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Means Testing of Public Pensions: The Case of Australia

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Abstract

The Australian government has recently strengthened the means test of the age pension by raising the income reduction (taper) rate and also introduced labour earnings exemptions from the means testing to encourage labour supply of older Australians. This paper assesses economy-wide implications of further hypothetical changes to the means testing of the age pension that represents Australia's first pension pillar. To this end, we apply an overlapping generations (OLG) model for Australia, with the capacity to investigate changes in the taper and labour earnings exemptions. Our results indicate that further increases in the taper combined with lower income tax rates lead to higher per capita labour supply and assets, as well as to welfare gains in the long run, while labour earnings exemptions have largely positive effects on average labour supply at older ages. Further increases in the taper also generate significant reductions in overall government spending on the pension and, therefore, could be used as an alternative policy to increasing the pension access age.

Keywords: Pension Reform, Means Test, Retirement, Overlapping Generations, Dynamic General Equilibrium

JEL Classification: H55, J26, C68

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1 Introduction

The Australian age pension represents the first pillar of Australia's retirement income policy and is currently the major income source for most Australian retirees. The pension is non-contributory, funded through general tax revenues and means tested against pensioners' private resources, including labour income. The means test has been an important component of the age pension since its introduction more than a century ago. The Australian government has recently implemented several changes to the means testing of the pension, with aims to better target the payments to those in need and to encourage labour supply of older Australians. These changes include an increase in the income taper rate from 0.4 to 0.5 in 2009 and an exemption of up to $6,500 of annual labour earnings from the means testing.[1]

In this paper, we assess economy-wide implications of further hypothetical policy changes to the means testing of the age pension.[2] The primary objective is to examine further increases in the income taper and higher exemptions of labour earnings from the means testing as extensions of the 2009 age pension reform. We also assess the policy changes that partially relax or completely remove the existing means test of the age pension by reducing the taper. These hypothetical policy changes are motivated by the fact that many countries do not have targeted public pensions (e.g. New Zealand). Specifically, we consider the following two sets of policy experiments: (*i*) changes in the income taper rate from the current rate of 0.5 to zero, 0.25, 0.75 and one; and (*ii*) changes in labour earnings exemptions from the current exemption of up to $6,500 per year to 100% and 0%.

The purpose of this study is to explore the implications of these policy changes for incentives of individuals to work and save, for macroeconomic aggregates and for individual welfare. One specific aim is to determine whether the policy changes encourage labour supply of older Australians. While it is well known that public pensions may discourage lifecycle labour supply and saving as they act as a substitute for private income in retirement, the effects of the means testing on labour supply and saving are not a clear-cut. On the one hand, means tests generate high effective marginal tax rates (EMTRs), which have negative

[1] The increase in the income taper was part of the 2009 age pension reform that also included (*i*) a 10 percent increase in the maximum pension for single pensioners, (*ii*) gradual increases in the pension access age to 67 years and (*iii*) a new work bonus with only half of the first $13,000 of annual labour earnings subjected to the means testing (see Kudrna and Woodland (2011b) for the analysis of that reform). In 2011, the work bonus was enhanced such that the labour earnings exemption from the means testing applied up to the first $6,500 per year.

[2] Note that the means test consists of the income and assets tests, with the test that results in a lower pension payment being used. In this paper, we focus on the income test as it currently affects the majority of those receiving part age pension. Furthermore, it would be the income test that would bind for those on full (maximum) pension (about half of Australians aged 65 years and over), if they experienced an increase in their assets holdings. This is because the income test, which also includes assets income, binds for smaller amounts of assets.

implications for labour supply and saving of older people. On the other hand, means tests reduce public pensions, thus resulting in higher lifecycle labour supply. Other aims of the paper are to determine distributional welfare effects and to draw out budgetary implications for the government.

To undertake this task, we apply the Australian overlapping generations (OLG) model developed by Kudrna and Woodland (2011a, b), which is extended in this paper to include a more detailed disaggregation of households into income quintiles and an updated calibration to recent Australian data. Our methodology has a range of features that make it particularly appropriate for the analysis of the means testing of public pensions. First, the model employs life-cycle utility maximisation with endogenous retirement and a broader pension means test imposed on both assets income and labour earnings, allowing for a different means test treatment of the two sources of private income. Note that most studies on this topic use models with exogenous retirement and thus assess only assets income under the means test - see, for example, Sefton *et al.* (2008), Kumru and Piggott (2009, 2012), Cho and Sane (2013) and Fehr and Uhde (2014). Second, we incorporate inter- and intra-generational heterogeneity among households into the model, which allows us to evaluate policy impacts upon different household types. Third, the model includes a detailed model-equivalent representation of Australia's age pension, superannuation and income tax policy settings and hence captures important interactions between household behaviour and these policy settings. Another important contribution of our analysis to existing literature on the means testing of public pensions, which has focused largely on the long term effects (e.g., Määttänen and Poutvaara (2007) and Tran and Woodland, 2014), is that we investigate the implications of policy changes upon impact, over the transition and in the long term.

The simulation results for further increases in the income taper show significant reductions in the age pension expenditures (by 17.04% for taper increased to one), allowing for lower income tax rates that are adjusted to maintain a balanced government budget. We show that further increases in the taper combined with lower income tax rates have positive effects on per capita labour supply (0.82% increase), domestic assets (4.28% increase) and consumption (1.63% increase).[3] Interestingly, average labour supply at older ages also improves as most older households see their pensions reduced, with some elderly not qualifying for any pension and, therefore, no longer facing high EMTRs on their earnings. Similarly to Kumru and Piggott (2009) and Tran and Woodland (2014), we find positive effects of the increased taper on average welfare in the long term, driven by welfare gains attained by higher income types of households benefiting from reduced income tax rates. However, the short term welfare effects

[3]The percentage changes in the brackets show the long run implications of the income taper increased to one, relative to the benchmark scenario with the current taper of 0.5.

are significantly negative for current pensioners experiencing large cuts in their pensions, as shown by Fehr and Uhde (2014).

The examined policy changes in labour earnings exemptions have much smaller aggregate effects due to relatively small numbers of people affected and assumed productivity rates of the elderly workforce. More importantly, we find that the labour earnings exemptions from the means testing have largely positive implications for average labour supply of older Australians. This result supports the findings of empirical literature that examined labour supply responses to changes in the earnings tests of social security benefits in other developed countries (see, for example, Baker and Benjamin (1999) for Canada, Disney and Smith (2002) for the UK and Friedberg (2000) for the US).

The rest of this article is organised as follows. In the next section we provide an overview of the simulation model and present the benchmark solutions for key life-cycle profiles and macroeconomic aggregates. Section 3 reports on the simulation results for the examined policy changes in the income taper and labour earnings exemptions. Section 4 is devoted to a sensitivity analysis of several modifications of the model. The final section offers some concluding remarks.

2 The model and benchmark economy

We start this section by briefly describing our model that is used to simulate the changes to the pension means testing. We provide technical details on our modelling of retirement income policy in this section, with an algebraic description of the rest of the model relegated to the Appendix. We then report on benchmark solutions for key variables at both household and aggregate levels and provide comparison with Australian data.

2.1 Model overview

We use an extension of the general equilibrium OLG model developed for Australia by Kudrna and Woodland (2011a, b) with (*i*) a more detailed intra-generational heterogeneity based on income distribution data from Australian Bureau of Statistics [ABS] (2012a) and (*ii*) an updated calibration including a detailed representation of the age pension settings in 2012. The model is a small open economy version of Auerbach and Kotlikoff's (1987) model that consists of household, production, government and foreign sectors.

The household sector is populated with 70 overlapping generations aged 21 to 90 years, with each generation consisting of five income types of households distinguished by their

productivity and social welfare payments. Households face lifespan uncertainty described by survival probabilities and make optimal consumption/saving and leisure/labour supply choices to maximise their inter-temporal utility. Importantly, retirement from workforce is also endogenous and, similarly to labour supply, consumption and savings, affected by the tax and retirement income policy settings. In terms of the Australian retirement income policy, the model incorporates essential features of the age pension and mandatory superannuation, which are discussed in details below.

The production sector contains a large number of perfectly competitive firms. The firms demands capital and labour to produce a single all-purpose output good that can be consumed, invested in production capital or traded internationally. The government collects tax revenues from households and firms to pay for general government consumption and transfer payments to households. In this paper, we assume that the government maintains a balanced budget by adjusting the progressive income tax schedule, as in Tran and Woodland (2014).

We employ a small open economy framework with an exogenous interest rate since that description best fits the Australian economy. Finally, equilibrium in the model requires labour, capital and goods markets to clear. That is, in every time period, (i) the demand for labour from perfectly competitive firms must equal the supply of labour from households; (ii) the value of the capital stock must equal the domestic and foreign assets; and (iii) output is equal to the sum of private and public consumption, investment and trade balance.

2.1.1 Retirement income policy

The Australian retirement income system contains three pillars. The first is a mandatory, publicly-managed "safety net" pillar represented by the age pension. The second is also mandatory, but is a privately-managed and fully-funded superannuation guarantee scheme. The third pillar includes other long term private savings such as voluntary superannuation. In the model, we consider the two publicly stipulated pillars - age pension and mandatory superannuation.

