pointed out that our model tends to over-estimate the welfare losses as households are assumed to derive utility only from private consumption and hence the improvements in non-age related government expenditures (i.e., public consumption) reported in Table 7 have no effect on household behaviour and welfare.

future generations of well-off households are minimal (with the highest quintile in fact gaining in welfare in the longer term) as for them the age pension is not as important.

Components of aggregate pension cut. We have so far focused our discussion on the effects of the aggregate pension cut. However, the extent to which each of the three components – higher pension access age, reduced maximum pension and increased taper rate – contributes to the results for the overall pension cut is unclear. Below we compare the macroeconomic and distributional welfare effects of the three policy changes.

The macroeconomic results in Table 8 show positive effects of all three pension changes on per capita labour supply, assets, output and overall taxation revenue, as well as reduced age pension expenditures, with an improved fiscal position for the government depicted by higher non-age related expenditures. Although the effects of the pension changes are qualitatively similar with the same direction of the impacts, the sizes of these effects differs to a some degree across the policy changes. The most effective policy change in terms of the reduction in pension expenditures and fiscal costs is the two step reduction in the maximum pension by 10 percent after 2023. This policy reduces age pension expenditures by 16 percent and increases other (budget-equilibrating) expenditures by 14.39 percent, which is more than double the increase reported for the higher access age reform in 2050. The main reason for this difference is that the reduced maximum pension lowers pension benefits for all skill types, while the increased pension eligibility age affects only the pensions paid to lower income households.

Insert Table 8 here

Interestingly, the reduced maximum pension increases labour supply and reduces average consumption upon the policy announcement, whereas the other two pension policy changes have the most significant effects on these variables when they are actually implemented. The reduced maximum pension represents a pure negative income effect, with per capita labour supply increasing and average consumption decreasing by 0.86 percent and 0.81 percent in 2015, respectively. In the succeeding years of the demographic transition, households accumulate larger assets, thus effectively replacing public pensions with private income in retirement. The transitional growth in domestic assets allows for reductions in per capita labour supply and improvements in average consumption relative to the short run results. On the contrary, the announcement effects of the other two pension policy changes are smaller for per capita labour

supply compared with the two years (2018 and 2023) when the eligibility age and the income taper rate are actually increased.

The distributional welfare effects of each of the three pension policy changes are depicted in Figure 6. Starting with the gradual increases in the age pension eligibility age, Figure 6a shows than only the third income quintile and the two lower income types aged 59 years and younger at the time of the policy announcement have their welfare affected. The welfare of all generations aged 60 years and over in 2012 is unchanged as their pensions are treated under the current pension rules with the access age at 65 years, while higher income households younger than 60 years do not qualify for any pension at early age pension ages because of the means testing. However, the welfare implications for lower income households are quite negative, with two significant welfare reductions for lower income cohorts aged 59 and 55 years in 2012 – first generations of pensioners that must wait to receive a pension at 66 and 67, respectively.

Insert Figure 6 here

The reduced maximum pension policy has particularly negative effects on welfare of lower income types approaching the current pension access age, with the largest loss of over 2 percent in remaining welfare experienced by the lowest income households.[18] Welfare of younger and future generations improves due to increased savings and self-funding in retirement, but only future generations of the highest skill type gain in welfare.

The policy change of strengthening the pension means test by lifting the income taper has no impact on welfare of lower income households, as demonstrated by Figure 6c. These households receive the full age pension regardless whether the taper rate is 0.5 (as in benchmark) or 0.75 (as under this reform). While the lowest income households are unaffected by this policy change, most generations of the other income types attain lower welfare as the more binding income test lowers their pension benefits. Note that the largest welfare losses due to the increased taper rate for the third and fourth income quintiles are about half of the losses attained by the lowest income quintile under the higher access age and reduced maximum pension changes.

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[18]Notice that because the policy change (as the other two pension changes) is phased in from 2018, which is six years after the policy announcement, some very old generations have their pension payments and welfare unchanged.

5.2 Fiscal reform 2: Tax hikes

We now turn our attention to tax hikes. To mitigate the fiscal costs arising from the population ageing along the demographic transition, we consider policy changes in (*i*) the consumption tax rate, (*ii*) progressive income taxation (proportional changes in average/marginal income tax rates) and (*iii*) the payroll tax rate. Our approach is to assume that there is no change in the economy except for demographics and one tax rate that is adjusted in order to produce the same reduction in the fiscal costs measured in terms of improvements in non-age related government expenditures as under the aggregate pension cut.[19] This allows us to compare not only the effects among the three different tax hikes, but also their effects with those discussed above for the aggregate pension cut.

Macroeconomic effects. The macroeconomic implications of the three tax hikes are provided in Table 9 as percentage changes in the selected per capita variables relative to the effects of the baseline demographic transition (included in Tables 5 and 6). As expected, all budget-equilibrating tax policy changes require higher taxes to reduce the fiscal burden of population ageing. However, the size of increases in each tax rate varies significantly, which is due partly to differences in the amount of revenues collected by each tax and also because of different effects of each tax increase on the underlying tax base. For example, the payroll tax rate needs an increase of almost 290 percent by 2015 (with the effective rate increasing from 2.6 percent in 2012 to 7.45 percent by 2050) to generate the same reduction in fiscal costs as the aggregate pension cut. The increases in the consumption tax rate and/or in the progressive income taxation (i.e., the average income tax rate) are much smaller in percentage terms as these tax rates are higher and the government collects significantly larger revenues from the two tax sources. Interestingly, the percentage increases in the consumption tax rate required to balance the government budget with the improved non-government expenditures are smaller than the required increases in the average income tax rate. Although the income tax revenue is larger by almost 3 percentage points of GDP than the consumption tax revenue (as shown in Table 2 for 2012), the income tax rates are required to increase 26.69 percent by 2050, compared to a 21.75 percent increase in the consumption tax rate by that year. The reason is that the increases in progressive income taxation are more distortive for household behaviour than the consumption tax hike, negatively

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[19]In other words, each of these tax hikes produces the same increases in other non-age related expenditures as those obtained under the aggregate pension cut and reported in Table 7.

affecting lifecycle labour supply and savings and thus reducing the income tax base.

