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The Australian Retirement System: Seven Alternatives

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Abstract

For many countries, age pension expenditure will increase dramatically over the next few decades due to a shift in demographics. In the literature, research and solutions have mostly been concerned with separate financing systems, such as pay-as-you-go, means-testing and superannuation. A broad comparison between the systems has received limited attention. This paper examines the cost and economic welfare of these programs using a stochastic overlapping generations model calibrated to the Australian economy. Including the benchmark, eight different models are evaluated. In addition to reducing fiscal burden, analysis indicates that models with an enforced savings component result in increased social welfare as agents accumulate large asset stockpiles allowing them, in aggregate terms, to consume more with a lower labour supply.

Keywords: Social Security, Welfare, Superannuation

JEL Classification: E21, H55

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1 Introduction

Demographic pressures are triggering pension reforms throughout the developed world. In many countries, retirement social security payouts currently run at 10% or more of GDP, and the present value of liabilities adds alarmingly to estimates of the stock of public debt. In addition, mature labour force participation, while rising modestly in some countries, has fallen far short of the participation rates observed half a century ago, in an era when mature age life expectancy was considerably less, and average health status among the mature population considerably lower.

Australian retirement policy has not followed the traditional approach to providing income security in old age, which has entailed setting up a pay-as-you-go (PAYG) social security system to both alleviate poverty and contribute to consumption smoothing between work and retirement. Instead, its policy approach combines a relatively generous flat rate means tested age pension, financed out of general revenue, with a mandatory pre-funded tax-preferred defined contribution superannuation scheme. The structure allows for additional (voluntary) contributions, up to contribution limits.

This has generated far lower fiscal obligations than in most OECD countries, and over the last decade, as it has matured, has been associated with steadily rising mature labour force participation. Policymakers internationally are increasingly seeking information about the Australian structure, which has consistently been seen as one of the world's best retirement policies (Mercer (2014)).

In this paper we study the relative contributions of particular aspects of Australian retirement policy design in generating these outcomes. We use a stochastic overlapping generations (OLG) model calibrated to the Australian economy and public sector to examine a series of alternative economic policy structures, to assess what elements of the policy deliver, or combine to deliver, aggregate economic outcomes and welfare impacts. We proceed by stipulating different combinations of retirement transfer and pre-funded policy elements, and comparing the economic outcomes generated by the model with the calibrated benchmark. In addition to the retirement policy elements already existing in Australia, we construct a typical PAYG policy and compare that with the benchmark as well, to inform comparisons with a broader family of retirement policy structures.

We replicate the current Australian retirement system to evaluate the effect of a retirement system overhaul, and then consider seven alternative programs with respect to their expected cost and impact on aggregate economic variables and social welfare. The alternatives are: (1) a means-tested benefit scheme, (2) a pay-as-you-go (PAYG) system, (3) a PAYG system with mandatory superannuation, (4) no public benefit program, (5) a system with only mandatory superannuation, (6) a means-tested and PAYG benefit program and (7) a means-tested and PAYG benefit program with mandatory superannuation. Under each option individual life-cycle behaviour differs, resulting in starkly different aggregate levels of economic variables.

Our research builds upon and extends several different strands of theoretical and applied literature. A long tradition in the analysis of social security policies extends back to Auerbach and Kotlikoff (1987), demonstrating the intergenerational impacts of social security while pioneering a large scale deterministic OLG model. This multi-period model was highly influential in the field of macroeconomics as it could analyse transitional paths resulting from fiscal reform. Significantly, agents in the Auerbach and Kotlikoff (1987) formulation did not experience idiosyncratic income shocks or stochastic life-spans. Extending the model to incorporate these allowed Imrohoroglu et al. (1995) to demonstrate that with incomplete annuity markets, social security programs provided insurance against longevity risk and income fluctuations, generating the possibility that social welfare may be enhanced under social security. Our model lies firmly in this tradition.

There is a small but growing group of papers focused on the economy-wide modelling of the impacts of means testing. In particular, Kitao (2014) compares a PAYG and means-tested pension benefit programs within the framework of fiscal sustainability in the US. The paper also evaluates a range of social security reform proposals such as increasing retirement age and raising taxes. Notably, the means-tested reform, while a viable budgetary option, produced the strongest labour disincentive, particularly amongst the elderly.

Specific to Australia, Kudrna and Woodland (2011) present similar findings. Using an OLG model they demonstrate that the current Australian means test produces a strong disincentive for older middle and higher income households to work. This means test consists of separate income and assets tests. As the asset test is only binding for high income household, the paper determined that the income test produced the main economic distortions. Conspicuously, the owner occupied house is exempted from the current assets test. Cho and Sane (2013) studied the link between this asset test and its effect on owner-occupied housing. Using a life-cycle model they demonstrated that removing this distortion predictably decreased housing ownership and investment, but also increased social welfare via a large increase in non-housing consumption. While the wealthiest households suffered a welfare loss of 1.17%, the remaining households experience welfare gains between 0.01% and 1.77%.

In the literature, the study of how a mandatory savings system - such as superannuation - affects aggregate economic variables has been limited. This is partly because such a regime exists in only a few countries (including Australia, Singapore and Switzerland). With respect to labour supply, the computational analysis produced by Freebairn (1998) concluded that wages and employment would fall as a result of the policy. Notably, the removal of superannuation from this model did not account for the implicit increased fiscal burden on government expenditure due to higher pension payments.

Recent studies quantifying the effects of means tested pensions on savings, labor supply and welfare in an OLG framework emphasize the impacts of taper rates operating on both labor supply and saving. These models typically impose an exogenous retirement age.

This is unsurprising, since a means tested structure provides more policy flexibility than a demogrant. Kumru and Piggott (2009) also find a welfare gain from introducing means tests in a model calibrated to the UK and find that the optimal taper rate is 100%. Fehr et al. (2008) extend this model to incorporate dynamics, but this does not impact on steady state results. Kudrna and Woodland (2011) analyze the general equilibrium effects of changing taper rates of the Australian pension system in a deterministic overlapping generations model. Tran and Woodland (forthcoming) analsye optimal (linear) means test design, and find that the optimal taper rate depends, *inter alia*, on the level of the maximum benefit.

This paper extends this existing literature in several ways. Importantly, it extends earlier modelling work by endogenising the retirement decision, allowing the impacts of extended working life to be measured, consistent with Australian circumstance. We then sequentially assess a series of alternative policy packages, combining different elements of the Australian system, and occasionally modifying them.

We find the labour supply of older workers is consistently lower under models with a superannuation specification, due to large stockpiles of accumulated wealth. This led to lower aggregate levels of labour, but higher aggregate consumption as agents are better able to consumption smooth over their life-cycle due to more optimal intertemporal decision-making. As such, the mandatory savings schemes were found to be welfare enhancing over their counterparts without mandatory savings. Additionally, these programs are less fiscally demanding than their respective counterparts.

The remainder of this paper is organized as follows. Section 2 outlines the model economy, while section 3 outlines calibration methodology, and shows the fit of the model to the data. In section 4 we present and interpret our findings.

2 Model Specification

This paper extends the closed economy general equilibrium OLG model utilized by Huggett and Parra (2010) and Kumru and Piggott (2009). It has been calibrated to the Australian economy and features heterogeneous individuals, a public sector and a private sector.

Demographics and Endowments

The model economy is populated overlapping generations of individuals. In every period t, a new generation of agents is born.[1] The population grows at the constant rate n. Individuals live a maximum of J periods and retire by age j^R. All agents face a probability p_j of surviving up to age j that is conditional on surviving until age $j-1$. Demographic patters are stable such that agents aged j represent a constant share of population μ:

$$\mu_j = \frac{\mu_{j-1} p_j}{1+n} \quad \text{where} \quad \sum_{j=1}^{J} \mu_j = 1 \tag{1}$$

In a given period, an individual's productivity is dependent on their age j and an idiosyncratic productivity shock, e_j. The functional form $\epsilon_j e_j$, is used where $\epsilon_j \in \epsilon$, the set of age-dependent mean efficiency profiles. This paper considers a permanent shock case in which an individual experiences a shock at birth that endures over their lifetime. Consequently, there

[1] As this paper is primarily interested in the equilibrium steady state values, time subscripts will henceforth be dropped for the rest of the analysis.

is uncertainty over individual labour endowments. However, as shocks are independently distributed, there is no uncertainty over the aggregate labour endowment. The shocks are assumed to be log-normally distributed, $log(e_j) \sim N(\mu, \sigma^2)$ and approximated by five evenly spaced log discrete values along the interval: $[\frac{-\sigma^2}{2} - 3\sigma, \frac{-\sigma^2}{2} + 3\sigma]$. Probabilities are found via calculation of the area under the normal distribution, conditional over e_j.

Preferences

All agents have identical preferences over consumption and leisure, represented by the following utility function:

$$E\left[\sum_{j=1}^{J} \beta^j \Big(\prod_{i=1}^{j} p_i\Big) u(c_j, 1-l_j)\right], \tag{2}$$

where β is the time-discounting factor. Individuals are endowed with one unit of labour each period. At age j, individuals choose labour l_j and consumption c_j. Individuals can also choose to work up until age j^R, when it is assumed that they retire fully from the labour force. The period utility function $u(c_j, 1-l_j)$, is defined as:

$$u(c, 1-l) = \frac{c^{1-\rho}}{1-\rho} + \kappa\frac{(1-\varphi)^{1-\varphi}}{1-\varphi} \quad \text{where} \quad \rho \in (0, +\infty) \tag{3}$$

The parameter ρ represents relative risk aversion and κ determines an individual's aversion for work relative to their value for consuming. The parameter φ determines the Frisch elasticity of labour supply, while the intertemporal elasticity of consumption is $\frac{1}{\rho}$. Following King et al. (2002), the utility function is compatible with the balanced growth path if $\rho = 1$. Hence the utility function collapses into $u(c, 1-l) = log(c) + \kappa\frac{(1-l)^{1-\varphi}}{1-\varphi}$ so the log period utility function can be used.

Technology

The production technology of the economy is represented using a Cobb-Douglas production function with constant returns to scale:

$$Y = AK^{\alpha}L^{1-\alpha} \tag{4}$$

Here, Y is output produced using capital K, labour L and technology A. Technology is exogenously determined, growing at a constant rate g. Capital's share of output is $\alpha \in (0, 1)$ and the aggregate capital stock is assumed to depreciate at a constant rate, $\delta \in (1, 0)$. The rental rate r and the wage rate w are exogenously determined.