The age pension, AP_a^i, is paid to households of income type i and age pension age ($a \geq 65$) if they satisfy the following income test.[4] Let p denote the maximum age pension paid by the government to pensioners provided that their assessable income does not exceed the income threshold, IT_1. The maximum pension, p, is then reduced at the taper rate, θ, for every dollar

[4] As mentioned, we consider only the income test. Although currently about one third of part-age pensioners have their pension reduced due to the assets test, the assessable assets of pensioners are never high enough in the model for the assets test to be binding. Note that for the given interest rate and the means test parameters (i.e., taper rates and thresholds), it can be shown that the income (assets) test is binding for lower (higher) assessable assets.

of assessable income above IT_1. Algebraically, the age pension benefit can be written as[5]

$$AP_a^i = \begin{cases} p & \text{if } \widehat{y}_a^i \leq IT_1 \\ p - \theta\left(\widehat{y}_a^i - IT_1\right) & \text{if } IT_1 < \widehat{y}_a^i \leq IT_2 \\ 0 & \text{if } \widehat{y}_a^i > IT_2 \end{cases}, \tag{1}$$

where IT_1 and IT_2 denote the lower and upper bound thresholds for the assessable income, $\widehat{y}_a^i = rA_{a-1}^i + \max((LE_a^i - \varpi), 0)$. Notice that $\widehat{y}_a^i$ consists of interest earnings, rA_{a-1}^i, (from assets holdings) and labour earnings, LE_a^i, exceeding the exempted amount, ϖ.

The superannuation guarantee mandates employers to contribute a given percentage of gross wages into the employee's superannuation fund. Accordingly, the model assumes that mandatory contributions are made by firms on behalf of working households at the contribution rate, cr, from their gross labour earnings, LE_a^i. The contributions net of the contribution tax, $\tau^s \cdot cr$, are added to the stock of superannuation assets, SA_a^i, that earns fund income at the after-tax interest rate, $(1 - \tau^r)\, r$. Superannuation assets are assumed to be preserved in the fund until households reach age 60. At that age, households are assumed to be paid out their superannuation assets as lump sums. The superannuation assets accumulation in the fund during $a \leq 60$ can be expressed as

$$SA_a^i = \left[1 + (1 - \tau^r)\, r\right] SA_{a-1}^i + (1 - \tau^s)\, cr \cdot LE_a^i, \tag{2}$$

where τ^r and τ^s denote the fund earnings tax rate and the contribution tax rate, respectively. We further assume that working households aged 60 years and over are paid mandatory contributions directly into their private assets accounts.[6]

The policy changes to the means testing that we examine involve the changes in (i) the income taper denoted by θ in (1) and (ii) labour earnings exemptions. In case of labour earnings exemptions, we consider two policy changes. The first change is to extend the exemptions to 100%. Under that policy change, the assessable income in (1) is altered to include only interest earnings, $\widehat{y}_a^i = rA_{a-1}^i$. The second policy change is to abolish the exemptions, with the assessable income altered to include both sources of private income in full, $\widehat{y}_a^i = rA_{a-1}^i + LE_a^i$.

[5] The subscript t for the time period is omitted in the following description of the pension income test and the superannuation assets accumulation.

[6] This is consistent with post-July 2007 policy, which allows such contributions by seniors to be immediately removed tax free from the fund.

2.2 Benchmark results and comparison with data

The benchmark economy is assumed to be in a steady state equilibrium. We calibrate this benchmark economy to key Australian data averaged over the 5-year period ending in June 2012 and assume stationary demographics. The values assigned to the model parameters are taken from related literature, calibrated to key macroeconomic aggregates or exactly matching actual policy settings in 2012.[7]

The benchmark steady state solution as well as transition paths for the examined policy changes are obtained via the Gauss-Seidel iterative method, using GAMS software (see Kudrna and Woodland (2011a) for details).

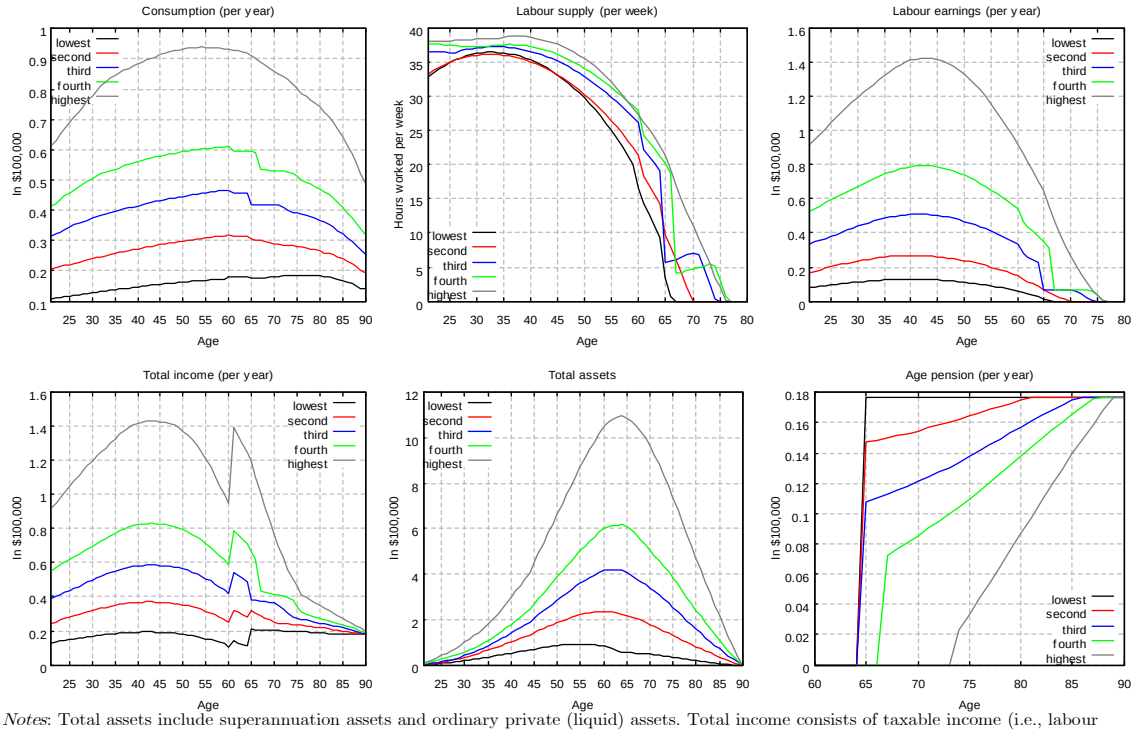
2.2.1 Life-cycle profiles

The benchmark solution for life-cycle profiles of consumption, labour supply, total assets, labour earnings, total income and age pension payments is depicted by Figure 1. The life-cycle profiles of consumption expenditures, labour supply and labour earnings for each income quintile exhibit the standard hump-shape, rising at early ages and then declining. The shapes of these profiles reflect the assumed hump-shaped productivity profile and the increasing mortality risk, while the age profile of total assets reflects the saving decision along with the assumed zero initial and terminal asset holdings by households.[8]

[7] As for the demographics, the age specific survival rates are taken from the 2010-12 life tables (ABS, 2013a) and the annual population growth rate of 1.8% is chosen to generate a realistic old-age dependency ratio of 0.22. The calibrated parameters of the utility function include the subjective discount factor and the leisure preference parameter that target the capital to output ratio (=3) and the average fraction of time spent working by those aged 25 to 60 years (=0.33), respectively. Most of the production function parameters are also calibrated to replicate other calibration targets averaged over the 5-year period ending in 2012, including the investment rate of 0.09 and the foreign debt to capital ratio of 19.5%. The wage rate is normalised to one and the exogenous interest rate is set to 5%. We also make use of the adjustment parameters to target the ratios of consumption and corporate tax revenues to GDP and the ratios of public consumption, pension expenditures and other social welfare to GDP. The tax and pension parameters match actual policy settings in 2012. The key parameters of the model and their values are reported in Table A1 in the Appendix.

[8] Following Gokhale *et al.* (2001), we assume that all inter-generational transfers are accidental and, hence, that there are no intended bequests. We also assume that accidental bequests are equally redistributed to all surviving households of the same income type aged between 45 and 65 years.

Figure 1: Benchmark steady state solution for life-cycle household variables



Notes: Total assets include superannuation assets and ordinary private (liquid) assets. Total income consists of taxable income (i.e., labour earnings, private asset income and the age pension) and other social transfers, which are income-specific.