Insert Table 9 here

The consumption tax hike has quite distinct impacts on key macroeconomic variables compared to those produced by the progressive income and payroll tax hikes. Specifically, the consumption tax hike results in positive effects on per capita labour supply, assets and output, while the required increases in progressive income or payroll taxes, which to a large extent impact on middle-age working households, have negative effects on the economy. Table 9 shows that using the progressive tax adjustment policy, the declines in average labour supply and domestic assets are 1.82 percent and 7.62 percent by 2050, respectively. Even the decrease in consumption per capita in 2050 is more than a double of the consumption reduction under the consumption tax hike. This demonstrates a highly distortive nature of progressive income taxes for household behaviour. The payroll tax is collected at a flat rate from labour earnings of the working age population. The effects on the macroeconomic aggregates are also negative during the transition, but not as large as under the progressive income tax hike. The changes in labour supply and assets also impact the age pension expenditures. For instance, the progressive tax hike increases pension expenditures because of the means testing of reduced private income (i.e., assets income and labour earnings) at older ages.

Welfare implications. The distributional welfare effects of the investigated tax hikes are plotted in Figure 7. As for the age pension policy changes, the welfare effects of the tax changes are presented as percentage changes in the remaining utility for each income quintile of every generation relative to the remaining utility level under the baseline demographic transition.

Insert Figure 7 here

Several observations can be drawn from these results. First, the welfare losses of younger and future generations are much larger than the effects on welfare of older generations. In the case of the payroll tax hike (with the payroll tax collected only from labour income of working households), the welfare of many older generations is not affected at all. In contrast, recall the large welfare losses attained by retired generations and those approaching retirement that were displayed in Figure 5 for the aggregate pension cut. Second, although all examined tax hikes reduce welfare along the demographic transition, the size of the losses for future generations differs greatly among the tax hikes. The least distortive consumption tax hike generates smaller

average welfare losses for future generations compared to those attained by these generations under the income and payroll tax hikes.

Finally, taxing consumption or directly income through either progressive or payroll taxes have opposing intra-generational welfare implications. In particular, the direct income tax hike reduces the welfare of higher income households more than the welfare of lower income types. This is the case especially when the progressive income tax rates are increased to limit the fiscal costs, with the largest welfare loss of over 3 percent experienced by the highest income quintile of future generations. In contrast, the consumption tax hike produces larger welfare losses for future generations of lower income households because of the regressive nature of the flat consumption tax rate. Further note that under the consumption tax hike, the differences in the welfare effects among the five income types are much smaller in comparison with the effects resulting from the progressive income tax hike, with a 2.5 percentage point range between the minimum and maximum welfare losses for future generations.

5.3   Fiscal reform 3: Mix of pension cuts and tax hikes

In the fiscal policy adjustments examined above, households are only partially responsible for the fiscal costs of population ageing as the government is allowed to reduce its non-age related spending to balance its budget with either pension cuts or tax hikes. In this section, we consider experiments in which the government not only cuts the pension benefits (as in Reform 1), but also increase taxes to fully cover the fiscal costs arising from the demographic shift.[20]   More specifically, we implement the following two experiments: (i) the aggregate pension cut with a consumption tax hike, and (ii) the aggregate pension cut with a payroll tax hike.[21]

Macroeconomic effects.   Table 10 summarizes the changes in macroeconomic variables between 2015 and 2100 under the two fiscal reform scenarios, with population ageing and rising age-related public spending financed by the pension cuts and adjustments in either the consumption tax rate or the payroll tax rate.

Insert Table 10 here

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[20]Notice that the macroeconomic and welfare effects discussed in this section are not comparable to those obtained for fiscal reforms 1 and 2.

[21]In both experiments, the non-age related government expenditure is assumed to be unchanged at the 2012 level over the demographic transition.

The tax rate reported in Table 10 is either the effective consumption tax rate or the effective payroll tax rate that maintains a balanced government budget, which is also impacted by the aggregate pension cut. The tax rate initially declines, partly due to the demographics (with increased tax revenues and reduced expenditures on education and family benefits) but largely due to pension cuts (with reduced pension expenditures).[22] However, in the longer term, the effective tax rate needs to increase to close the fiscal gap, with the payroll tax rate in particular rising substantially to over 19 percent by 2100.

The initial decline in either the consumption or payroll tax rates has positive effects on the economy, with per capita labour supply, assets and output increasing more that under the aggregate pension cut alone. For instance, the aggregate pension cut with the payroll tax adjustments increases per capita assets by 8.13 percent by 2030, compared to 4.3 percent increase displayed in Table 5 for the aggregate pension cut alone. As mentioned, pension cuts reduce retirement income provided by the government, which induces households to work and save more to replace lower pension benefits with higher private income in retirement. The income tax rate reductions provide further incentives to work and save. In contrast, the increases in the effective payroll tax rate after 2030 negatively affect the selected macroeconomic variables. As shown in Table 10, the decrease in per capita labour supply, assets and consumption by 2100 is 1.04 percent, 2.14 percent and 11.17 percent, respectively.

Table 10 also demonstrates important differences between the two tax adjustments, with increases in consumption or payroll tax rates after 2030 leading to opposing effects on the economy in the long run. Note that an increase in the payroll tax directly reduces the effective wage rate (i.e., the price of leisure), generating a substitution effect and leading to lower labour supply. In contrast, an increase in the consumption tax leads to higher consumption expenditures, making households work more to meet these expenditures.

The opposing aggregate effects imply trade-offs for policy selection based on macroeconomic aggregates. To have a better view of how the effects of these two policy mixes map into the welfare effects across households and generations, we consider a welfare analysis.

Welfare implications. The welfare effects of the two combinations of pension cuts and tax hikes are depicted by Figure 8. The top panel shows the effects of the aggregate pension

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[22]Recall that in 2012 the effective consumption tax rate and the effective payroll tax rate are 14.5 percent and 2.6 percent, respectively.

cut with adjustments in the consumption tax rate, while the bottom graph shows the effects of pension cuts combined with adjustments in the payroll tax rate.