Retirement policy

The means-tested public pension program is run by the government. To receive a pension, individuals must be over the age of j^* and satisfy a means test comprised of separate asset and income tests. Only the binding test applies so the resulting payment to individuals is equal to the age pension amount the results in the lower pension. That is, the age pension b_j, received by individuals is expressed as:

$$b_j = \begin{cases} min(b_j^i, b_j^a) & \text{if} \quad j \geq j^* \\ 0 & \text{if} \quad j < j^* \end{cases} \tag{5}$$

Under the income test, an eligible individual receives the maximum pension benefit, m, provided that their assessable income, y_j is less than the income threshold, IT. They receive no pension benefit if y_j is greater than the maximum income threshold, IT_{max}. For every additional dollar in between these thresholds, the pension benefit received is reduced at the income taper rate θ_1. The age pension paid under this test is:

$$b_j^i = \begin{cases} m \quad \text{if} \quad y_j \leq IT \\ min(m, m - \theta_1(y_j - IT) \quad \text{if} \quad j \geq j^* \text{ and } IT < y_j < IT_{max} \\ 0 \quad \text{if} \quad j > j^* \text{ and } y_j \geq IT_{max} \\ 0 \quad \text{if} \quad j < j^* \end{cases}$$

Assessable income is comprised of an individual's effective wage at age $j, \epsilon_j e_j w$ and investment income ra_j, where a_j is the individual's private savings and r_s is the mandatory superannuation contribution rate.

$$y_j = (1 - r_s)\epsilon_j e_j w + ra_j \tag{6}$$

For the assets test, an eligible individual receives the maximum pension benefit, m, provided that their private asset stock a_j is less than the asset threshold, AT. They receive no pension benefit if a_j is greater than the maximum asset threshold, AT_{max}. For each dollar in between these thresholds, the pension benefit received is reduced at the asset taper rate θ_2. The age pension paid under this test is determined as:

$$b_j^a = \begin{cases} m \quad \text{if} \quad a_j \leq AT \\ min(m, m - \theta_2(a_j - AT) \quad \text{if} \quad j \geq j^* \text{ and } AT < a_j < AT_{max} \\ 0 \quad \text{if} \quad j > j^* \text{ and } a_j \geq AT_{max} \\ 0 \quad \text{if} \quad j < j^* \end{cases}$$

For this model specification, mandatory superannuation contributions are paid by the representative employers on behalf of employees until j^S. Contributions are taxed at rate τ_s and are taken from gross employee earnings $\epsilon_j e_j w$ before being added to the stock of superannuation assets, s_j. This earns investment income at the after-tax interest rate $(1 - \tau_a)r$. Individuals are assumed to hold their superannuation assets in the fund until age 60, whereupon their superannuation is absorbed into their private savings a_j as a lump-sum[2] and superannuation accumulation ceases. This is reflected as follows:

$$s_j = \begin{cases} (1 - \tau_s)r_s\epsilon_j e_j w + 1 + (1 - \tau_a)rs_{j-1} \quad \text{if} \quad j < j^S \\ 0 \quad \text{if} \quad j \geq j^S \end{cases} \tag{7}$$

[2]While recent empirical work from Rothman and Wang (2013) suggest an increasing trend towards a superannuation income stream, this paper follows Kudrna and Woodland (2011) and assumes that superannuation is only taken as a lump-sum.

For individuals aged over 60, it is assumed that mandatory superannuation contributions are paid out directly as part of their labour income. These contributions are still taxed at the concessionary rate and are not counted as accessible income.

Taxation

To isolate any budgetary implications, the age pension is assumed to be financed through a payroll tax on labour earnings τ_p, independent from the general budget. To finance its consumption expenditure, the government collects income, superannuation and consumption taxes and confiscates any accidental bequests. Australia has a progressive income tax system with five different bands and rates. Average income tax rates are approximated by a quadratic function $\tau_i(y_j)$ that passes through the origin.

An Individual's Decision Problem

To summarize, accessible income for an individual at age j is as followed:

$$y_j = \begin{cases} (1-r_s)\epsilon_j e_j w + ra_j & \text{if} \quad j < j^S \\ (1-r_s)\epsilon_j e_j w + ra_j + s_j & \text{if} \quad j = j^S \\ (1-r_s)\epsilon_j e_j w + ra_j & \text{if} \quad j^S < j < j^* \\ (1-r_s)\epsilon_j e_j w + ra_j + b_j & \text{if} \quad j^* \leq j \leq j^R \\ ra_j + b_j & \text{if} \quad j > j^R \end{cases}$$

Consequently, the individual's growth adjusted budget-constraint can be expressed as:

$$\begin{cases} c_j + (1+g)a_{j+1} \leq (1+g)a_j + (1 - r_s - \tau_p)l_j\epsilon_j e_j w - \tau_i(y_i) & \text{if} \quad j < j^S \\ c_j + (1+g)a_{j+1} \leq (1+g)a_j + (1 - \tau_p)l_j\epsilon_j e_j w + s_j - \tau_i(y_i) & \text{if} \quad j = j^S \\ c_j + (1+g)a_{j+1} \leq (1+g)a_j + (1 - \tau_p)l_j\epsilon_j e_j w - \tau_i(y_i) & \text{if} \quad j^S < j < j^* \\ c_j + (1+g)a_{j+1} \leq (1+g)a_j + (1 - \tau_p)l_j\epsilon_j e_j w + b_j - \tau_i(y_i) & \text{if} \quad j^* \leq j \leq j^R \\ c_j + (1+g)a_{j+1} \leq (1+g)a_j + b_j - \tau_i(y_i) & \text{if} \quad j^R \leq j \leq J \\ c_j \leq (1+g)a_j + b_j - \tau_i(y_i) & \text{if} \quad j = J \end{cases} \tag{8}$$

It is assumed that individuals can never borrow against their future income:

$$a_j \geq 0, \forall j \tag{9}$$

In this model economy, an agent's decision problem can be expressed as a dynamic programming problem. The individual state space is represented as X and x denotes state space vector of the form (a, v), where $x \in X$ and x' denotes the next period's state vector. If the value function of the individual at age j is denoted as V_j, then the decision problem can be written as:

$$V_j(x) = \max_{c_j, l_j} \{u(c_j, 1 - l_j) +_{j+1} EV_{j+1}(x')\} \tag{10}$$

subject to Equations (8) and (9).

Equilibrium

The equilibrium definition follows from Auerbach and Kotlikoff (1987), Imrohoroglu et al. (1995), Huggett and Ventura (1999), Imrohoroglu et al. (2003) and Kumru and Piggott (2009). The pension system is assumed to be self-financing with the pension tax rate τ_p and the consumption tax rate τ_c, endogenously determined such that government's budget balances.

Given the set of exogenous government policy variables $\{\tau_i(.), \theta_1, \theta_2, IT, AT, r_s, \tau_s, \tau_a\}$, a stationary equilibrium consists of agents' decision rules $\{c_j(.), a_j(.), l_j(.)\}_{(j=1)}^{J}$, exogenous factor prices $\{w, r\}$, pension, superannuation and consumption tax rates, $\{\tau_p, \tau_s \quad and \quad \tau_c\}$, a set of value functions, $\{V_j(a_j, e_j)\}_{(j=1)}^{J}$ and age dependent distributions of individuals $\bigwedge_j(x)$ that they must satisfy the following conditions:

1. Given fiscal policy and prices, individuals' decision rules $\{c_j(.), a_j(.), l_j(.)\}_{(j=1)}^{J}$, solve individuals' decision problem (10), subject to equations (8) and (9).

2. The distribution of agents across states is stationary, that is: $\bigwedge_{j+1}(x) = \sum_v \prod(e_{j+1}, e_j) \int\limits_X d\bigwedge_j$ where $\prod(e_{j+1}, e_j)$ is the transition matrix for the shocks and $\bigwedge_1(x)$ is given.

3. Aggregate variables are derived from individual behaviour:

$$K = \sum_{j=1}^{J} \mu_j \int\limits_X a(x) d\bigwedge_j$$
$$L = \sum_{j=1}^{J} \mu_j \int\limits_X l_j(x) d\bigwedge_j$$
$$C = \sum_{j=1}^{J} \mu_j \int\limits_X c_j(x) d\bigwedge_j$$

4. Total income and superannuation tax revenue equals:

$$T_i = \sum_{j=1}^{J} \mu_j \int\limits_X \tau_i(y_i(x)) d\bigwedge_j$$
$$T_i = \sum_{j=1}^{j^S} \mu_j \int\limits_X (\tau_s r_s \epsilon_j e_j w(x) + \tau_a r s_{j-1}(x)) d\bigwedge_j$$

5. The social security system is self-financing:

$$\tau_s = \frac{\sum_{j=j*}^{J} \mu_j \int\limits_X b_j(x) d\bigwedge_j}{\sum_{j=1}^{j*-1} \mu_j \int\limits_X l_j \epsilon_j e_j w(x) d\bigwedge_j}$$

6. The total sum of bequests is equal to the amount of assets left by the deceased:

$$\omega = \sum_{j=1}^{J} \mu_j \int_X (1 - e_{j+1}(x)) d \bigwedge_j$$

7. The government runs a balanced budget:

$$G = \tau_c C + T_i + T_s + \omega$$

8. The goods market clears:

$$C + (1+g)(1+n)K + G = Y + (1-\delta)K$$

3 Model Calibration

The model is calibrated to the Australian economy where one model period corresponds to one year. It is a partial equilibrium model with an exogenous real interest rate r. All demographic, policy and tax variables have been determined from the 2010-11 financial year. Key parameters are summarized in Table 1.

Demographics and endowments

The model features stationary demographics where individuals are born at the real-time age of 21 (model age of 1). Agents may work until the real age of 75 and have a maximum life expectancy of 85. The growth of new entrants to the model n, is equal to the long-run average population growth rate of Australia, 1.2%. The conditional survival probabilities $p_j$have been taken from the Australian 2010-2012 life tables for males (ABS (2013)).

The age-dependent efficiency index ϵ, follows Tran and Woodland (2011) estimates of age-dependent hourly wages. This is based on HILDA data, using the hourly average wage as a proxy of work ability. The estimates were normalised relative to age 40 and have been interpolated using the spline method for missing data. The variance of the permanent shock to income is chosen to match the Gini coefficient for earnings, 0.34.