Figure 1 also shows sudden reductions in consumption, labour supply and labour earnings for some income quintiles at older ages, which are due to the retirement income policy. First, the superannuation savings are illiquid until age 60, at which each quintile is assumed to receive a lump sum payout. Subsequently, the payout have an income effect on labour supply, with the drop in labour supply being particularly large for lower income types.[9]

Second, households at age 65 become eligible for the age pension, provided that they satisfy the means test. The graph with the age profiles of pension payments shows that the lowest quintile gets full age pension from age 65 onwards. The second and third quintiles receive part age pension at age 65, while households in the highest quintile do not receive any pension until age 72. The two lowest quintiles reduce their working hours at age 65 as a result of the income effect of the pension payment. The sudden drop in labour supply of the third quintile is due predominantly to the effective means testing with the preferential treatment of labour earnings. In particular, households in the third quintile at early age pension ages reduce their working hours to earn exactly $6,500 per year that is not means tested. The same

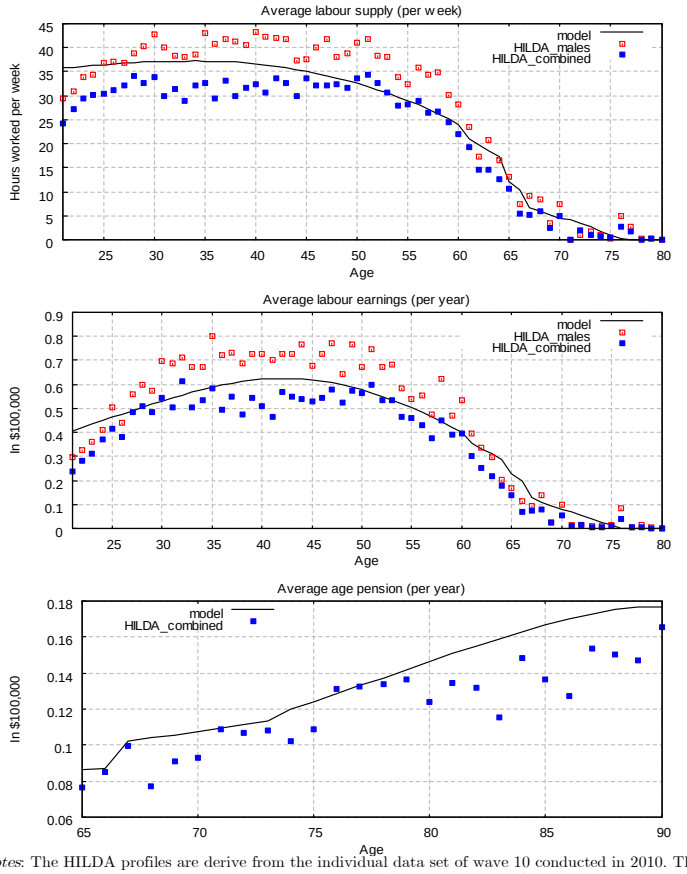
[9] As the legislation prohibits from borrowing against superannuation assets, we impose the non-negative assets constraint to prevent younger households from such borrowing. This constraint binds for lower income types prior to reaching age 60 and so the availability of their superannuation at age 60 increases their consumption as well as demand for leisure.

labour supply behaviour is shown for the fourth quintile at age 67.[10] The behavioural effects of the age pension on the highest income quintile are insignificant because the pension is of less importance to them in comparison with lower quintiles.

2.2.2 Data comparison

We now compare some of the life-cycle profiles and the main macroeconomic solutions generated by the benchmark steady state model with Australian data. The model-generated profiles for labour supply, labour earnings and pension payments averaged across the quintiles and the cross-section data derived from HILDA surveys (Wooden *et al.*, 2002) are plotted in Figure 2. The comparison reveals similar shapes as well as levels of the model-generated and data-based profiles for the three selected household variables.[11]

Figure 2: Comparison of the selected average life-cycle profiles with actual data



Notes: The HILDA profiles are derive from the individual data set of wave 10 conducted in 2010. The combined profiles relate to the average across males and females. The HILDA 2010 values for labour income and age pension are inflated at the wage inflation rate of 3.5% to 2012.

[10] Note that older households in the fourth quintile work less than households of the same ages in the third quintile because they are assumed to earn a higher effective wage.

[11] The reason for somewhat higher average pension payments obtained from the model for households aged 80 years and over is the model requirement of zero terminal assets. This requirement means that even households in the highest income quintile eventually qualify for the maximum pension as they draw down their assets and their assets income (subject to the pension income test) declines rapidly at very old ages.

Table 1 compares main aggregate solutions with actual values averaged over 5 years ending in June 2012 and taken from ABS (2012b, 2013b, 2013c). As shown, the benchmark model solution for the components of aggregate demand presented in percent of GDP (or output) are very close to their actual values, except for the trade balance, which is positive and implied by the targeted foreign debt to capital ratio. Similar conclusions can be drawn for government indicators, some of which are used as the calibration targets. In more detail, we calculate adjustment factors for the pension expenditures, the consumption tax (GST) revenue, the corporation tax revenue and other social transfers to match exactly the targeted ratio of each indicator to output.[12] The model overestimates the tax revenues from superannuation as it assumes 40 years of superannuation accumulations with 9% compulsory contributions, whereas the superannuation guarantee was introduced only in 1992 with 3% minimum contributions initially. The personal income tax revenue is also larger in the model as our approximation tax function abstracts from any income tax offsets. Finally, we include other taxes and calculate the other tax revenue as a residual that balances the government budget with the targeted government consumption to GDP ratio. These other taxes are income-specific, derived from ABS (2012a) and collected in a lump-sum manner in the model.

[12]The adjustment factor for the pension expenditures is 0.9. This means that the pension payments in Figure 1 are scaled down to account for the maximum pension rate for single pensioners used in the model, which is higher than the maximum payment to couple pensioners. The statutory consumption tax (GST) rate of 10% and the adjustment parameter of 0.65 imply the effective consumption tax of 6.5%, accounting for the fact that the GST is being imposed on about 65% of all consumption goods in Australia. Finally, the implied effective corporation tax rate is about 25% in the benchmark steady state (i.e., the product of the corporate tax adjustment factor and the statutory rate of 30%).

Table 1: Comparison of the model solution for 2012 with Australian data

Variable	Model	Australia [a]
Expenditures on GDP (percent of GDP)		
Private consumption	52.96	54.75
Investment	27.06	27.60
Government consumption	18.10	18.10
Trade balance	1.88	-0.54
Government indicators (percent of GDP)		
Age pension expenditure	2.80	2.80
Other social transfers [b]	4.20	4.20
Personal income taxes	12.92	11.50
Corporation taxes	5.10	5.10
Superannuation taxes	1.34	0.75
Consumption taxes (GST only)	3.50	3.50
Other taxes	2.44	2.84
Calibration targets		
Capital-output ratio	3	3
Investment-capital ratio	0.09	0.09
Foreign debt-capital ratio	0.195	0.195
Average hours worked	0.33	0.33

Notes: Actual data are taken from ABS (2012b, 2013b, 2013c) and all are averages over 2008-12; [b] These are social security payments excluding payments to the aged (e.g., disability pensions and family benefits).

The model also does a reasonably good job in matching the net income shares of each income quintile and the Gini coefficient in net income with the actual ABS (2013d) data on income distribution. Details of this comparison are available from the author.

3 Policy simulations and analysis

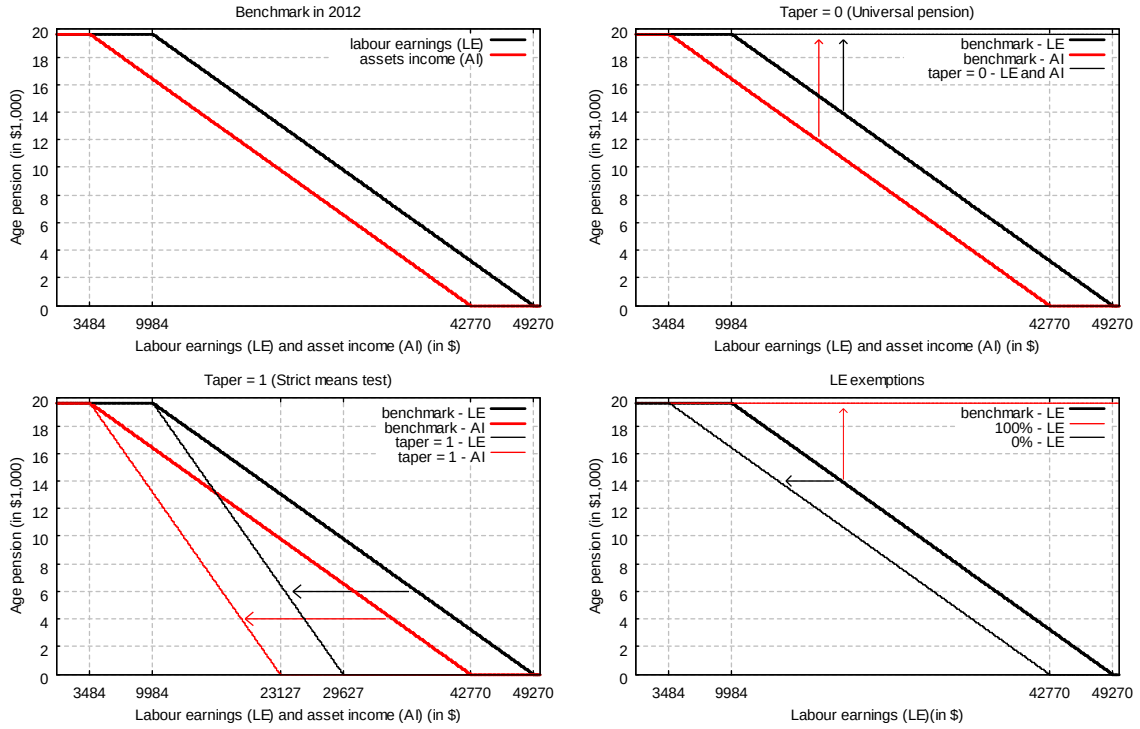
We now use the model described in the previous section to simulate hypothetical policy changes in (i) the income taper rate to zero, 0.25, 0.75 and one; and (ii) labour earnings exemptions to 100% and 0%. As already mentioned, the main objective is to assess further increases in the income taper and higher concessions to labour earnings in the pension means test as extensions of the 2009 age pension reform. We assume that each of the hypothetical policy changes is implemented in 2012.[13]

