Optimising the Superannuation Guarantee over People's Lifetimes

Rhys Creer

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School of Economics
University of Sydney

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Supervised by Dr Christian Gillitzer & Dr James Graham

Abstract

Is it optimal to have a constant superannuation guarantee at all ages? A key objective for increasing compulsory superannuation is reducing reliance on the age pension. But increasing compulsory superannuation negatively impacts young people who consume the majority of their income, dis-save and face borrowing constraints. By varying compulsory superannuation as people age, this thesis demonstrates that the welfare of young people can be improved while mitigating age pension reliance.

Statement of Originality

I hereby declare that this submission is my own work and to the best of my knowledge it contains no material previously published or written by another person. Nor does it contain any material which has been accepted for the award of any other degree or diploma at the University of Sydney or at any other educational institution, except where due acknowledgment is made in this thesis.

Any contributions made to the research by others with whom I have had the benefit of working with at the University of Sydney is explicitly acknowledged. I also declare that the intellectual content of this study is the product of my own work and research, except to the extent that assistance from others in the project's conception and design is acknowledged.

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1 Introduction

In 2023, all Australian workers are required by law to save 11% of their salaries and wages into a superannuation account. It is hoped that over a life-time of compulsory saving, superannuation balances at retirement provide a comfortable 'nest egg' to live off in old age. But is this 11% rate optimal? As Australians continue to age, increasing compulsory superannuation is an essential policy to reduce reliance on the age pension (Keating, 1995). At the same time, young Australians consume the majority of their income, face borrowing constraints and dis-save. High superannuation saving means young people face an opportunity cost of consumption today (Evans and Razed, 2019), likely preferring lower compulsory superannuation. These issues pose a trade-off between encouraging the accumulation of savings for retirement and maintaining desired levels of consumption while young. This thesis proposes a novel solution: varying the proportion of income that is compulsorily saved into superannuation accounts as people age. This policy allows individuals to smooth required savings across their working lives, while maintaining sufficient retirement balances to mitigate pension pressure on the government budget.

Superannuation in Australia is a monthly payment made by employers into an employee's superannuation account, a fund which is only accessible when the employee has reached the preservation age of 58 and retired, or reached 65 years old. The superannuation guarantee (SG) is the government legislated proportion of an employee's wage employers must pay into a worker's superannuation account. Changing the level of the SG has been a topic of debate since its introduction in 1992, with a steady increase from 3% to the current 11% leading to a clear increase in Australia's savings (Connolly, 2007). Superannuation contributions are subject to a low 15% tax rate (ATO, 2023) compared to generally higher rates in the progressive income tax system. This incentivises contributions into superannuation accounts and creates an attractive retirement investment opportunity.

This thesis builds a model of the superannuation system in Australia, studying alternative SG policies that vary the rate of contributions linearly across a person's lifetime (Figure 1). For example, instead of a flat contributions rate in every period of working life, households may face a low contributions rate while young and a higher contribution rate when older. This concept is captured using a heterogeneous agent life-cycle model calibrated to the Australian economy. This model includes people with different levels of income, employment, superannuation, and non-superannuation assets. Working agents can choose to either spend or save their income as well as consume a portion of their savings. In line with Australian policy, agents are forced to save a portion of their income as superannuation. Retired agents draw down their total assets to fund consumption and can fall back on a pension if required, subject to an asset means test.

This model suggests the optimal SG that does not vary across the lifetime is 13% (Figure 1 (b)). It finds the SG that maximises well-being begins at 9% when starting work and increases linearly to 17.9% just before retirement(Figure 1 (c)).

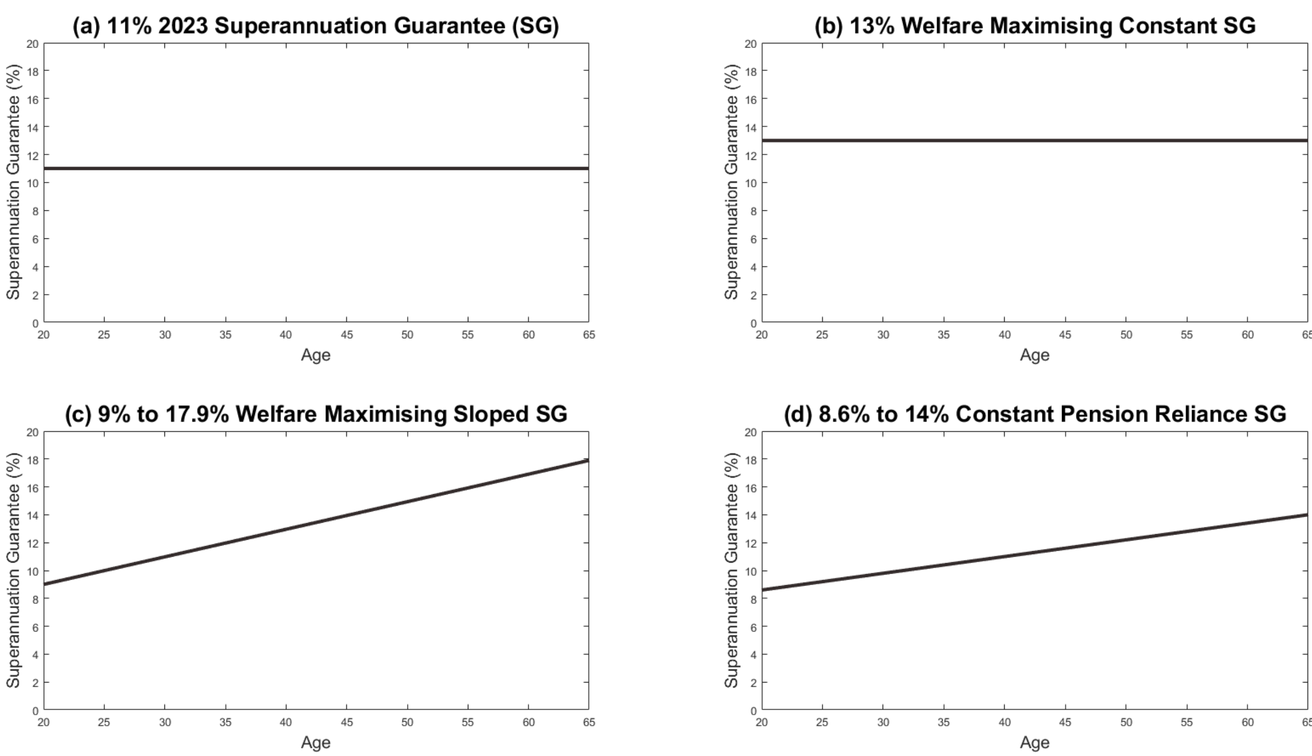


Figure 1: Main Results

The Australian pension is asset means tested, meaning the more assets an individual owns in retirement, the less pension they receive (ATO, 2023). Saving superannuation increases retirement assets, leading to reduced reliance on the age pension, a key objective of superannuation (Keating 1995). Individuals saving too little for retirement create a fiscal externality, with the current working age population facing the burden of higher taxes to fund pensions. In this thesis, I assume that a policy maker hopes to maximize individuals welfare subject to the constraint imposed by this fiscal externality. That is, any change in the superannuation guarantee must satisfy a constraint that government pension expenditures are held constant. So, for example, a policy maker that hopes to reduce the SG rate on young workers will need to raise the SG on old workers to ensure that they retire with similar levels of superannuation wealth so that they do not make additional claims on the pension system. With this policy goal of superannuation in mind, I conduct experiments finding the optimal SG given a certain level of fiscal expenditure on the age pension. While keeping the level of government pension expenditure at the same level generated by the 2023 11% SG, I find that an SG that starts at 8.6% in the first year of work and linearly increases to 14% by retirement significantly increases well-being compared to the 11% SG.

These optimal levels are determined by three effects. First, younger people receiving additional income from a lower SG will likely spend this income on consumption or precautionary saving. This is because young people have a higher marginal propensity to consume (MPC) and a higher marginal propensity to save (MPS) for non-retirement precautionary savings against unemployment shocks (Gourinchas and Parker, 2003). A lower SG will therefore lead to higher utility while people are young.

Second, superannuation assets left in accounts over longer periods of time will lead to higher returns because of compound interest (Treasury, 2020) and lower tax rates compared to take home income. Therefore, a high SG while people are young will mean higher levels of superannuation are accessible in retirement, likely leading to higher retirement consumption and utility (Treasury, 2020).

Third, the superannuation substitution effect occurs when people substitute superannuation saving for decreases in other types of saving. The tax incentives of superannuation make higher superannuation guarantees attractive, with people substituting their liquid bank account savings for illiquid superannuation savings (Connolly, 2004). But if the SG increases to a high level, say an extreme example of 50%, the government forces people to save more than they would like to, causing a decrease in welfare.

Section 2 reviews related literature, section 3 details the current model, which includes unique aspects of Australia's superannuation, pension and tax systems. Section 4 details the calibration of the model to Australian data. Section 5 reports the results, examining the transmission paths of superannuation policy and how this influences the optimal superannuation guarantee.

2 Related Literature

This thesis is motivated by a range of literature debating the optimal SG in Australia. Kudrna and Woodland (2013) analyse the macroeconomic and welfare impacts of the 2010 changes to the SG using an Overlapping Generations (OLG) model. This includes gradual increases of the SG from 9% to 12% as well as the Low Income Superannuation Tax Offset (LISTO). The authors find that low-income households exhibit welfare gains from the LISTO and high-income households benefit from higher SG rates due to superannuation's lower tax rates.

Khemka, Tang and Warren's (2020) stochastic lifecycle model investigates the welfare impact of a range of SG levels on Australians. The authors find that no one SG is optimal for all Australians. It is a "blunt instrument" applied to Australians that differ across income, objectives, access to the pension, investment returns and whether the cost is borne by the employer or employee. With the aim of reaching the Association of Superannuation Funds of Australia (ASFA) comfortable or modest standards for superannuation, SG rates of 2.5% to 9.5% are found to be optimal for individual agents' dependent on income. SG rates above 9.5% are only found to be optimal for individuals if their objectives include becoming a self-funded retiree or insuring against risks in retirement.

Kudrna (2022) continues their 2013 work, looking at the long run impacts of various SGs on household welfare and macroeconomic aggregates. OLG modelling shows that higher superannuation rates of 12% generate larger average consumption, wealth, household welfare and output per capita. It is evident from the range of conclusions in this literature that an agreed upon optimal SG has not been found. This thesis contributes to this literature through aiming at a specific gap: No previous work has analysed how the SG should vary through the life-cycle.

This thesis also contributes to government superannuation research. The Federal Treasury Retirement Income Review (Treasury, 2020) investigates the implications of the entire Australian retirement system, including the SG, on the Australian economy. The SG section of the review compares the 9.5% SG to the future legislated 12%, finding that the efficiency of draw down rates [1] determine which SG level is optimal. If superannuation assets are drawn down in an efficient manner, a 9.5% rate will allow most Australians to have sufficient retirement income when combined with the age pension. Increasing the SG from 9.5% to 12% is shown to increase superannuation balances but shows young people are vulnerable when compulsory saving rates are set too high.

Connolly and Kohler (2004) investigated the effect of superannuation on household savings behaviour, providing an empirical estimation of the superannuation substitution effect. The authors find that for each dollar of extra superannuation saving, other voluntary saving falls by 38 cents. This means increased superannuation saving is partially substituted by other saving, but overall causes an increase in total savings. Connolly (2007) undertakes further investigation, finding a range of explanations for this low rate of superannuation substitution. Households may face financial constraints and require liquid savings to insure against income shocks. Superannuation may act as a signal to households that they are not saving enough for retirement. Finally, the automatic nature of superannuation may make it more convenient to save for retirement.

This thesis supplements a wider literature employing heterogenous lifecycle and OLG models to the Australian retirement system. Kudrna, Tran and Woodland (2016) analyse the policies of pension cuts and tax hikes to finance Australia's ageing population. They show that while both reforms achieve the same goal, younger generations prefer pension cuts while older generations prefer tax increases. Kudrna, Tran and Woodland (2021) explore the sustainability and equitability of means tested pension systems.

[1] Draw Down Rates: Proportion of superannuation assets extracted from superannuation accounts in retirement on a regular basis.

3 A Model of the Australian Economy Including Superannuation

This section details the heterogeneous agent life-cycle model used to characterise the Australian Economy. The model includes novel elements essential to answering the research question, including Australia's superannuation system, income tax bracket system and pension system. The model abstracts from other aspects such as labour supply, superannuation fund choice and voluntary superannuation contributions.

Agents differ in non-superannuation assets (liquid money saved in bank accounts), superannuation assets, income and age. They work for a fixed number of periods earning income which agents either choose to consume or save as non-superannuation assets. As agents work, they are forced to accumulate superannuation assets. Eventually, agents exogenously retire and begin consuming their superannuation wealth. I now describe the model in detail.

Age is indexed by j, c is consumption, y_j is pre-tax income for agents at age j, a is liquid assets saved in bank accounts, k is illiquid superannuation assets and e an idiosyncratic income shock (see section 3.4). Agents live for J periods and solve the following life-cycle value function:

$$V(a,k,e,j) = \max_{c,a'} \left(\frac{c^{1-\sigma}}{1-\sigma} + s_{j+1}\beta E(V(a',k',e,j+1)) + (1-s_{j+1})W(a,k) \right)$$

$$Subject\ to\ age\ dependant\ budget\ constraints\ detailed\ below$$

$$a' \geq 0, k' > 0, 0 \leq \beta \geq 1$$

$$e = \pi_e(e) is\ a\ seven\ state\ Markov\ Chain$$

In any given period, agents choose consumption c and saving through liquid assets in the next period a' to maximise the present discounted value of lifetime utility. This value is captured by the function $V(a',k',e,j+1)$, which depends on assets, superannuation, income, and age. There is a different value function for each of these variables, one for each age $j = 1, 2, \ldots J$, asset level, income level and superannuation amount. The value function has three key parts.

Firstly, the consumption utility function defines the utility derived from consuming in the current period and is in the constant relative risk aversion form. Secondly, expectations over the next periods value function $E(V(a', k', e, j+1)$ captures the effect of current savings choices a on future utilities. This is because assets saved today will be available for consumption c in the future. Expectations over the next periods value function are discounted by β, determining how forward-looking agents are.

The conditional probability of survival in the next period is given by s_{j+1}. If agents are alive in the next period, they care about continuing to maximise their lifetime utility. If agents die in the next period, they only care about maximising their bequest once they die. The probability of survival therefore changes how much households discount future value functions dependent on how likely they are to survive.

Third, to encourage saving later in life, the value function includes a bequest function $W(a, k)$ discounted by the probability of death in the next period $(1 - s_{j+1})$.

$$W(a, k) = \psi \frac{(a(1+r) + k(1+r) + \overline{w})^{1-\sigma}}{1-\sigma}$$

Following De Nardi (2004), agents enjoy warm-glow utility over bequests left behind at death. I assume that both liquid assets and illiquid superannuation assets are left behind for use by a household's descedents. This bequest function ensures that households continue to accumulate large asset balances until late in life, as observed in Australian data (See calibration section 4.2). Households derive utility from saving the sum of their assets $a(1+r) + k(1+r)$, where r is the interest rate on both non-super liquid assets and superannuation assets. I assume the interest rate on both liquid and illiquid assets is the same, so the only difference between investing in super assets is their generally lower tax rates, detailed in the following sections. ψ determines the relative preference of households between consumption and saving a bequest. $\overline{w}$ determines the luxuriousness of these bequests.

3.1 Budget Constraints

The agent's decision problem is subject to different budget constraints depending on whether a household is working $j < Jr$, in the first year of retirement $j = Jr$, or in later retirement $j > Jr$ where Jr is the first year of retirement. Working age households earn labour market income, deposit into liquid asset and superannuation accounts, earn returns on their assets, and face various taxes described below. In the first year of retirement, I assume that all households transfer the entirety of their superannuation funds into their liquid asset account. As discussed below, I do this to simplify the model solution. Finally, during retirement households can earn a government pension and actively manage their remaining savings

3.1.1 Working Life Budget Constraint

While working, agents face a budget constraint where consumption in the current period c and assets saved to the next period a' equal post tax income I . Post tax income I is a function of pre-tax income y_j which is subject to idiosyncratic employment shock e. y_j is a quadratic function of age, a standard assumption used in the literature designed to capture the hump-shaped life-cycle profile of individuals income observed in Australian data (see calibration section 4.2). τ_j is the superannuation guarantee, the proportion of income compulsorily saved into superannuation accounts, and therefore taken from pre-tax income. Assets in the current period a also accumulate according to interest rate r. The term on the right hand side of this budget constraint is taxed according to the Australian Income Tax system, detailed in section 3.3.

Now consider the super accumulation equation k'_j. People earning up to $37,000 are eligible to receive a Low Income Super Tax Offset (LISTO), given by l, of 15% of compulsory superannuation contributions before tax, up to a maximum of $500, paid automatically into their superannuation account. This is required to prevent low income earners who are in the tax free threshold from paying more tax on their superannuation income than their take home income. The LISTO is modelled as part of superannuation in the next period k'_j. Agents are also subject to an annual superannuation concession cap of $27,500, a legislated limit on how much money can be saved in an individual's superannuation account in a given year.

If $j < Jr$

$$c + a'_j = I((1-\tau_j)ey_j + a(1+r))$$

$$y_j = quadratic\, function\, of\, age$$

If $y_j \geq \$37000$

$$k'_j = k(1 + r(1-t_k)) + \min(\tau_j ey_j(1-t_k), \$27500(1-t_k))$$

If $y_j \leq \$37000$

$$k'_j = k(1 + r(1-t_k)) + \min(\tau_j ey_j(1-t_k), \$27500(1-t_k)) + \min(\tau_j ey_j l, \$500)$$

Firstly, consider the situation where income is above $37,000 so there is no LISTO. Superannuation in the next period k'_j accumulates at interest rate r, which is subject to superannuation tax t_k, currently equal to 15%. Note that the return on liquid savings is taxed at the regular income tax rate owed on all other agents earnings, while the return on superannuation savings is taxed at the fixed rate of 15%. Simultaneously, a proportion of pre-tax income $\tau_j ey_j(1-t_k)$ is added to the superannuation account, subject to the $27,500 contribution cap. τ_j is the superannuation guarantee, equal to 11% in 2023. The contribution limit is modelled as the minimum between the portion of annual pre-tax income $\tau_j ey_j(1-t_k)$ and $27,500. This means 11% of annual pre-tax income is put into an agents superannuation account up until $27,500. If an agent has a relatively higher pre-tax income (i.e., 11% of their pre-tax income is above $27,500), only $27,500 of pre-tax income is placed into their superannuation account. All remaining pre-tax income enters their non-superannuation bank account.

Now consider when income is below $37,000, which includes the LISTO. Superannuation in the next period is equivalent to the equation described in the previous paragraph, but includes the LISTO, modelled as the minimum between $l = 15\%$ of pre-tax income and $500.