Insert Figure 8 here

As seen before, the welfare effects presented in the figure above are non-linear and vary across generations and income groups. As expected, the pattern of the welfare effects shows a combination of the effects reported for fiscal reforms 1 and 2. The aggregate pension cut lowers the welfare of existing generations born prior to the reform (with particularly large losses to lower income groups), whereas tax hikes decrease the welfare of future generations.

A comparison of the two experiments with different tax adjustments reveals that the welfare losses for future generations across all income types are much larger when the payroll tax is adjusted. This indicates that taxing labor income to finance the fiscal costs of population ageing not only has a negative impact on the economy but also reduces the welfare of households. The economic mechanism is provided by the distortion that a specific labor income tax has on work incentives and labor supply. In a small open economy, the adverse labor supply effect translates directly into lower demand for capital and output. In the context of population ageing, that adverse effect is even more detrimental. This finding indicates that the option of relying on labor income taxes to finance the ageing cost is dominated by the option relying on consumption taxes.

Sensitivity analysis. We also carry out some sensitivity checks for the simulations of the aggregate pension cut combined with the consumption or payroll tax hikes. We first consider a high ageing scenario based on low future fertility and net immigration rates and high future survival probabilities assumed by Productivity Commission (2013). The second modification assumes imperfect capital mobility with an endogenous interest rate determined by the changes in level of foreign debt (as in Guest, 2006).

The results for the two robustness checks are qualitatively similar to those presented above, with the direction of both macroeconomic and welfare changes unchanged. Quantitative differences, which are available from authors, can be summarized as follows. The high ageing scenario in the short and medium terms allows for lower budget-equilibrating tax rates (either consumption or payroll tax rates). This is partly due to increased income tax revenues (as households response to increased life expectancy by working and saving more) and partly due to reduced spending on education and family benefits. However, in the longer term substantial increases in

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old age related government expenditures (arising from the increased proportion of the elderly in the total population) require further tax hikes, leading to larger welfare losses to future born generations. The results obtained from the imperfect capital mobility simulations are similar to those in a closed economy. We have shown that pension cuts lead to higher domestic assets and lower net foreign debt. As a result, the domestic interest rate in this amended framework declines, driving up the demand for investment and leading to a higher capital stock, with positive effects on wages. The welfare implications of pension cuts and tax hikes are negative for old households (due to a lower return on their assets) but positive for future born generations (due to lower tax rates and higher wages) when compared to small open economy framework with the exogenous and constant interest rate.

6   Conclusions

In this paper, we analyse the fiscal costs caused by the ageing demographic shift in Australia, and study the effects of structural fiscal reforms to mitigate such fiscal challenges. Our analysis is based on a computable dynamic general equilibrium, overlapping generations model calibrated to match the demographic developments and macroeconomic data in Australia. We identify three fiscal programs, including health care, age pension and aged care programs, that are sources of fiscal instability in Australia. We quantify the contribution of each program in the long-run and during the transition. We then quantify the macroeconomic and welfare implications of the two fiscal reform options: pension cuts and tax hikes.

We first introduce an aggregate pension cut that consists of (i) legislated increases in pension access age, (ii) hypothetical reductions in the maximum pension and (iii) hypothetical increases in the taper of the pension means test. Our experiment results indicate that people receiving the pension and those approaching the pension access age experience significant welfare losses, especially households in lower income groups. We then analyse the effects of each component of the aggregate pension cut and find significant differences in the distributional welfare implications. The higher pension age and reduced maximum pension changes have negative welfare effects on lower income households, whereas the increased taper rate policy has no impact on their welfare since they still qualify for the full age pension.

We compare the effects of the aggregate pension cut to that of three options to increase taxes. We find that while the two policy options achieve the same fiscal goal, the macroeconomic and welfare outcomes differ significantly. Young and future generations prefer pension cuts to mitigate the fiscal pressure because they are worse off by having to pay higher taxes over their entire life cycle. Meanwhile, the current retiring and working generations prefer no pension cuts and increases in future taxes.

Our results suggest interesting outcomes when choosing between consumption and income tax policies. Taxing consumption or income results in opposing effects on the economy and welfare across different income groups of households. Specifically, the required increases in consumption tax rate result in positive effects on per capita labour supply, assets and output, but reduce the welfare of lowest income households most. Conversely, the increases in progressive income or payroll taxes result in negative effects on output but reduce the welfare of poor households least.

Finally, we analyse the consequences of combining pension cuts with tax hikes to maintain a balanced government budget. The results for these experiments indicate that a mix of pension cuts and labour income tax hike has some advantages by 2030. However, a mix of pension cuts and a consumption tax hike is the dominant policy option in the long run. Welfare losses to future generations from increased payroll taxes are more than double those resulting from consumption tax adjustments.

Our findings have important policy implications. Even though the costs of population ageing in the coming decades are inevitable, the transitional cost on aggregate economy and welfare can be minimized by the choice of fiscal policy option and the timing of policy implementation. Reforms that allow individuals to have enough time to adjust and those that minimizes the fiscal distortion on labor supply stand out as the best policy options. However, none of these policy reform options is likely to gain political support as each policy results in welfare losses for the current retiring and working generations. The conflict of interest between current and future generations suggests political infeasibility for any structural fiscal reforms.

Our results also suggest that a gradual shift from the retirement income support scheme that relies heavily on a means-tested pension system (e.g., an unfunded public pension scheme) towards a superannuation system (e.g., a self-financed private pension scheme) may effectively

help control fiscal cost of demographic transition while allowing individuals to adjust labor supply and savings for retirement. How to design a means-tested pension system to exploit interactions between these two retirement systems is an interesting issue that needs further exploration. We leave this question for our future research.

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Appendix - Solving the model

Following Fehr (2000) and Fehr and Habermann (2006), we assume that the benchmark economy is in a steady state equilibrium. We first compute this artificial steady state equilibrium to match key Australian macro data and to derive the initial distribution of assets across the generations alive in 2012 (i.e., the base year for our calculations). We use the observed age distribution of Australia's population and age-dependent mortality rates for 2012 in this computation. Given the initial asset distribution, we then use the model that is fitted with demographic projections based on Productivity Commission's (2013) demographic assumptions to numerically solve for the transition path to a new steady state. Note that we compute several transition paths, including the baseline demographic transition without and with pension cuts or tax hikes.