The associations between the age pension and the two sources of private income in the benchmark setting and under the selected hypothetical reforms are depicted by Figure 3. As shown, setting the taper to zero represents a shift to the universal pension (or demogrant)

[13]Note that our analysis abstracts from any other policy changes that may affect pension payments and total government spending on the age pension, including the legislated increases in the pension access age from 65 to 67 and in the superannuation guarantee rate from 9% to 12% of gross wages that are to be phased in gradually in the near future.

that is paid to all individuals of the age pension age regardless of their assets income and/or labour earnings. In contrast, setting the taper to one represents a strict income test policy that almost halves the maximum private incomes of pensioners to qualify for any pension. As for the two changes in labour earnings exemptions, the figure only shows the association between the age pension and labour earnings because the unchanged taper of 0.5 implies the same age pension schedule for assets income as in the benchmark. In the case of 100% labour earnings exemptions, only the assets income is means tested, while the 0% labour earnings exemptions policy treats the two sources of private income in the same way as in the benchmark for assets income.

Figure 3: Association between age pension and private incomes



Notes: The benchmark assumes pension policy settings for single pensioners in 2012, with the income taper of 0.5 and the current labour earnings exemptions of up to $6,500 per year. The arrows show the effects of selected policy changes on the association between age pension and private income.

The changes in the age pension schedule reported in Figure 3 are expected to have direct effects upon life-cycle behaviour of households and also indirect or general equilibrium effects due predominantly to the assumed, budget-equilibrating adjustments in the income tax schedule (i.e., proportional changes to average/marginal income tax rates). In this section, we present and discuss disaggregate behavioural effects, as well as the macroeconomic and welfare implications. We start with long run steady state implications and then proceed to short term and transitional implications of the investigated policy changes.

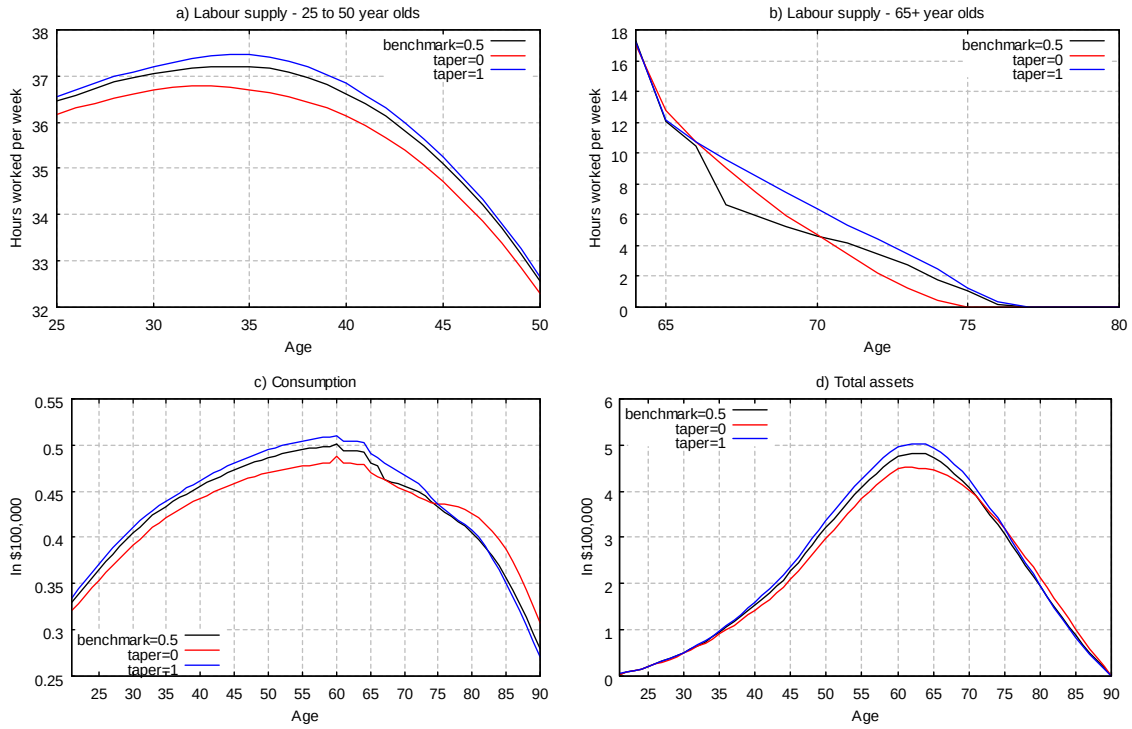
3.1 Long run implications

The long run steady state implications apply if we assume that there has been sufficient time for the economy to adjust completely to the new policy settings. In this case, households of different generations, but of the same income type, face exactly the same economic environments (though at different calendar times) and so behave in exactly the same way. Below we discuss the long run implications separately for the taper rate changes and the change in labour earnings exemptions.

3.1.1 Taper rate changes

The long run effects of the taper rate changes on average life-cycle labour supply, consumption and total assets are presented in Figure 4. For ease of exposition, each graph compares the benchmark steady state profile, which is averaged across five income types of households, only with the average profiles obtained from the two extreme changes in the taper to zero (i.e., universal pension) and to one (i.e., strict means test). Similarly to Kumru and Piggott (2009) and Fehr and Uhde (2014), the life-cycle results indicate that the high taper rate policy leads to less consumption smoothing, but larger assets accumulations for most of the life-cycle with steeper assets withdrawals at older ages. Furthermore, as the increased taper lowers average pension payments to elderly households, the associated disincentive of the pension to work declines, partly explaining increased labour supply of young and middle age cohorts (Figure 4a). The indirect effect of reduced income tax rates resulting from the strict means test policy also encourages higher average labour supply. The results for the shift to universal pension payments with the taper set to zero show the opposite behavioural effects, compared to those outlined above for the strict means test policy change.

Figure 4: The long run steady state effects of taper rate changes on average life-cycle profiles



The effects on average labour supply of the high taper rate policy are not only positive for young and middle age cohorts but also for older households aged 65 years and over, as shown in Figure 4b. Table 2 with the disaggregate effects on average labour supply for the 25 to 55 and 65 plus year olds shows that under the high taper policy change, many income types aged 65 years and over work longer hours, with average labour supply of 65 plus year olds up by 13.43% relative the benchmark.[14] While the labour supply of older households in the lowest quintile who receive the maximum pension regardless of the taper increases only marginally, the second, third and fourth quintiles at older ages experience significantly higher labour supply. Although the elderly in these quintiles work more to offset reduced pension payments, the labour supply effects differ among the three income groups. Specifically, households in the second quintile work and earn more but the EMTRs on their labour income are not affected by the increased taper because they do not exceed the maximum earnings exemption. The increase in average labour supply of 65 plus year olds in the third quintile is due to an increased retirement age. Note that these households work the same hours at early age pension ages as in the benchmark, in order to avoid high EMTRs on their earnings that they would pay if their labour earnings exceeded the maximum exemption. Finally, households in the fourth quintile no longer qualify for any pension at early age pension ages as a result of the increased

[14]Note that the absolute increase in average labour supply of the 65 plus age group is small, with the effects on per capita labour supply discussed below due largely to the changes in working hours of young and middle age cohorts.

taper. They no longer face any labour supply distortions arising from the means testing and, therefore, increase their labour supply and work similar hours as the highest income type of households.

Table 2: Long run effects of taper rate changes on household labour supply
(Percentage changes in hours worked per week relative to benchmark in 2012)

Income quintile	Taper = 0		Taper = 1	
	25-50	65+	25-55	65+
- Lowest	-0.21	-21.64	0.09	2.03
- Second	-0.36	-29.39	0.04	36.04
- Third	-1.20	39.99	0.40	21.96
- Fourth	-1.93	24.77	0.93	54.65
- Highest	-1.50	-14.73	0.69	-4.56
Average	-1.41	-0.68	0.62	13.43

Note: The results relate to average labour supply for 25-55 and 65 plus year olds.