Preferences and technology

The coefficient φ governs the Frisch elasticity of labour (i.e. $\varepsilon_{labour} = \frac{1}{\varphi}\frac{1-l}{l}$). Following Huggett and Parra (2010), the leisure parameter is set to 0.4. Buddelmyer et al. (2007) calculate labour elasticity across different categories of men and women. This paper takes the average of all categories bar lone parents to estimate the Frisch elasticity of labour.

Following Heathcote et al. (2008), the parameter of κ is set to 1 without loss of generality. To ensure there is no artificial welfare gain due to the choice of time discount factor β , this paper follows Auerbach and Kotlikoff (1987) and Hubbard and Judd (1987) and sets $\beta < 1$. The value of β is calculated using the long-run average Australian Treasury bond interest rate as a proxy for the risk-free interest rate, r. Labour's share of income is set at 0.6, following from Tran and Woodland (2011).

The public sector Government expenditure as a percentage of GDP is estimated as its long-run average. Income tax rates are approximated using the following quadratic function:

$$\tau_i = 0.3516425\frac{y_j(x)}{1000} - 0.0104018(\frac{y_j(x)}{1000})^2 \tag{11}$$

Means-tested age pension An individual's access to the age pension is dependent on their age, income level and assets. The current pension access age is 65 which is planned to gradually increase to 67 by 2023. The maximum age pension benefit is benchmarked to the greater of CPI or 27.7% of average weekly male earnings and is paid to individuals with income and assets under the defined thresholds. Under the income test, the benefit is reduced by 50 cents for every additional dollar of accessible income above the income threshold until reaching zero. Similarly, under the asset test, the pension benefit is reduced by $1.50 for every $1,000 of accessible assets over the asset threshold until reaching zero. While a higher threshold level is used for non-homeowners, the owner occupied home itself is exempt from the test. As this model does not include housing, the higher asset threshold is used. While age pension expenditure in Australia is funded from current taxation revenue, this model uses specifc payroll tax τ_p in order to more effectively estimate policy costs.

Superannuation The superannuation guarantee was introduced in 1992 as part of a major reform package of the Australian retirement system. It is a privately managed and fully funded system requiring employers to pay a legislated percentage of an employee's gross income into the employee's superannuation fund. Initially, the mandatory contribution level was 3% of gross earnings and was intended to increase to 15% over time. In 2014, the contribution rate increased from 9% to 9.5%. The contribution is taxed at a flat rate, with additional, voluntary contributions taxed at a concessionary rate. Note that in the model it is assumed that individuals do not make additional contributions. Investment income is also taxed at a flat rate. Once the employee reached the required statutory age, superannuation could be withdrawn tax-free as a lump sum or income stream. Depending on how the superannuation fund is accessed, it could count as either an asset or income under the means-tested age pension.

Table 1: Parameters

Parameters	Observation / Comment / Source
Demographics	
Initial age j	21 (model age 1)
Maximum age J	85(model age 65)
Obligatory retirement age j^R	75 (model age 55)
Annual Population Growth n	1.2%
Conditional survival probabilities $\{p_j\}_{(j=1)}^{J}$	ABS(2013)
Age efficiency profile $\{\epsilon_j\}_{(j=1)}^{J}$	Tran and Woodland (2011)
Variance of employment shock σ^2	0.32
Markov transition matrix for skills	$\begin{bmatrix} 0.1704 & 0.3296 & 0.3296 & 0.1704 \\ 0.1704 & 0.3296 & 0.3296 & 0.1704 \\ 0.1704 & 0.3296 & 0.3296 & 0.1704 \\ 0.1704 & 0.3296 & 0.3296 & 0.1704 \end{bmatrix}$
Preferences and technology	
Annual discount factor of utility β	0.9511
Frisch elasticity of labour supply φ	4.29
Labour share of income $(1-\alpha)$	0.6
Technology A	1
Interest rate r	5.14%
Public sector 2010-11	
Government expenditure G	24% of GDP
Income tax rate $\tau_i(y_j)$	Estimated by a quadratic function
Maximum pension benefit m	\$17,367 per year
Age pension eligibility age $j*$	65 (model age of 45)
Income threshold IT	\$3,796 per year
Maximum income threshold $ITmax$	\$41,146 per year
Income taper rate θ_1	50%
Asset threshold AT	\$313,250
Maximum asset threshold AT_{max}	\$790,750
Asset taper rate θ_2	0.15%
Superannuation eligibility age j^S	60 (model age of 40)
Contribution rate r_s	9%
Tax rate for contributions τ_s	15%
Tax rate for investment income τ_a	15%

*Note: policy parameters are determined from the 2010-11 financial year.

The solution procedure is outlined in Appendix A.

4 Results

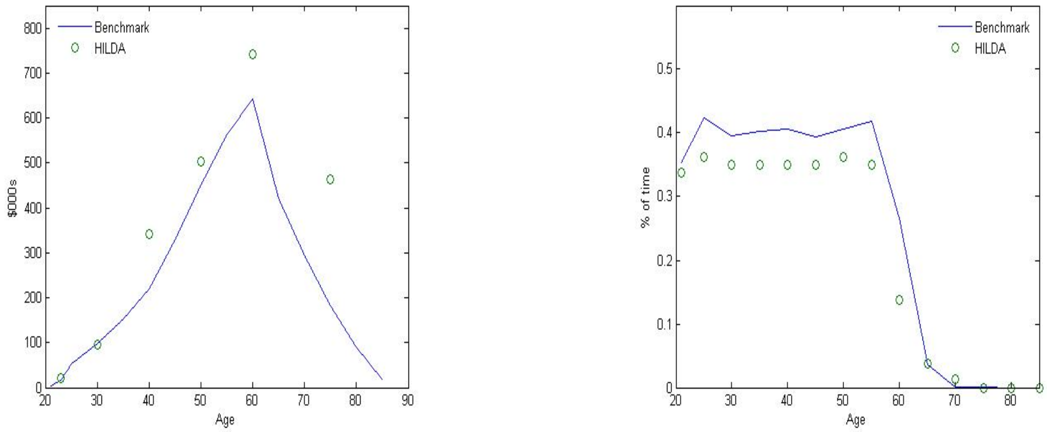
In this section the results of the benchmark economy are presented, focusing on the aggregate life-cycle profile of individual decision variables. Then, the seven alternative social security systems are presented and discussed in comparison to the benchmark. Finally, the welfare implications of the different systems are discussed. Notably, in order to properly compare these different systems, the overall tax burden has been set as a constant for each system. This constant tax burden is equal to the benchmark economy's 9% superannuation rate plus the payroll tax that results in the 27.7% maximum means-tested pension benefit. These results are summarised in Table 2. The superannuation contribution rate, PAYG social security tax, means-tested payroll tax and the total taxation burden are denoted as r_s, tau_p, tau_o and $total$, respectively. Given the constant tax burden, the maximum pension benefit (m) for options 1, 6 and 7 are different to the benchmark. A sensitivity analysis is outlined in Appendix B.

Table 2: Overview of taxation burden

	Benchmark	Opt.1 Means-test	Opt.2 PAYG	Opt.3 PAYG w/ super	Opt.4 No pension	Opt.5 Super	Opt.6 Means-test w/ PAYG	Opt.7 All
total	28.7	28.7	28.7	28.7	-	28.7	28.7	28.7
super	9.0	-	-	14.3	-	28.7	-	9.6
PAYG	-	-	28.7	14.3	-	-	14.3	9.6
means-test	19.7	28.7	-	-	-	-	28.6	25.6
benefit	27.7	46.6	-	-	-	-	14.4	9.6

4.1 Benchmark model

Figure 1a shows the total asset accumulation of individuals along the life-cycle in the benchmark model. This includes mandatory superannuation savings and private savings. This broadly matches the data drawn from the HILDA panel set, displaying the same lump-



(a) Total asset comparison

(b) Labour supply comparison

Figure 1: Benchmark results compared to HILDA data

shaped pattern of asset holdings, peaking around age 60. As the model does not include housing, the HILDA data has been adjusted to remove the owner occupied house from the total asset calculation. However, Harris and Webster (2002) report that one of the main determinants of savings behaviour for households aged 18 to 44 is to buy or improve a house. Individuals in the benchmark economy lack this motivation hence accumulate assets at a slower rate than the observed data. Individuals also divest their assets faster than the observed data due to a lack of savings incentives such as bequest motives and healthcare expenditure shocks.[3]

The profile of work hours in the benchmark economy is presented in Figure 1b, reported as a fraction of disposable time. Compared to the data, individuals undertake relatively more hours of at early stages of the life cycle. The reason for this is twofold. First, the model does not include a bequest motive. Accordingly, agents are born without assets so there is no corresponding wealth effect on labour. Therefore individuals optimally choose to work in order to maintain consumption. Furthermore, the model excludes the time spent on human capital investment undertaken by many agents early in their life-cycle. Incorporating these

[3]Reported by De Nardi and Jones (2010) to be the main savings motivation for the elderly.

aspects would likely improve the fit. Otherwise, the hours of labour supply are analogous to the data, lying fairly flat before steeply decreasing after age 55.

The life-cycle consumption behaviour of the benchmark economy illustrates the expected consumption-smoothing behaviour by individuals. However at age 60 when agents can access their superannuation as a lump-sum there is a corresponding spike in consumption. This follows from empirical evidence such as Rothman and Wang (2013), that demonstrates that around 50% of retirees who access superannuation as a lump sum use it to finance current consumption or pay off debt. The aformentioned lack of savings incentives also explains this spike.

4.2 Policy results

In this section, the eight different social security systems, including the benchmark model, are evaluated according to their aggregate impacts. A life-cycle comparison of aggregate variables is presented in Table 3. In order to facilitate comparison, the benchmark economy is used as baseline with results normalised to 100 - except for the labour supply change, which is expressed as the difference in hours worked per week. Private savings are defined as savings outside of superannuation, while total assets include mandatory superannuation accumulation. That is, private savings are equal to total savings under options 1, 2 and 4. Total pension benefits are defined as the amount of money individuals receive from the social security system, that is a means-tested benefit, PAYG annuity, or both. Also presented is the mandatory superannuation accumulated by agents and their consumption.