3.1.2 Budget Constraint in First Year of Retirement

If $j = Jr$

$$a_{Jr} = a_{Jr-1}(1+r) + k_{Jr-1}(1+r)$$

$$c + a'_j = a(1+r) + p_(a)$$

$$k'_j = 0$$

In the first year of retirement, it is assumed for ease of modelling that all superannuation is transferred into an agent's bank account (non-superannuation assets). This is because once agents reach retirement they no longer accumulate superannuation as a proportion of income, but draw down on it to fund consumption in retirement. In the real world where superannuation accounts are subject to different returns based on fund choice, this assumption is unrealistic. But as this model has equal interest in both super and non-super accounts, this makes no difference to the amount of savings available to agents. This assumption is achieved by setting assets in the first year of retirement a_{Jr} equal to the sum of assets and superannuation in the year before retirement, both subject to interest rate r. Superannuation assets in the next period k'_j are also set to zero.

The left side of the budget constraint in the first year of retirement is as before, but now equals assets accumulated from the previous period $a(1+r)$ and the pension $p(a)$, which is a function of assets (see section 3.2).

3.1.3 Budget Constraint for Remaining Years of Retirement

If $j > Jr$

$$c + a'_j = a(1+r) + p(a)$$

$$k'_j = 0$$

In all remaining years of retirement, the budget constraints are the same and superannuation assets in the next period are set equal to zero.

3.2 Pension System

This section details the modelling of Australia's pension system, including the asset means test. The asset means test is a restriction on how much of the age pension an individual can receive based on the value of all assets they own. The model abstracts from the income means test as agents in this model are assumed to not receive income once in retirement. This assumption is to simplify modelling, but in the real world people can access the pension while still earning a small amount of income in retirement. The model also abstracts from other aspects of the age pension such as couples receiving different pension levels compared to single retirees.

If $a \leq \$301750$

$$p_a = \$28514.20$$

If $\$301750 < a < \$656500$

$$p_a = 301750 - 0.003a$$

If $a \geq \$656500$

$$p_a = 0$$

The current total fortnightly rate for a single person on the aged pension is \$1096.70 (Services Australia, 2023). Converting this to the annual pension, we reach $\$28,514.20$. The asset means test for the age pension restricts the amount of age pension someone can receive by the value of the assets they own. When the assets of a single homeowner are worth less than \$301,750, an individual is able to access their entire age pension. As including home ownership in this model would be computationally intensive, it is assumed each agent in the model implicitly owns a home.

When a homeowner has an asset value between \$301,750 and \$656,500, the amount of a pension they can access decreases according to a taper rate set by the government. For every \$1,000 increase in a person's assets, the amount of age pension received decreases by \$3. This tapers until the cap of \$656,500, above which agents do not receive any age pension (Services Australia, 2023). This pension policy is depicted in figure 2.

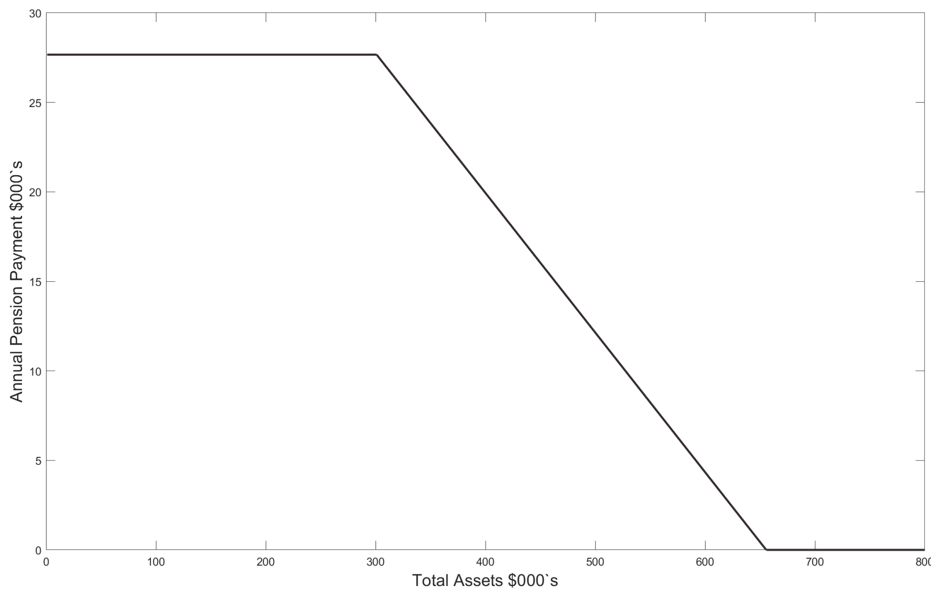


Figure 2: Age Pension Asset Means Test

3.3 Income Tax System

Australian income tax rates for 2023-24 are detailed in the Table 1. In this model, an individual's before tax income y_j and non-superannuation asset income ar are subject to this tax system, modelled as follows. Firstly, the annual pre-tax super contribution S is defined as a portion of pre-tax income, where τ_j is the superannuation guarantee, and y_j is pre-tax income, as seen in section 3.1.

$$S = \tau_j e y_j$$

Taxable Income	**Tax on this Income**
0-$18,200	Nil
$18,201 - $45,000	19c for each $1 over $18,200
$45,001 - $120,000	$5,092 plus 32.5c for each $1 over $45,000
$120,001 - $180,000	$29,467 plus 37c for each $1 over $120,000
$180,001 and over	$51,667 plus 45c for each $1 over $180,000

Table 1: Australian Income Tax System (Australian Tax Office, 2023)

Post superannuation income A is the money left after superannuation has been extracted. This money is then taxed before agents can choose to save it as a non-superannuation asset or spend it on consumption. A is also subject to the superannuation contribution cap of $27,500.

If $S \leq \$27500$

$$A = (1 - \tau_j)ey_j + ar$$

If $S > \$27500$

$$A = ey_j - \$27500 + ar$$

When S is less than $\$27,500$, A is the proportion of pre-tax income that does not go into an agent's superannuation account plus interest accumulated on non-superannuation assets. Under the current SG of 11%, this is 89% of pre-tax income. When S is above $\$27,500$, A is equal to pre-tax income minus the contribution cap plus interest accumulated on non-superannuation assets.

Now that after super income A has been defined, this income is subject to specific tax rates, modelled based on Table 1. These rates follow the progressive income tax system currently present in Australia. I is after tax income, as seen in section 3.1.

If $A \leq \$18200$

$$I = A$$

If $A > \$18200$

$$I = \$18200 + (1 - 0.19)(\min(\$45000, A) - \$18200)$$

If $A > \$45000$

$$I = (1 - 0.325)(\min(\$120000, A) - \$45000)$$

If $A > \$1200000$

$$I = (1 - 0.37)(\min(\$180000, A) - \$120000)$$

If $A > \$1800000$

$$I = (1 - 0.45)(A - \$180000)$$

When A is less than \$18,200, agents do not pay any tax, so after tax income equals after super income. When A is between \$18,201 and \$45,000, agents receive \$18,200 tax free, but are then taxed 19c for every dollar between \$18,200 and \$45,000. Higher tax brackets continue this pattern, as described in Table 1.

3.4 Idiosyncratic Income Shock

Agents income during working life is made up of two components. A deterministic life-cycle component described by y_j, and an idiosyncratic stochastic component described by e. This stochastic component is supposed to capture unexpected fluctuations in household incomes, such as unemployment spells, promotions, career changes, bonuses, and so on. I model this stochastic component with a Markov chain, which captures both the randomness and persistence of household income across time. The idiosyncratic income shock $e_{j,i}$ is given by:

$$e_{j,i} = [e_1, e_2, e_3, e_4, e_5, e_6, e_7]$$

$$s.t.$$

$$e_1 < e_2 < e_3 < e_4 < e_5 < e_6 < e_7$$

$$\pi_e = \begin{bmatrix} p_{e,1,1} & \cdots & p_{e,1,7} \\ \vdots & \ddots & \vdots \\ p_{e,7,1} & \cdots & p_{e,7,7} \end{bmatrix}$$

Given an initial state of income $e_{j,i}$, a household will stay at their current level of income in the next period $e_{j+1,i} = e_{j,i}$ with probability $p_{e,i,h}$ and will move to a new level of income where $p_{e,i,h}$ stands for the probability of moving from state i to h.

4 Model Calibration and Data

The model is calibrated to match key life-cycle moments related to income, asset ownership and superannuation. To do this, the model is simulated with individuals facing idiosyncratic shocks in each period and optimally choosing savings and consumption across their lives. This simulation process is completed in the steady state of the model, where there is 100,000 agents. This number of agents is according to the Law of Large Numbers, which ensures average characteristics (such as income and utility) at each age do not change between different draws of the idiosyncratic component of income.

4.1 Externally Calibrated Parameters

Parameter values in this section were assigned directly from related literature or Australian data. The main data sources used include:

- 2019-20 Survey of Income and Housing (Australian Bureau of Statistics, 2022)
- 2021 Deaths Australia (Australian Bureau of Statistics, 2021)
- 2021 Australian Census (Australian Bureau of Statistics, 2022)

Table 2 provides a summary of the externally calibrated parameters that are constant across age. The period of the model is annual. The following text provides further details on the calibrations.

Description	Parameter	Value	Source
Superannuation Guarantee	τ_j	0.10	ATO
Coefficient of Risk Aversion	σ	2	Standard
Maximum Age / Year of Death	J	100	Standard
First Year of Retirement Age	J_r	65	Standard
First Year of Work Age	J_w	19	Standard
Interest Rate	r	0.0156	RBA
Persistence of idiosyncratic income process	ρ_e	0.941	Cho, Li, and Uren (2022)
Standard deviation of idiosyncratic income shock	σ_e	0.03	Cho, Li, and Uren (2022)
Superannuation Tax	t_k	0.15	ATO

Table 2: External Calibration

Death - Age varying survival probabilities s_j are obtained from the Australian Bureau of Statistics 2021 Death data covering all of Australia.

Risk Aversion - The coefficient of relative risk aversion, $\sigma = 2$, is standard in the literature and implies an elasticity of substitution of 0.5.

Interest Rate - The interest rate used in the model is the average of the Reserve Bank of Australia's cash rate over the last 10 years, from September 2013 to September 2023, equal to 1.56%. A 10 year average was used to mimic the current average interest rate in Australia, while minimising the impact of major shocks such as Covid-19.

Idiosyncratic Income Shock - The idiosyncratic income shocks follow Cho, Li, and Uren (2022) calibrations, who estimated parameters using HILDA. The persistence of the idiosyncratic income process is $\rho_e = 0.941$ and the standard deviation set as $\sigma_e = 0.03$. The income process is discretised with seven states using the Rouwenhorst (1995) method.

4.2 Model Fit and Internal Calibration

This section describes the model fit and internal calibration, demonstrating how the median of each variable is calibrated to fit Australian data, as shown in figure 3. The green line in each chart is all of Australia data. The black dashed line in each chart is the median of each variable in the model. Since there are 100,000 agents in the model, each with different paths of income, superannuation etc, this black line represents the median of these agents, or can be thought of as the 'median agent' at each age.

The income distribution closely follows median income data from the Australian Bureau of Statistics 2021 Census.

Superannuation follows the data from the Australian Bureau of Statistics 2019-20 Survey of Income and Housing at younger ages. At older ages the model deviates from the data. This is because in this calibration, the SG is set at 10%, the rate to which people measured in the 2021 Census were subject to. Those at older ages were subject to lower levels of superannuation throughout their life. Those who were aged 65 in 2021 were not subject to compulsory superannuation until 1992 when they were aged 36, a considerable portion of their working life without super. The model therefore fits the data as it is expected a 10% SG would lead to greater superannuation savings than Australian data, and that this difference would be more extreme for older ages.

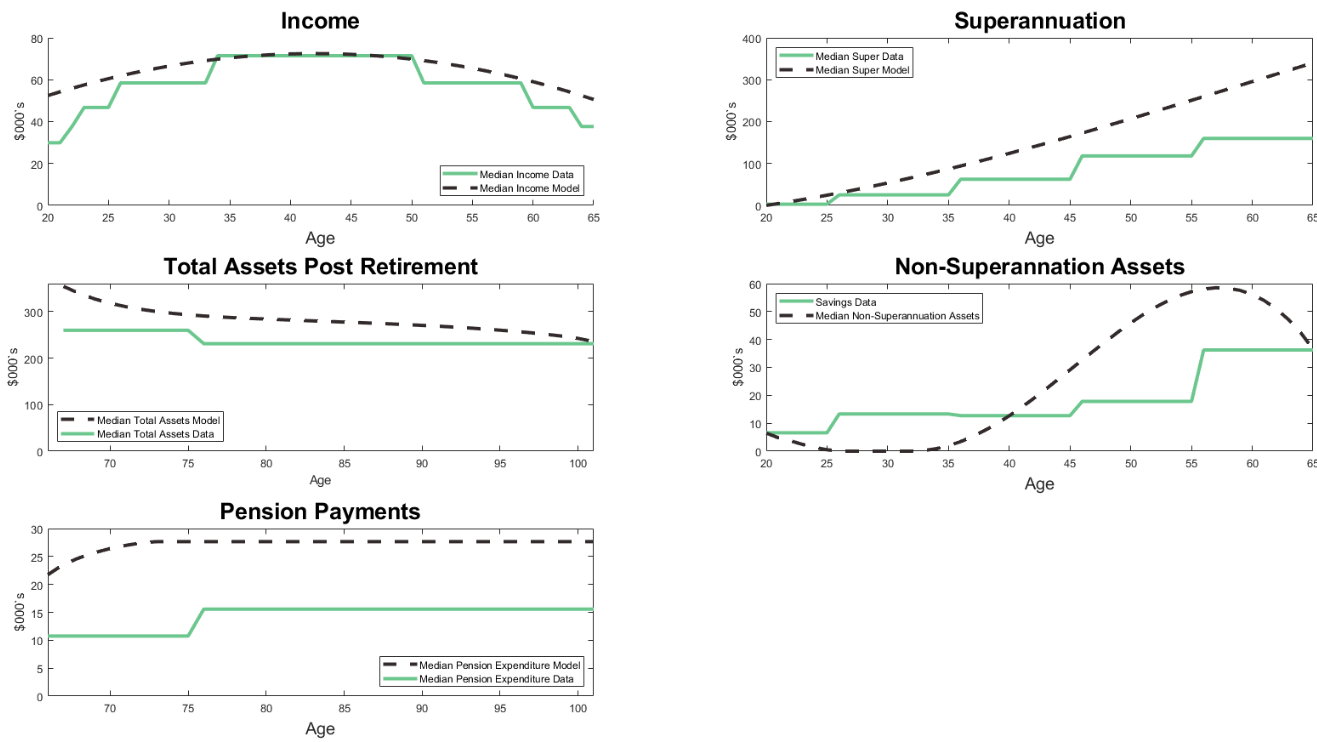


Figure 3: Model Fit

Five parameters are internally calibrated to match Australia wide data from the 2019-20 Survey of Income and Housing on superannuation and non-superannuation asset accumulation across the life cycle, summarised in Table 3.

As detailed in the model, super and non-super assets are combined in retirement, so these are shown in the Total Assets Post Retirement plot. The bequest parameters are chosen to match median total assets post retirement, exactly equalling the data at the end of life. Total assets sit above the data for the majority of retirement as superannuation assets where already higher than the data pre-retirement.

The discount factor is chosen to target non-superannuation assets in the year before retirement. In working life the median of non-superannuation assets does not exactly meet data from the 2019-2020 Survey of Income and Housing, but is relatively equal on average over time.

Description	**Parameter**	**Value**	**Moment**
Discount Factor	β	0.98	Median Wealth at Retirement
Bequest Preference	ψ	80	Median Wealth at Death
Luxuriousness of Bequests	$\overline{w}$	0.5	Median Wealth at Death
Mean of Initial Asset Distribution	μ_a	-2	Initial Non-super assets
SD of Initial Asset Distribution	σ_a	0.5	Initial Non-super assets

Table 3: Internally Calibrated Parameters

In the first year of work, an agent's assets are randomly assigned according to a log normal distribution, modelling the fact that people may already have some assets at age 19 from working at younger ages or other income streams. The mean and standard deviation of this distribution are calibrated to equal the data an non-superannuation assets in the first year of work.

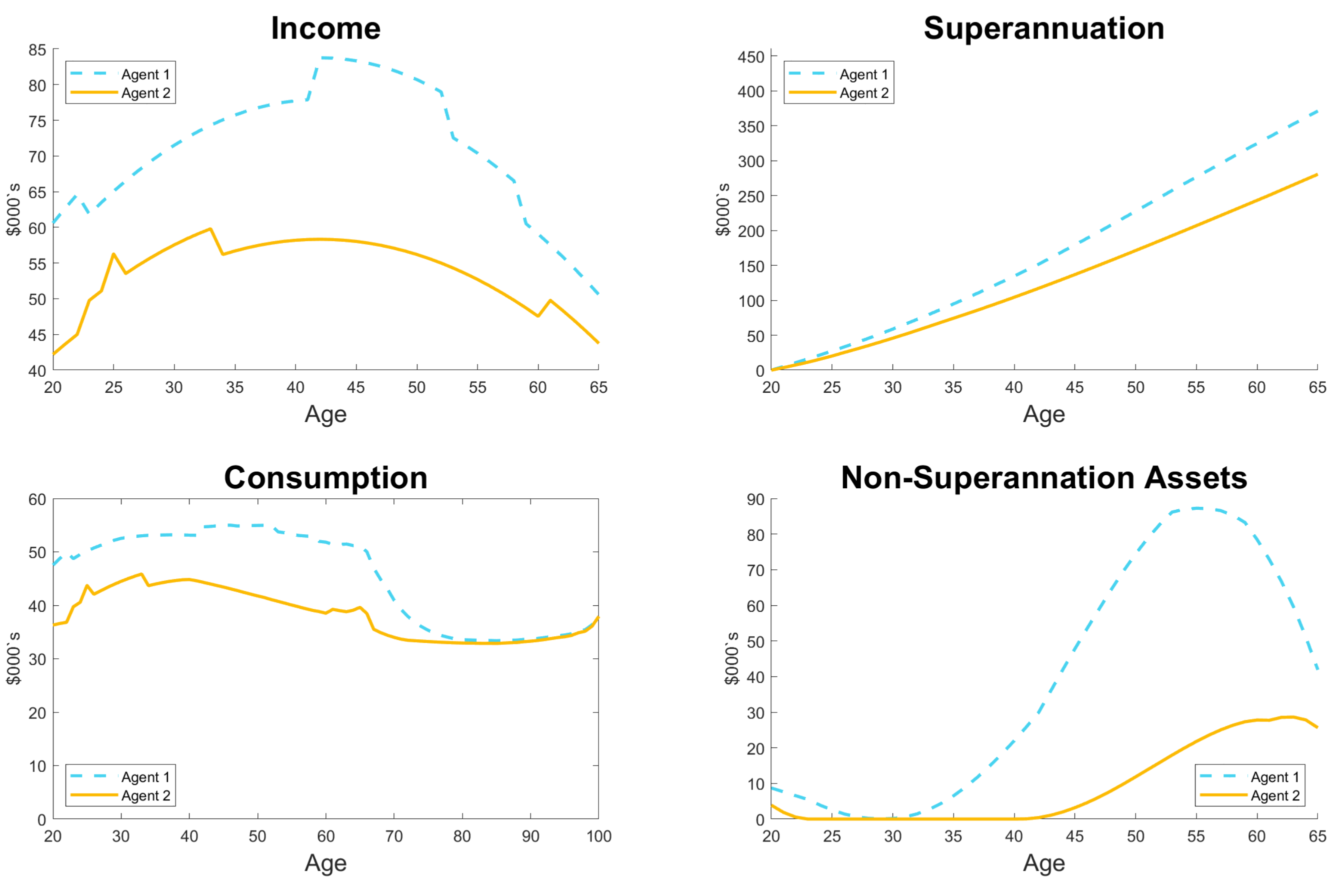
The median of pension payments in the model sits significantly above the data, but follows a similar functional form, increasing between 65 and 75 years before staying constant. This dissimilarity from the data is for two reasons. Firstly, higher pension payments in the model are likely due to older Australians having received a lower pension than the 2023 payout in the model. This is because pension payouts have continuously increased over time. Secondly, the model is calibrated with a pension assuming each agent is a single person, although in Australia many people are married at retirement. Couples receive lower per person pension payments, meaning the models assumption of single pension payments will mean higher pensions than Australian data.