Table 3 reports the long run macroeconomic implications of the examined taper rate changes as percentage changes in the selected per capita variables relative to the benchmark in 2012. The simulation results of hypothetical increases in the income taper show positive long run effects on most macroeconomic variables, including labour supply, assets and consumption as well as reduced age pension expenditures to the government.[15] In particular, the taper increased to one generates 0.82% increase in labour supply, 4.28% increase in domestic assets, 1.63% increase in per capita consumption (a measure of living standards) and 17.04% reduction in age pension expenditures. The positive effects on per capita labour supply are driven by higher average labour supply of working age households, as shown in Table 2. On the contrary, we find that lowering the current taper rate of 0.5 has negative macroeconomic and fiscal implications in the long term. For example, the results for the removal of the income test with the taper set to zero show a significant increase in the age pension expenditures by almost 42% from current 2.8% of GDP to over 4% of GDP, requiring an income tax hike of over 11% in the long run.

[15] In our small open economy framework, the capital labour ratio as well as the marginal products of capital and labour and the wage rate faced by the firms are all determined by the exogenously given and constant interest rate in the long run. To keep the capital labour ratio unchanged in the long run, the percentage changes in the per capita labour supply have to be matched by the percentage changes in the capital stock. The long run changes in average labour supply also determine the percentage changes in the output per capita because of the constant return to scale property of the production function.

Table 3: Macroeocnomic effects of taper rate changes in the long run
(Percentage changes in selected variables relative to benchmark in 2012)

Variables	Taper rate changes			
	0	0.25	0.75	1
Labour supply	-1.38	-1.06	0.40	0.82
- 25-55 year olds	-1.41	-0.59	0.34	0.62
- 65+ year olds	-0.68	-24.06	4.97	13.43
Domestic assets	-4.41	-2.94	1.98	4.28
Consumption	-2.30	-1.69	0.78	1.63
Age pension expenditures	41.66	18.23	-9.89	-17.04
Income tax rates [a]	11.16	6.28	-3.19	-6.01

Notes: [a] Adjustments to income taxes assumed to balance government budget.

The results reported above are generally supported by related literature simulating means testing pensions (e.g., Kumru and Piggott (2009), Tran and Woodland (2014) and Fehr and Uhde, 2014). However, Määttänen and Poutvaara (2007) and Kudrna and Woodland (2011a) found opposite effects on aggregate labour supply and consumption. This is due largely to a different choice of the government budget-neutralising policy instrument, with Määttänen and Poutvaara (2007) assumed increases in the maximum pension benefits arising from increasing the taper, while Kudrna and Woodland (2011a) used budget-equilibrating increases in the consumption tax rate resulting from their simulation of the means test removal. In addition, Kudrna and Woodland (2011a) assumed only three income types of households, with 30% of each generations in the low income class, 60% in the middle income class and the remaining 10% in the high income class. Therefore, their positive labour supply effects of the means test removal were to some extent a result of increased working hours of middle income households eligible for the age pension. Note that in Table 2, we also show positive labour supply effects of the means test removal (i.e., Taper=0) for the 65 plus year olds in third and fourth quintiles, but in the present model these two income types together only account for 40% of population in that age group.

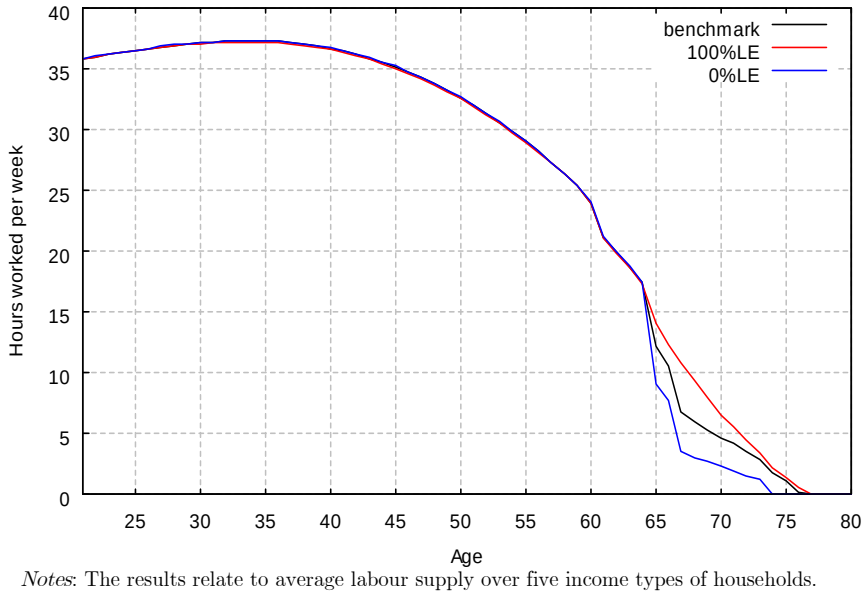
3.1.2 Changes to labour earnings exemptions

Here we discuss the long run simulation results for the hypothetical changes in the labour earnings (LE) exemptions from the means testing to 100% and to 0%. The main objective of these two simulations is to examine the effects of a preferential treatment of labour earnings in the income test of the age pension on labour supply of older Australians.

Figure 5 compares the life-cycle labour supply in the benchmark averaged over 5 income types of households with the average labour supply profiles obtained from the two policy

changes. The differences among the three profiles are significant for older households aged 65 years and over. While the hypothetical removal of the current labour earnings exemptions reduces labour supply at older ages, the 100% exemption of labour earnings from the means testing increases average labour supply of older households in comparison with the benchmark labour supply. Under the 100% labour earnings exemptions, the increased labour supply of older households is also shown to decline gradually with age. This is because elderly households in the third and fourth quintiles no longer face high EMTRs on their labour income as they did in the benchmark case. Recall that in the benchmark with the current labour earnings exemption, the working hours of the two income types drop suddenly at early age pension ages (see the life-cycle labour supply in Figure 1 for the two quintiles).

Figure 5: Long run labour supply effects of changes in LE exemptions



Notes: The results relate to average labour supply over five income types of households.

The long run macroeconomic effects of the two policy changes in labour earnings exemptions are provided in Table 4. Compared to the examined taper rate changes, the changes in labour earnings exemptions have much smaller aggregate effects, which is due to low productivity, labour supply and earnings at older ages. Importantly, labour earnings exemptions have significant and positive effects on average labour supply of older Australians. The results for the 100% labour earnings exemptions show a 24.64% long run increase in average labour supply of households aged 65 years and over, which is almost a double of the long run increase in the labour supply of the elderly resulted from the strict means test policy with the taper increased to one.

Table 4: Macroeocnomic effects of labour earnings exemptions in the long run
(Percentage changes in selected variables relative to benchmark in 2012)

Variables	Changes in labour earnings exemptions to	
	100%	0%
Labour supply	0.30	-0.48
- 25-55 year olds	-0.34	0.12
- 65+ year olds	24.64	-24.47
Domestic assets	-2.94	1.33
Consumption	-0.07	-0.38
Age pension expenditures	2.64	-0.22
Income tax rates [a]	0.88	0.35

Notes: [a] Adjustments to income taxes assumed to balance government budget.

Table 4 also shows increased age pension expenditures as a result of the 100% labour earnings exemptions, which calls for higher income tax rates that are assumed to maintain a balanced government budget. Higher income tax rates together with increased pension payments lead to smaller assets accumulations. As mentioned, the magnitude of these aggregate effects is much smaller relative to the macroeconomic implications of the taper rate changes (see Table 3 for comparison).

3.2 Short-term and transitional results

The long run simulation results established that only the investigate changes in the income taper rate had significant effects on the Australian economy. In this subsection, we therefore focus on transitional implications of the taper rate changes for the key macroeconomic variables and welfare of different households.

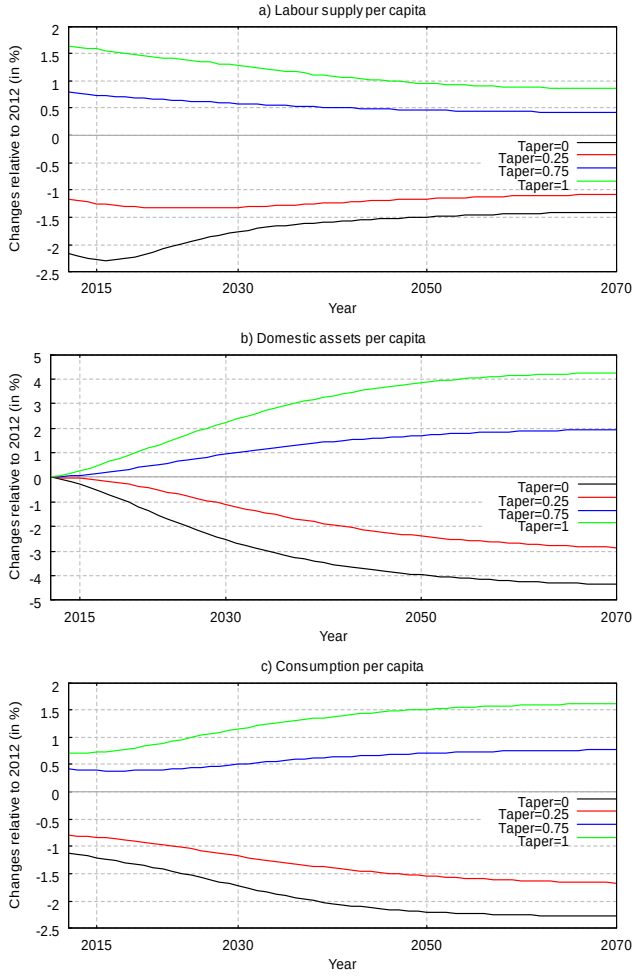
3.2.1 Macroeconomic implications

The macroeconomic effects of the taper rate changes on labour supply, domestic assets and consumption (all measured in per capita terms) upon the impact in 2012 and over the transition are depicted by Figure 6. These effects are presented as percentage changes in the selected variables relative to their benchmark steady state values, with the results for year 2070 approximating the long run effects presented above.