Table 3: Life-cycle results

Age	Bench-mark	Opt.1 Means-test	Opt.2 PAYG	Opt.3 PAYG w/ super	Opt.4 No pension	Opt.5 Super	Opt.6 Means-test w/ PAYG	Opt.7 All
labour								
25	0.00	13.15	0.81	0.00	-1.98	1.26	0.26	0.27
35	0.00	0.30	0.49	0.17	-1.37	1.26	0.20	0.20
45	0.00	0.57	1.25	0.16	8.41	1.38	11.19	0.14
55	0.00	1.22	2.21	0.77	-0.12	2.08	1.42	0.08
65	0.00	10.26	21.98	0.19	26.30	0.63	1.15	2.95
70	0.00	13.12	20.57	0.31	23.30	1.06	1.90	1.12
consumption								
25	100.00	102.78	95.69	113.11	152.21	72.18	106.49	106.66
35	100.00	95.20	107.28	107.52	142.97	118.97	105.34	104.31
45	100.00	97.30	106.77	117.30	137.76	125.79	107.29	109.41
55	100.00	90.45	96.72	102.78	108.01	102.05	96.38	107.42
65	100.00	68.49	65.90	128.59	63.83	138.62	69.02	117.43
75	100.00	78.14	70.16	132.27	75.56	160.95	81.18	118.42
private savings								
25	100.00	75.13	110.50	74.95	54.86	2.21	112.79	104.61
35	100.00	139.97	219.36	103.46	186.37	66.12	197.89	115.35
45	100.00	112.83	161.60	69.22	240.45	36.13	129.50	84.52
55	100.00	172.99	243.72	73.69	577.60	58.15	227.36	89.51
superannuation								
25	100.00	-	-	166.48	-	294.78	-	107.87
35	100.00	-	-	164.44	-	325.12	-	107.76
45	100.00	-	-	162.03	-	321.14	-	106.47
55	100.00	-	-	162.25	-	322.25	-	106.64
60	100.00	-	-	161.90	-	320.74	-	106.67
total assets								
25	100.00	29.53	43.43	130.50	21.56	179.79	44.33	106.58
35	100.00	18.45	28.91	156.40	24.56	290.98	26.08	108.76
45	100.00	15.17	21.72	149.55	32.32	282.82	17.41	103.52
55	100.00	16.91	23.83	153.59	56.47	296.43	22.23	104.96
65	100.00	4.80	13.25	132.00	87.15	225.11	7.50	92.82
75	100.00	3.92	14.40	144.90	130.23	285.63	5.61	83.15
total pension benefits								
65	100.00	289.33	290.40	298.61	-	-	350.94	306.51
70	100.00	236.60	212.32	216.06	-	-	269.39	232.31
75	100.00	197.99	165.40	167.78	-	-	216.09	190.82
80	100.00	174.68	144.36	146.42	-	-	190.39	175.43

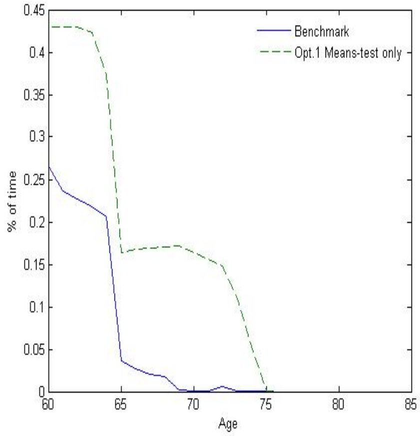
Table 4 shows the economic aggregates normalised to 100 in relation to the benchmark. This includes labour (L), consumption (C) and total assets (TA). It also presents aggregate variables relating to the expenditure of the different models. That is, consumption (τ_c) tax (presented as the actual taxation amount) and the expected present value cost ($EPVC$) of the pension program, with respect to the benchmark.

Table 4: Aggregate results

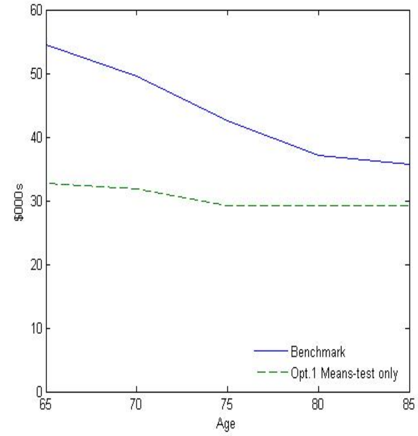
	Benchmark	Opt.1 Means-test	Opt.2 PAYG	Opt.3 PAYG w/ super	Opt.4 No pension	Opt.5 Super	Opt.6 Means-test w/ PAYG	Opt.7 All
L	100.00	113.21	117.39	98.29	110.39	96.00	108.89	99.83
C	100.00	82.94	90.68	121.37	109.89	148.54	86.55	107.82
TA	100.00	42.55	70.42	122.44	166.68	187.58	57.55	92.75
$\tau_c(\%)$	10.82	39.86	27.97	-1.94	-6.14	-23.03	31.52	11.49
$EPVC$	100.00	150.04	129.66	53.60	-	-	134.22	81.09

Option 1. Means testing without mandatory superannuation: This model uses the same asset and income taper rates and thresholds as the benchmark model, but forgoes the compulsory savings. Note that the superannuation taxation incentives are not kept. That is, wage income, defined as $y_j^{gr} = \epsilon_j e_j w$, is now equal to assessable income. The total social security taxation burden is assigned to the payroll tax resulting in a maximum pension benefit of 46.6%. The aggregate life-cycle results are compared with the benchmark in figure 2 with respect to labour, consumption, total assets and total benefit payments.

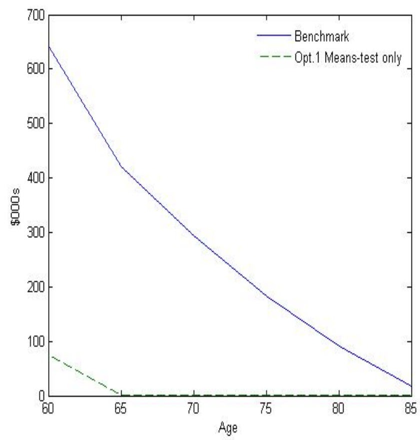
Table 3 and Figure 2b show that benchmark agents consume strictly more than their option 1 counterparts throughout most stages of their life-cycle. Similarly, between ages 45 to 60, agents in the benchmark and option 1 supply similar hours of labour per week. Consequently, the consumption difference is due to option 1 agents rapidly increasing their private savings by decreasing current consumption in order to fund a higher retirement income stream. However, due to the effects of compounding, agents in the benchmark generate



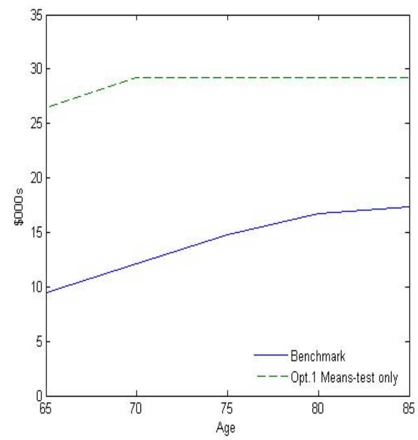
(a) Labour



(b) Consumption



(c) Total assets



(d) Total benefits

Figure 2: Comparison between the benchmark and option 1

a much higher total asset stockpile and are able to work less and consume more in retirement, despite receiving fewer benefit payments.

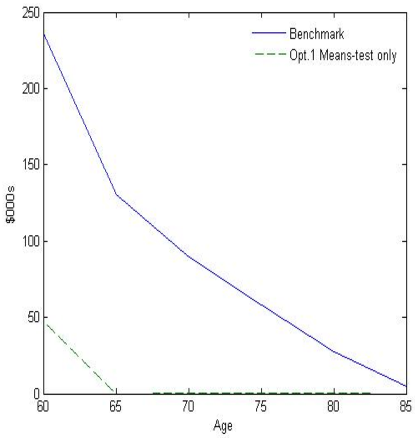
Note that for benchmark agents aged 59 to 60, Figure 2a demonstrates that their labour supply sharply declines as they receive their superannuation lump sum. Their labour supply then stabilises before sharply declining again between ages 64 and 65, as agents attempt to qualify for the means-tested age pension by reducing their income. While the labour supply disincentive is echoed for option 1 agents, the first decline at age 60 is not.

The reasoning behind the first decline is twofold. First, Figure 2d and Table 3 present that agents in the benchmark have much higher total asset stockpiles compared to option 1 agents. As such, on an aggregate level, the decrease in labour supply represents a preference for leisure. However, for lower-skilled agents, the decline also reflects the negative work incentives resulting from the means-tested pension program. In order to maximise their benefit, their labour supply decrease is steeper than their higher-skilled counterparts (as shown in Figures 3c and 3d) and they draw down relatively more assets than their higher-skilled option 1 counterparts (as shown in Figures 3a and 3b). As the overall fall in labour supply is much larger under the benchmark, the mandatory superannuation is shown to exacerbate the existing means-test labour supply disincentives.

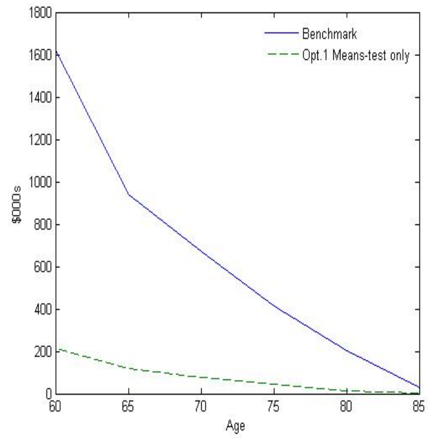
In spite of this, mandatory superannuation does prevent agents in the benchmark economy from claiming the maximum means-tested pension benefit until very late in life, as shown in Figure 2d. As such, Table 4 shows that the cost of the benchmark program is about two-thirds that of option 1.

Option 2. PAYG pension program: Under this option, the means-tested pension benefit is abolished and replaced with a stylised PAYG model. As per option 1, the superannuation taxation specification is excluded under this model. The earnings-dependant social security system, denoted as $T_j^1(y_j^1, y_j^{gr})$, is similar to the current US model. As such, an agent's labour income y_j^{gr}, is taxed proportionally up to a maximum level, y_{max}. The social security tax rate, τ_o is set equal to 28.7% during computations as per table 2. Received benefits $b(y^1)$, are a fixed function of the accounting variable y^1, which is an equally weighted average of past earnings prior to $j*$. The post-retirement y^1 remains equal to its retirement value.