Each of transition paths spans over the period from 2013 to 2300 and includes: (*i*) the demographic projection period from 2013 to 2100 for which the results are provided; (*ii*) the adjustment period from 2101 to 2200 period to reach a stable population by setting the number of births to be constant after 2100; and (*iii*) additional 100 years from 2201 to 2300 for the model reach a final steady state.

We use the GAMS software to solve for the initial steady state equilibrium and the transition paths. Our algorithm applies the iterative Gauss-Seidel computational method suggested by Auerbach and Kotlikoff (1987). The exact computational steps needed to solve for a steady state of a small open economy model such as ours are provided in Kudrna and Woodland (2011). In brief, the algorithm involves choosing initial values for some endogenous variables and then updating them by iterating between the production, household and government sectors until convergence. The same algorithm is used to compute the transition path, but the generations of heterogeneous households (i.e., five income or skill types) alive at the time the policy change is announced must be treated differently from the steady state simulation. At the time of the policy announcement, existing generations solve their utility maximization problems again but over shorter lifetimes given their assets accumulated prior to the policy announcement. As mentioned above, the initial distribution of assets for these generations is obtained from the artificial steady state simulation.

Tables

Table 1: Values of the main model parameters

Description	Value	Source
Utility function		
Inter-temporal elasticity of substitution	0.35	Literature
Intra-temporal elasticity of substitution	0.9	Literature
Subjective discount factor	0.98	Calibrated
Leisure parameter	1.5	Literature
Technology		
Production constant	0.898	Calibrated
Elasticity of substitution in production	0.968	Calibrated
Capital share	0.45	Data
Depreciation rate	0.07	Calibrated
Adjustment cost parameter	2.265	Calibrated
Age pension		
Maximum age pension p.a. (in $100,000)	0.19643	Data
Income test threshold (in $100,000)	0.03484	Data
Income reduction (taper) rate	0.5	Data
Superannuation		
Mandatory contribution rate	0.09	Data
Contribution tax rate	0.15	Data
Effective earnings tax rate	0.075	Data
Taxation		
Statutory consumption tax rate [GST]	0.1	Data
Statutory corporation tax rate	0.3	Data
Statutory payroll tax rate	0.0545	Data
Progressive income tax function	-	Estimated

Table 2: Calibrated adjustment parameters for government indicators

Description	Value	Target (% of GDP)
Adjustment parameters		
Health care	1.27	6.40
Education	1.03	5.10
Aged care	0.74	0.80
Age pension	0.89	2.80
Family benefits and other transfers [a]	1.00	4.20
Personal income taxes	0.81	10.23
Superannuation taxes	0.57	0.68
Payroll taxes	0.47	1.32
Corporation taxes	0.97	4.71
Consumption taxes [b]	1.45	7.50
Other taxes [c]	1.00	2.30

Notes: Data targets for Australia are averages over 2008-12, taken from ABS (2013a, 2013b); [a] Other transfers includes disability pension and unmeployment benefits; [b] These include the GST revenue and revenues from all excise taxes; [c] These include property taxes collected by the state governments.

Table 3: Benchmark solution and Australian data

Variable	Benchmark model	Australia 2008-12
Expenditures on GDP (% of GDP)		
Private consumption	51.61	54.75
Investment	26.49	27.60
Government consumption	19.83	18.10
Trade balance	2.07	-0.54
Net income shares		
Lowest quintile	0.07	0.08
Second quintile	0.12	0.13
Third quintile	0.18	0.17
Fourth quintile	0.24	0.23
Highest quintile	0.38	0.40
Gini coefficient (in net income)	0.34	0.33

Notes: The data for Australia are five-year averages ending in June 2012, taken from ABS (2012b, 2013c).

Table 4: Demographic transition in Australia - key population statistics

	Base year	Projection period			
	2012	2015	2030	2050	2100
Population (million)	22.73	23.85	28.93	35.15	47.81
Population growth (%)	1.70	1.56	1.14	0.87	0.45
Age distribution	%	%	%	%	%
0-14 years	18.90	18.95	18.34	17.06	16.11
15-64 years	66.90	66.22	62.72	60.51	57.94
65 years and over	14.20	14.82	18.94	22.43	25.95
85 years and over	1.80	1.90	2.44	4.47	6.16
Dependency ratios	%	%	%	%	%
Youth (0-14/ 15-64)	21.20	22.38	30.20	37.07	44.79
Aged (65+ / 15-64)	28.30	28.62	29.25	28.20	27.81
Total (Youth+ Aged)	49.50	51.00	59.45	65.27	72.60

Notes: The projections are based on Productivity Commisson's (2013) medium population scenario.

Table 5: Macroeconomic effects of baseline demographic transition
(Percentage changes in the selected macroeconomic variables from 2012)

Variable	Benchmark 2012 [a]		Transition period			
			2015	2030	2050	2100
Labour supply	0.31	%	3.04	-3.11	-7.51	-11.63
Wage rate	1.00	%	-1.25	0.07	0.15	0.30
Domestic assets	1.77	%	0.19	-2.97	-7.20	-11.03
Capital Stock	1.65	%	3.23	21.87	35.40	39.64
Asset price	1.15	%	-0.30	-1.44	-1.70	-2.04
Gross Domestic Product (GDP)	0.59	%	2.01	-2.50	-6.77	-10.69
Gross National Product (GNP)	0.57	%	2.56	1.34	-0.33	-3.05
Consumption	0.30	%	-2.60	0.14	3.70	5.73
Investment	0.16	%	-3.35	-13.93	-19.56	-25.18

Notes: [a] The monetary varables are expressed in units of $100,000 and per capita.