Several observations can be drawn from Figure 6. First, the examined increases in the taper from the benchmark rate of 0.5 (combined with the budget-equilibrating reductions in income tax rates) lead to higher per capita labour supply, assets and consumptions during the transition. Second, the short run effects on per capital labour supply are larger than the long run implications as current middle age and older cohorts work more to offset large cuts in their

pensions. The transitional decreases in per capita labour supply relative the impact effect are due to greater assets accumulations by future born generations, which have an income effect on their labour supply. Nevertheless, the strict means test policy with the taper increased to one still generate a more than 0.8% long run increase in per capita labour supply. Third, the effects of the two examined reductions in the taper rate are almost symmetrically opposite to the higher taper rate changes. For example, the shift to universal pension payments with the taper set to zero is shown to reduce per capita labour supply more in the short run than in the long run. Older households significantly reduce their working hours because of receiving higher (full) pensions, while future born generations accumulate smaller assets due to increased income tax rates. As a result, per capita labour supply improves but per capita consumption worsens in the subsequent years of the transition.

Figure 6: Macroeconomic effects of taper rate changes over the transition



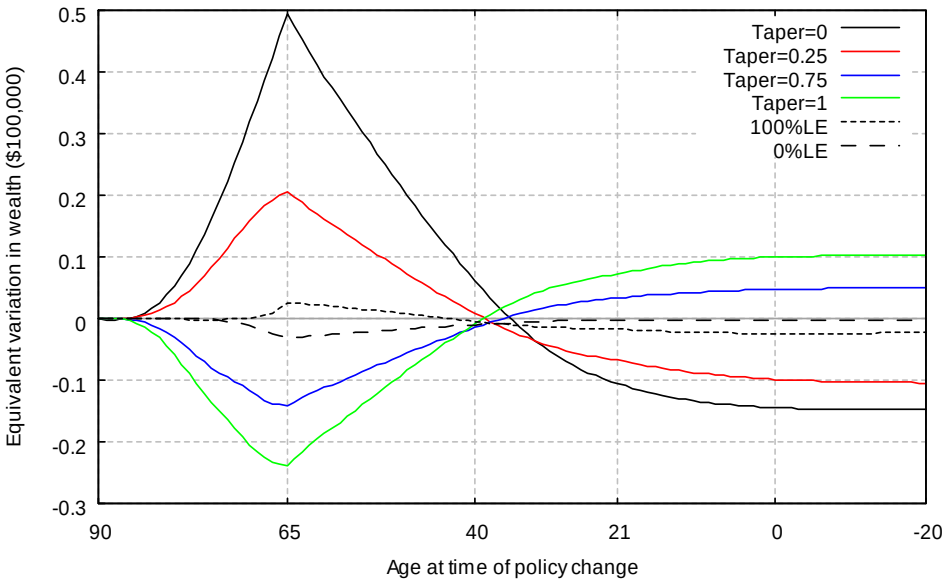
The transitional effects of the taper rate changes on the age pension expenditures and the budget-equilibrating income tax rates (not presented) are similar to the long run effects (see Table 3). Specifically, the zero taper policy change increases the age pension expenditures

by 41.66% upon the impact and in the long run as we assume stationary demographics. The examined increases in the income taper reduce the pension expenditures significantly in the short run, allowing for an immediate income tax cut. Over time, the pension expenditures (and thus income tax rates) decline further because future generations accumulate larger assets that generate higher assets income assessed under the income test of the age pension.

3.2.2 Welfare effects

The welfare effects are assessed on the basis of standard equivalent variations. Following Nishiyama and Smetters (2007), we calculate the change in initial wealth/assets for each generation needed in the benchmark to produce remaining lifetime utility obtained under the policy change. The average welfare effects of the examined policy change (i.e., average welfare across the five income groups) as a function of cohort's age at the time of the policy change are plotted in Figure 7. Recall that each hypothetical change is assumed to be adopted in 2012, with the cohort aged 21 years being the youngest alive at the time of the policy implementation.

Figure 7: Average welfare effects of the policy changes in income test
(Equivalent variations of one-time wealth transfers at time of policy change)



Notes: The presented welfare results for each cohort show an average over the five income groups.

Similarly to the long run macroeconomic effects, Figure 7 indicates that (*i*) the welfare effects are almost symmetrically opposite for the two increases and the two reductions in the income taper rate, and (*ii*) the welfare effects of the changes in the labour earnings exemptions are much smaller compared to those obtained from the taper rate changes. Under the increased

taper rate changes, the elderly population and households approaching retirement in 2012 experience larger welfare losses due to pension cuts, while young and future generations, on average, gain in welfare as they benefit from lower income tax rates and increased savings. On the contrary, the investigated reductions in the income taper have significantly positive effects on the welfare of currently old and middle-age households (who all receive full pension) but negative effects on the welfare of future generations. For instance, consider the generation aged 65 years in 2012. This generation would gain almost $50,000 in initial resources under the zero taper policy, whereas the same cohort looses, on average, almost $24,000 in the case of the taper increased to one. In the long run, however, the average welfare is shown to increase by over $10,000 for the increased taper policy and to decline by about $15,000 as a result of the zero taper policy. One should also note that current young and future generations who gain from the increased taper are larger in size compared to currently old generations.

In Table 5, we further decompose the average welfare effects of the taper rate changes to show both the inter-generational implications for the selected cohorts and the intra-generational implications for each income quintile. The effects are presented as equivalent variations of one-time wealth transfers and are shown to be greater for higher income quintiles as they hold much larger lifetime wealth compared to lower income types. In fact, the welfare of households in the lowest quintile is affected only indirectly through the budget-equilibrating changes in income tax rates as these households eligible for the pension receive the maximum payment regardless of the taper. The welfare implications for higher income quintiles are also affected by direct effects of the changes in their current or future pension payments.

Table 5 shows that the examined increases (reductions) in the taper result in welfare losses (gains) to currently older generations due to lower (higher) pension payments. For example, in the case of the zero taper, the welfare gain for the highest quintile aged 65 years in 2012 is $119,000 in initial wealth. In other words, the initial wealth of this high income household would need to increase by that amount to generate the level of remaining lifetime utility in the benchmark with the taper of 0.5 as under this policy change with the zero taper. In contrast, future generations of households in the highest quintile experience large welfare losses ($52,000 in initial wealth) under the zero taper policy that increases disincentives to work and save and requires higher income tax rates. Note that lower income tax rates resulting from the increased taper are particularly important for higher income households to attain welfare gains in the long run.

Table 5: Distributional welfare effects of changes in income taper rate
(Equivalent variations of one-time wealth transfers at time of policy change)

Policy change	Age in 2012	Household Income Type				
		Lowest	Second	Third	Fourth	Highest
Taper = 0	80	-0.01	-0.01	0.02	0.07	0.19
	65	-0.02	0.12	0.41	0.78	1.19
	40	-0.02	0.05	0.12	0.16	-0.01
	21	-0.01	0.01	-0.01	-0.08	-0.42
	-80	-0.02	-0.01	-0.05	-0.14	-0.52
Taper = 0.25	80	0.00	0.00	0.01	0.03	0.10
	65	-0.01	0.06	0.20	0.38	0.41
	40	-0.01	0.03	0.06	0.07	-0.11
	21	-0.01	0.00	-0.01	-0.05	-0.27
	-80	-0.01	-0.01	-0.03	-0.09	-0.37
Taper = 0.75	80	0.00	0.00	-0.01	-0.04	-0.10
	65	0.01	-0.06	-0.20	-0.28	-0.17
	40	0.00	-0.03	-0.08	-0.08	0.12
	21	0.00	-0.01	-0.02	0.00	0.19
	-80	0.01	-0.01	-0.01	0.02	0.23
Taper = 1	80	0.00	0.00	-0.02	-0.07	-0.21
	65	0.01	-0.11	-0.38	-0.48	-0.23
	40	0.01	-0.06	-0.17	-0.09	0.27
	21	0.01	-0.02	-0.05	0.05	0.37
	-80	0.01	-0.01	-0.03	0.09	0.45

Note: Initial wealth transfers presented in units of $100,000.

4 Sensitivity analysis

In this section, we examine the sensitivity of long run macroeconomic and welfare results obtained from the taper rate changes and presented above to several modifications of the model. The first modification assumes an alternative policy instrument to balance the government budget, while the second alteration allows for the domestic interest rate to be endogenous. In the third modification, we consider the long run effects of the taper rate changes in an ageing environment.