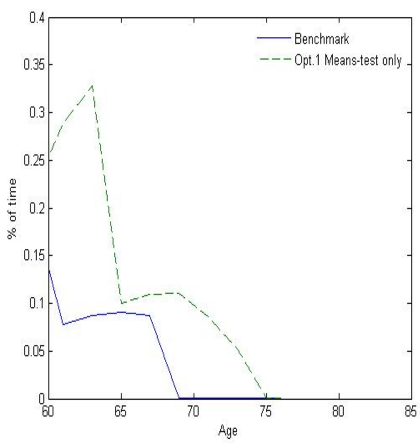
$$y_{j+1}^1 = \frac{min(y_j^{gr}, y_{max}) + (j-1)y_j^1}{j}$$



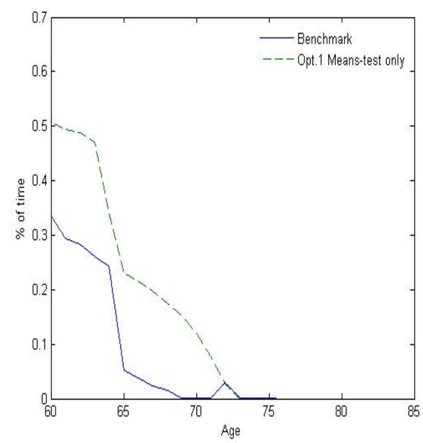
(a) Low-skilled workers



(b) High-skilled workers



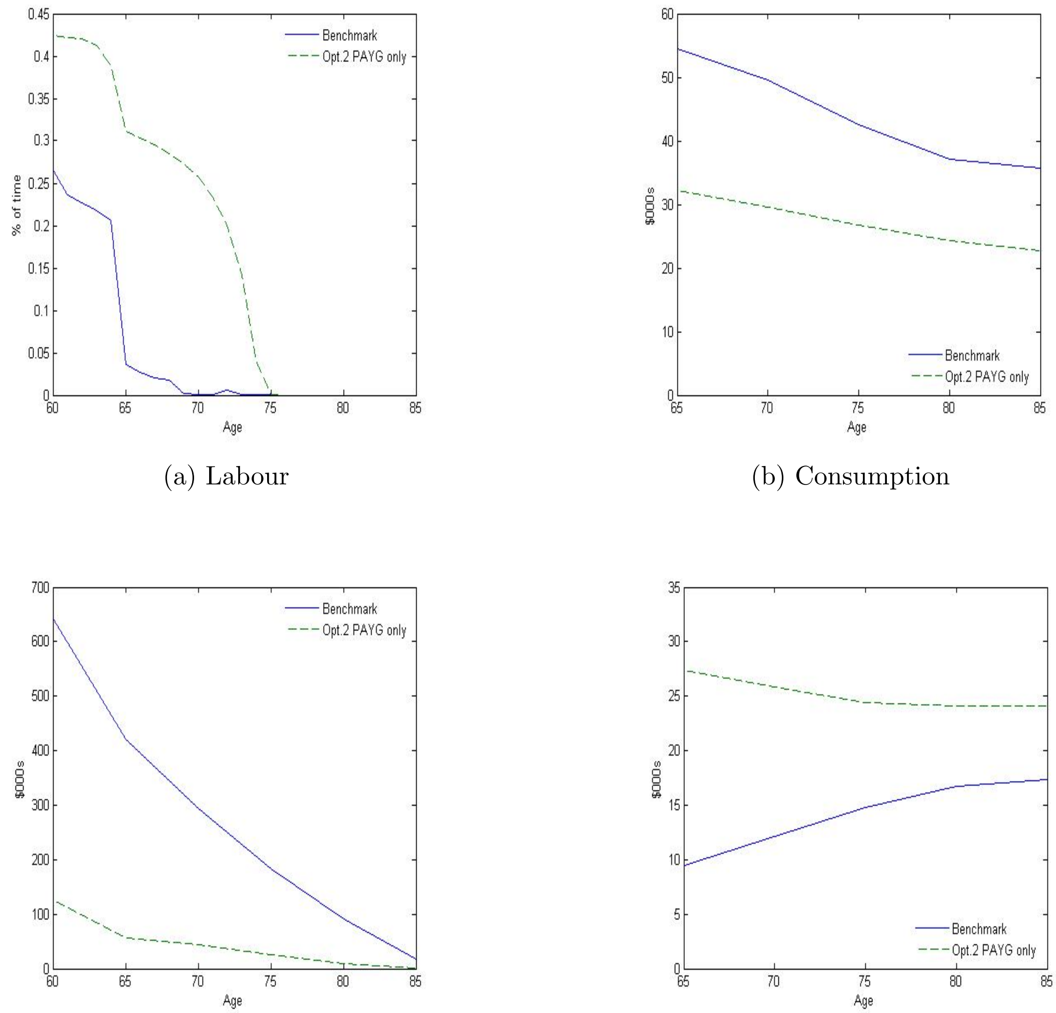
(c) High-skilled workers



(d) Low-skilled workers

Figure 3: Comparison of high and low-skilled workers

$$T_j^1(y_j^1, y_j^{gr}) = \begin{cases} \tau_o min(y_j^{gr}) & \text{if} \quad j < j* \\ -b(y^1) & \text{if} \quad j \geq j* \end{cases}$$



(a) Labour

(b) Consumption

(c) Total assets

(d) Total benefits

Figure 4: Comparison between the benchmark and option 2

In the early stages of their life-cycle, Table 3 shows that option 2's aggregate consumption is slightly higher than the benchmark. Table 4 and Figure 4b demonstrate that this does not hold for the individuals' later life-cycle, or in aggregate terms. The latter is due to lower levels of asset accumulation in comparison to the benchmark both over their life-cycle (Table 3 and Figure 4c and in overall aggregate terms as per Table 4).

As all agents under option 2 receive a pension benefit, they do not have the same labour supply disincentive as agents under the benchmark. That is, the small fall in option 2's labour supply in Figure 4a represents a preference for leisure, as agents do not need to decrease their labour supply to maximise their pension benefit. However, this causes the aggregate benefit payments to be higher at every eligible life-cycle stage, as shown in Figure 4d. Consequently, Table 4 shows that option 2 is roughly 23% more expensive than the benchmark.

In comparison to the benchmark, Table 3 demonstrates that option 1 and 2 have directionally similar life-cycle results with respect to labour, consumption and benefits. Where the quantum of results differs is with respect to total asset accumulation. As a direct result of means-testing, table 3 shows that agents under option 1 amass consistently lower amounts of private savings in order to maximise their pension benefit. Consequently, they consume more in their later years, while agents under option 2 consume more in their early life cycle, financed through a slightly higher labour supply.

The key difference between options 1 and 2 is that means-tested programs attempt to target benefits and consequently create labour supply and asset accumulation disincentives not seen under a PAYG scheme. The overall effect of the distortions is reflected in Figure 5 as option 2 agents accumulate roughly 40% more assets at the peak and divest them much more slowly after age 65. This occurs because agents under option 1 have an incentive to work and save less in order to qualify or maximise their age pension benefit. Consequently, option 1 is more expensive than option 2 as the distortions pervert the benefit-targeting aim.

Option 3. PAYG pension program with mandatory superannuation: This option uses the same PAYG social security system as option 2, but includes the same mandatory superannuation guarantee (and corresponding tax specification) as the benchmark model. That is, the

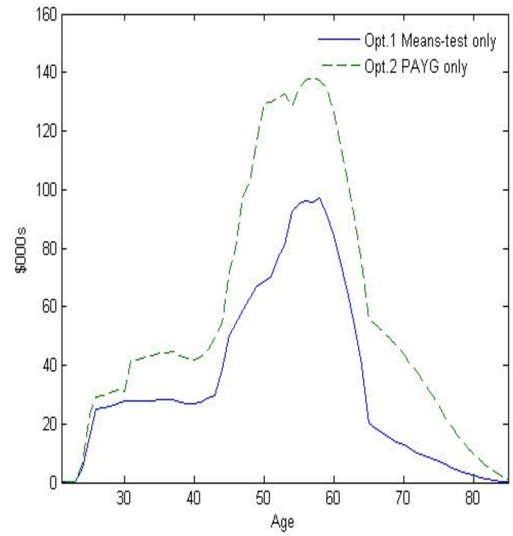
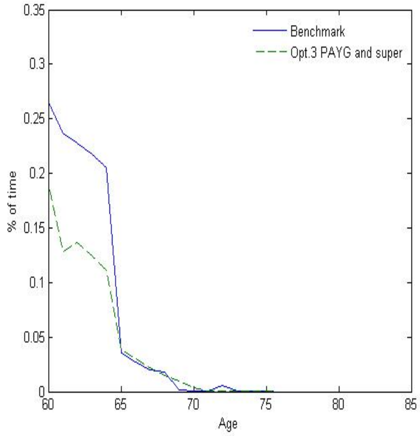


Figure 5: Total assets

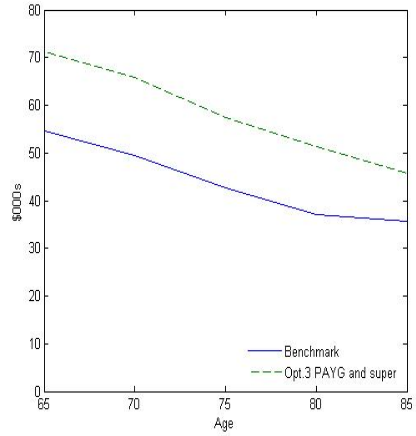
tax burden is split evenly between the superannuation tax concession and the social security tax rate as per table 2.

As shown in Table 3 and Figure 6b, consumption is strictly higher under option 3 than the benchmark. In retirement, this is partly due to higher benefit rates, as shown in Figure 6d. Additionally, while Table 3 demonstrates that total labour supply is broadly similar between the benchmark and option 3, a much higher superannuation contribution rate of 14.3% (see Table 2) allows option 3 agents to accumulate more assets (as shown in Figure 6c).

