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Comparing Budget Repair Measures for a Small Open Economy with Growing Debt

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Keywords

Fiscal Deficit, Public Debt, Fiscal Consolidation, Welfare, Dynamic General Equilibrium, Small Open Economy

JEL Classification

C68, E21, E63, H31, H60, J26

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Comparing Budget Repair Measures for a Small Open Economy with Growing Debt*

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1 Introduction

Recent unfavourable macroeconomic conditions have put many advanced economies in a tough fiscal situation with large budget deficits and rapidly growing government debt. According to IMF (2010), Japan tops the list with a gross government debt-GDP ratio well over 200%. Greece is the second with gross debt over 150% of GDP. Countries with gross government debt-GDP ratios over 100% include Italy, Portugal, Ireland, and the United States. Major European countries face a similar debt problem. France and the United Kingdom are in the 80%-100% range, as is fiscally responsible Germany. Persistently sluggish economic growth has prevented the normal cyclical improvement in fiscal balances. Accordingly, fiscal consolidation has become a topical policy issue in Europe and America.

Among advanced economies, Australia stands out as a special case as it has not experienced any economic recession over the last 20 years. However, since the global financial crisis, it has suffered from significant fiscal deficits that have resulted in fast-growing government debt. Specifically, the underlying cash deficit reached 4.2% of GDP in 2010 and 3.1% of GDP in 2014, with net (gross) Commonwealth government debt amounting to 12.8% (over 20%) in June 2014 (Australian Government, 2015). Similarly to many other developed countries, the Australian government is committed to returning its budget to surplus as soon as possible. According to the recent government projections in the 2015-16 Federal Budget (Australian Government, 2015), the government plans to gradually eliminate budget deficits by 2020, with a modest surplus of 0.4% of GDP forecasted for the final projection year of 2026.

A number of fiscal consolidation measures have been proposed to achieve this goal, including temporary tax increases and/or spending cuts. There is a significant degree of uncertainty regarding achieving this projected path to budget surpluses. Undoubtedly, the proposed budget repair measures will have some unpleasant macroeconomic and welfare impacts. However, ambiguity over potential outcomes of the proposed budget repair measures and disagreement on the timing of these interventions have exacerbated uncertainty and therefore stimulated heated debates among the Australian public and policymakers. More specifically, there are no clear answers to several fundamental questions: What exactly are the macroeconomic effects during the austerity period and in the long run? What are the effects on the wellbeing of households? Which households and generations will be the winners or losers and how much will they gain or lose comparatively? Which combination of policy actions is the most preferable - weighing up

the macroeconomic effects and the implications for intergenerational and distributional equity?

In this paper, we aim to address these questions in the context of a dynamic general equilibrium, overlapping generations (OLG) framework. In particular, we aim to quantify and compare the economy-wide implications of several budget repair measures to achieve either the immediate elimination of the 2014 budget deficit (in 2015) or the gradual elimination of the existing budget deficit (starting in 2015), as projected by Australian Government (2015). These fiscal policy measures include: (*i*) temporary increases in the progressive income taxes; (*ii*) temporary increases in the consumption tax rate; and (*iii*) temporary cuts in the transfer payments. We are especially interested in the welfare implications for different age cohorts and household income types. Understanding these implications (and the macroeconomic effects) of the examined budget repair measures in the Australian context will benefit not only Australian fiscal policy but also other small open economies facing similar problems with large budget deficits and rapidly-growing public debt.

To undertake this quantitative analysis, we employ a small open economy OLG model that is calibrated to the Australian economy. The model comprises overlapping generations of heterogeneous households, perfectly competitive firms, a government sector incorporating essential fiscal policy settings, and a foreign sector with an exogenous interest rate. The heterogeneous households are different with respect to ages and skill types. The government sector consists of various public transfer programs and a variety of tax financing instruments such as progressive income, consumption, superannuation and corporate taxes. The government can also issue debt to finance its fiscal deficits. Importantly, the economic decisions made by households and firms (i.e., labour supply, saving and investment decisions) are subject to the distortions introduced by the fiscal policy. The rich structure of household heterogeneity and the detailed composition of government fiscal activities are essential to study the effects of various budget repair measures on macro aggregates and wellbeing of different households.