Table 6 reports the percentage point deviations between the taper rate changes obtained under each alternative model assumption and those obtained using the baseline model reported above for selected macroeconomic variables and welfare measures, respectively.

Table 6: Sensitivity of long run effects of taper changes to alternative assumptions
(Percentage point deviations in the selected variables from baseline results in the long run)

Alternative assumptions	Variables	Taper rate changes to			
		0	0.25	0.75	1
(i) Consumption tax balancing government budget	Labour supply	1.03	0.41	-0.18	-0.30
	Domestic assets	4.03	3.60	-2.32	-3.92
	Consumption	1.82	1.01	-0.57	-0.95
	Tax rate [a]	28.79	15.31	-7.69	-15.63
	Welfare - lowest type	-0.39	-0.20	0.09	0.20
	Welfare - highest type	0.80	0.48	-0.26	-0.46
	Welfare - average	-0.03	0.00	-0.01	0.02
(ii) Endogenous domestic interest rate	Labour supply	-0.27	-0.14	0.08	0.22
	Domestic assets	0.65	0.23	-0.54	-0.83
	Interest rate	1.27	0.90	-0.56	-1.39
	Consumption	-0.39	-0.25	0.07	0.30
	Tax rate [b]	0.80	0.54	-0.14	-0.49
	Welfare - lowest type	-0.07	-0.05	0.03	0.08
	Welfare - highest type	-0.15	-0.10	0.04	0.11
	Welfare - average	-0.08	-0.06	0.03	0.09
(iii) Population ageing	Labour supply	-1.83	-1.14	0.52	1.09
	Domestic assets	-0.42	-0.45	1.70	5.69
	Consumption	-2.51	-1.61	1.16	2.97
	Tax rate [b]	4.58	2.80	-2.34	-5.47
	Welfare - lowest type	-0.29	-0.18	0.14	0.30
	Welfare - highest type	-1.32	-0.74	0.51	1.19
	Welfare - average	-0.55	-0.32	0.23	0.51

Notes: Welfare is measured by standard equivalent variations; [a] Budget-equilibrating consumption tax changes; [b] Budget-equilibrating income tax changes.

4.1 Consumption tax changes balancing budget

We have so far assumed proportional changes in the income tax schedule to balance the government budget. In this variation of the model, the income tax schedule is assumed to be unchanged and the government budget is balanced by adjustments made to the consumption tax rate, as assumed by Kudrna and Woodland (2011a) and Fehr and Uhde (2014). The motivation for this robustness check is that the two tax instruments have potentially different incentive effects upon households and, hence, upon the economy.

The two examined increases (reductions) in the income taper allows for (requires) a lower (higher) consumption tax rate, as shown in Table 6. The percentage changes in the consumption tax rate are significantly greater than in the income tax rates (see Table 3 for comparison) because of much smaller revenues generated by consumption taxes. More importantly, given that taxing consumption is less distortive for household behaviour than income taxation, tightening the taper with a reduced consumption tax rate has relatively negative long run effects

on the selected macroeconomic variables. For instance, using the consumption tax rate rather than the income taxation to balance the government budget, the policy change of the taper increased to one reduces the long run increases in per capita labour supply and domestic assets by 0.3 and 3.92 percentage points, respectively.

The two tax policy instruments have also different effects on welfare of low and high income households, which in Table 6 are depicted by the effects on the lowest and highest income quintiles. In particular, increasing the taper with a reduced consumption tax rate improves (worsens) welfare of the lowest (highest) income quintile, whereas the opposite is shown for the examined taper reductions. Note that consumption taxes are regressive and income taxes are progressive. Hence, a reduction in the consumption tax rate has stronger positive welfare effects on low income households than on high income households. In contrast, well-off households would benefit more from an income tax cut with reduced marginal income tax rates.

4.2 Endogenous domestic interest rate

We now relax the small open economy assumption and assume imperfect capital mobility with an endogenous domestic interest rate that depends upon the level of foreign debt. Specifically, the domestic interest rate is given by $r_t = \overline{r} + \gamma \left(FD_t/Y_t - FD_{2012}/Y_{2012} \right)$, where $\overline{r}$ is the exogenous world interest rate and FD_t/Y_t is the ratio of net foreign debt to output. The parameter γ gives responsiveness to the changes in FD_t/Y_t and is set to 0.02, as in Guest (2006). Under this specification, the domestic interest rate will fall if the ratio of net foreign debt to output declines and similarly to a closed economy, the capital labour ratio and the wage rate will no longer be constant in the long run.

As shown in Table 6, increasing the taper rate leads to a lower domestic interest rate. The interest rate declines because of larger domestic assets (also depicted by the baseline simulations with a constant interest rate) being partly invested abroad, which reduces foreign debt. On one hand, the reduced rate of return has somewhat negative effects on per capita assets in the long run, as reported in Table 6 for the two increases in the taper. On the other hand, the positive effects on per capita labour supply and consumption (and on the economy through increases in GDP per capita) are higher than those obtained previously with the fixed interest rate. These effects are due to increased wages (not displayed).[16]

The long run welfare gains from the increased taper reforms also improve further for the

[16] The lower interest rate drives up investment, leading to a capital stock. Consequently, the capital labour ratio increases, which has positive effects upon wages. Note that similar effects would occur in a closed economy.

two selected quintiles and average welfare, due primarily to relatively higher wages and lower income tax rates. On the basis of these welfare results (and the implications presented above for key macro variables) we conclude that an endogenous interest rate setup such as the one applied in this section provides an additional support for the means testing of the age pension.

4.3 Population ageing

Our sensitivity analysis of the baseline results to population ageing makes use of the medium population projections by Productivity Commission (2013). In particular, we use their age-specific survival rates in 2060 and calculate the annual rate of population growth to generate an old-age dependency ratio of 0.42 taken from their projections for 2060. The long run steady state effects of the taper rate changes in this ageing environment (with improved survival rates and lower population growth) are then compared with the baseline effects in Section 3.

The results in Table 6 indicate that both the reported macro aggregates and welfare increase more in this ageing environment than in the baseline model with existing demographics. For instance, domestic assets per capita and average welfare across the income quintiles are 5.69 and 0.51 percentage points higher, respectively, in the long run.

The logic behind the results in Table 6 for the changes in the taper in an ageing economy goes as follows. Population ageing with an increasing proportion of the elderly in the population results in higher pension expenditures, which need to be financed with higher taxes. Strengthening the means testing of the pension limits the increases in pension expenditures and in income taxes. This is due, in part, to an increased taper but also due to the means testing of larger assets and assets income. Notice that households rationally respond to increased longevity and improved survival probabilities by accumulating larger assets, which generates higher assets income assessed under the means test. Therefore, the percentage decline in the required tax rates in an ageing environment is greater than that reported in the previous section with the current demographic structure. This explains positive effects of the means testing on the economy and welfare in an ageing economy when compared with the effects in a non-ageing environment.[17]

[17] In contrast, the policies that relax the means testing require significantly higher income tax rates, which distort households' work and save behaviour and lead to larger percentage declines in per capita labour supply and assets than in a non-ageing environment.

5 Concluding remarks

In this paper, we have examined hypothetical policy changes in the taper rate and labour earnings exemptions applied to the income test of the age pension. The primary objective was to assess further increases in the income taper and the labour earnings exemptions as extensions of the 2009 age pension reform. To complete our analysis, we have also considered reductions in the income taper and the removal of current labour earnings exemptions.

Using an OLG model stylised to the Australian economy, we find that further tightening the taper leads to higher per capita labour supply, assets, consumption and long term welfare gains, but also to significant welfare losses of many currently older generations. These positive macro implications and long term welfare improvements are to a large extent due to lower income taxes assumed to support a balanced government budget with reduced age pension expenditures. Similarly to Kumru and Piggott (2009), we show that tightening the taper leads to faster drawdowns of assets in retirement. However, the asset decumulations are not large and only gradual, compared to large adjustments in labour supply of some pensioners who face high EMTRs on their earnings. We also find that while relaxing the income test for earned income has little aggregate impact (including implications for pension expenditures to the government), the policy has important and largely positive effects on labour supply at older ages.

The fiscal effects of increasing the taper show significant reductions in total government spending on the age pension. Such policy could be used as an alternative with potentially more equitable distributional implications to increasing the pension access age. Furthermore, policy reforms of tightening the taper combined with labour earnings exemptions from the means testing have recently been recommended to advanced economies by the International Monetary Fund [IMF] (2014).

The robustness checks that we have examined in this paper indicate that (i) the results for the taper rate changes are sensitive to the choice of a budget-equilibrating policy instrument, with the observed increases in macro variables and welfare being conditional on reduced income tax rates and (ii) an endogenous interest rate framework and population ageing in particular further strengthen the case for the means testing of public pensions.

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Appendix: Technical description of the model

This Appendix provides a technical description of our model and presents the values of main model parameters.