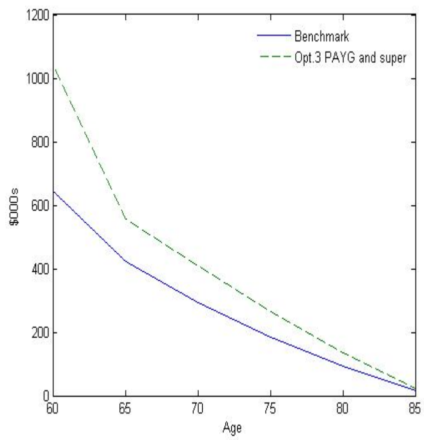
The key difference between option 3 and the benchmark is the removal of the means-tested distortions. This results in a smoother labour supply with a smaller kink at age 65, as shown in Figure 6a. Notably, option 3 agents decrease their labour supply more than benchmark agents when they access their superannuation lump sum. As Figure 6c shows, this is not because they are drawing down their assets at a relatively faster rate, but because they have higher assets overall. This plus the certainty of the guaranteed pension payment results in a preference for leisure. Benchmark agents on the other hand, must manipulate



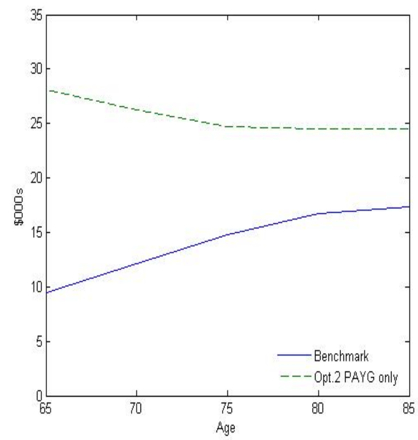
(a) Labour



(b) Consumption



(c) Total assets



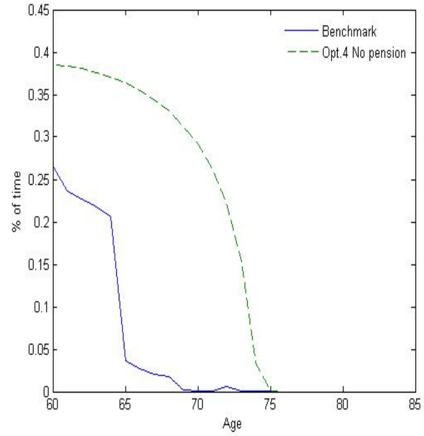
(d) Total benefits

Figure 6: Comparison between the benchmark and option 3

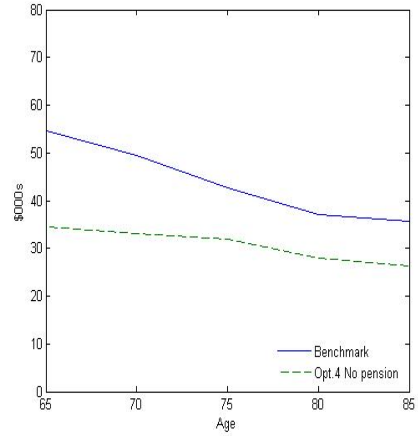
their labour supply and asset holdings before age 65 in order to maximise their pension benefit.

Option 4. Removal of pension programs and mandatory superannuation (privatisation): Under this specification individuals do not receive any age pension benefits, nor are they forced to save. As per options 1 and 2, the superannuation taxation incentives are not kept.

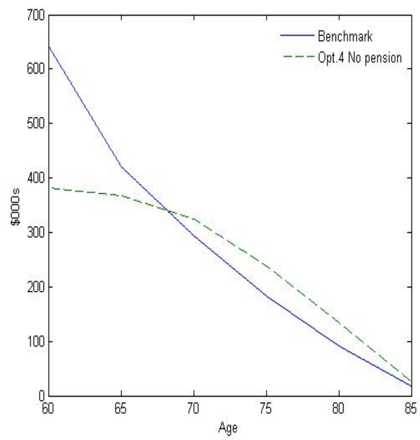
Table 3 shows that option 4 individuals have the highest consumption in their early-to-



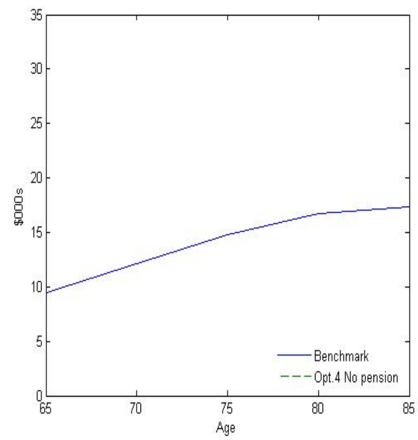
(a) Labour



(b) Consumption



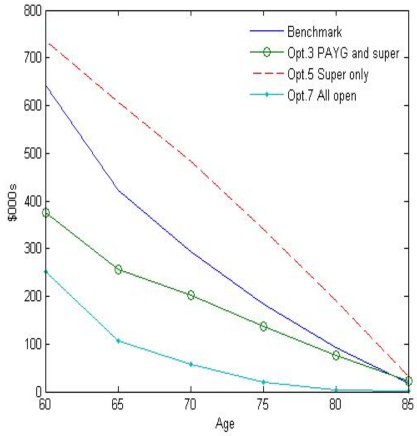
(c) Total assets



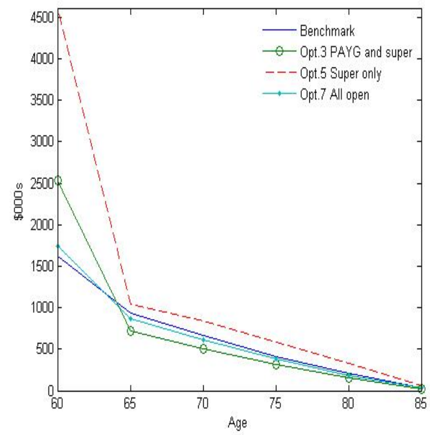
(d) Total benefits

Figure 7: Comparison between the benchmark and option 4

mid life-cycle stages. As a result, individuals have less private savings at first, before substantially increasing their private asset holdings after middle age via a much higher labour supply and reduced consumption as shown in Figures 7a and 7b. Without the social security safety net (and subsequent distortions), option 4 individuals supply the highest labour levels after age 65. This is also seen in Figure 7d which shows that while benchmark agents have a higher peak stockpile of assets, they divest them quickly as a result of the social security safety net and the means-test distortions.



(a) Lowest skilled worker



(b) Highest skilled worker

Figure 8: Total asset comparison

Option 5. Mandatory superannuation with the removal of age pension programs: This is an extension of option 4, with the addition of forced savings. As a consequence, this model specification allows an explicit governance role for policy-makers. Additionally, as superannuation is a privately managed scheme there is no explicit fiscal burden. Like the benchmark and option 3, this system forces individuals to save during their early to mid life-cycle due to mandatory contributions. The superannuation contribution rate is set to 28.7%.

It is worth examining all of the models with superannuation specifications - that is, the benchmark and options 3, 5 and 7. Notably, under mandatory superannuation, assets are held over a long time-frame so individuals easily amass wealth. This results in smoother life-time consumption. In contrast, agents under options without mandatory superannuation heavily favour current consumption. Consequently, superannuation is an effective policy tool because it demonstrably forces individuals into action. Notably, this is despite the fact that the savings are accessed as a lump-sum - in contrast to previous retirement studies that demonstrate the welfare-enhancing potential of annuities.[4]

[4]See Brown (2007) for more a complete overview.

The intuition for this is as follows. Under all four superannuation options, individuals can only access their mandatory savings late in life -where their effective wage is trending down, irrespective of labour supply decisions or taxation. As a result, agents must consider future life-time consumption more predominately. Hence individuals consumption smooth for the remainder of their life-time. This is a similar result to Poterba et al. (1998)'s empirical study, but notably does not apply for lower-skilled agents under the benchmark due to the means-tested distortions.[5] However Figure 8, implies that without the means-tested distortions, this result holds broadly for the lowest skilled agents.[6] Figure 8a shows that the lowest-skilled agents under the Benchmark and option 7 have a kink between ages 60 and 65, not present under option 5 or for any of the higher skilled agents presented in Figure 8b.[7]

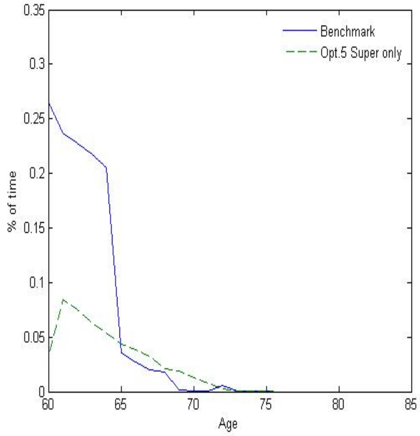
The effect of the means-test distortion on the benchmark is also evident in Figure 9a. More interestingly, labour supply for option 5 drops almost to zero at age 60. As stated previously, this labour supply decline at the superannuation access age is primarily due to the agents' preference of leisure, given their large asset holdings. From Table 4, Option 5 agents have the largest aggregate asset holdings, over 85% more than the benchmark. This can also be seen in Figures 9c and 8. Consequently option 5 agents also have the highest aggregate consumption, over 45% more than the benchmark. This is demonstrated in life-cycle terms in Figure 9b and Table 3. Note that since option 5 agents are forced to save so much of their income due to a high contribution rate, they also have the lowest private savings out of any options.

Option 6. Means-tested pension benefit program and guaranteed PAYG pension payout:

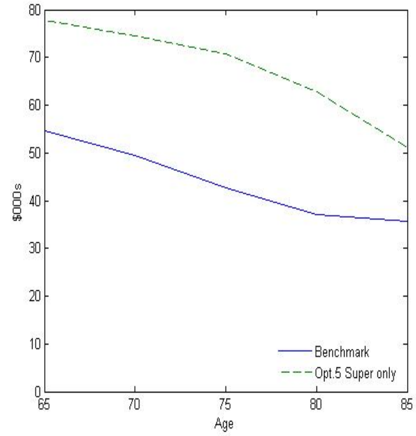
[5] This study broadly found that older individuals receiving lump-sums were more likely to reinvest into retirement accounts.

[6] This is with respect to the shape of the curve; as option 5 agents have a much higher super contribution rate than the benchmark agents, their total stockpile of wealth is correspondingly larger.