We first discipline households in our model to mimic the lifecycle behavior of Australian households, including labour supply and earnings and pension payments observed from the household survey data. We also calibrate our benchmark economy to target key Australian macroeconomic aggregates, the government budget deficits and net debt between 2000 and 2014. Next, we compute the baseline transition that assumes an unchanged budget deficit-GDP ratio (as observed in 2014) and allows for net government debt to gradually increase to a new steady state debt implied by the current budget deficit. Finally, we apply our model to

simulate the two fiscal consolidation plans achieved by either increasing tax rates or cutting social benefits, and compare their macroeconomic and welfare effects with those derived under the baseline transition.

Our simulation results indicate that while all three budget measures achieve the same fiscal goal (of reducing and eventually eliminating government debt), the macroeconomic and welfare effects of each budget measure differ significantly across households, generations and over time. More specifically, each examined fiscal measure results in favourable long-run macroeconomic and welfare outcomes, but have adverse short run consequences that are particularly severe under the immediate fiscal consolidation plan. The current generations born before the fiscal consolidation are likely not be supportive of any of the fiscal measures as they would suffer significant welfare losses of (on average) up to 12% in their remaining resources due to cuts in transfer payments (including age pensions) or facing higher tax rates. In contrast to the welfare losses attained by current generations, future generations are shown to experience welfare gains of up to 0.8% in their lifetime resources, as a result of no net public debt in the long run allowing for smaller taxes or higher transfer payments.

We show that taxing consumption or income leads to opposing macroeconomics and welfare implications. In particular, temporary increases in the consumption tax rate generate only small economic distortions with the impact on per capita labour supply, assets and output being modest, but they reduce the welfare of poor households most. Conversely, temporary increases in progressive income tax rates have largely negative effects on the economy, but reduce the welfare of poor households least. Moreover, there are interesting welfare trade-offs when choosing between transfer payment cuts and tax hikes. Cutting the transfer payments results in the largest welfare losses for current generations (particularly those on low incomes who have their pension cut), but the highest welfare gains for future generations, compared to the two tax measures.

In general, our results highlight challenges for the government when implementing any of the proposed budget repair measures. We show that each of the fiscal consolidation plans improves the wellbeing of future generations, but at the expense of large welfare losses borne by current generations. These welfare trade-offs between current and future generations, as well as between the rich and poor, indicate political infeasibility to implement either of the fiscal consolidation plans. Therefore, a proper fiscal policy design (requiring time-variant combinations of fiscal policy measures) is needed to smooth out the fiscal burden on current generations.

Our paper contributes to several branches of the literature. There is a fairly large body of literature that has been devoted to analysing the macroeconomic and distributional effects of fiscal policy. Jäger and Keuschnigg (1991) examine the burden of increased public debt in open economies, using a numerical overlapping generations model with inelastic labour supply. Baxter and King (1993) use a infinitely-lived, representative agent model to explore the general equilibrium effects of temporary and permanent changes in government spending and tax financing instruments. Heathcote (2005) investigates the effects of tax cuts in a heterogeneous agent model with infinitely-lived agents and incomplete markets. Fehr and Ruocco (1999) investigate the distributional and efficiency consequences of the Italian debt reduction, whereas Kitao (2010), using a similar large-scale OLG model, examines the effects of temporary tax cuts and rebate transfers in the US. Recently, Imrohoroglu *et al.* (2016) develop a large-scale OLG model to measure the effects of pension and tax reforms on pension and non-pension deficits in Japan and Glomm *et al.* (2016) quantify the macroeconomic and welfare effects of fiscal austerity measures in Greece. In this paper, we also use an OLG model, but focus on the fiscal consolidation in Australia that has a fast-growing but relatively low government debt, which is far below the steady state level implied by the existing budget deficit.