Table 6: Fiscal effects of baseline demographic transition
(Percentage changes in the selected fiscal variables from 2012)

Variable	Benchmark 2012 [a]		Transition period			
			2015	2030	2050	2100
Total tax revenues	0.158	%	1.58	2.07	2.16	1.11
- Income taxes	0.060	%	3.08	4.84	4.46	2.18
- Payroll taxes	0.008	%	1.75	-3.05	-7.37	-11.36
- Corporation taxes	0.028	%	5.70	1.73	-2.14	-5.63
- Consumption taxes	0.044	%	-2.60	0.14	3.70	5.73
Age related expenditures	0.059	%	1.71	18.60	39.77	61.11
- Health care	0.038	%	1.33	12.84	27.33	40.60
- Aged care	0.005	%	2.53	38.56	111.85	179.96
- Age pension	0.017	%	2.35	26.05	47.62	74.04
- Education	0.030	%	-0.53	-2.82	-10.10	-14.47
- Family benefits	0.014	%	-1.11	-8.11	-13.91	-20.67
Other expenditures [b]	0.044	%	4.26	-11.32	-31.68	-57.74

Notes: [a] The monetary varables are expressed in units of $100,000 and per capita; [b] These represent non-age related expenditures that are assumed to balance the budget.

Table 7: Macroeconomic implications of aggregate pension cut
(Percentage changes in selected macroeconomic variables from baseline transition)

Variable	Transition period			
	2015	2030	2050	2100
Labour supply	1.41	1.57	1.19	1.05
Domestic assets	0.73	4.31	5.71	6.12
Output (GDP)	0.91	1.53	1.18	1.05
Consumption	-1.14	-0.63	-0.21	-0.09
Total tax revenues	0.37	0.81	0.77	0.69
- Income taxes	1.19	1.55	1.42	1.27
- Payroll taxes	0.98	1.52	1.17	1.05
- Consumption taxes	-1.14	-0.63	-0.21	-0.09
Age related expenditures	-0.14	-5.67	-6.35	-6.67
- Age pension	-0.84	-30.39	-31.57	-30.52
Other expenditures [a]	1.59	19.40	29.48	52.63

Notes: [a] These represent non-age related expenditures that are assumed to balance the budget.

Table 8: Macroeconomic implications of three components of aggregate pension cut
(Percentage changes in the selected macroeconomic variables from baseline transition)

Variable	(i) Higher access age				(ii) Reduced maximum pension				(iii) Increased taper rate			
	2015	2030	2050	2100	2015	2030	2050	2100	2015	2030	2050	2100
Labour supply	0.21	0.44	0.41	0.40	0.86	0.57	0.37	0.33	0.44	0.86	0.62	0.60
Domestic assets	0.11	0.79	1.07	1.13	0.49	2.76	3.41	3.64	0.12	0.83	1.30	1.38
Output (GDP)	0.14	0.43	0.41	0.40	0.55	0.58	0.38	0.33	0.29	0.81	0.63	0.60
Consumption	-0.18	-0.05	0.06	0.13	-0.81	-0.41	-0.15	-0.08	-0.16	-0.13	-0.11	-0.11
Total tax revenues	-0.01	0.14	0.18	0.20	0.17	0.31	0.29	0.25	0.24	0.47	0.38	0.32
- Income taxes	0.05	0.14	0.18	0.19	0.62	0.72	0.63	0.52	0.61	0.79	0.70	0.58
- Payroll taxes	0.15	0.43	0.41	0.40	0.58	0.57	0.38	0.33	0.31	0.81	0.63	0.60
- Consumption taxes	-0.18	-0.05	0.06	0.13	-0.81	-0.41	-0.15	-0.08	-0.16	-0.13	-0.11	-0.11
Age related spending	0.00	-1.43	-1.47	-1.32	-0.14	-2.85	-3.22	-3.49	0.03	-2.14	-2.34	-2.49
- Age pension	0.01	-7.69	-7.30	-6.06	-0.83	-15.26	-15.98	-15.98	0.17	-11.47	-11.61	-11.39
Other expenditures [a]	-0.03	4.64	6.83	10.99	0.90	9.35	14.39	26.60	0.79	8.01	11.38	20.20

Notes: [a] These represent non-age related expenditures that are assumed to balance the budget.

Table 9: Macroeconomic implications of different tax hikes
(Percentage changes in the selected macroeconomic variables from baseline transition)

Variable	(i) Consumption tax				(ii) Progressive income tax				(iii) Payroll tax			
	2015	2030	2050	2100	2015	2030	2050	2100	2015	2030	2050	2100
Labour supply	0.50	0.06	0.13	0.23	1.28	-2.57	-1.82	-1.30	1.52	-1.54	-1.12	-0.17
Domestic assets	0.23	0.84	0.55	0.24	0.45	-1.39	-7.62	-14.21	0.61	1.37	-3.22	-8.99
Output (GDP)	0.31	0.08	0.13	0.23	0.79	-2.33	-1.85	-1.31	0.95	-1.35	-1.12	-0.19
Consumption	-0.51	-2.13	-2.44	-2.76	-0.48	-3.14	-5.30	-8.60	-0.89	-3.30	-4.92	-7.59
Total tax revenues	0.44	4.69	5.48	6.15	0.45	4.80	5.85	7.18	0.46	4.84	5.78	6.92
- Income taxes	0.44	0.37	0.31	0.30	0.48	15.89	19.99	25.94	1.62	-7.23	-9.96	-12.84
- Payroll taxes	0.32	0.08	0.14	0.23	0.72	-2.35	-1.84	-1.31	-5.03	190.84	256.17	332.27
- Consumption taxes	0.63	16.52	18.78	20.45	-0.48	-3.14	-5.30	-8.60	-0.89	-3.30	-4.92	-7.59
Age related spending	-0.02	-0.06	-0.07	-0.03	-0.01	0.09	0.42	1.22	0.01	0.16	0.32	0.91
- Age pension	-0.14	-0.30	-0.34	-0.15	-0.05	0.50	2.10	5.58	0.07	0.88	1.61	4.15
Tax rate [a]	1.15	19.05	21.75	23.87	-0.70	20.04	26.69	35.60	-6.06	212.21	289.29	379.89

Notes: [a] These are changes in (i) consumption tax rate, (ii) average income tax rate or (iii) payroll tax rate to generate the same improvements in non-age related expenditures as under the aggregate pension cut.