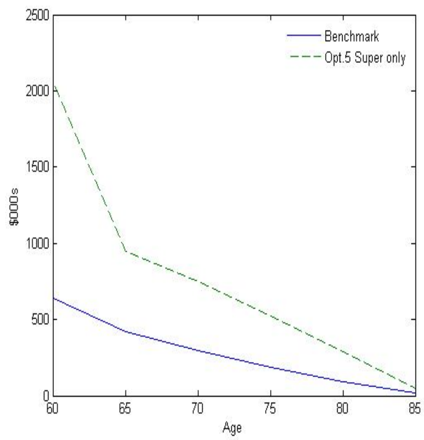
[7] Option 3 has a slight kink for both lower and higher skilled workers due to the preference for leisure as they are guaranteed a pension benefit.



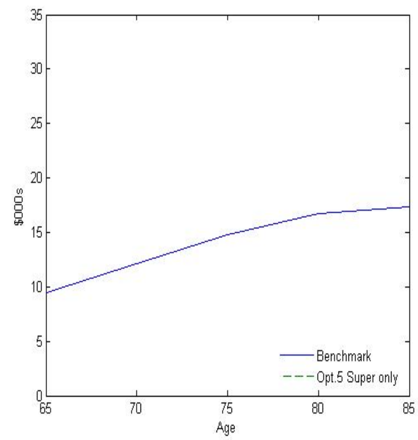
(a) Labour



(b) Consumption



(c) Total assets

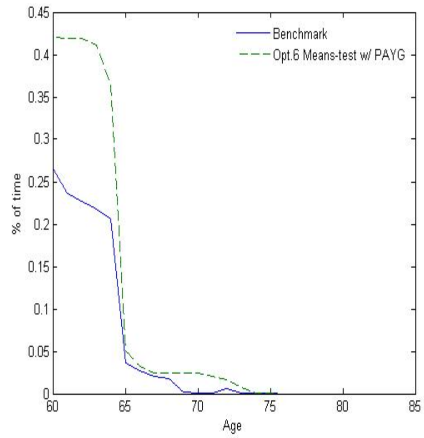


(d) Total benefits

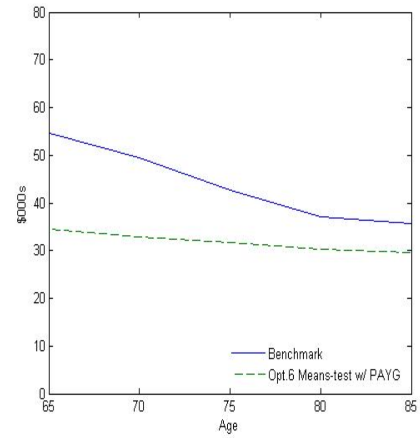
Figure 9: Comparison between the benchmark and option 5

This is a combination of options 1 and 2. This is similar to the current United Kingdom system. Here, the PAYG pension payment is counted as income under the means-test. The taxation burden is split evenly between the PAYG social security tax and the payroll tax funding the means-tested benefit program.

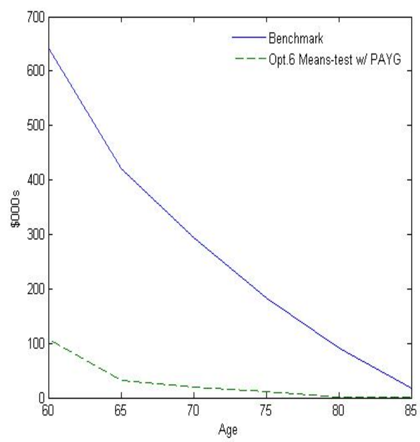
As option 6 agents are certain to receive a pension benefit, their labour supply decreases substantially at age 65, as shown in Figure 10a. Further, as the guaranteed pension benefit counts towards the income test, agents are incentivised to substantially distort their labour



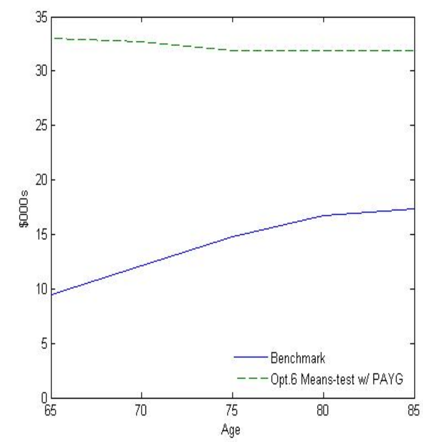
(a) Labour



(b) Consumption



(c) Total assets



(d) Total benefits

Figure 10: Comparison between the benchmark and option 6

supply to almost zero in aggregate terms, in order to qualify. Similar to option 1 agents, Table 3 and Figure 10c shows that option 6 agents hold very little assets after age 70, relative to the benchmark. As a result of the distortions, Figure 10b demonstrates that option 6 agents have low levels of consumption in retirement, in comparison to the benchmark. In fact, Table 4 shows that option 6's aggregate consumption is the second lowest out of all the options.

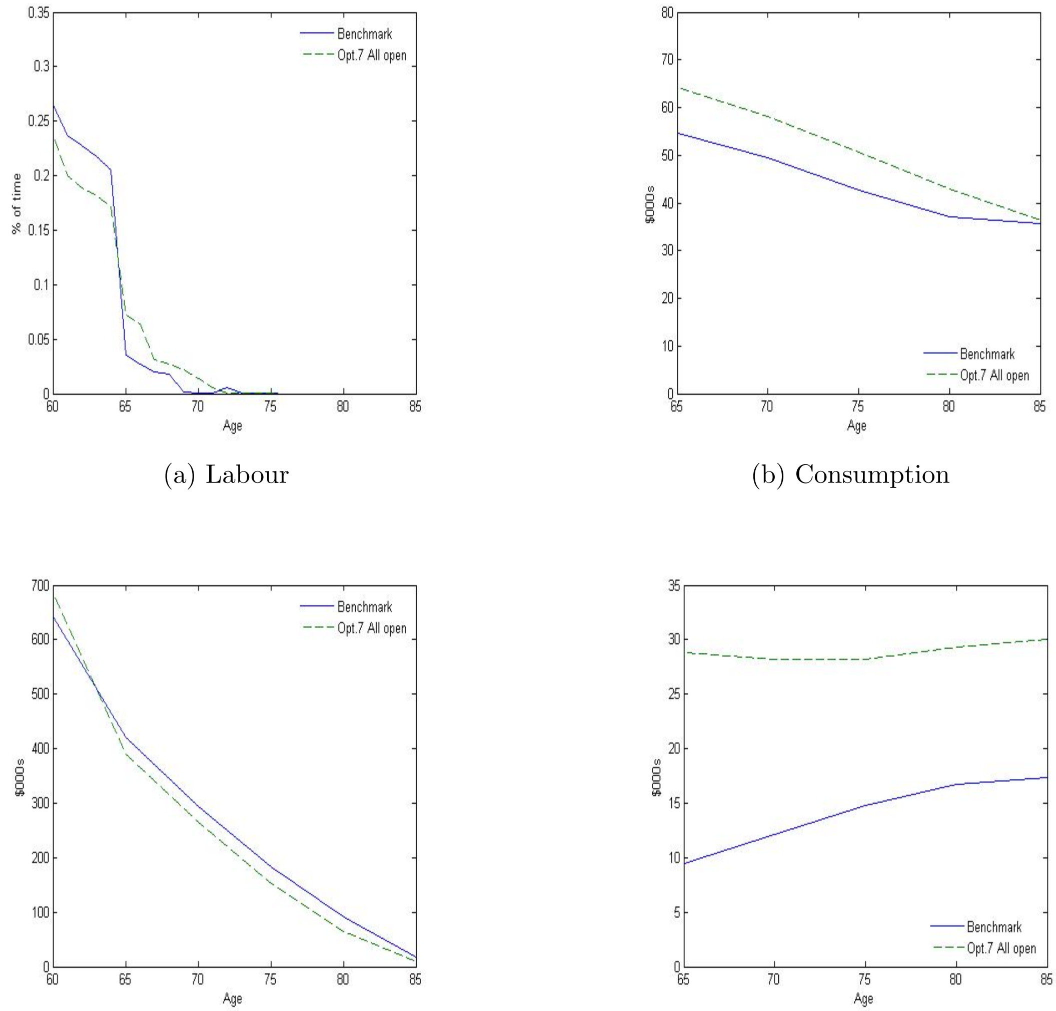
This is despite Figure 10d indicating that aggregate means-tested and PAYG benefits are higher under option 6 compared to the benchmark. Additionally, as per option 1, agents are implicitly encouraged to consume all of their pension benefits and hold few assets. As such, the decrease in consumption is due to the effect of the means-testing disincentive to work or save with respect to asset accumulation. Due to these distortions and high benefit payments, option 6 is the second most expensive option, after option 1.

Option 7. Means-tested pension benefit program, guaranteed PAYG pension payout and mandatory superannuation: Taxation burden is split evenly between the superannuation contribution rate, the PAYG social security tax and the payroll tax funding the means-tested benefit program.

Figure 11b and Table 3 show that option 7 agents have consistently higher consumption than the benchmark. While Table 3 show that early life-cycle total asset accumulation were higher under option 7, Figure 11c indicate that both are similar or lower after age 60. As such, the higher consumption is due entirely to the higher benefits payments indicated in Figure 11d.

With regards to labour supply, Figure 11a indicates that option 7 labour supply is lower between ages 60 to 65 and subsequently equal or lower. The former is for the same reason as the option 6 labour supply decrease. That is, due to the guaranteed PAYG pension benefit counting towards the means-tested income test, option 7 agents are incentivised to reduce their labour supply more sharply than the benchmark in order to qualify or maximise the pension benefit. However, after age 65, benchmark agents supply slightly less labour than their option 7 counterparts. As Figure 11c indicates that option 7 agents are not saving it over the total asset stockpile of the benchmark, the consumption indicated in Figure 11b's is funded by high pension payouts (see Figure 11d).