There is also a growing body of macroeconomic literature that analyses the effects of public debt financing. Erceg and Linde (2012) study the effects of fiscal consolidation in relation to whether monetary policy is constrained by a currency union membership or by the zero lower bound on policy rates. Forni *et al.* (2010) quantify the macroeconomic implications of permanently reducing the public debt to GDP ratio in euro area countries. Chen and Imrohoroglu (2016), using a neoclassical growth model with an infinite horizon and complete markets, investigate the consequences of different tax policies to reduce government debt for the US economy, while Hansen and Imrohoroglu (2016) build a similar neoclassical growth model to measure the impact of different tax policies needed to restore fiscal balance in Japan. Notice that since these papers use a representative agent framework, they abstract from intergenerational and other distributional effects of fiscal consolidations. Our paper is complementary to these papers as we incorporate agent heterogeneity and a variety of government activities into our model. We are able to analyse not only the aggregate welfare effect but also the distributional welfare effects within and across cohorts.

Finally, we contribute directly to the literature evaluating the economic effects of fiscal policy in Australia. The core models for fiscal projections and policy analyses by the Federal

Treasury (Australian Government, 2015) and the Productivity Commission (Productivity Commission, 2013) are micro-simulation models, which abstract from modelling microfoundations of household behaviour. Contrary to the micro-simulation approach, there is a growing body of literature, using general equilibrium OLG models that incorporate the behaviour of households and firms to analyse the impacts of fiscal policy reforms in Australia (e.g., Kudrna and Woodland (2011a, b) and Kudrna *et al.*, 2015). In this paper, we follow a similar modelling approach, but extend these studies by incorporating a more detailed disaggregation of households into income quintiles, technical progress and the government's ability to issue public debt. Notably, this paper is the first attempt to evaluate the welfare effects of the proposed budget repair measures, using an OLG model calibrated to the Australian economy.

The paper is structured as follows. In the next section, we set up a dynamic, general equilibrium OLG model used for the fiscal policy analysis. Section 3 provides details on the calibration of our model to the Australian economy as well as to the lifecycle behaviour of Australians derived from the household survey data. In Section 4, we examine a range of policy experiments to eliminate the existing fiscal deficit, with the results presented in terms of macroeconomic and welfare implications. Section 5 performs a sensitivity analysis of alternative assumptions of the model. Section 6 offers some concluding remarks.[1]

2 Model

The model is essentially a small open economy variant of Auerbach and Kotlikoff's (1987) model augmented to capture main features of the Australian economy and that consists of household, production, government and foreign sectors. Details on each of the sectors of the model and a definition of its competitive equilibrium are provided below.[2]

2.1 Household sector

Demographics. The household sector is populated by 70 overlapping generations aged 21 to 90 years ($j = 21, ..., 90$) in every year t. Every year, a new generation aged 21 years

[1] There are also two appendices containing supporting materials on the computation of the model and results for alternative budget repair measures.

[2] The model is an extended version of the general equilibrium OLG model developed for the Australian economy by Kudrna and Woodland (2011a, b). The extensions include (*i*) a detailed intra-generational heterogeneity based on income distribution data from Australian Bureau of Statistics (ABS) (2007), (*ii*) technical progress and (*iii*) a detailed calibration of the fiscal structure.

enters the model structure and faces random survival with the maximum possible lifespan of 70 years, while the oldest generation aged 90 years dies. Lifespan uncertainty is described by the conditional survival probabilities, π_j. The model assumes stationary demographics with a constant population growth rate, n, which implies time-invariant cohort shares, $\mu_j = [\pi_j \diagup (1+n)]\,\mu_{j-1}$.[3]

Endowments. Each cohort consists of five skill (or income) types i - the lowest, second, third, fourth and highest quintiles that are distinguished by their exogenously given labour productivity and social welfare payments. The skill type is pre-determined and unchanged over the life span and time periods. We denote the intra-generational shares by ω_i.