Table 10: Macroeconomic implications of pension cuts and tax hikes
(Percentage changes in the selected macroeconomic variables from baseline transition)

Variable	(i) Consumption tax				(ii) Payroll tax			
	2015	2030	2050	2100	2015	2030	2050	2100
Labour supply	1.43	1.83	1.19	1.27	1.36	2.71	0.54	-1.04
Domestic assets	0.72	5.71	8.15	7.38	0.60	8.13	12.32	-2.14
Output (GDP)	0.92	1.79	1.19	1.27	0.89	2.63	0.52	-0.95
Consumption	-0.30	0.20	-1.32	-4.18	0.00	0.72	-1.45	-11.17
Total tax revenues	-1.26	-0.83	3.84	10.41	-1.29	-0.86	3.83	11.03
- Income taxes	1.24	2.35	2.37	1.92	2.86	7.08	0.28	-20.30
- Payroll taxes	1.01	1.77	1.18	1.28	-49.86	-95.78	88.56	523.89
- Consumption taxes	-7.19	-8.06	9.27	32.14	0.00	0.72	-1.45	-11.17
Age related spending	-0.13	-5.71	-6.49	-6.83	-0.18	-5.74	-6.50	-6.08
- Age pension	-0.78	-30.61	-32.25	-31.25	-1.11	-30.80	-32.30	-27.83
Tax rate [a]	0.13	0.13	0.16	0.20	0.01	0.00	0.05	0.19

Notes: [a] This is either (i) the effective consumption tax rate or (ii) the effective payroll tax rate.
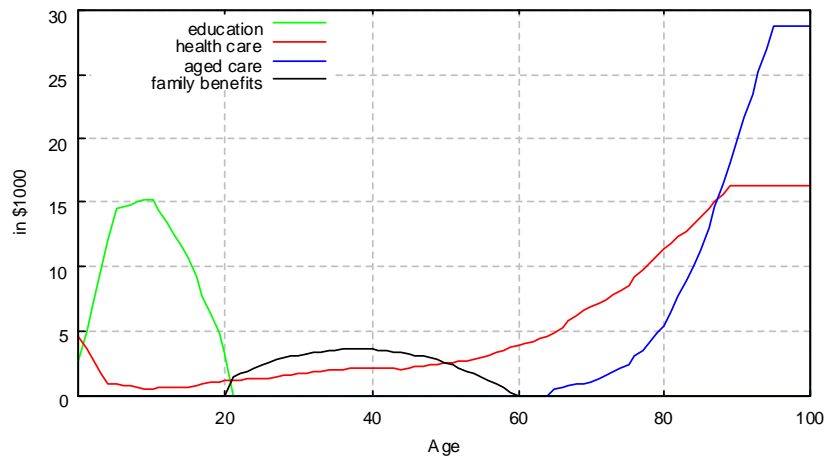
Figures

### Figure 1: Demographic assumptions - Age-specific vital rates
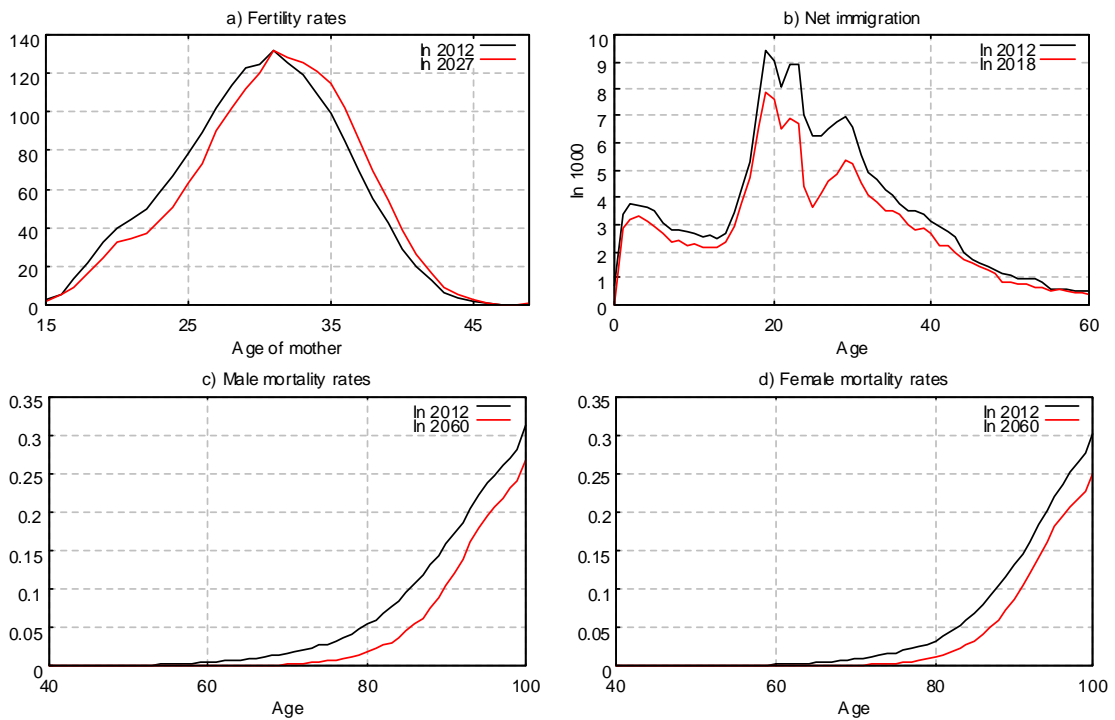
Source: Productivity Commission (2013) - assumptions used in medium demographic projections.