4.3 Model with Two Agents

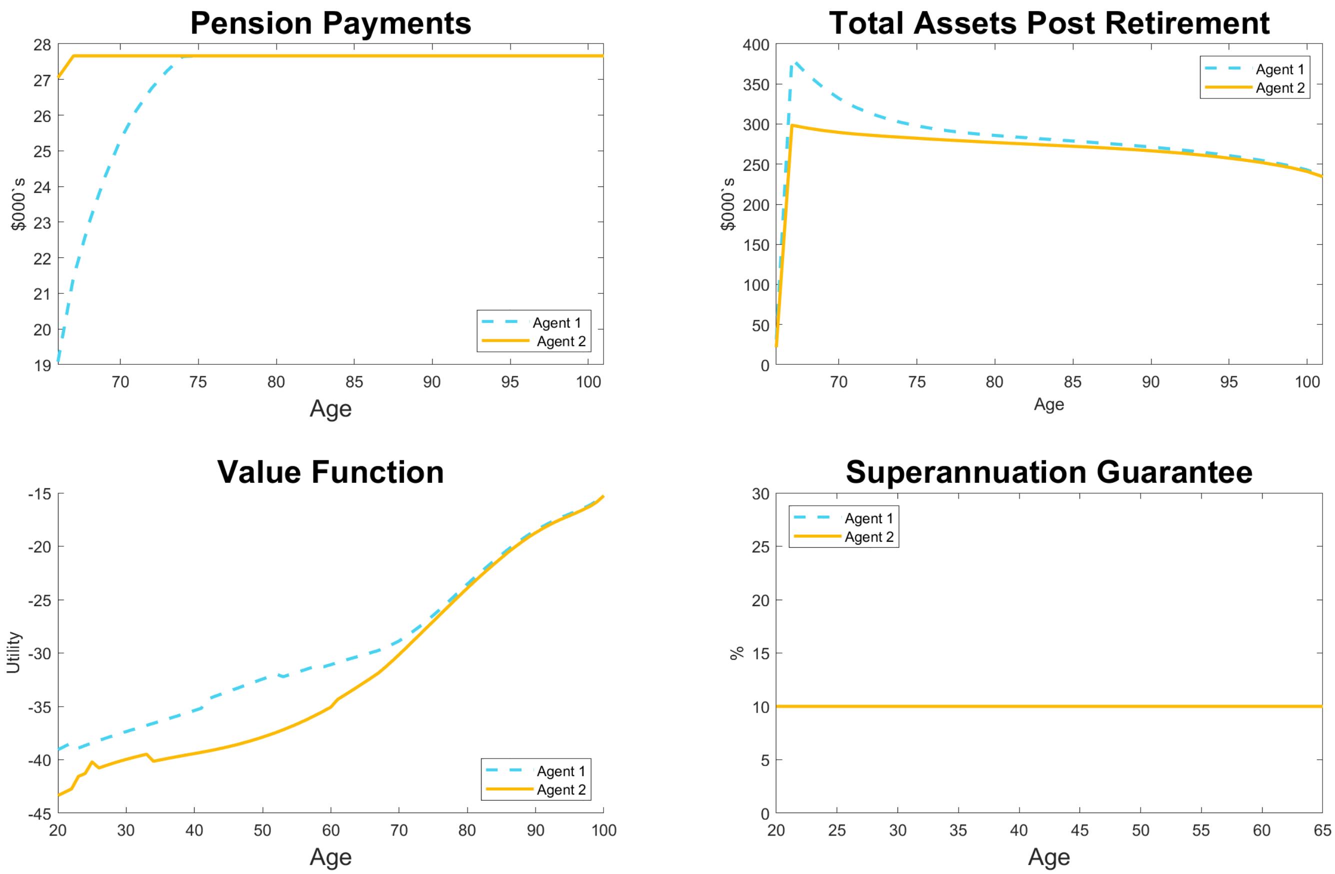
Having solved and calibrated the model, this section builds intuition by detailing the life-cycle of two random agents. Figure 4 graphs the life-cycle profiles of these two agents, showing their income, consumption, non-superannuation assets, superannuation, pension payments and utility.

The income graph depicts the idiosyncratic income shocks between the seven levels of the Markov chain probability matrix. Lower levels of income can be thought of as a working part-time job or receiving an unemployment benefit. Higher levels of income can be interpreted as working full time or receiving a promotion leading to a higher wage.

Agent 1 (blue dashed line) achieves relatively high income throughout their life-cycle, starting work at age 19 and reaching their highest income by the age of 42. Their income then drops slightly across their 50s before retirement at age 65. Agent 2 (orange line) receives a low income through much of their working life. They reach their highest income at age 33 before retiring at a lower income.



Panel A



Panel B

Figure 4: Model with 2 Agents

The income of an agent determines their levels of assets through superannuation accumulation and saving. An agent's assets are randomly assigned in their first year of work as calibrated in section 4.2 according to a log normal distribution, modelling the fact that people may already have some assets at age 19 from working at younger ages or other income streams. Assets are accumulated throughout the life-cycle because of the income risk associated with the idiosyncratic income shock, people save to smooth consumption in case they lose their job.

Agent 1's labour productivity (high level of employment) means they simultaneously see high levels of consumption, asset saving and superannuation saving throughout their working life. As agent 1 reaches retirement, their income begins to fall, causing them to draw down their assets to keep consumption relatively stable. Agent 2's low income means they spend their income for the first 40 years of their life, only saving a small amount to superannuation.

In retirement, agents are able to access their superannuation accounts, as evident by agent 1's significantly higher post-retirement assets. Since agent 2 has lower post retirement assets, they are able to access more pension assets according to the asset means test. As agents become older in retirement they spend more of their assets, allowing them to access more pension payments. At the same time, agents look to hold a certain amount of assets as a bequest at the end of life. This causes consumption to fall across retirement as both agents eventually start receiving and consuming the maximum pension level.

The value function, as defined in the model, is a function of current consumption, bequests and all future value functions, subject to a discount factor. The utility axis is negative as it is measured ordinally. Value is lowest in the first year of work and increases across the life-cycle. Value is lowest in the first year of work because it is a function of all future value functions, which are negative, so adding them together creates a more negative number. Agent 1's value function is higher through their working life as their consumption is higher than agent 2. In retirement, the value functions of both agents begin to align as their consumption and the value of their bequests equalise.

5 Changing the Superannuation Guarantee

Now that a model of the Australian economy has been built and calibrated, experiments on this model of changing the SG over people's life-cycles can begin. This section begins by building intuition through examining economies with no superannuation in section 5.1. It then explores a marginal change from the baseline 10% SG in section 5.2, and a comparison of all flat linear SG rates in section 5.3. I then move onto the novel contributions. Sections 5.4 and 5.5 investigate how the optimal slope depends on different target levels of pension reliance. Section 5.6 presents the papers main result. Section 5.7 outlines a simplified model to understand how different aspects of Australia's economy and superannuation system impact the results.

The cap on superannuation contributions is removed for these experiments. This is so changes in superannuation policies are not limited by the cap, allowing the unrestricted effect on the economy to be measured [2].

5.1 Economy with no Superannuation

As a counterfactual to future results, consider the economy where every agent is subject to a SG of 0% (black line) for their entire life compared to the baseline economy where every agent saves a 10% SG (blue line) for their entire life in figure 5. This is achieved by changing the value of τ_j from 10% as in the base calibration to 0% for all ages j. The median lines in this comparison can be thought of as the 'Median Agent' in each economy.

Median income is set independently and therefore equivalent across the SG rates. No superannuation is accumulated in the economy with the 0% SG.

[2] For instance in an extreme example where the SG were set to 50%, the majority of agents would only save superannuation up to the contributions cap, not actually saving 50% of their income into superannuation.

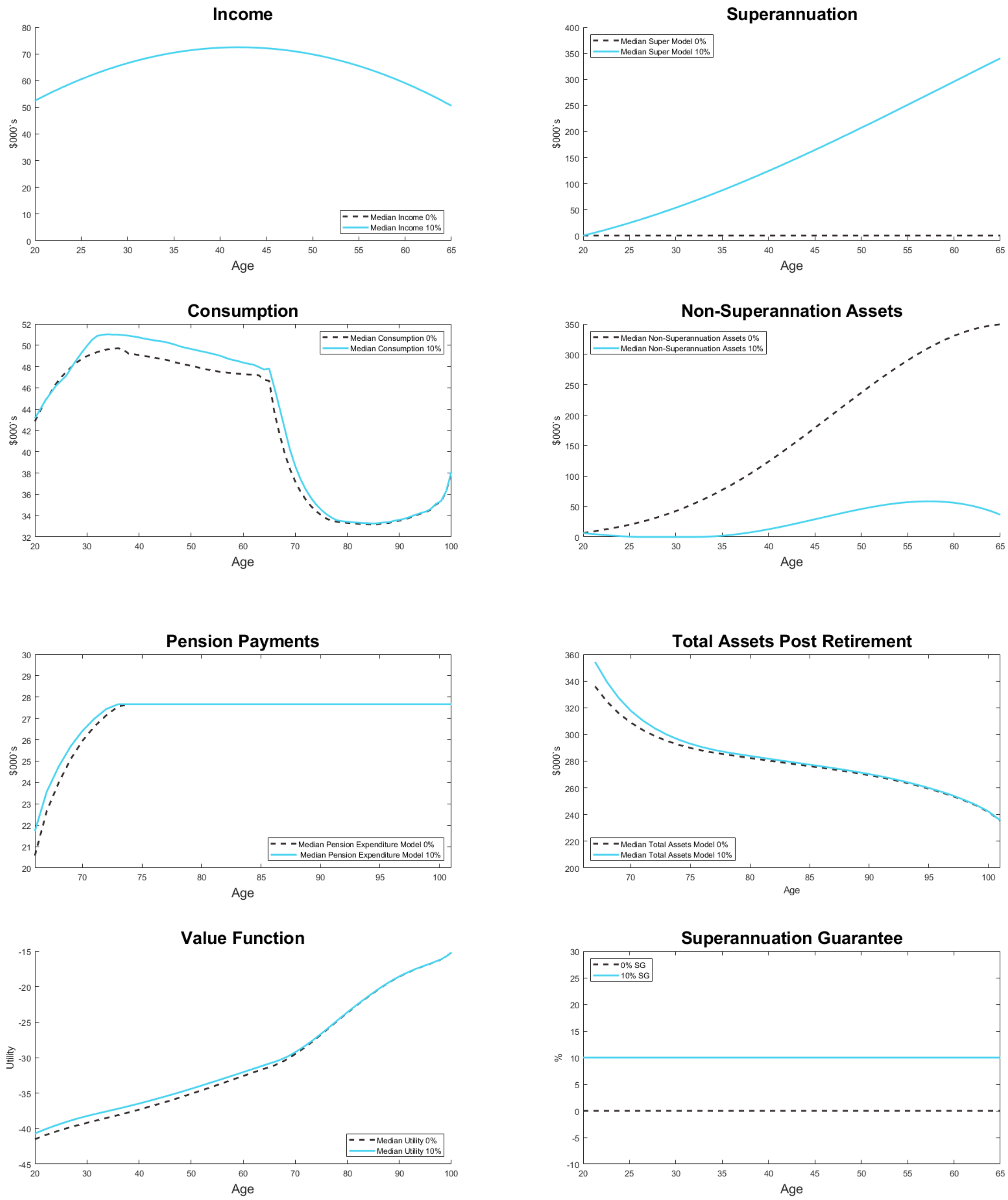


Figure 5: Economy with no Superannuation

Median consumption is initially equal between the economies for the first 10 years of work before the economy with the 10% SG exhibits higher consumption for the rest of life due to a wealth effect. Because of superannuation's higher after tax returns, saving more money in superannuation therefore leads to more total savings for retirement. Because of this, agents are able to consume a higher portion of income throughout life, as they have to save less for retirement.

A key difference is median non-superannuation assets, which accumulate significantly higher in the economy with a 10% SG. This is because without superannuation, agents in the economy with the 0% SG have to save for retirement using just non-superannuation assets. This highlights the superannuation substitution effect (Connolly, 2004), where the economy with the 10% SG substitutes out higher superannuation saving for lower non-superannuation saving.

Post retirement, the economy with the 10% SG sees higher total assets for the median agent in the first few years of retirement. This is because, although non-superannuation assets were lower in the year before retirement, superannuation assets are significantly higher due to the effect of longer term compound interest and higher returns due to tax incentives. Total assets post retirement for both economies equalise in later retirement as they aim for the same bequest level. The amount of pension payments made to the median agent is initially lower in the economy with the 10% SG due to higher total assets. As total assets equalise later in retirement, so do pension payments.

The value function of the median agent in the 10% SG economy sits above the median agent in the 0% SG economy for working life before equalising in retirement. Working life utility is higher because consumption is higher throughout life in the economy with the 10% SG. Utility equalises in retirement as total assets equalise in retirement.

In summary, an economy with a 10% SG has both higher utility and lower pension expenditure compared to an economy with a 0% SG.

5.2 Flat Linear SG Rates around the Baseline

The simplest experiment, as seen in a variety of related literature, is to compare the calibrated SG of 10% across the life cycle to a marginal change, for instance the 2023 level of 11%. Although similar to the previous section, Figure 6 compares the differences in key variables between these two economies.

Income is set independently and therefore equivalent across the SG rates. Median superannuation accumulation is higher for the 11% SG rate compared to the 10% as more income is compulsorily saved into agents' superannuation accounts.

The optimal choices of the median agents are depicted by comparing the consumption and non-superannuation asset graphs across their working life. At the beginning of their working life, the median agent already chooses to save close to zero, such that a higher superannuation rate causes a reduction in consumption until the median agent is around the age of 32. From age 32 until retirement, consumption is relatively equal between the economies with the 10% and 11% SG rates. This is because agents are undertaking precautionary saving due to the risk of negative income shocks and are beginning to save for forthcoming retirement as seen in the non-superannuation assets chart. The median agent with the 11% SG rate saves less non-superannuation assets as they are substituted for by higher superannuation saving.

Post retirement, the economy with the 11% SG sees higher total assets for the median agent in the first few years of retirement. This is because, although non-superannuation assets were lower in the year before retirement, superannuation assets are significantly higher due to the effect of longer term compound interest and higher returns due to lower taxes. Total assets post retirement for both economies equalise in later retirement as they aim for the same bequest level. The amount of pension payments made to the median agent is initially lower in the economy with the 11% SG due to higher total assets. As total assets equalise later in retirement, so do pension payments.

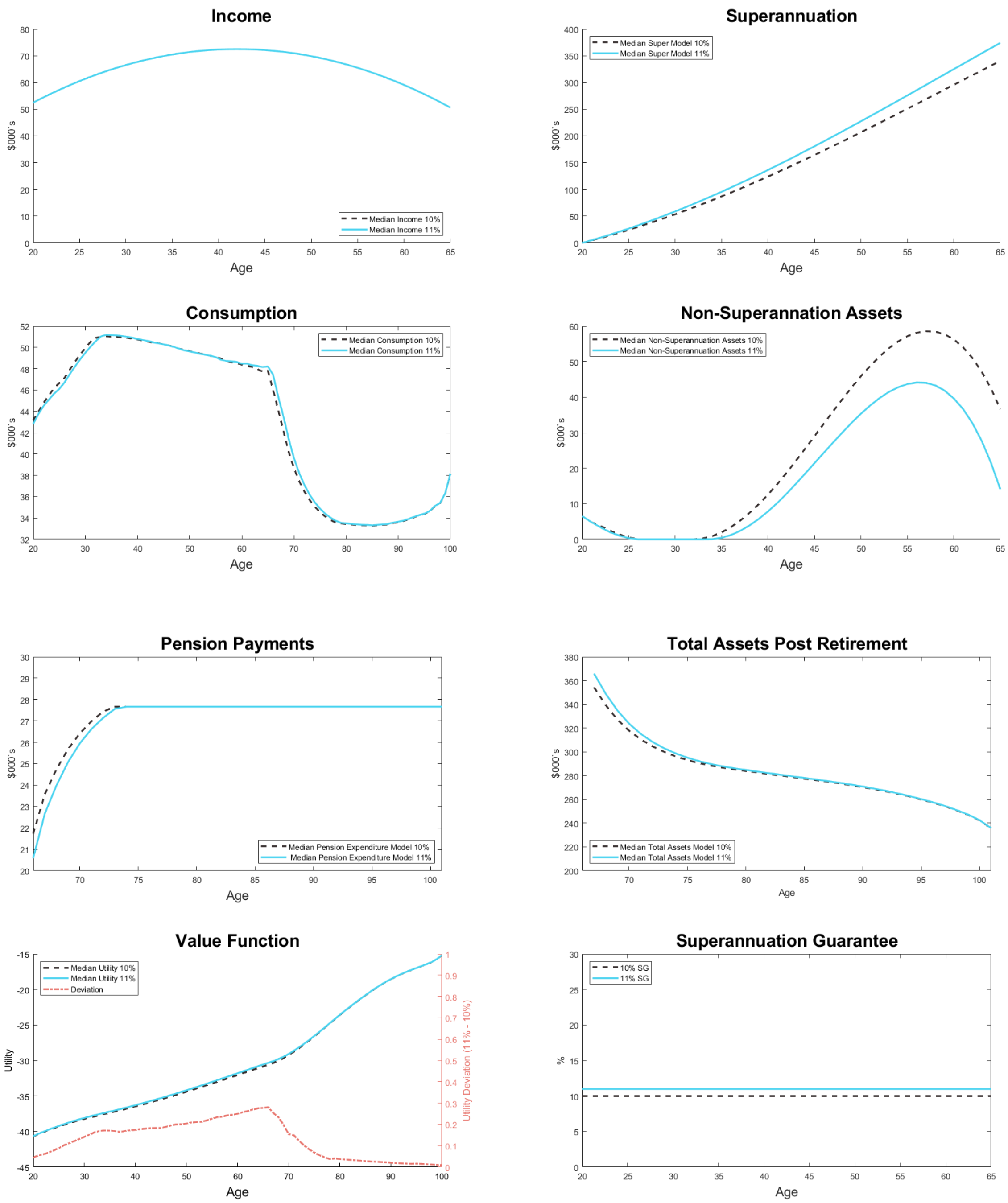


Figure 6: 10% vs 11% SG Levels

As the value functions are visually similar, the secondary horizontal axis of the value function graph depicts the difference between the two value functions. This involves subtracting the value function of the 11% SG economy from the 10% SG economy for every age. The value function of the median agent in the 11% SG economy sits just above the median agent in the 10% SG economy across the life-cycle. This is due to lower consumption in the 11% SG economies median agent's early working life being outweighed by higher consumption and asset saving in the first 10 years of their retirement.