Notably, the option 7 is much cheaper than the benchmark, with a cost of approximately



(a) Labour

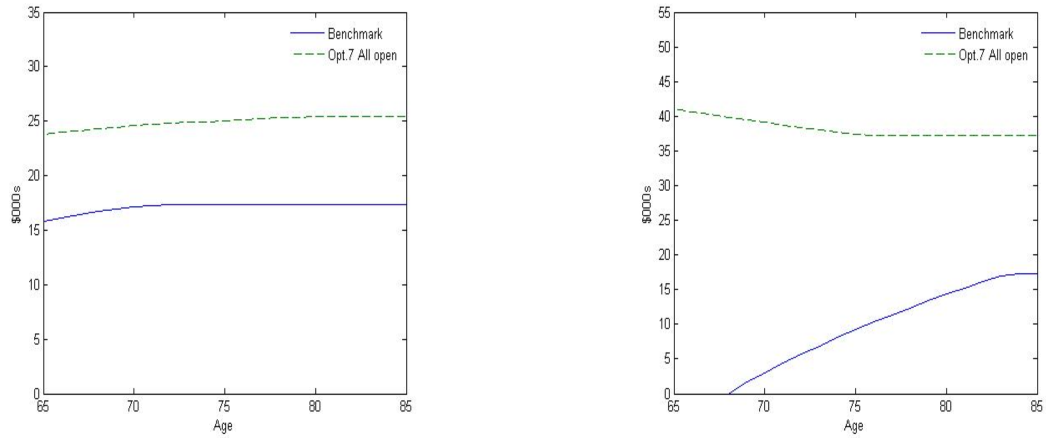
(b) Consumption

(c) Total assets

(d) Total benefits

Figure 11: Comparison between the benchmark and option 7

81.09% of the benchmark, despite a higher level of benefits payments. This is because the combination of mandatory superannuation and PAYG guaranteed benefits reduces makes it difficult for agents to distort their behavior in order to maximise their age-pension payout. This is evident in Figure 12. Figure 12a shows that the lowest skilled option 7 agents only receive the maximum means-tested pension benefit after age 77. The lowest skilled benchmark agents however, are able to claim the full pension after age 69. Further, the highest skilled option 7 agents will never receive an age pension benefit. This is shown in Figure 12b. This is in direct comparison to benchmark agents who are able to distort their labour and



(a) Lowest skilled worker

(b) Highest skilled worker

Figure 12: Means-tested benefits comparison

savings behavior to receive a part pension after age 67. Taken together, this implies that the benefit-targeting ability of the current means-tested program is limited in its ability to reduce fiscal burden.

4.3 Welfare implications

Table 5 presents a relative welfare measure for the benchmarks and all the options. The employed welfare criterion is the ex-ante expected lifetime utility of newly born agent within the stationary equilibrium. This is the consumption equivalent variation (CEV) that makes individuals indifferent between the alternative social security systems, compared to the benchmark. A CEV greater than one demonstrates that a welfare gain exists when switching from the benchmark to an alternative. Note that an ideal welfare comparison between different policy options should also take into account transition effects. However, as we are comparing long-term policy packages, a steady-state solution will suffice.

Table 5: Welfare results

Age	Benchmark	Opt.1 Means-test	Opt.2 PAYG	Opt.3 PAYG w/ super	Opt.4 No pension	Opt.5 Super	Opt.6 Means-test w/ PAYG	Opt.7 All
CEV	1.00	0.88	0.91	13.70	18.85	23.25	0.90	1.001

Significantly, the highest welfare gain exists under option 5 (pure superannuation), in contrast to previous studies have showing that privatisation (option 4) produces the highest welfare gains. This is due to the taxation benefits that agents can claim under superannuation - recall that the superannuation contribution amount is subtracted from the individual's assessable income for income tax calculations. As such, Table 4 demonstrates the option 5 has the lowest aggregate level of income taxation, around 80% of the benchmark, compared to option 4's 124%. Further, in the context of this analysis, it also shows that superannuation programs are generally welfare enhancing. For instance, when comparing options 4 and 5, superannuation's largest impact is the timing of savings; agents under option 4 do not start saving until well after their counterparts under option 5, by which time they are unable to catch up. Overall, these results suggest that there is a substantial role for fiscal intervention with regard to superannuation policy-making and administration.

Option 3 (PAYG and superannuation) is shown to produce the next highest welfare gain, due to removal of labour and savings disincentives. Total cost is also lower. Interestingly, Table 5 shows that welfare is almost unchanged between the benchmark and option 7 (1.001 compared to 1.00). This is despite the life-cycle results in Table 3 showing that agents under option 7 have consistently higher levels of consumption. In retirement, this is partially funded through slightly higher levels of labour supply and a higher stockpile of assets resulting from the slightly higher superannuation contribution rate (9.6% compared to the benchmark's 9%).

Welfare losses are experienced under options 1 (pure means-testing), 2 (pure PAYG) and

6 (means-testing and PAYG) compared to the benchmark. Option 1 represents the lowest welfare due to the strong labour supply and savings disincentives caused by means-testing. These distortions also cause option 6 to produce a higher welfare loss than option 2. Option 2 represents a welfare loss in comparison to the benchmark because welfare is represented by the benefit from consumption and leisure. That is, as shown in Table 4, option 2 produces the highest aggregate labour supply (around 17% more than the benchmark), but the third lowest consumption (around 90% of the benchmark).

5 Conclusion

Even with mandatory superannuation, the Australian social security system represents an immense and increasing fiscal burden for the government. This paper presents a partial equilibrium comparison of three alternative policy options, motivated by recent international policy debate. The seven alternative options are: (1) a means-tested benefit scheme, (2) a pay-as-you-go (PAYG) system, (3) a PAYG system with mandatory superannuation, (4) no public benefit program, (5) a system with only mandatory superannuation, (6) a means-tested and PAYG benefit program and (7) a means-tested and PAYG benefit program with mandatory superannuation. Each case provides substantially different economic and welfare implications.

The benchmark model closely replicates the current Australian retirement system in terms of key macro and micro features of the economy. Within the model, individuals make life-cycle decisions regarding consumption, savings and labour. Notably, the labour supply decisions differed significantly depending on whether superannuation was present, particularly with respect to an individual's endogenous retirement decision. This flowed on to affect the consumption and private savings decisions of agents, implying that fiscal policy can have considerable impact on the pattern of life-cycle labour supply. Unsurprisingly, analysis suggested that programs with forced savings mechanism posses a lower fiscal burden than other alternatives. Significantly, this was always accompanied by a welfare gain as the mandatory savings systems included a taxation benefit, allowing individuals to accumulate significant asset stockpiles, resulting in lower aggregate labour supply and higher life-time consumption. However, comparing the benchmark and option 1 also demonstrates that enforced savings can increase the effect of the distortions resulting from means-testing. Otherwise, consistent with the literature, option 4 produces the second largest economic welfare gain and option 5 the highest. The latter is an informative result for policy-makers trying to balance budgetary expenditure. This is in comparison to the benchmark model which produced the third lowest economic welfare, due to labour market and savings distortions. It was also the fourth highest fiscal burden.

While the model captures key dimensions of individual heterogeneity across age and labour productivity, it abstracts from other areas of potential interest such as unemployment or the inclusion of retiree savings motive due to health status or as a bequest motive. While these extensions are left to be explored in future research, it should be noted that the modelling of health issues may be of particular importance due to the similar sustainability issues of public heath expenditure programs such as Medicare.

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Appendix A

Solution procedure

This procedure follows from Huggett and Ventura (1999) and Imrohoroglu et al. (2003).

1. Values for aggregate labour L, capital stock K and tax rates (τ_p and τ_c) are guessed.

2. The optimal decision rules for $c_j(.)$,$a_j(.)$ and $l_j(.)$ are calculated as followed: The discrete sets $A = \{0, ..., a_q\}$, $E = \{e_1, ..., e_4\}$ and $W_h = \{w_{h_1}, ..., w_{h_20}\}$ are created for asset values, productivity shocks and average past earnings. The upper bound a_q is chosen such that it never binds. Starting from the last period, the control variables $y = (c, l)$ are solved at each grid point $x = \{a, s, w_h\}$ using the simplex method. The value function and off-grid decision rules are computed using linear interpolation.

3. The optimal decision rules and balanced budget condition determine the new values of K, L and tax rates (τ_p and τ_c). The time paths of consumption, labour, asset holdings and means-tested pension benefits are simulated for many individuals. The productivity shocks and survival outcomes for newly born individuals are randomly determined and the optimal policy functions are used to construct the next period's state variables. This procedure is recursively followed until the individual dies. The process is repeated 10,000 time and aggregate values are computed as the averages across the 10,000 simulations.

4. The iterations continue until the stationary recursive equilibrium is defined. This occurs when the computed values in the third step approximately equal the guessed values from the first step.

Appendix B

Sensitivity analysis

The robustness of our results are tested using alternative values over the risk aversion parameter, ρ and the Frisch elasticity of labour supply φ. In the benchmark model, ρ and φ are set equal to 2 and 4.29, respectively. Two additional values of each are tested, with ρ set equal to 1.5 and 2.5 and φ equal to 3.49 and 5.31. Welfare, along with aggregate labour, consumption and assets are displayed in tables 6 and 7. As the tax burden changes under different parameter values, the sensitivity analysis is presented with respect to option 4 (privatisation) and the benchmark, with the different benchmark aggregate results normalised to 100. The other options also exhibit the same magnitude changes between the different parameters.

Table 6: Sensitivity analysis - ρ

	Benchmark	Opt.4 No pension	Benchmark	Opt.4 No pension	Benchmark	Opt.4 No pension
ρ	1.50	1.50	2.00	2.00	2.50	2.50
φ	4.29	4.29	4.29	4.29	4.29	4.29
$Labour$	100.00	111.39	100.00	110.39	100.00	106.25
$Cons$	100.00	114.21	100.00	109.89	100.00	104.24
$Asset$	100.00	163.03	100.00	166.68	100.00	158.49
CEV	1.00	8.14	1.00	18.85	1.00	25.49

Table 7: Sensitivity analysis - φ

	Benchmark	Opt.4 No pension	Benchmark	Opt.4 No pension	Benchmark	Opt.4 No pension
φ	3.49	3.49	4.29	4.29	5.31	5.31
ρ	2.00	2.00	2.00	2.00	2.00	2.00
$Labour$	100.00	108.28	100.00	110.39	100.00	110.21
$Cons$	100.00	108.58	100.00	109.89	100.00	110.11
$Asset$	100.00	153.10	100.00	166.68	100.00	130.70
CEV	1.00	17.90	1.00	18.85	1.00	2.46