Figure 2: Age-specific average public expenditures

Notes: Health, aged care and education expenditure profiles are taken from Productivity Commission (2013); Family benefits are derived from 2010 HILDA individual data set

Figure 3: Comparison of model-generated and HILDA lifecycle data in 2012
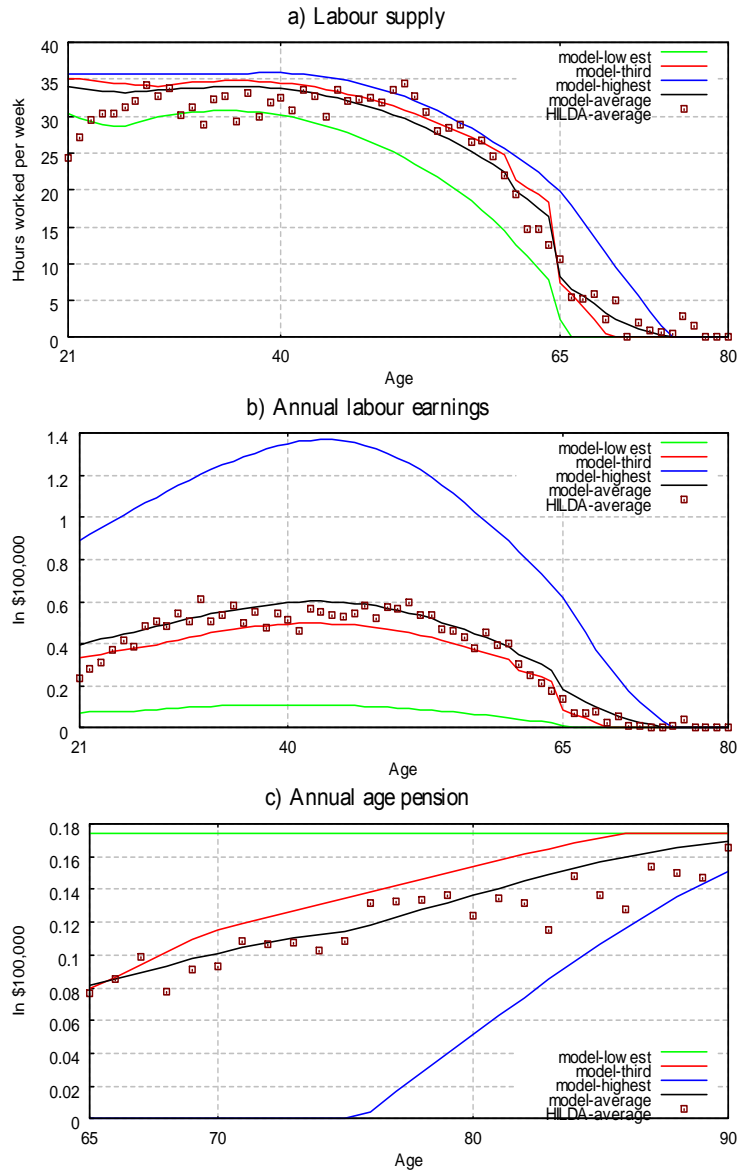
Notes: HILDA profiles are derived from the 2010 individual data set and inflated at an inflation rate of 3 percent to 2012 for labour earnings and age pension.

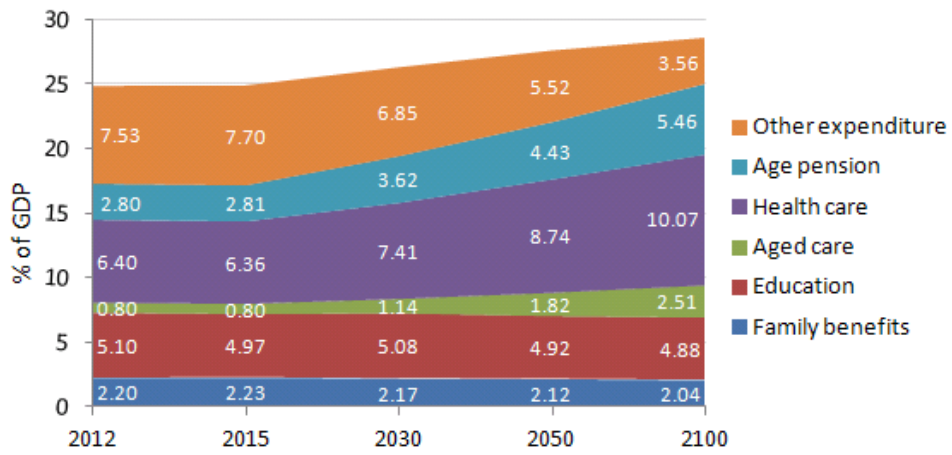Figure 4: Government expenditures during the baseline transition

Figure 5: Distributional welfare effects of aggregate pension cut
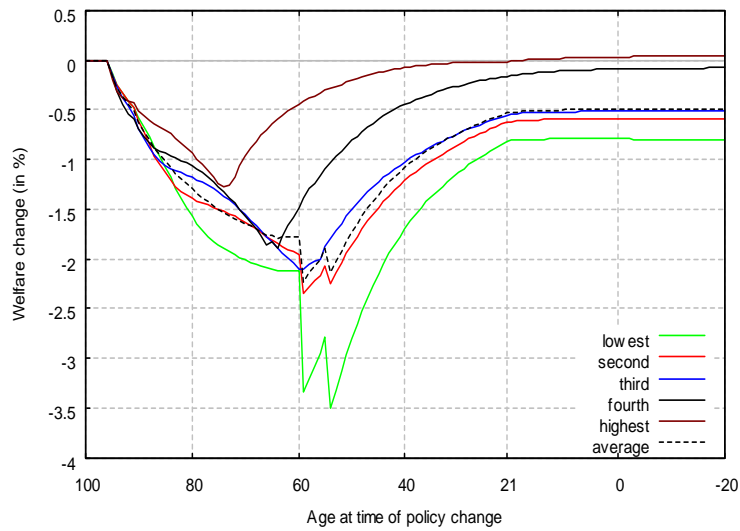(Percentage changes in remaining utility relative to baseline transition)