In summary, we see that an economy with an 11% SG has both higher utility and lower pension expenditure compared to an economy with a 10% SG.

5.3 Flat Linear SG Rates Comparison

The next step, also already performed in related literature, is to test a range of different SG rates that are uniform across the life-cycle. To measure the relative differences between each of these superannuation policies, the median utility in the first year of work, per-capita pension expenditure and total saving will be compared. Median utility in the first year of work is used as it is a function of utility in all future periods, therefore encapsulating utility across the entire life-cycle. Per-capita pension expenditure is the addition of money spent on pension payments across every agent in every year of their life divided by the total number of agents. It is used to measure the impact of changing the SG on the government budget. Total savings is the addition of all savings of every agent in every year of their life. It is used to understand how the SG impacts the savings of Australians.

Figure 7 compares economies with flat linear SG rates from 0% to 30% at 1% intervals. SG rates at higher than 30% are likely to push the calibration of the model to become unrealistic, and are therefore not tested. To interpret this diagram, consider the economy with a 10% SG detailed in the previous section. This is represented by the red mark on each graph at 10%, showing the associated per-capita pension expenditure, first year of work utility and total lifetime savings of this economy. The 11% SG economy detailed in the previous section is represented just to the right of the red dot on each graph, at 11% on the horizontal axis.

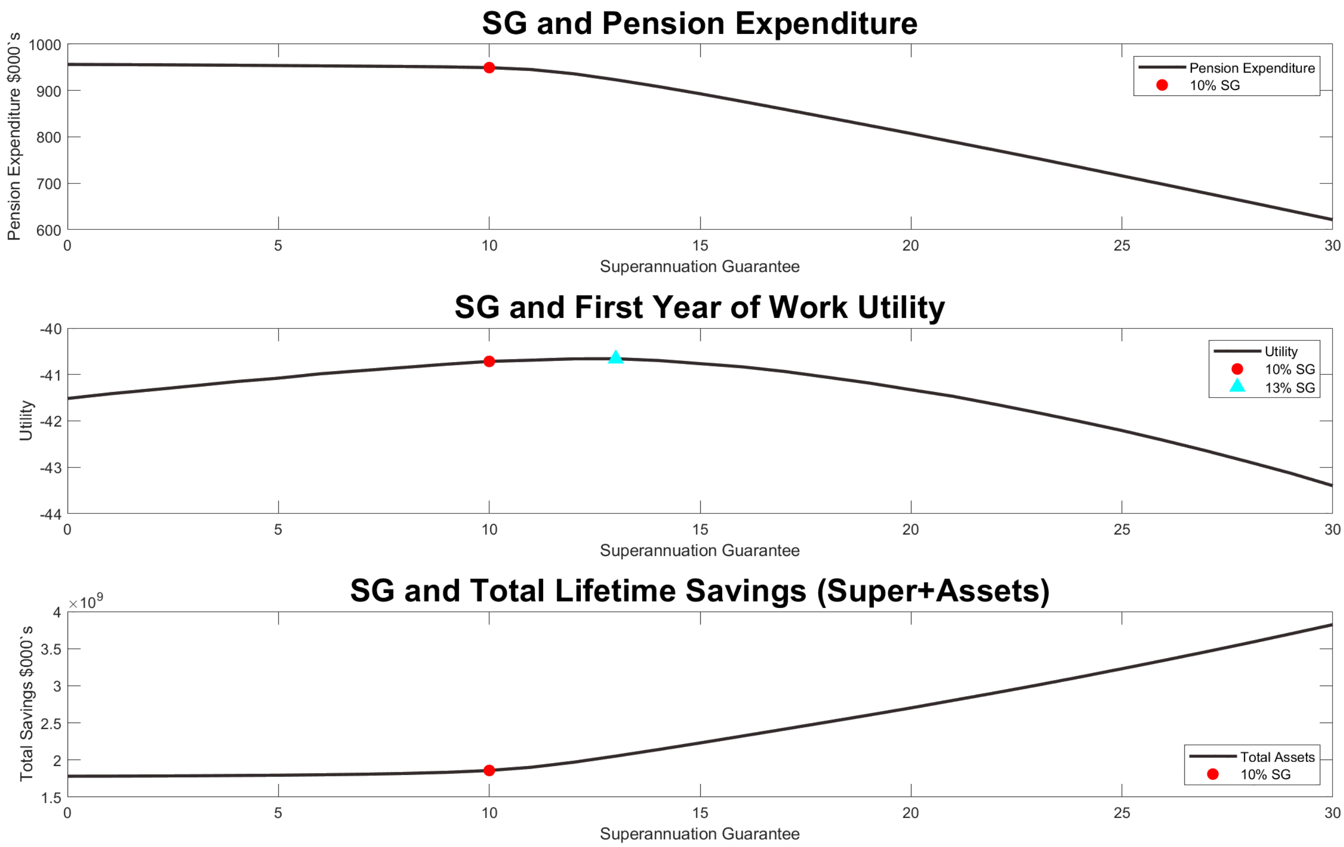


Figure 7: Flat Linear SG Comparison

Looking first at total lifetime savings, for economies with SGs of up to just under 10%, the SG rate does not cause a substantial increase in total saving. This is because of the aforementioned superannuation saving substitution effect: people will substitute all superannuation savings for decreases in non-superannuation savings. For economies with above 10% SG levels, the superannuation guarantee begins to bind as a budget constraint in working life, causing an increase in total lifetime savings higher than consumers would optimally choose without superannuation.

Pension expenditure is inversely related to total savings. Economies with SG rates below approximately 10% have high pension expenditure as agents have low total assets and therefore receive large pensions. Economies with above 10% SG's have higher total lifetime savings and therefore per-capita pension expenditure is lower as the asset means test for the pension begins to take effect.

The key result of this section is that utility is maximised in an economy with an SG rate of 13% in this model, represented by the blue triangle [3]. Utility reaches a maximum through the interplay of a variety of effects. Firstly, the differentiated tax treatment of superannuation means it has higher returns compared to non-superannuation assets in this model. Agents pay equal or less tax on superannuation accumulation than take home income, as detailed in section 3. This means economies with SG levels less than or equal to 13% cause agents to gain utility by saving in superannuation accounts rather than non-superannuation assets as they receive higher returns. This means agents have more money to consume or save as a bequest over their lifetime.

Economies with SG levels above 13% see agents saving a higher level than they would optimally choose. This causes a reduction in utility as the positive effect of higher superannuation returns is outweighed by the negative effect of being forced to save so much that consumption across working life is significantly lower.

Economies with SGs between 10% and 13% in this model are particularly interesting. Although lifetime saving has increased above what agents believe is optimal, the higher returns of superannuation mean it is still utility improving to save in this asset. The combination of these two effects is what causes utility to maximise at an SG of 13%.

5.4 Optimal Upward Sloped Linear SG Rate

This section details the first addition of this thesis to the existing literature. It compares an SG that is uniform across the life-cycle to one that is sloped linearly upward across the life-cycle. SGs that are sloped linearly upwards across the life-cycle are advantageous as they increase utility early in life while while keeping the amount of pension expenditure constant. Figure 8 displays an example comparing an economy with an SG level of 12% (blue line) across

[3] In reality, people will likely use voluntary superannuation to save this amount.

the working life to an economy with an SG that begins at 10% at age 20 and slopes upwards reaching 14.5% by the final year of work (black line). These SG functions were chosen as they have equal total per-capita pension expenditure, meaning they have equal impact on the government budget. To find economies with equivalent pension expenditures, all possible economies with different linear SG's where tested and pension levels measured. A full methodology is detailed in Appendix 1. As before, median income is equivalent between these two models.

Median superannuation accumulation is higher for the economy with the 12% SG throughout working life. It only equates to the economy with the upward sloped linear SG in the year before retirement. This relationship is due to the functional form of each SG rate. Earlier in the working life, the economy with the sloped SG is saving less than 12% of income into superannuation and therefore accumulates less superannuation than the economy with the 12% SG. As the economy with the sloped SG sees increased SG levels over agents life-cycles, the median agent's superannuation savings increases as they get older.

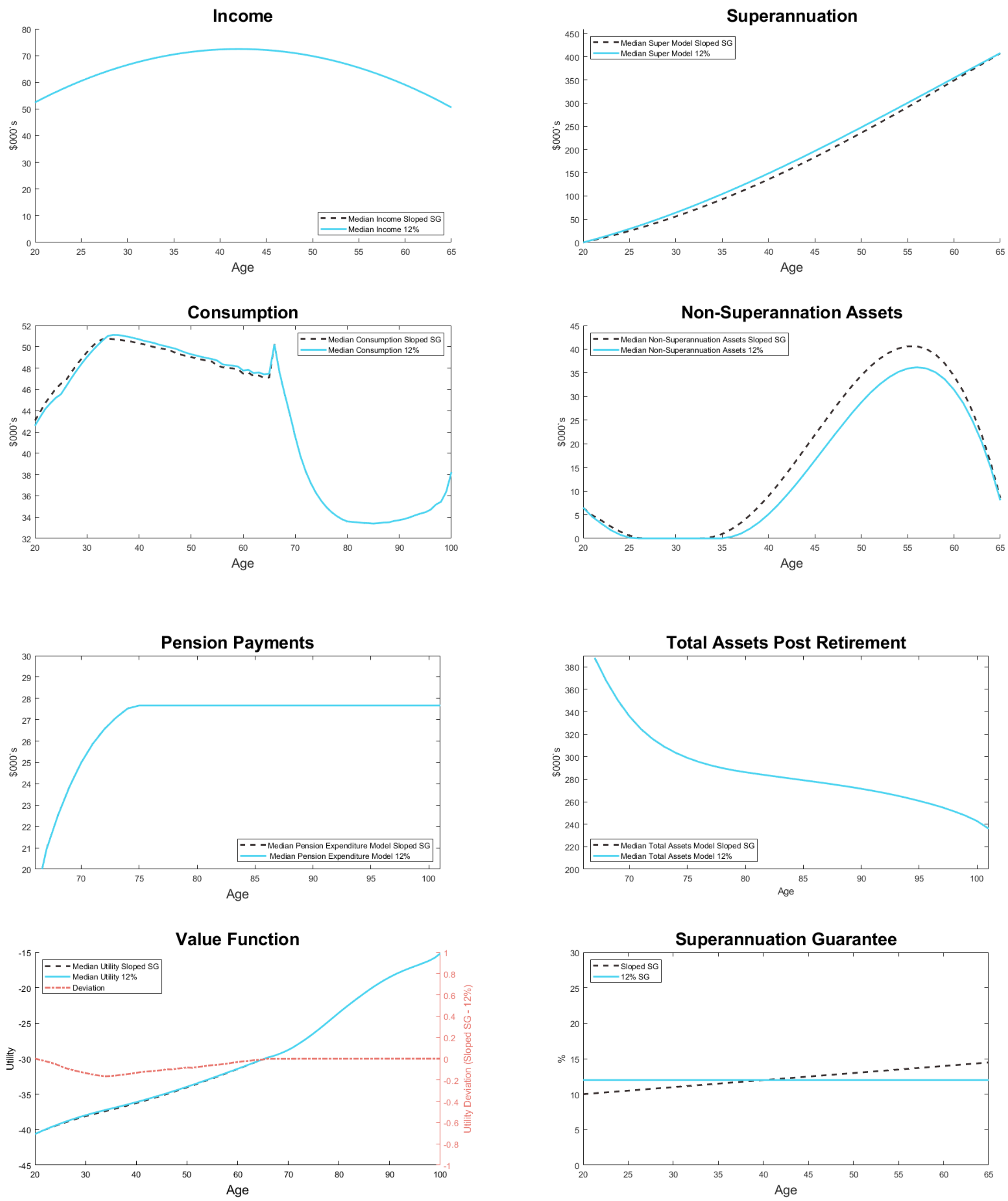


Figure 8: 12% SG and Linear Slope Comparison

The optimal choices of the median agents are found by comparing the consumption and non-superannuation assets graphs across working life. At the beginning of working life, the median agent already chose to save close to zero non-super assets. This means the economy with the sloped SG sees higher consumption until age 33 compared to the economy with the flat 12% SG. This is because the economy with the sloped SG has more income that is not locked away in superannuation compared to the economy with the 12% SG, which it can then spend. Above the age of 33, the economy with higher consumption switches to the flat linear 12% SG economy. This is because agents in the sloped linear SG economy expect that their superannuation will continue to increase in the future, and therefore decrease consumption today. In the first year of retirement consumption jumps upwards as agents are able to access their entire superannuation account and spend a portion of it in the first years of retirement as they move towards the target bequest level.

Now examining non-superannuation assets, we can see how the superannuation saving substitution effect works with a sloped linear SG function. The median agent of the economy with the sloped SG function begins saving non-super assets earlier than the 12% SG economy as they are not required to save this money in superannuation. The sloped SG economy continues to save more non-super assets across the life-cycle, substituting for its lower level of superannuation assets. Both economies reach the same level of non-superannuation saving in the final year as work as they also simultaneously reach the same amount of superannuation savings. The composition of savings between super and non-super assets at retirement is the same between the economies due to the superannuation substitution effect.

Post retirement, total assets for both economies are equal as they start with the same level of super and non-super assets, before aiming for the same level of bequests. As total assets are the same in retirement, consumption is also equivalent between the two economies. As intended, median pension payments are equivalent between these two economies as total assets are also equal.

The value function of the median agent in the sloped linear SG economy sits above the 12% flat linear SG economy for the first year of work due to higher consumption. The value function of the sloped SG then sits lower than the 12% economy for working life as consumption is lower, before equalising in retirement. Median utility in the first year of work encapsulates utility across the entire life-cycle as it is a function of utility in all future periods. Therefore even though utility is negative for later working life, overall utility for the median agent in the sloped SG economy is higher.

In summary, by using an upwards sloping SG function between 10% and 14.5% across working life, a policymaker can achieve higher utility for agents in the economy and equal per-capita pension payments compared to a flat linear SG of 12%.

5.5 Optimal Downward Sloped Linear SG Rate

At higher levels of pension expenditure, where the average level of the SG over the lifecycle is lower, the model suggests downward slopping SG functions over the life-cycle are optimal. Figure 9 displays an example comparing an economy with an SG level of 6% (blue line) across working life to an economy with an SG that begins at 10.5% at age 20 and slopes downwards reaching 1% by the final year of work (black line). These SG functions were chosen as they have equal total per-capita pension expenditure.

Agents have an incentive to save throughout retirement in this model. They must save later in retirement to leave a larger bequest and also look to save to smooth consumption throughout early retirement. In section 5.3 the model suggested a 13% uniform SG was optimal, indicating that agents would like to save more of their money in superannuation than the 6% SG presented here. Given pension expenditure equal to that of the 6% SG, a downward sloping SG curve is utility increasing as it increases the total amount of money invested in super. A higher SG earlier in life will net agents more super savings due to the effect of compound interest and superannuation tax incentives.

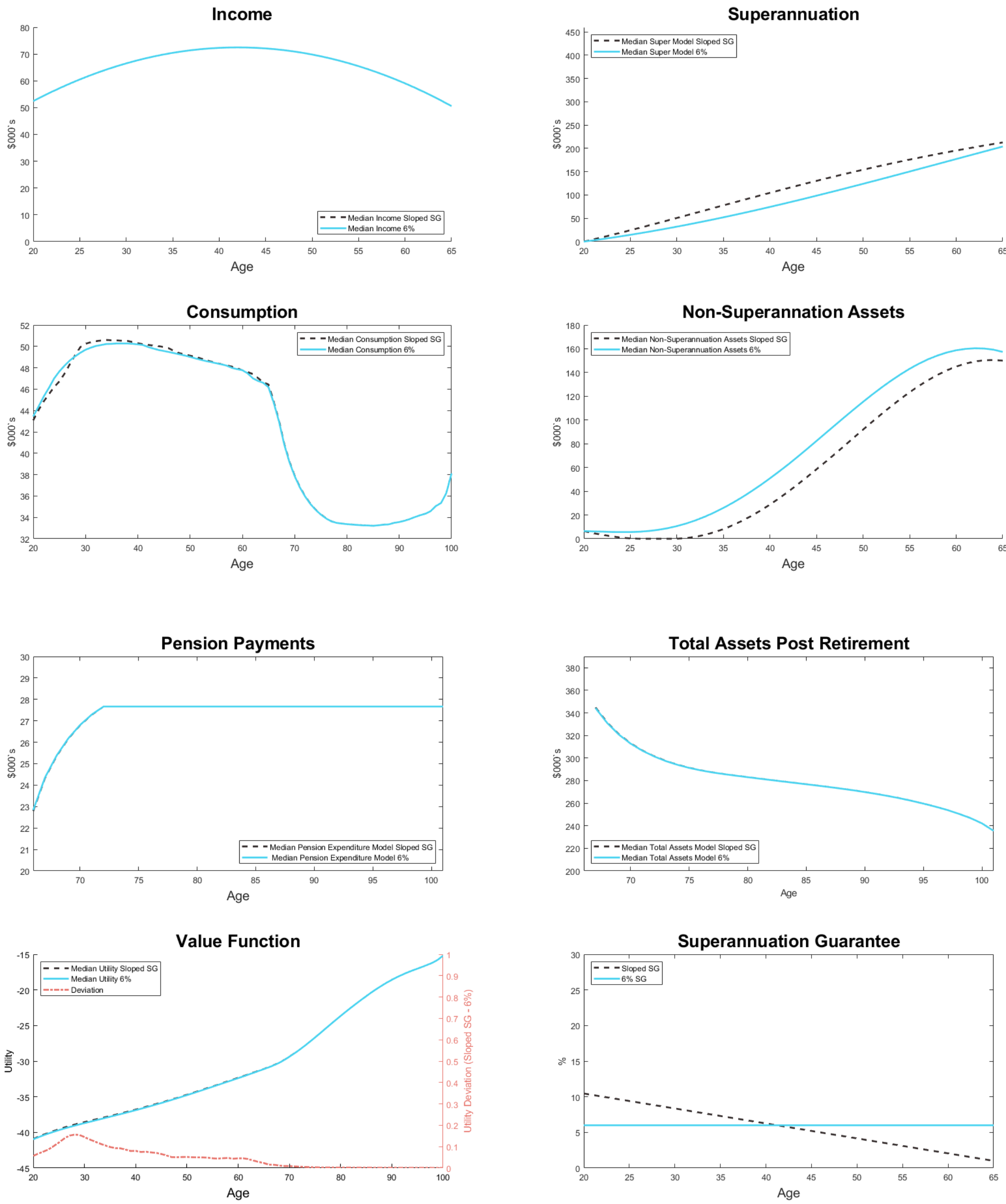


Figure 9: 6% SG and Linear Slope Comparison

As described above, superannuation is higher throughout life in the economy with the sloped SG because their SG rate is higher earlier in life. This means the median agent in the sloped SG economy needs to save less non-superannuation assets throughout working life. Consumption is initially lower for the sloped SG as they trade this off for higher superannuation saving. Consumption in the sloped SG economy then overtakes the flat 6% economy at the age of 28 and stays like this for the rest of working life as they are forced to pay less superannuation. The economies are equivalent in retirement. The value function is higher for the sloped SG throughout life, reflecting overall higher consumption throughout working life.