Demographics

We consider a model economy that is populated by sequences of generations aged between 21 and 90 years ($a = 21, ..., 90$) at any time t. Each generations consists of five income types i - the lowest, second, third, fourth and highest quintiles, with intra-generational shares given by ω_i. Every year, a new generation aged 21 years enters the model structure and faces random survival with the maximum possible lifespan of 70 years, while the oldest generation aged 90 dies. Lifespan uncertainty is described by the conditional survival probabilities, s_a. We assume stationary demographics with a constant population growth rate, n, which implies time-invariant cohort shares, $\mu_a = [s_a \diagup (1+n)]\, \mu_{a-1}$.

Households

Each i-type household who begins her economic life at time t is assumed to optimally choose consumption, c, and leisure, l, at each age and the timing of retirement to maximise the expected lifetime utility function given by

$$\max_{\left\{c^i_{t+a-21},\, l^i_{t+a-21}\right\}} \frac{1}{1-1/\gamma} \sum_{a=21}^{90} S_a \beta^{a-21} u(c^i_{t+a-21}, l^i_{t+a-21})^{1-1/\gamma},$$

subject to the per-period budget constraint written as

$$\begin{aligned} A^i_{a,t} \;\; = \;\; & (1+r) A^i_{a-1,t-1} + w_t e^i_a (1 - l^i_{a,t}) + AP^i_{a,t} + SA^i_{60,t} \\ & SP^i_{a,t} + ST^i_a + B^i_{a,t} - \lambda_t T(y^i_{a,t}) - (1+\tau^c)\, c^i_{a,t}, \end{aligned}$$

where the annual utility, $u(c,l) = \left[c^{(1-1/\rho)} + \alpha l^{(1-1/\rho)}\right]^{1/(1-1/\rho)}$, being discounted by the subjective discount factor, β, and the unconditional survival probability, $S_a = \prod_{j=21}^{a} s_{j-1}$. The remaining utility function parameters are the inter- and intra-temporal elasticities of substitution denoted by γ and ρ and the leisure distribution parameter, α.

In the per-period budget constraint, $A^i_{a,t}$ denotes the stock of ordinary private assets held at the end of age a and time t, which equals the assets at the beginning of the period, plus the sum of interest income, $rA^i_{a-1,t-1}$, labour earnings, $w_t e^i_a (1 - l^i_{a,t})$, age pension, $AP^i_{a,t}$, superannuation payouts, $SA^i_{60,t}$ and $SP^i_{a,t}$, social transfer payments, ST^i_a, and accidental bequest receipts, $B^i_{a,t}$, minus the sum of income taxes, $\lambda_t T(y^i_{a,t})$, and consumption expenditures, $(1+\tau^c)\, c^i_{a,t}$. Labour earnings are the product of labour supply, $1 - l^i_{a,t}$, and the hourly wage, $w_t e^i_a$, where w_t is the market wage rate and e^i_a is the age- and income-specific earnings ability variable. The labour supply is required to be non-negative, $1 - l^i_{a,t} \geq 0$. The income tax is a function of the

taxable income, $y^i_{a,t}$, which comprises labour earnings, assets income and the age pension.[18] We also assume that households are born with no wealth and exhaust all wealth at age 90 (i.e., $A^i_{20,t} = A^i_{90,t+70} = 0$) and that they are constrained from borrowing (i.e., $A^i_{a,t} \geq 0$).

Firms

The production sector assumes a large number of perfectly competitive firms that demand capital, K_t, labour, L_t, and investment, I_t, to maximise the present value of all future profits subject to the (per capita) capital accumulation equation:

$$\begin{aligned} \max_{\{K_t,\ L_t,\ I_t\}} \quad & \sum_{t=0}^{\infty} D_t \left[\left(1-\tau^f\right) \left(F(K_t, L_t) - C(I_t, K_t) - I_t - (1+cr) w_t L_t\right)\right] \\ \text{s.t.} \quad & (1+n)K_{t+1} = I_t + (1-\delta)\, K_t, \end{aligned}$$

where $D_t = (1+n)^t/(1+r)^t$ accounts for discounting and population growth and τ^f stands for the effective corporation tax rate. The adjustment cost function is taken from Fehr (2000) and given by $C(I_t, K_t) = 0.5\psi \left(I_t/K_t - (n+\delta)\right)^2 K_t$, where ψ is the adjustment cost coefficient and δ denotes the capital depreciation rate. The CES production function is $F(K_t, L_t) = \kappa \left[\varepsilon K_t^{(1-1/\sigma)} + (1-\varepsilon) L_t^{(1-1/\sigma)}\right]^{[1/(1-1/\sigma)]}$, with the productivity constant, κ, the capital intensity parameter, ε, and the elasticity of substitution in production, σ.

Solving the firm's maximisation problem yields the first-order necessary conditions and gives expressions for the equilibrium wage rate, w_t, interest rate, r, and capital price, q_t.

Government

The government is assumed to maintain a balanced budget, which can be expressed, in per capita terms, as

$$TR^Y_t + TR^C_t + TR^S_t + TR^F_t = G + ST + AP_t,$$

where the per capita expenditures are government consumption, G, and social transfer payments, ST, which both are assumed constant, and the expenditure on the age pension, AP_t, while TR^Y_t, TR^C_t, TR^S_t and TR^F_t are per capita tax receipts from the taxation of household income, consumption, superannuation and corporate profits, respectively. The proportional changes in the income tax schedule that are assumed to adjust endogenously to balance the government budget are given by

[18] The parameter λ_t (that proportionally increases/reduces the progressive income tax schedule and its tax rates) adjusts in each period to maintain a balanced government budget and is specified on the next page.

$$\lambda_t = \frac{G + ST + AP_t - \left(TR_t^C + TR_t^S + TR_t^F\right)}{\sum_{i=1}^{5} \omega_i \sum_{a=21}^{90} \mu_a T\left(y_{a,t}^i\right)}.$$

Small Open Economy and Market Equilibrium

The model is a small open economy model with the exogenous interest rate, r. The accumulation of net foreign debt, FD_t, in per capita terms, is

$$(1+n)FD_{t+1} - FD_t = TB_t - rFD_t,$$

where TB_t is the trade balance and rFD_t is the interest payments on net foreign debt.

The endogenous variables in the model are determined such that all agents (i.e., households, firms and the government) make their choices optimally and that all markets clear in every time period. The equilibrium conditions for labour, capital and output markets may be expressed as

$$\begin{aligned} L_t &= \sum_{i=1}^{5} \omega_i \sum_{a=21}^{90} e_{a,t}^i (h - l_{a,t}^i)\mu_a, \\ q_t K_t &= \sum_{i=1}^{5} \omega_i \sum_{a=21}^{90} \left(A_{a,t}^i + SA_{a,t}^i\right)\mu_a - FD_t, \\ Y_t &= \sum_{i=1}^{5} \omega_i \sum_{a=21}^{90} c_{a,t}^i \mu_a + I_t + G_t + TB_t. \end{aligned}$$

Parameterisation of the model

The benchmark model is calibrated to key Australian aggregates over the five-year period ending in June 2012, with the age pension, superannuation and tax policy settings and parameter values of that year. Table A1 displays the values of the parameters used in the benchmark steady state.

Table A1: Values of the main model parameters

Description	Value	Source
Demographics		
Population growth rate	0.018	Calibrated
Fraction of households of income type	All 0.2	Data [a]
Conditional survival probabilities	ABS(2013a)	Data
Utility function		
Inter-temporal elasticity of substitution	0.35	Literature [b]
Intra-temporal elasticity of substitution	0.9	Literature [b]
Subjective discount factor	0.0153	Calibrated
Leisure parameter	1.32	Literature [b]
Technology		
Production constant	0.885	Calibrated
Elasticity of substitution in production	0.929	Calibrated
Capital share	0.45	Data
Depreciation rate	0.07	Calibrated
Adjustment cost parameter	10	Literature [c]
Policy parameters		
Maximum age pension p.a. (in $100,000)	0.17469	Data
Income test threshold (in $100,000)	0.03976	Data
Maximum earnings exemption (in $100,000)	0.065	Data
Income reduction rate	0.5	Data
Mandatory contribution rate	0.09	Data
Contribution tax rate	0.15	Data
Effective earnings tax rate	0.075	Data
Statutory consumption tax rate [GST]	0.1	Data
Statutory corporation tax rate	0.3	Data
Income tax function	-	Estimated [d]

Notes: [a] Households are disaggregated into income quintiles based on ABS (2012a); [b] The values of these parameters are similar to Auerbach and Kotlikoff (1987) and Fehr (2000); [c] This value is taken from Auerbach and Kotlikoff (1987); [d] The function is estimated, using the 2010-11 income tax schedule.

The five income types of households (i.e., income quintiles) differ by their exogenously given earnings ability, e_a^i, and social transfer payments, ST_a^i (excluding the age pension). The earnings ability (or the potential wage earned with all time endowment allocated to work) is constructed using the estimated lifetime wage function taken from Reilly *et al.* (2005) and income distribution shift parameters based on ABS (2012a) data. The social transfer payments are assumed to be received by households in the lowest to fourth quintiles aged younger than 65 years ($a < 65$) and are also derived from ABS (2012a), which provides the share of social welfare in gross total income for each income quintile. These government benefits, which aim to represent welfare payments such as family benefits and disability support pensions, allow us to match not only private income but also gross total income for each quintile.