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Figure 6: Distributional welfare effects of components of aggregate pension cut
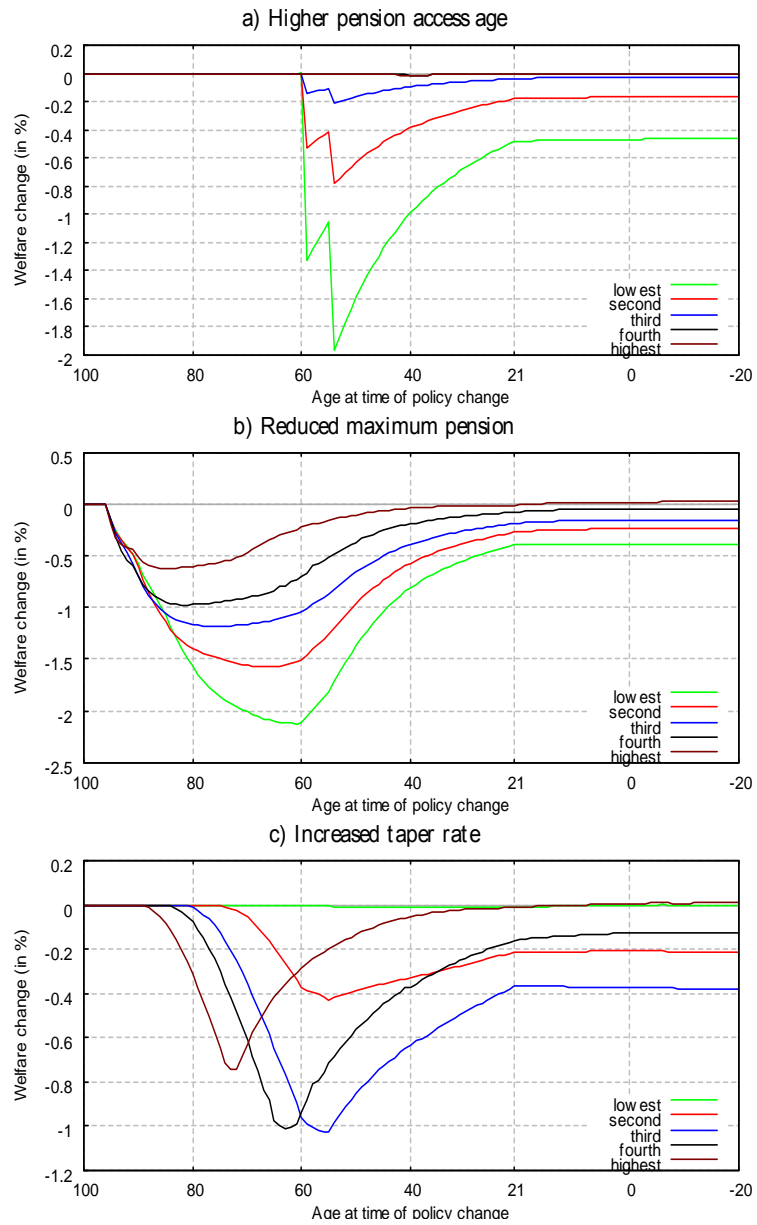(Percentage changes in remaining lifetime utility relative to baseline transition)

Figure 7: Distributional welfare effects of different tax hike policies
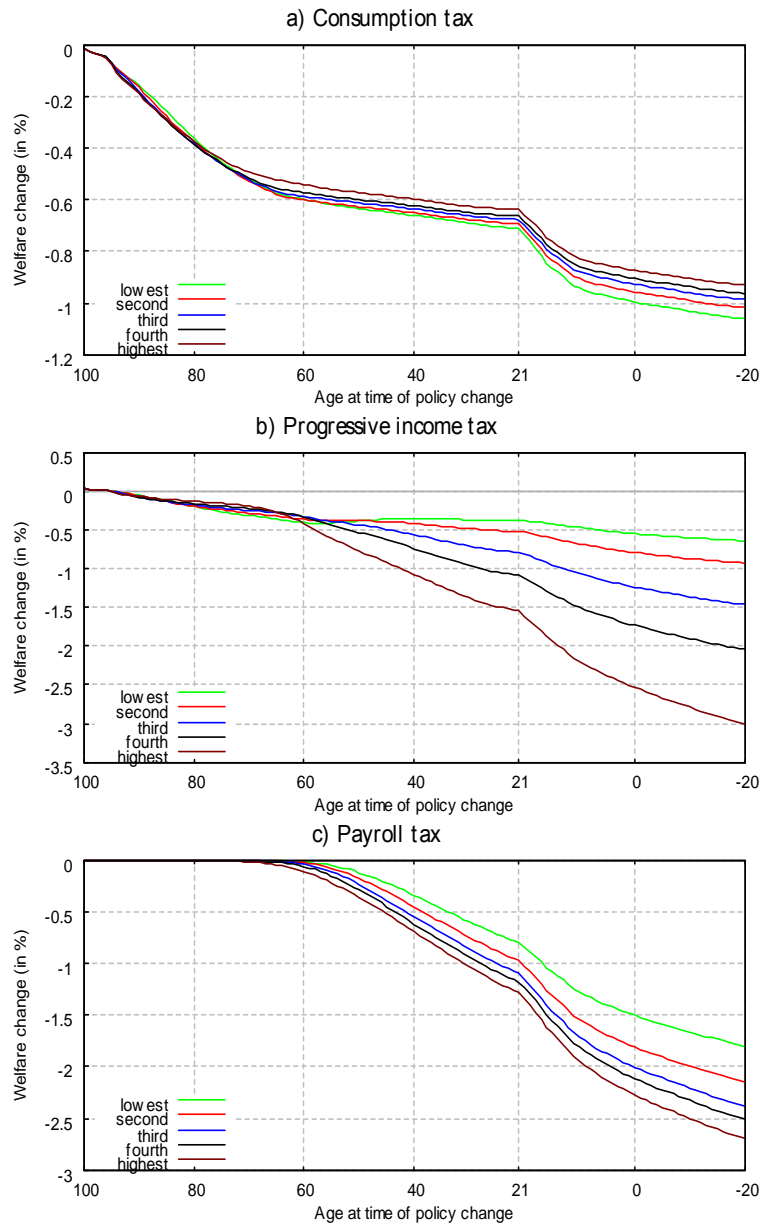(Percentage changes in remaining lifetime utility relative to baseline transition)

Figure 8: Distributional welfare effects of pension cuts and tax hikes
(Percentage changes in remaining lifetime utility relative to baseline transition)

a) Consumption tax

b) Payroll tax