Overall, the median agent in the economy with the sloped SG betweeen 10.5% and 1% was able to make an investment in superannuation earlier in life, allowing them to consume more throughout later working life while reaching an equivalent level of savings in retirement compared to a flat 6% SG.

5.6 Sloped Linear SG Rates Comparison

As seen in previous sections, saving superannuation increases retirement assets, leading to reduced reliance on the age pension through the assets means test, a key objective of superannuation (Keating, 1995). If individuals save too little for retirement, this creates a fiscal externality, forcing the government to increase expenditure on the age pension. This section repeats the methodology of the previous section, but for all linearly sloped SG's between 5% and 25%. That is, any change in the SG must satisfy a constraint that government pension expenditures are held constant. The results of this section allow policy makers to choose an SG function that maximises individuals utility subject to a given level of fiscal externality imposed by the age pension. SGs higher than 25% and lower than 5% are likely to push the calibration of the model to become unrealistic, and are therefore not tested (these results can be found in appendix 1).

Table 4 displays the main results. The first column is the uniform SG function, the second is the total per capita pension expenditure and the third is the first year of work utility associated with the uniform SG. The fourth and fifth columns describe the sloped linear SG function that maximises utility given the same pension expenditure level. Column 6 is this maximised utility.

For instance, the uniform SG of 12%, which will be reached in Australia by 2025, has an estimated total per capita pension expenditure of $936,046 and a utility ranking of -40.6605. An upward slopping SG function that starts at 10% in the first year of work and reaches 14.5% by the final year of work leads to an increase in utility to -40.6553.

Uniform SG	Pension Expenditure	Utility	First Year of work SG	Final Year of work SG	Utility Max
5%	$953,727	-41.0793	9.82%	0.00%	-41.0059
10%	$949,290	-40.7178	10.00%	10.00%	-40.7178
11%	$945,133	-40.6911	8.60%	14.00%	-40.6752
12%	$936,046	-40.6626	10.00%	14.47%	-40.6553
13%	$923,078	-40.6605	9.00%	17.90%	-40.6495
14%	$908,567	-40.6976	11.00%	17.66%	-40.6799
25%	$715,967	-42.2078	20.91%	30.00%	-42.1310

Table 4: Main Results

Three key trends can be identified in table 4 in economies with different uniform SGs. Firstly as the SG increases, the amount of pension expenditure decreases as people are forced to save more into superannuation, allowing them to fund their own retirement. The rate of decrease in pension expenditure increases rapidly above the uniform SG of 13% as these SG forces people to save more than they would like to otherwise.

Secondly, consider the result from section 5.3 that a 13% flat linear SG maximises utility. By holding pension expenditure constant at this level, a sloped SG function with a SG of 9% in the first year of work and 17.9% in the final year of work performs even better, maximising utility compared to every other function tested. This is because the upward slope allows younger agents to consume more while still saving the same amount for retirement, maximising utility. This model therefore suggest that this sloped SG function is the most optimal superannuation policy to maximise Australians well being. Previous literature investigating only flat linear SG rates has therefore left a significant gap in its analysis.

The third trend involves the slope of the optimal SG function as the uniform SG varies. At lower uniform SGs, downward sloped functions are optimal. This then switches at the 10% SG, where a flat function is the most optimal. Above a 10% uniform SG, functions with upward slopes are optimal. The reasoning behind these optimal slopes are explained in the following section.

5.7 Determinants of the Optimal SG Slope

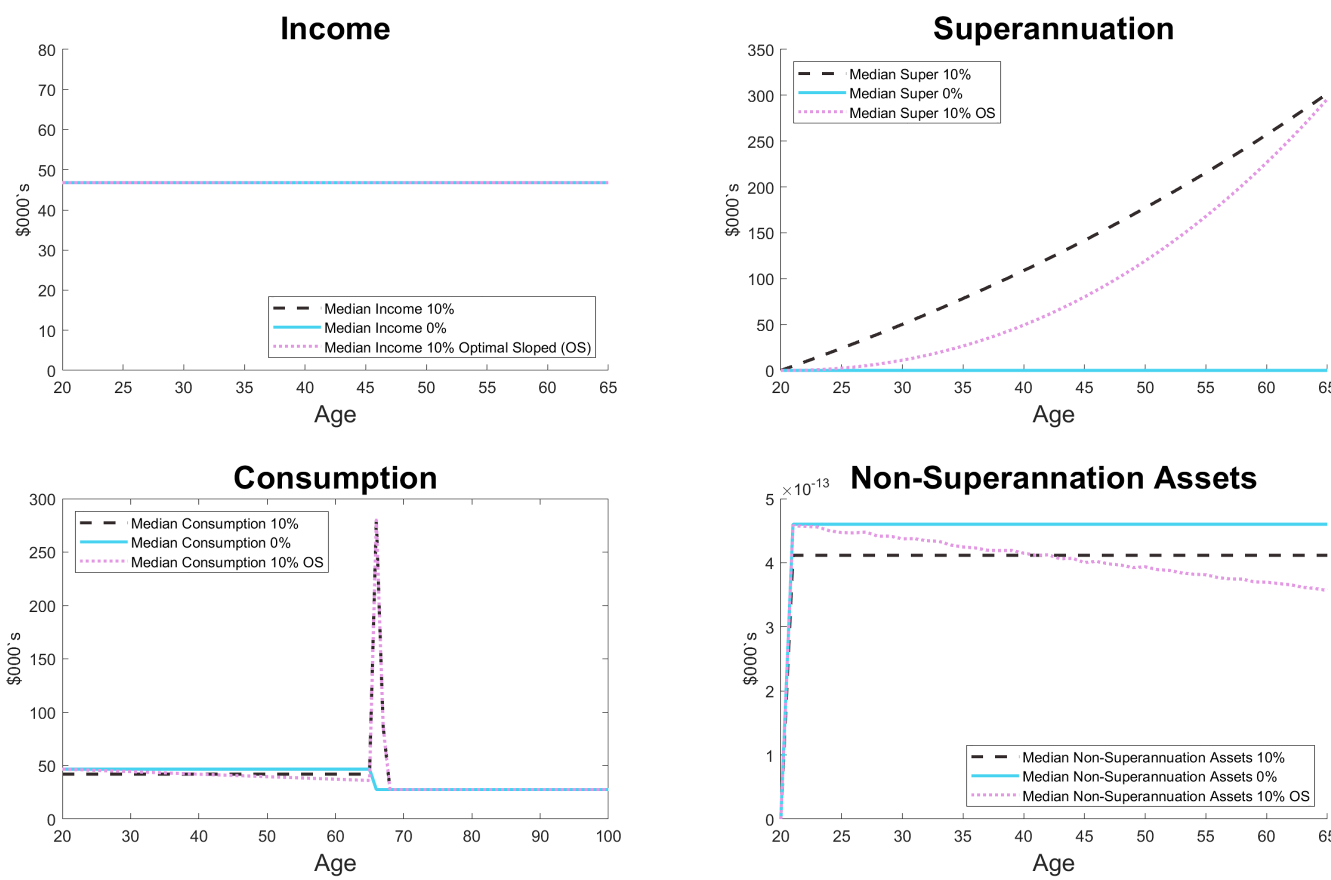
This section investigates why at different uniform SG's, and therefore at different levels of pension expenditure, different sloped SG's are optimal. To do this, I remove key components and assumptions of the model described in section 3. This includes removing the bequest incentive, hump shaped income profile, initial asset distribution, idiosyncratic employment shock and all taxes. This leaves a simplified model through which I add back model components one at a time. This is with the goal of gaining an understanding of how each aspect of Australia's economy and superannuation system influence the optimal SG function at each pension expenditure level. I focus on adding back the bequest incentive, taxes and idiosyncratic income shock, as these model components have the greatest impact on optimal slopes.

5.7.1 Simplified Model

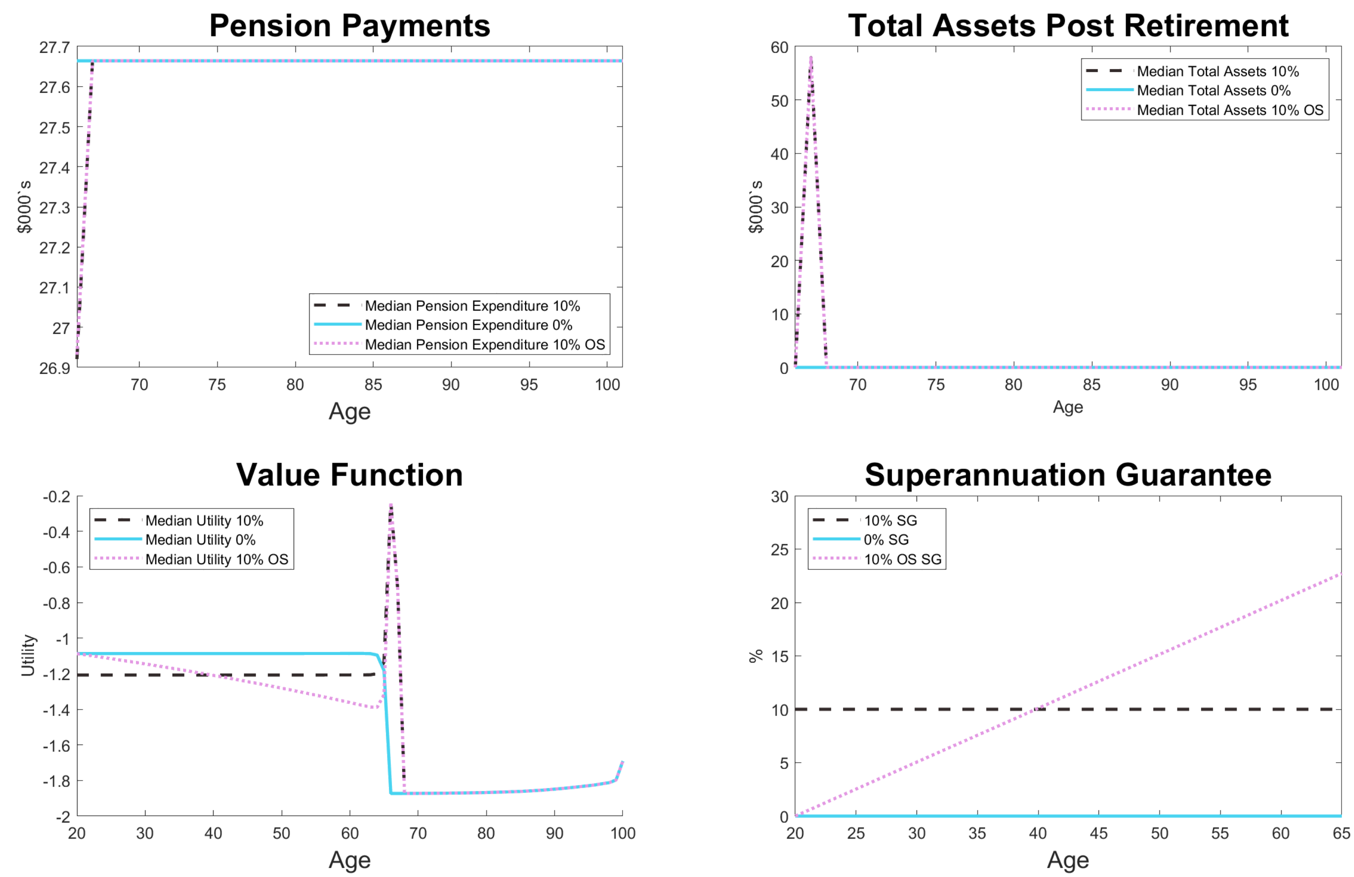
Here I describe a simplified model excluding the bequest incentive, hump shaped income profile, initial asset distribution, idiosyncratic employment shock and all taxes. Please note the model now moves far from the calibration in section 3, and therefore does not resemble the Australian economy well.

I remove the bequest motive by setting $\phi = 0$, agents no longer gain utility from leaving warm glow bequests at the end of life. I remove the assumption that pre-tax income y_j is hump shaped, instead adopting a flat income profile across the life-cycle that has equal total life-time income as the calibrated hump shaped profile. The internal calibration of an initial asset distribution is nullified so agents do not start life with any assets. This is achieved by setting ρ_e and σ_e to 0. The idiosyncratic employment shock is nullified so the model becomes a representative agent model, every agent follows the same income path across their life cycle.

This leaves the basic model depicted in figure 10. The blue line in this figure depicts the variables of the representative agent in an economy with a 0% SG. The black dashed line represents the representative agent in an economy with a 10% SG and the purple dotted line represents the SG that maximises utility given the same pension expenditure level as the flat linear 10% SG. All economies have the same flat linear income profile.



Panel A



Panel B

Figure 10: Simplified Model

Starting with the economy with the 0% SG, consumption follows the path of income, with agents only saving a small proportion of income into liquid assets. This income is then spent in the first years of retirement to smooth consumption as the representative agent takes full advantage of the age pension.

At a 10% SG the representative agent is forced to save super and therefore decrease consumption and saving of liquid assets[4]. In the first two years of

[4]Through a small superannuation substitution effect

retirement the agent spends all their superannuation assets, looking to reach the pension. This higher level of superannuation assets in the first years of retirement is enough to decrease pension reliance through the asset means test, leading to lower government pension expenditure. Because the SG in this economy moves saving far from what the agent would choose otherwise, it is strictly utility decreasing to save any superannuation as seen in the value function graph.

Now focusing on the economy with the sloped linear SG that maximises utility at the same pension expenditure level as the 10% flat SG. Utility is maximised by choosing the sloped SG the minimises superannuation saved earlier in life while still reaching the same pension expenditure level. This is achieved by an upward sloping SG starting at 0% in the first year of work and reaching 22.7% by the final year of work. Since superannuation is utility decreasing as described above, an upward slope has less superannuation early in life, therefore maximising first year of work utility. This is through increasing consumption early in life relative to the 10% SG leading to higher utility.

Uniform SG	Pension Expenditure	Utility	First Year of work SG	Final Year of work SG	Utility Max
5%	$995,904	-1.1441	0%	0%	-1.0869
10%	$995,160	-1.2076	0.0100%	22.7200%	-1.0874
11%	$992,732	-1.2212	0%	25%	-1.0874
12%	$990,304	-1.2351	0%	27.2800%	-1.0875
13%	$987,876	-1.2493	0.0100%	29.5400%	-1.0877
14%	$985,448	-1.2638	1.4400%	29.9900%	-1.1035
25%	$968,240	-1.4492	15%	29%	-1.2791

Table 5: Simplified Model Main Results

Table 5 displays expanded results for this base model, showing upward sloped SG functions are optimal at all pension expenditure levels. A flat 0% SG is found to be optimal at lower uniform SG's. This is because these low uniform SG's do not force enough saving to decrease pension expenditure, and therefore have the same level of pension expenditure as an economy with no SG. The representative agent therefore chooses the highest utility SG of 0% at all ages. An expanded version of table 5 can be found in appendix 2.

Now this base model has been set up, the following sections begin to individually add components to this model to understand how the optimal slopes change.

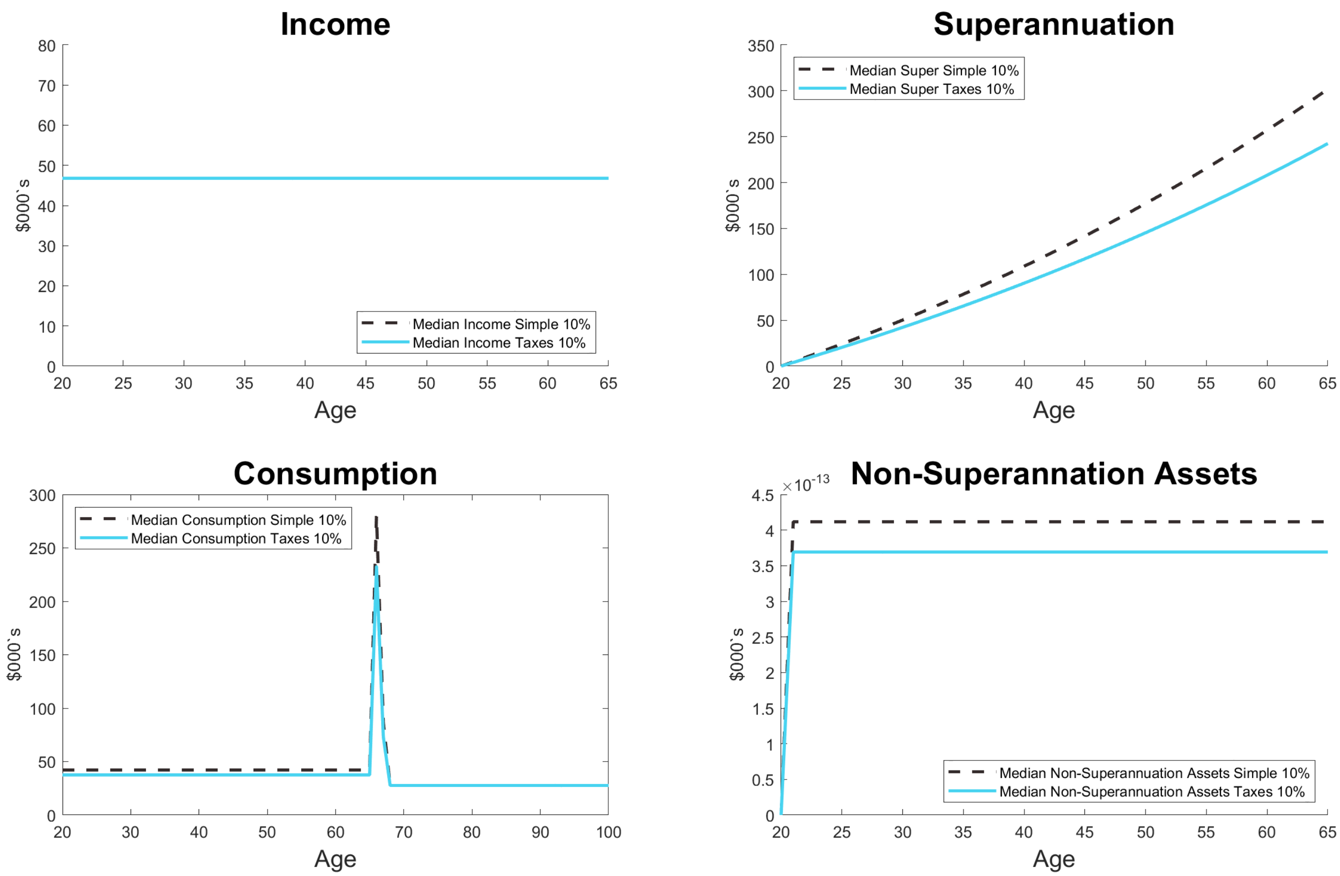
5.7.2 Simplified Model with Taxes

In the full calibrated model, the main effect of the superannuation and income taxes is to make superannuation an attractive investment through lower tax rates. But in this simplified model there is no incentive to accumulate large savings in retirement. Adding taxes to the base model by themself just leads to a decrease in after tax income, therefore reducing returns on super and non-super assets. This leads to a shift downwards in consumption as well as liquid and illiquid savings. Figure 11 depicts this effect with the blue line representing the simplified economy at a SG of 10% and the black dotted line representing the simplified model including taxes at a 10% SG. Lower total asset saving means the economy with taxes does not reach the required total asset level in retirement to decrease pension expenditure according to the asset means test.