In each period of life, households of age j in time t are endowed with $h_{j,t}$ unit of labor time that has earning ability (efficiency unit) given by e^i_j. Following Kotlikoff *et al.* (2007), we incorporate a time-augmenting technical progress to ensure that the model is consistent with a well-defined balanced growth path. This approach assumes that the time endowment, $h_{j,t}$, increases for every successive generation at the rate of technological progress, g, according to $h_{j,t} = (1+g)\,h_{j,t-1}$.[4] The efficiency unit, e^i_j, is skill and age dependent. Similarly to Altig *et al.* (2001), e^i_j is assumed to increase due to the accumulation of human capital and also due to technical progress that makes the labour productivity profile steeper for each skill type.

Preferences. Each i-type household who begins her economic life at time t chooses consumption, c, and leisure, l, at each age j to maximize the expected lifetime utility function given by

$$U^i_t = E\left[\sum_{j=21}^{90} \beta^{j-21} \left(\prod_{z=21}^{j} \pi_{z-1}\right) \frac{u(c^i_{t+j-21}, l^i_{t+j-21})^{1-\frac{1}{\gamma}}}{1-\frac{1}{\gamma}}\right], \tag{1}$$

where the annual CES 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, $\prod_{z=21}^{j} \pi_{z-1}$. The remaining parameters in (1) are the inter- and intra-temporal elasticities of substitution denoted by γ and ρ and the leisure preference parameter, α.

Household problem. Households are assumed to make optimal consumption/saving and leisure/labour supply choices by solving a utility maximization problem with the objective

[3] One of the robustness tests in Section 5 considers a more ageing demographic environment with reduced n and increased π_j.

[4] Notice that the typical approach of accounting for technical progress by multiplying the labour input in the production function by a growing productivity factor would not be compatible with a long run equilibrium path in our setup with CES preferences (see Auerbach and Kotlikoff, 1987, p.35). We therefore assume the time augmenting technical change, which implies that in a steady state, all household variables as well as aggregate variables (defined in per capita terms later in the text) grow at the rate of technical progress.

function (1) subject to the per-period budget constraints written as

$$\begin{aligned} a^i_{j,t} &= (1+r)a^i_{j-1,t-1} + w_t e^i_j ls^i_{j,t} + p^i_{a,t} + s^i_{j,t} \\ &\quad + st^i_{j,t} + b^i_{j,t} - c^i_{j,t} - tax^i_{j,t}. \end{aligned} \tag{2}$$

In (2), $a^i_{j,t}$ denotes the stock of ordinary private assets held at the end of age j and time t, which equals the assets at the beginning of the period, plus the sum of interest income, $ra^i_{j-1,t-1}$, gross labour earnings, $w_t e^i_j ls^i_{j,t}$, public age pension payments, $p^i_{j,t}$, private superannuation payouts, $s^i_{j,t}$, social transfer payments, $st^i_{j,t}$, and bequest receipts, $b^i_{j,t}$, minus the sum of consumption, $c^i_{j,t}$, and total household taxes denoted by $tax^i_{j,t}$.

The gross labour earnings are equal to the product of labour supply, $ls^i_{j,t} = h_{j,t} - l^i_{j,t}$, and the hourly wage, $w_t e^i_j$, where w_t is the market wage rate and e^i_j is the age- and skill-specific earnings ability variable. Notice that the labour supply is required to be non-negative and constrained by the time endowment, $0 \leq ls^i_{j,t} \leq h_{j,t}$. Thus, when the agent chooses to allocate all time endowment to leisure, $l^i_{j,t} = h_{j,t}$, that agent must be fully retired from workforce, $ls^i_{j,t} = 0$.