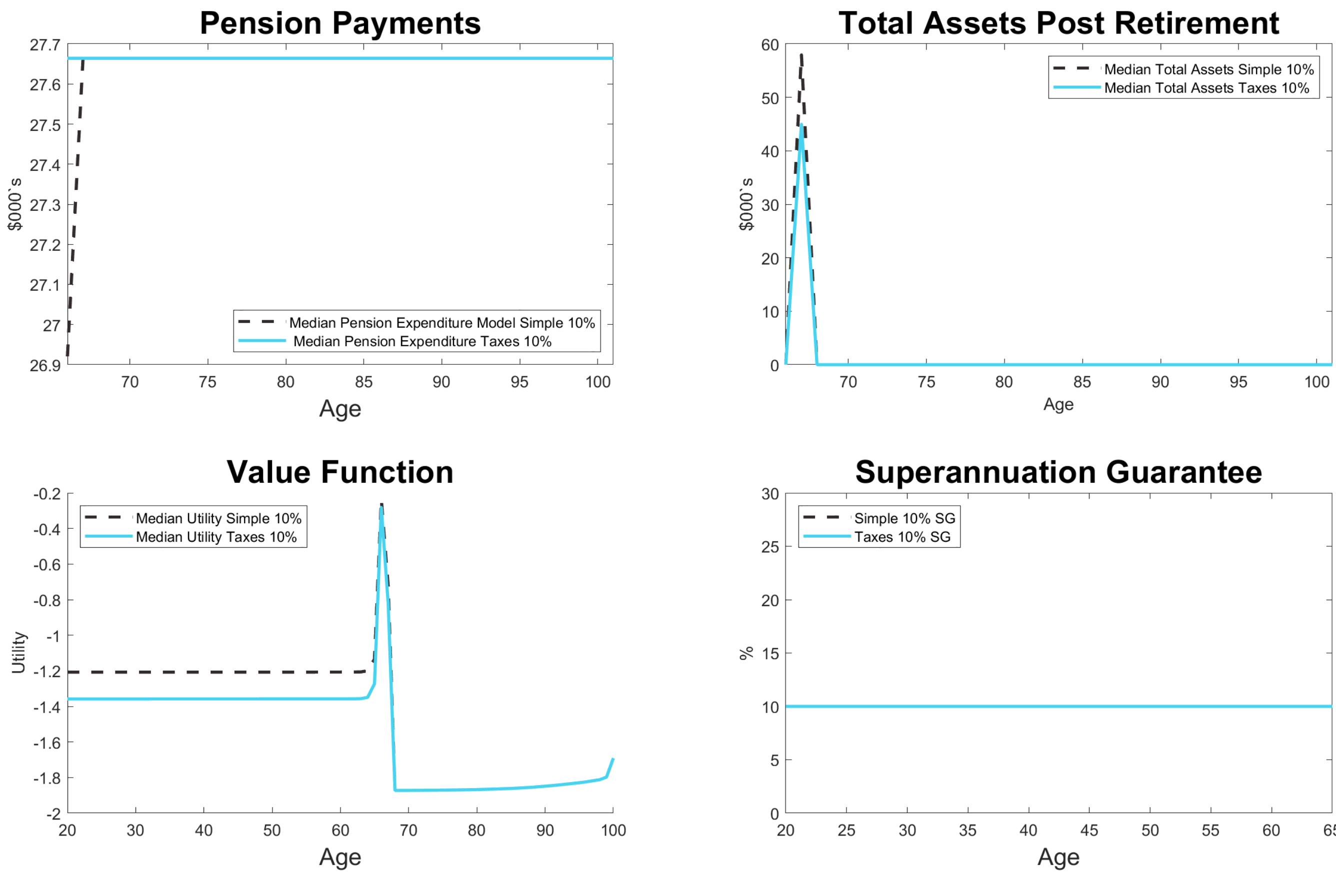
Uniform SG	Pension Expenditure	Utility	First Year of work SG	Final Year of work SG	Utility Max
5%	$995,904	-1.2937	0%	0%	-1.2416
10%	$995,904	-1.3582	0%	0%	-1.2416
11%	$995,904	-1.3719	0%	0%	-1.2416
12%	$995,904	-1.3858	0%	0%	-1.2416
13%	$994,115	-1.4001	0.0100%	28.9600%	-1.2422
14%	$992,167	-1.4147	0.9800%	30%	-1.2516
25%	$970,737	-1.5978	20.9300%	30%	-1.5248

Table 6: Simplified Model with Taxes Main Results

The overall effect of taxes is therefore to increase the level of uniform SG at which the asset means test decreases government pension expenditure. This can be seen in table 6, with upward sloping SG's only becoming optimal at and above a 13% uniform SG.



Panel A

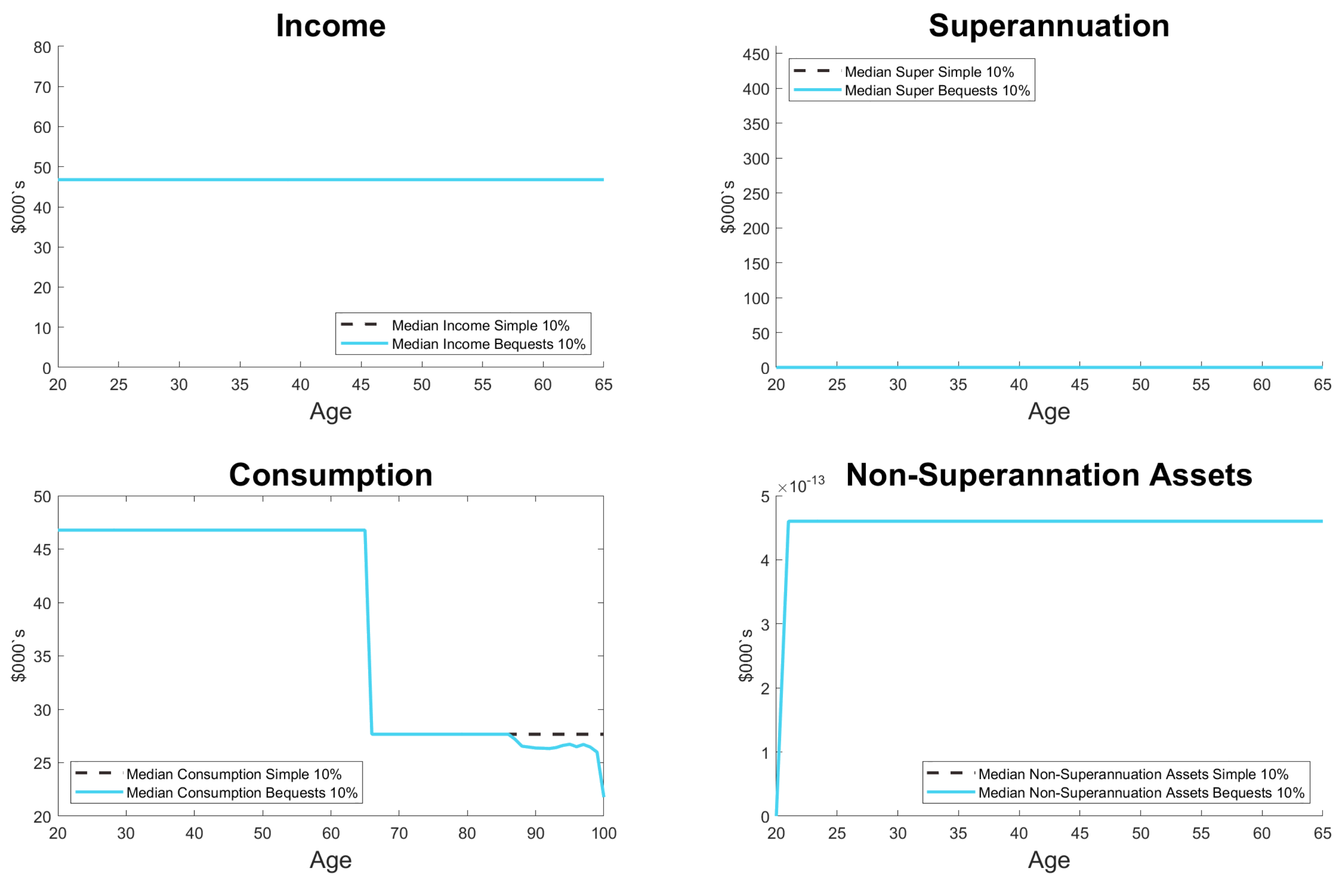


Panel B

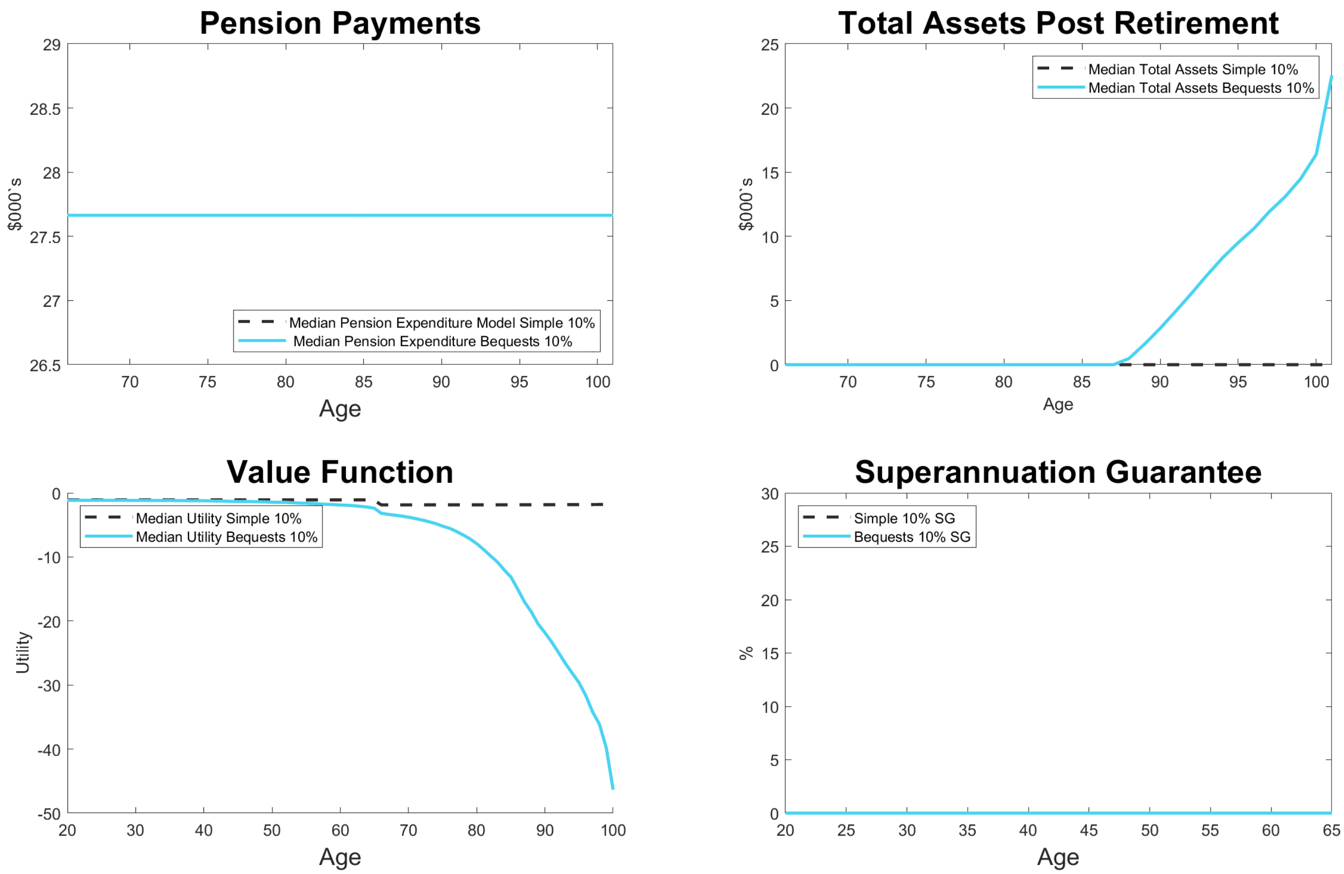
Figure 11: Simplified Model with Taxes

5.7.3 Simplified Model with Bequest Incentive

Adding back the bequest incentive by itself makes no impact on the optimal slopes, but has impacts on the choices of the representative agent that become important in section 5.7.5 on combined effects. Figure 12 compares the simplified economy (blue line) to the simplified economy with bequests at a 0% SG. The models are the same until mid retirement, where the representative agent begins saving for the bequest out of their pension, reducing consumption in the process.


Income
$000`s
Median Income Simple 10%
Median Income Bequests 10%
Age
Superannuation
Median Super Simple 10%
Median Super Bequests 10%
Consumption
Median Consumption Simple 10%
Median Consumption Bequests 10%
Non-Superannation Assets
×10-13
Median Non-Superannuation Assets Simple 10%
Median Non-Superannuation Assets Bequests 10%

Panel A



Panel B

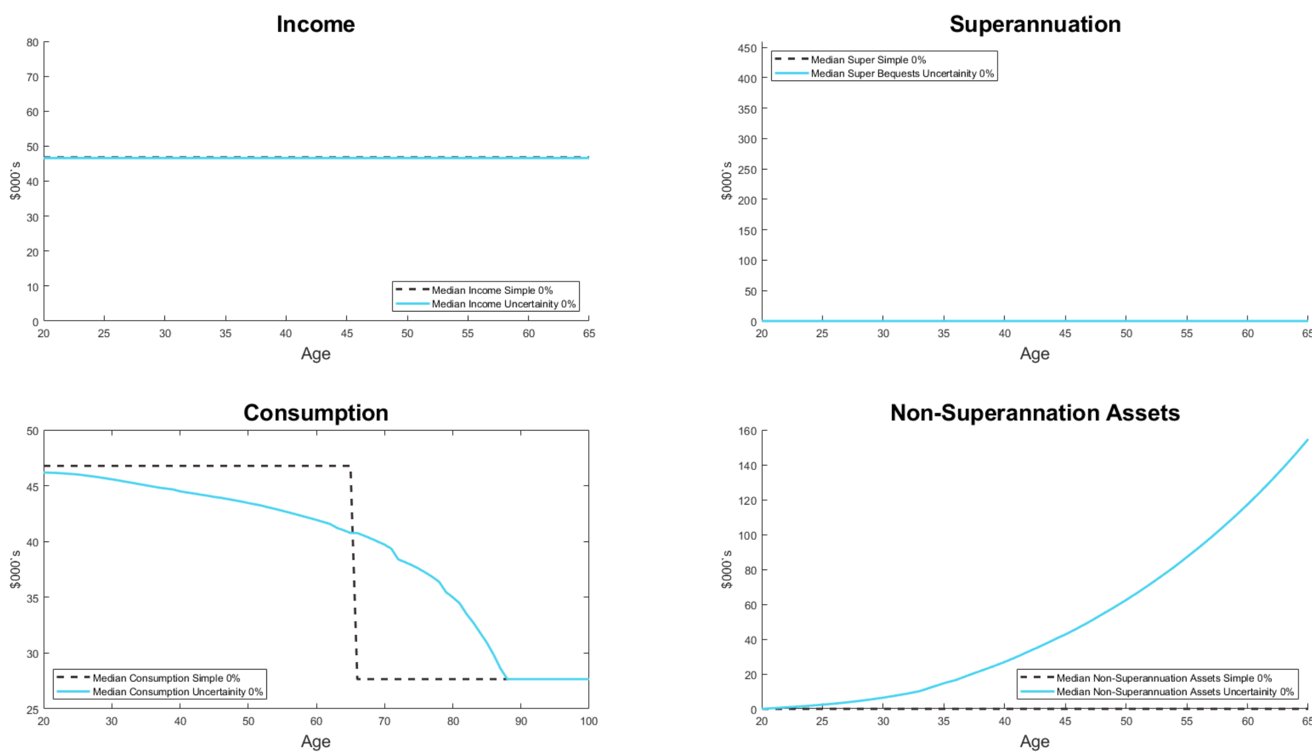
Figure 12: Simplified Model with Bequests

5.7.4 Simplified Model with Idiosyncratic Income Shock

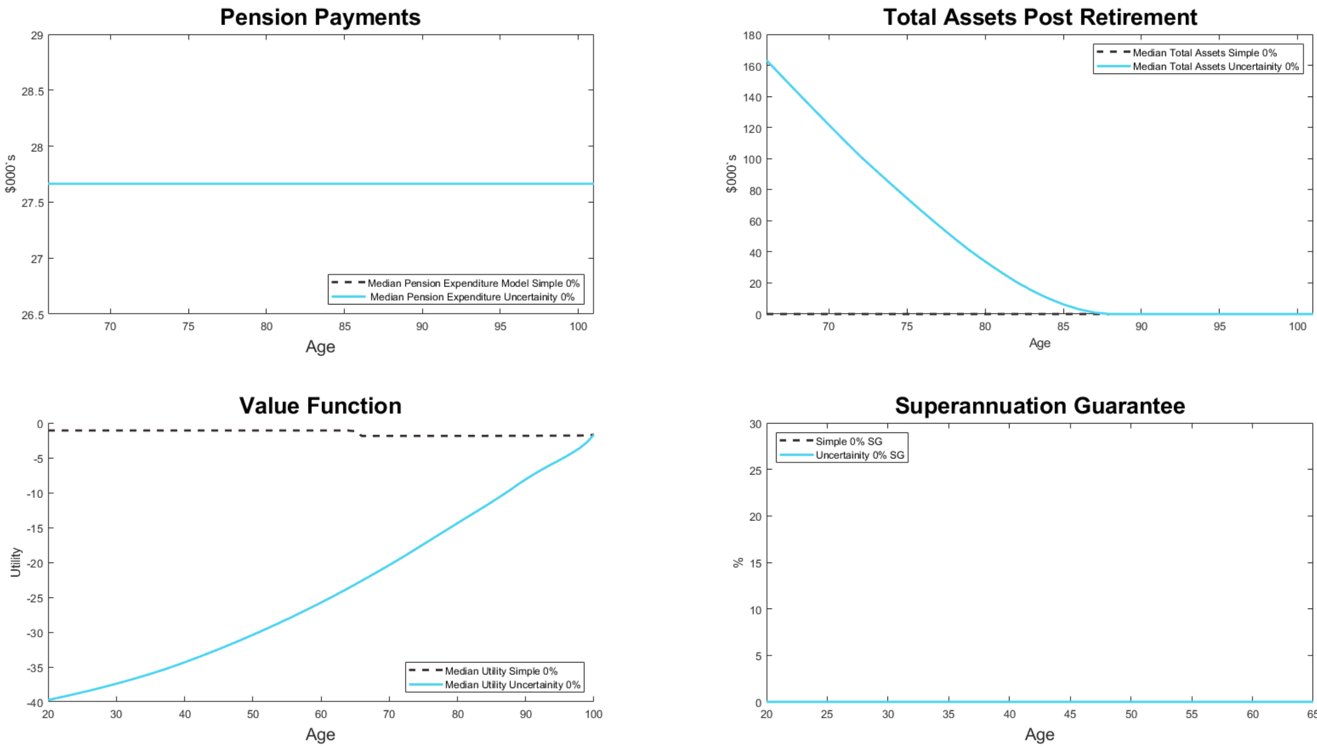
Adding the idiosyncratic income shock to the simplified model has three main effects. An increase in randomness in the model, precautionary saving in working life and smoothing of consumption in retirement. Figure 13 compares the simplified model with a 0% SG to a model with the idiosyncratic income shock at a 0% SG.

The uncertainty related to the employment shocks means each agent follows a slightly different income path through life. This means each draw of the model has slightly different levels of pension expenditure and utility, even if all other variables are the same. This impacts optimal SG functions by creating small random variations in what the optimal slope is at a given pension expenditure level between different draws of the model.

As outlined in section 3, the employment shocks create incentives for agents to precautionarily save in working life as seen in the non-superannuation assets graph in figure 13. This leads to overall lower utility as depicted in the value function graph. This also has the effect of smoothing consumption in retirement so total assets are not drawn down in the first years of retirement. A full results table can be found in appendix 2.



Panel A



Panel B

Figure 13: Simplified Model with Idiosyncratic Income Shock

5.7.5 Combined Effect

The combination of bequest incentives, taxes and idiosyncratic employment shocks in the model is what causes downward sloping SG curves to be optimal at higher pension expenditure levels. As shown in figure 12, bequests incentivise saving late in retirement. Figure 13 shows the employment shock incentives consumption smoothing through saving in early retirement. This combination effect incentivises saving for the entirety of retirement.

Lower superannuation taxes make superannuation an attractive investment through higher returns. By adding taxes to the model, agents are able to increase their utility by saving for retirement in superannuation accounts, gaining overall higher returns. It is through this combination of effects that downward sloped SG functions become optimal. Agents gain utility from saving more money in superannuation early in life. This superannuation compounds over time at a lower tax rate creating higher returns than in liquid savings accounts. This leads to a wealth effect where agents both meet the need to save for retirement while having more total money to increase consumption at younger ages.

5.8 Model Limitation: Voluntary Superannuation Contributions

Voluntary contributions have not been added to the model due to computational intensity. Since voluntary contributions are a large part of Australias superannuation system, this section delves into what the results of this research mean for voluntary contributions, how the model may change with voluntary contributions included and a comparison with voluntary contribution data.

Voluntary superannuation contributions are money individuals choose to add to their superannuation account added on top of their compulsory superannuation contributions determined by the SG. There are two types of voluntary super contributions, salary sacrifice and post tax contributions. Salary sacrafice involves an agreement with an employee and employer to divert a higher proportion of an employees wage into a superannuation account (ATO, 2023) . Post tax contributions are a lump sum investment of cash from an individuals bank account to their superannuation account (ATO, 2023).

The utility maximising SG of 9% in the first year of work and 17.9% in the final year of work means that for people working today, it would be optimal to attempt to mimic this SG function using voluntary superannuation contributions. With the current rate of 11%, it may be optimal for those above the age of approximately 35 to begin saving voluntary contributions according to this optimal linear SG function.

If voluntary contributions where added to the model, they would like lead to large changes in the results the model produces. Agents would have the choice between consumption and two savings devices, meaning in their fully rational state they would likely choose to save superannuation up to the utility maximising level. The superannuation guarantee would only impact saving at higher levels by forcing people to save more than the optimal level to decrease age pension reliance.

Figure 14 depicts voluntary contributions data from the Mercer database, including over 100,000 Australian employees from 2002 to 2011 (CSIRO, 2014). Both types of contributions show a relatively linear increase across the life-cycle, interestingly mimicking the linear SG curves investigated in this thesis.

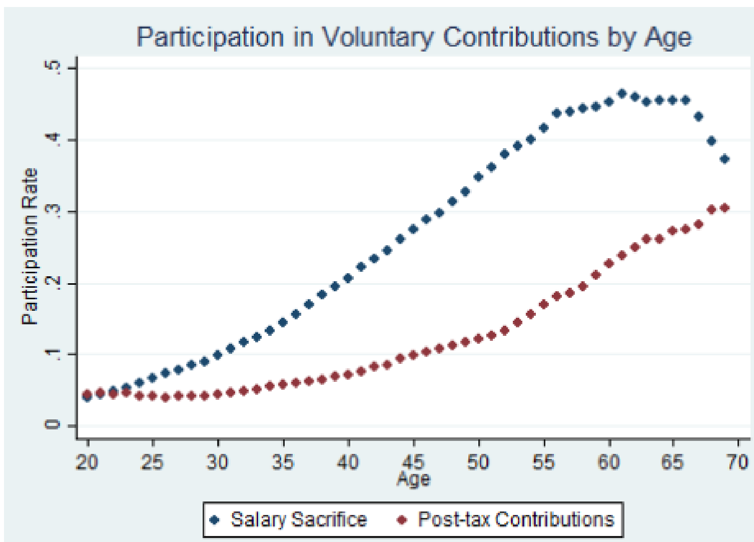


Figure 14: Voluntary Contributions Data (CSIRO, 2014)

6 Conclusion

This thesis studies the personal welfare and fiscal policy impacts of varying the proportion of income that is compulsorily saved into superannuation accounts as people age. For instance, instead of the 2023 11% compulsory contributions rate, individuals are faced with contributions rates that may be lower while young and higher while old. These experiments are conducted in a heterogeneous agent life-cycle model of the Australian economy. The model is constructed so working agents can choose to either spend or save their income as well as consume a portion of their savings. Agents are forced to save a portion of their income as superannuation, the superannuation guarantee (SG). Retired agents draw down their total assets to fund consumption and can fall back on a pension if required, subject to an asset means test.

When considering SG's that do not vary across the lifetime, I find that as opposed to the 2023 SG of 11%, a flat rate of 13% maximises utility. The model then suggests that a SG that linearly increases from 9% when starting work to 17.9% just before retirement performs even better. An upward sloping rate such as this maximises utility as young Australian's that face borrowing constraints are able to consume more when beginning work, while still reaching requisite retirement savings by saving in later life.

The Australian pension is asset means tested, meaning the more assets an individual owns in retirement, the less pension they receive (ATO, 2023). Those that save too little create a fiscal externality, forcing the government to pay a pension throughout their retirement. When people are forced to save superannuation, this increases their assets in retirement, decreasing how much age pension the government must pay. I assume that a policy maker looks to maximise individuals welfare subject to this fiscal externality. I conduct experiments determining the optimal SG function at different levels of government expenditure on the age pension. I find that while keeping government pension expenditure equal to that generated by the 2023 SG of 11%, an SG that starts at 8.6% in the first year of work and increases to 14% by retirement is welfare maximising.

In terms of future work, there are a variety of areas that can be researched further. Firstly, by measuring how the level of tax revenue changes for different SG functions, a full government budget constraint can be constructed. As compulsory superannuation increases, government tax revenue decreases as super is taxed at a lower rate than income tax. But as compulsory superannuation increases, pension expenditure decreases (see section 5.6), so there exists a point where total government revenue is maximised. Preliminary results not included in this paper showed that government revenue is maximised for a small upward sloping SG curve. Secondly, other functional forms of SG functions could also be tested such as a quadratic function over the life cycle to see if these can further improve welfare. There is essentially an infinite number of other functional forms including polynomials or stepped functions that could be tested. Finally, if this superannuation policy where to be enacted by government, the effects of changing compulsory saving rates on monetary policy would need to be considered. If young people are being forced to save less than older Australians, the effects of expansionary monetary policy will be greater for younger people. This is because they are able to spend more of their current income on consumption than older age groups.

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8 Appendix

8.1 Appendix 1: Sloped Linear SG Rate Comparison Methodology

This appendix describes the process through which economies with different sloped SG functions but the same pension expenditure are identified and the utility maximising SG function is extracted. This appendix also includes deeper analysis into the model as well as an extended main results table.

8.1.1 Utility Function

Figure A1 depicts the first year of work utility for all linear SG functions starting or ending between 0% and 30%. The two axis are able to describe any straight line starting between 0% and 30% and ending between 0% and 30%. This figure was created by running the model with all of these SG rates at 1% intervals and recording the associated first year of work utility. SG functions found at less than 1% intervals, for instance an SG function between 4.3% first year of work and 6.78% last year of work, where calculated by linearly interpolating the function between each 1% interval.

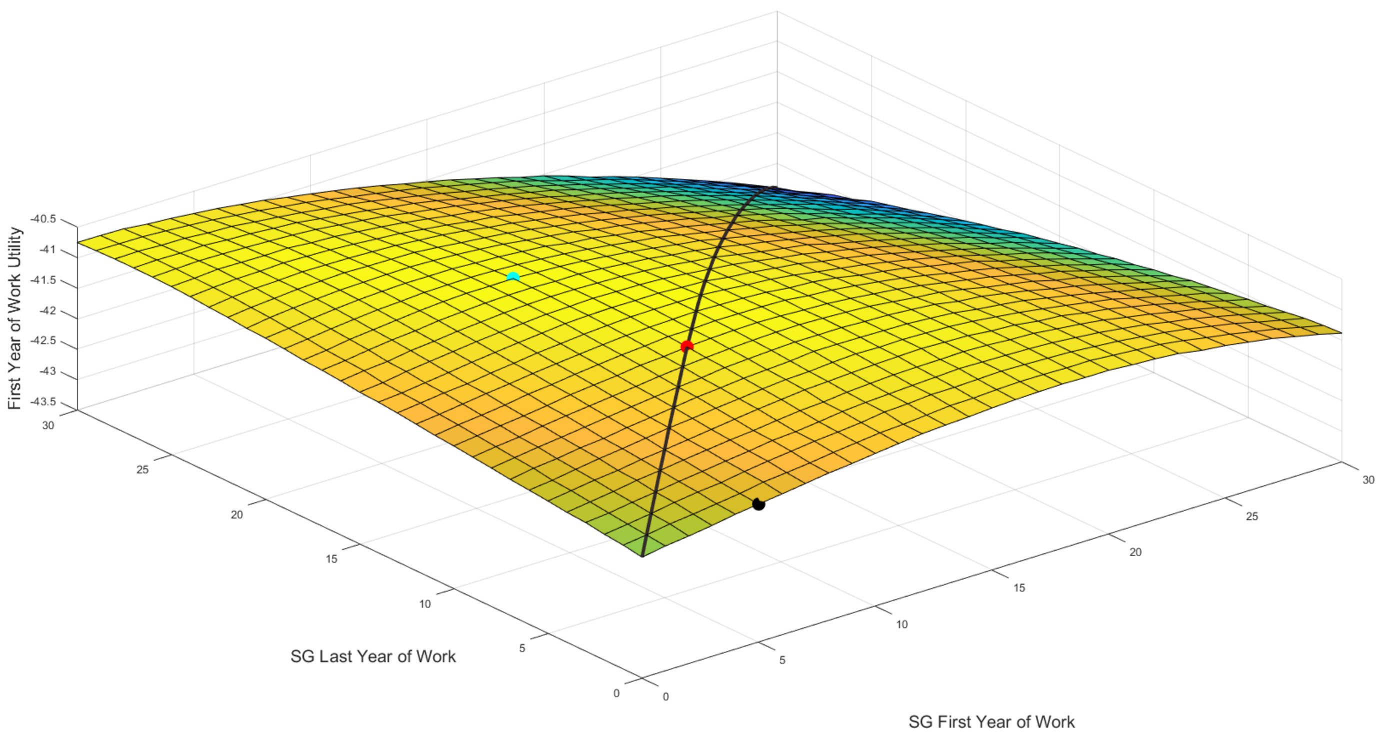

Figure A1: SG and First Year of Work Utility

For example, consider figure A2, chart 2, titled baseline. This is a graph of the baseline SG function used in the calibration of this model in section 3, with an SG of 10% for every year of working life. This sits at the red marked point on figure A1, with an SG First Year of Work of 10% and and an SG Last Year of Work of 10%.

Next consider figure A2 chart 1, titled Maximum Utility. This chart depicts an upward sloping linear SG function that starts at 9% in the first year of work and ends at 17.9% in the final year of work. The first year of work utility of an economy with this SG function is depicted by the cyan dot in figure A1, with an SG First Year of Work of 9% and and an SG Last Year of Work of 17.9%.

Now consider figure A2 chart 3 titled Downward Slope. This chart depicts a linear SG function with a downward slope over the life-cycle. It has a SG First

Year of Work of 5% and an SG Last Year of work of 0%, represented by the black dot in figure A2.

As a final example, consider the black line intersecting the diagonal of figure A1. This line traces out every point where the SG First Year of Work is equal to the SG Last Year of Work. Each point along this line therefore represents an SG function that is constant across the lifecycle, like the baseline 10% SG. The line line intersecting the diagonal in figure A1 is therefore equivalent to chart 2 in figure 7, every flat linear SG function between 0% and 30%. Any point to the left of this line like the cyan dot therefore represents an economy with an upward sloping SG function. Any point to the right of this line such as the black dot represents an economy with a downward sloping SG function.

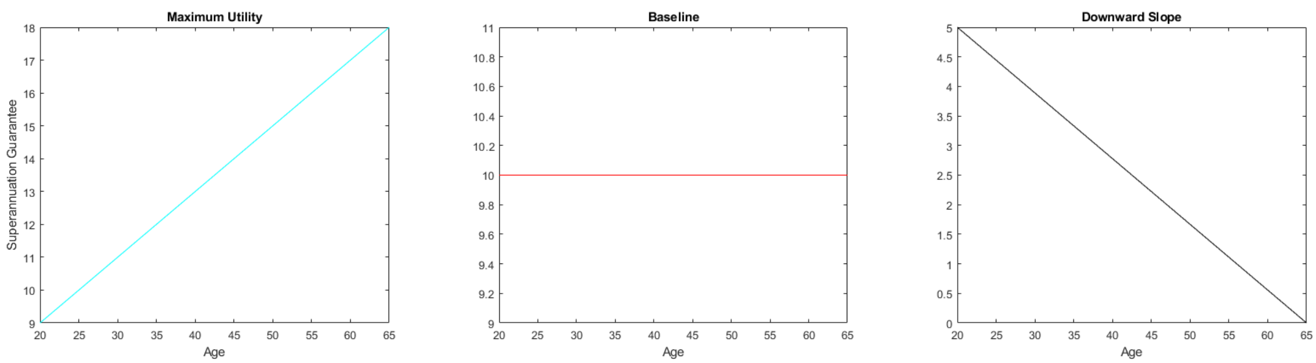

Figure A2: Marked SG Rates from Figure 7

Now that figure A1 has been described in detail, interpretation can begin. The figure is in the shape of a 3D hump sloping upwards at low SG rates, reaching a maximum and then sloping down again at higher SG rates. In economies with lower SG rates, utility in the first year of work is lower as described in sections 5.2 and 5.3; agents can only put a small % of money into higher return superannuation accounts. In economies with high SG rates, utility decreases as agents are forced to save more than they would like to. The entire function is humped and reaches a maximum because of the competition of these two effects, utility increases when the SG is high so agents receive the tax benefits of super, but not so high that agents are forced to save more than they would optimally choose.

Utility reaches a maximum at the cyan dot with an SG First Year of Work of 9% and and an SG Last Year of Work of 17.9%. This maximum arises as it is the sweet spot where the tax benefits of superannuation can be reaped while saving is not forced too high. An upward slope is optimal here as consumption is increased early in life

8.1.2 Pension Expenditure Function

Figure A3 depicts the level of total per-capita pension expenditure for all economies with linear SG functions starting or ending between 0% and 30%. This chart is set out similar to figure A1, with the coloured dots representing their associated SG functions from figure A2. Per-capita pension expenditure in each economy is calculated by adding together the total pension payments made to every person in the economy in every year of their life and dividing by the total number of people in the economy.

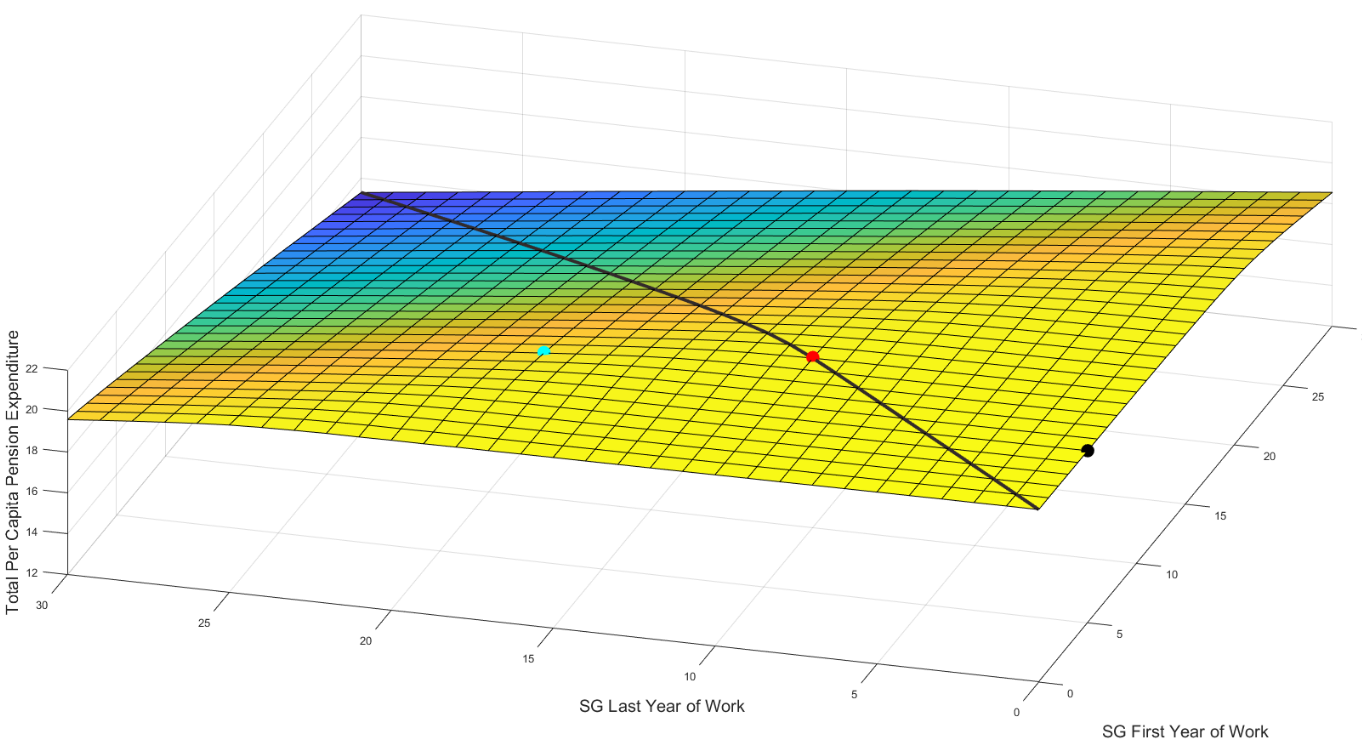

Figure A3: SG and Total Per-Capita Pension Expenditure

The function slopes downwards with higher SG functions leading to lower levels of pension expenditure. The shape of this function is driven by two key effects. Firstly, when SG functions have generally higher first and last year of work SG's, this leads to higher levels of superannuation saving and less pension payments as people have more assets and therefore receive a lower age pension according to the asset means test. Larger first and last year of work SG's mean people are able to fund their own retirement with their superannuation savings. Secondly, randomness in the model from the idiosyncratic employment shock smooths the function.

8.1.3 Identifying Economies with Equivalent Pension Expenditure and Extracting the Economy with Maximum Utility

Economies with equivalent pension expenditure are able to be identified from figure A3. Economies with a pension expenditure equal to that of the 5% flat linear SG rate of $953,727 are depicted in figure A4 by the line of red dots.

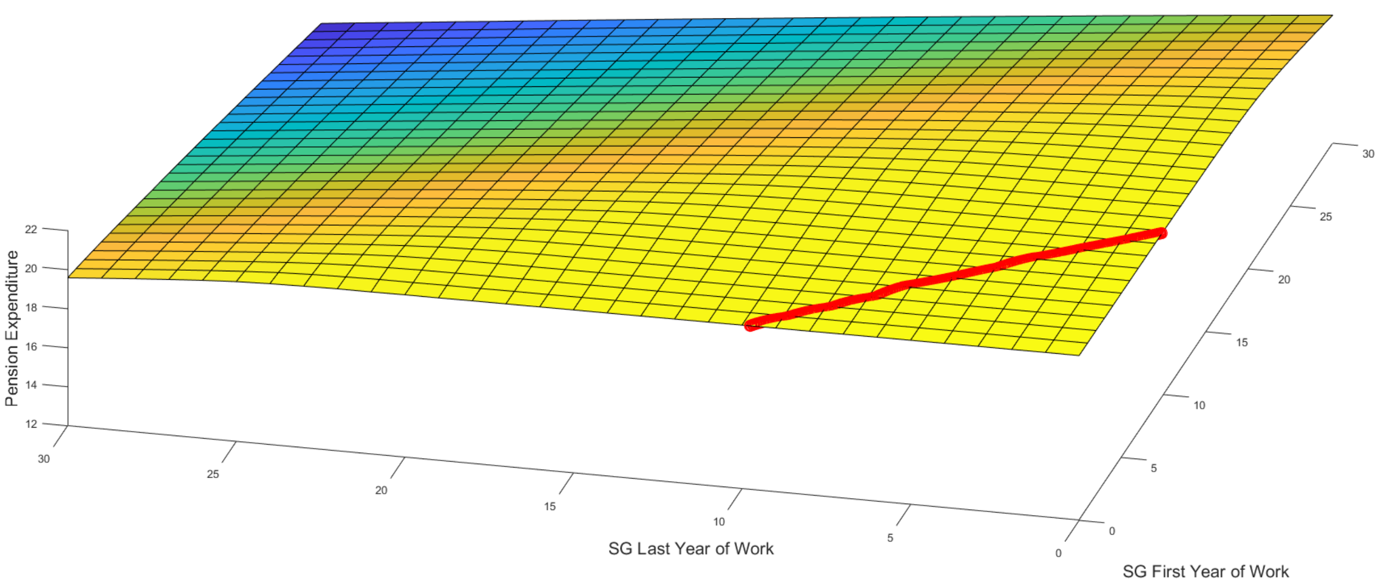

Figure A4: Economies with Pension Expenditure Equivalent to a 5% SG

From this result, these economies can then be graphed on the first year of work utility function in figure A5.

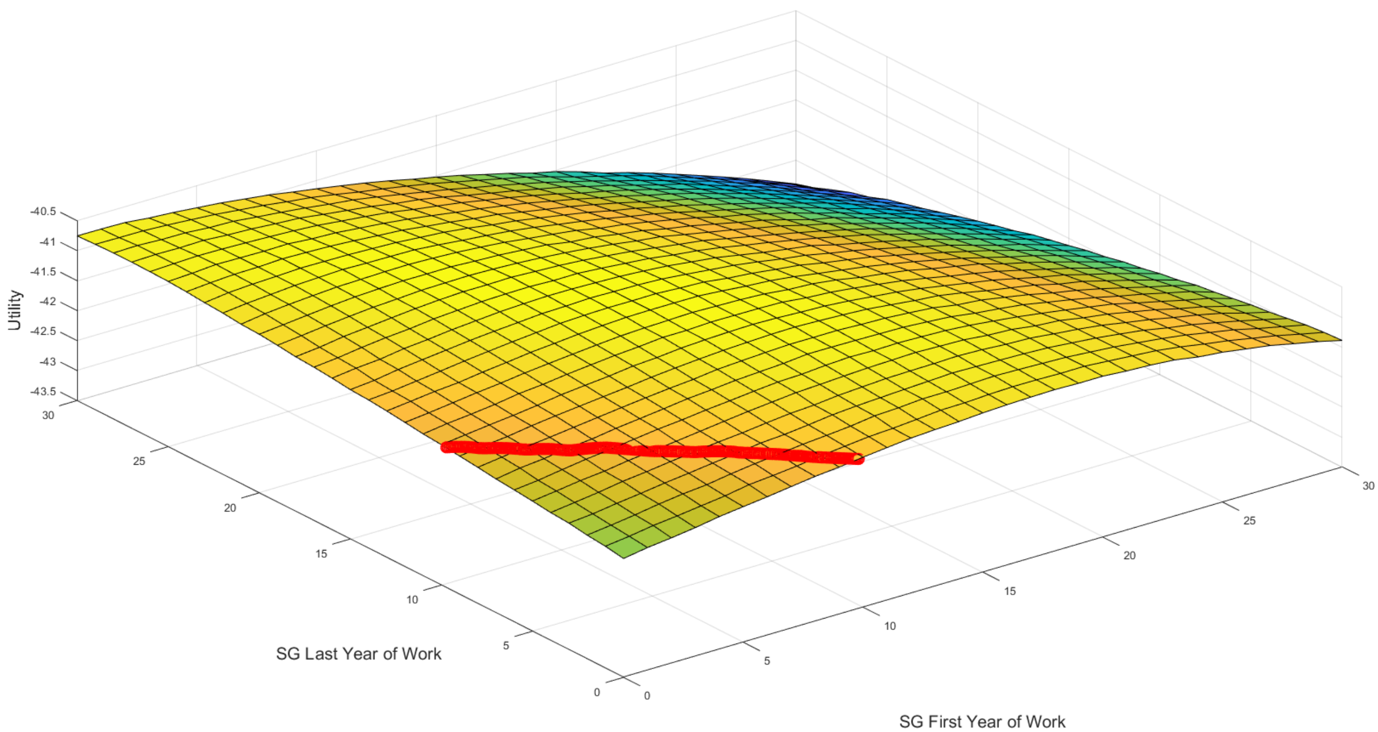

Figure A5: Utility Function depicting Economies with Pension Expenditure Equivalent to a 5% SG

A maximisation operation is then used to pick the economy with the maximum first year of work utility, an SG function starting at 9.8207% and reaching 0.0026% by the final year of work. This methodology is then repeated for every flat linear SG level and associated total per capita pension expenditure to reach the results in table 7, an expanded version of table 4.

8.2 Appendix 2: Extended Results Tables

Uniform SG	Pension Expenditure	Utility	First Year of work SG	Final Year of work SG	Utility
0%	$956,196	-41.5172	0%	0%	-41.5172
1%	$955,855	-41.4166	2.2092%	0.1959%	-41.3852
2%	$955,475	-41.3307	4.0675%	0.0044%	-41.2820
3%	$954,933	-41.2433	5.7639%	0.2062%	-41.1918
4%	$954,383	-41.1529	7.9759%	0%	-41.0841
5%	$953,727	-41.0793	9.8207%	0.0026%	-41.0059
6%	$953,061	-40.9843	10.4536%	1.0024%	-40.9485
7%	$952,430	-40.9152	8.8089%	4.9998%	-40.8951
8%	$951,764	-40.8461	9.8472%	5.3488%	-40.8434
9%	$950,869	-40.7775	8.0010%	10.1935%	-40.7773
10%	$949,290	-40.7178	10%	10%	-40.7178
11%	$945,133	-40.6911	8.6002%	13.9992%	-40.6752
12%	$936,046	-40.6626	10.0001%	14.4691%	-40.6553
13%	$923,078	-40.6605	8.9982%	17.8992%	-40.6495
14%	$908,567	-40.6976	11.0007%	17.6589%	-40.6799
15%	$892,942	-40.7663	10.0907%	20.9996%	-40.7297
16%	$876,379	-40.8349	10.2650%	22.9999%	-40.7981
17%	$859,351	-40.9348	12.8168%	22.1160%	-40.8959
18%	$842,051	-41.0579	13.0018%	24.0984%	-40.9974
19%	$824,696	-41.1831	12.4409%	26.9999%	-41.1230
20%	$807,215	-41.3293	15.0737%	25.9974%	-41.2612
21%	$789,221	-41.4711	14.4474%	29.0090%	-41.4070
22%	$771,327	-41.6438	15.4432%	29.9984%	-41.5667
23%	$753,198	-41.8241	18.0001%	29.0740%	-41.7326
24%	$734,708	-42.0125	19.2753%	29.7385%	-41.9327
25%	$715,967	-42.2078	20.9118%	29.9987%	-42.1310
26%	$697,340	-42.4217	22.9998%	29.6547%	-42.3542
27%	$678,469	-42.6462	24.5332%	30%	-42.5876
28%	$659,574	-42.8836	26.3662%	29.9977%	-42.8418
29%	$640,439	-43.1281	28.1794%	29.9980%	-43.1069
30%	$621,416	-43.3982	30%	30%	-43.3982%

Table 7: Extended Main Results

Uniform SG	Pension Expenditure	Utility	First Year of work SG	Final Year of work SG	Utility
0%	$995,904	-1.0869	0%	0%	-1.0869
1%	$995,904	-1.0979	0%	0%	-1.0869
2%	$995,904	-1.1091	0%	0%	-1.0869
3%	$995,904	-1.1205	0%	0%	-1.0869
4%	$995,904	-1.1322	0%	0%	-1.0869
5%	$995,904	-1.1441	0%	0%	-1.0869
6%	$995,904	-1.1563	0%	0%	-1.0869
7%	$995,904	-1.1687	0%	0%	-1.0869
8%	$995,904	-1.1814	0%	0%	-1.0869
9%	$995,904	-1.1944	0%	0%	-1.0869
10%	$995,160	-1.2076	0.0100%	22.7200%	-1.0874
11%	$992,732	-1.2212	0%	25%	-1.0874
12%	$990,304	-1.2351	0%	27.2800%	-1.0875
13%	$987,876	-1.2493	0.0100%	29.5400%	-1.0877
14%	$985,448	-1.2638	1.4400%	29.9900%	-1.1035
15%	$983,020	-1.2787	3.2200%	30%	-1.1237
16%	$980,592	-1.2939	5.0100%	30%	-1.1448
17%	$978,164	-1.3095	6.8000%	29.9900%	-1.1667
18%	$975,736	-1.3255	8.5800%	%29.9900%	-1.1895
19%	$973,308	-1.3418	10.3600%	30%	-1.2131
20%	$970,880	-1.3586	12.1500%	30%	-1.2377
21%	$968,452	-1.3758	13.9300%	30%	-1.2633
22%	$968,240	-1.3934	15%	29%	-1.2791
23%	$968,240	-1.4115	15%	29%	-1.2791
24%	$968,240	-1.4301	15%	29%	-1.2791
25%	$968,240	-1.4492	15%	29%	-1.2791
26%	$968,240	-1.4688	15%	29%	-1.2791
27%	$968,240	-1.4889	15%	29%	-1.2791
28%	$968,240	-1.5096	15%	29%	-1.2791
29%	$968,240	-1.5308	15%	29%	-1.2791
30%	$968,240	-1.5527	15%	29%	-1.2791

Table 8: Simplified Model Main Results

Uniform SG	Pension Expenditure	Utility	First Year of work SG	Final Year of work SG	Utility
0%	$995,904	-1.2416	0%	0%	-1.2416
1%	$995,904	-1.2512	0%	0%	-1.2416
2%	$995,904	-1.2610	0%	0%	-1.2416
3%	$995,904	-1.2710	0%	0%	-1.2416
4%	$995,904	-1.2815	0%	0%	-1.2416
5%	$995,904	-1.2937	0%	0%	-1.2416
6%	$995,904	-1.3061	0%	0%	-1.2416
7%	$995,904	-1.3187	0%	0%	-1.2416
8%	$995,904	-1.3316	0%	0%	-1.2416
9%	$995,904	-1.3448	0%	0%	-1.2416
10%	$995,904	-1.3582	0%	0%	-1.2416
11%	$995,904	-1.3719	0%	0%	-1.2416
12%	$995,904	-1.3858	0%	0%	-1.2416
13%	$994,115	-1.4001	0.0100%	28.9600%	-1.2422
14%	$992,167	-1.4147	0.9800%	30%	-1.2516
15%	$990,219	-1.4295	2.7900%	30%	-1.2695
16%	$988,270	-1.4447	4.6100%	30%	-1.2895
17%	$986,322	-1.4602	6.4200%	29.9900%	-1.3120
18%	$984,374	-1.4760	8.2400%	30%	-1.3352
19%	$982,426	-1.4922	10.0500%	29.9900%	-1.3594
20%	$980,478	-1.5088	11.8600%	30%	-1.3844
21%	$978,530	-1.5257	13.6800%	30%	-1.4104
22%	$976,582	-1.5430	15.4900%	30%	-1.4373
23%	$974,634	-1.5607	17.3000%	30%	-1.4654
24%	$972,685	-1.5790	19.1200%	30%	-1.4945
25%	$970,737	-1.5978	20.9300%	30%	-1.5248
26%	$968,789	-1.6171	22.7400%	30%	-1.5564
27%	$968,240	-1.6368	24%	30%	-1.5793
28%	$968,240	-1.6570	24%	30%	-1.5793
29%	$968,240	-1.6777	24%	30%	-1.5793
30%	$968,240	-1.6990	24%	30%	-1.5793

Table 9: Simplified Model with Taxes Main Results

Uniform SG	Pension Expenditure	Utility	First Year of work SG	Final Year of work SG	Utility
0%	$995,903	-39.7609	0%	0%	-39.7609
1%	$995,903	-39.7700	0%	0.0400%	-39.7612
2%	$995,903	-39.7924	0%	0.3000%	-39.7627
3%	$995,903	-39.8167	0%	0.3000%	-39.7627
4%	$995,903	-39.8420	0%	0.3000%	-39.7627
5%	$995,902	-39.8861	0%	0.3000%	-39.7627
6%	$995,901	-39.9457	0%	0.3000%	-39.7627
7%	$995,898	-40.0093	0%	0.3000%	-39.7627
8%	$995,890	-40.1026	0%	0.3000%	-39.7627
9%	$995,767	-40.2343	0%	0.3000%	-39.7627
10%	$994,549	-40.3800	0.3500%	22.2500%	-40.2527
11%	$991,180	-40.5765	1.9200%	22.5700%	-40.4397
12%	$985,711	-40.7924	0.6900%	26.4000%	-40.6529
13%	$978,722	-41.0239	2.9900%	25.7600%	-40.8892
14%	$970,733	-41.2987	1.4400%	30%	-41.1494
15%	$961,698	-41.5727	4.2100%	28.7500%	-41.4434
16%	$951,877	-41.8919	5.3100%	29.6200%	-41.7500
17%	$941,220	-42.1980	8.3700%	28%	-42.0696
18%	$930,167	-42.5584	8.5900%	30%	-42.4098
19%	$918,592	-42.9069	11v	29.1900%	-42.7683
20%	$906,750	-43.2677	12.9500%	29%	-43.1514
21%	$895,058	-43.6483	13.9400%	30%	-43.5328
22%	$883,447	-44.0625	16.5000%	29%	-43.9444
23%	$871,892	-44.4685	17.5100%	30%	-44.3702
24%	$860,518	-44.9073	20%	29.0800%	-44.8040
25%	$849,286	-45.3490	21.0900%	30%	-45.2684
26%	$838,130	-45.8150	22.8800%	30%	-45.7419
27%	$827,174	-46.2991	24.6600%	30%	-46.2430
28%	$816,478	-46.7863	26.5000%	29.9400%	-46.7581
29%	$806,053	-47.3072	28.2100%	30%	-47.2845
30%	$795,843	-47.8562	30%	30%	-47.8562

Table 10: Simplified Model with Idiosyncratic Income Shock Main Results