The household taxes in (2) include the progressive income, consumption and other taxes, $tax^i_{j,t} = t(y^i_{j,t}) + \tau^c_t c^i_{j,t} + \overline{t}^i$. The progressive income tax is a function of the taxable income, $y^i_{j,t}$, which comprises labour earnings and assets income. The term, τ^c_t, represents the consumption tax rate and $\overline{t}^i$ denotes other taxes assumed to be collected as lump sum taxes within each skill type i.[5]

Following Gokhale *et al.* (2001), we abstract from intended bequests, with all intergenerational transfers being accidental. The accidental bequests, $b^i_{j,t}$, are calculated by aggregating the assets of deceased agents within each skill type i and equally redistributing them to all surviving i-type agents aged between 45 and 65 years. The model is a pure life cycle model in the sense that households are assumed to be born with no wealth and exhaust all wealth if survive to the maximum age of 90 (i.e., $a^i_{20,t} = a^i_{90,t+70} = 0$). We also impose borrowing constraints (i.e., $a^i_{j,t} \geq 0$) to prevent younger households from borrowing against their superannuation (private pension) payouts, as such borrowing is prohibited by the current legislation.

[5] The taxes and government transfers are further specified in the next section on the calibration of the model.

2.2 Production sector

The production sector contains a large number of perfectly competitive firms that produce a single all-purpose output good that can be consumed, invested in production capital or traded internationally.

Technology. The technology is described by the standard CES production function

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

where K_t is the capital stock, L_t is the labour input, κ is the productivity constant, ε is the capital intensity parameter and σ is the elasticity of substitution in production.

The firms face adjustment costs when accumulating new capital. As in Fehr (2000), we assume that adjustment costs can occur only during the transition according to the following cost function

$$C(I_t, K_t) = 0.5\psi \left(I_t/K_t - [n + g + n \cdot g + \delta]\right)^2 K_t,$$

where ψ is the adjustment cost coefficient and δ is the capital depreciation rate.

Firm problem. The perfectly competitive firms demand capital, K_t, labour, L_t, and gross investment, I_t, to maximize the present value of all future profits subject to the (per capita) capital accumulation equation:

$$\begin{aligned} \max_{\{K_t,\ L_t,\ I_t\}} \quad & \sum_{t=0}^{\infty} D_t \left[\left(1-\tau^f\right)\left(F(K_t, L_t) - C(I_t, K_t) - I_t - (1+\nu) w_t L_t\right)\right] \\ \text{s.t.} \quad & (1+n)(1+g) K_{t+1} = I_t + (1-\delta) K_t, \end{aligned} \tag{3}$$

where $D_t = (1+n)^t (1+g)^t / (1+r)^t$ accounts for discounting, population and economic growth, and τ^f stands for the effective corporation tax rate that is imposed on profits comprising the sale of output, minus the costs of capital formation and of the labour input. Notice that labour costs also include the mandatory superannuation contribution at rate ν on gross labour earnings (discussed further below).

Solving the profit maximization problem (3) yields the first-order necessary conditions and gives expressions for the equilibrium wage rate, w_t, interest rate, r, and capital price, q_t (see Appendix A for details).

2.3 Government sector

Pension system. The model incorporates main features of the two publicly stipulated pillars of Australia's retirement income policy. The first is a publically-managed "safety net" pillar that is represented by a means tested age pension financed through general taxation revenues. The second pillar is a privately-managed Superannuation Guarantee scheme that is based on defined contributions made by employers.

The first pillar payment - the age pension, $p^i_{j,t}$, is paid to households of skill type i and age pension age ($j \geq 65$) if they satisfy the following income test.[6] Let $p^{\max}$ denote the maximum age pension paid by the government to pensioners provided that their assessable income does not exceed the income threshold, $\underline{y}$. The maximum pension, $p^{\max}$, is then reduced at the pension taper (withdrawal) rate, θ, for every dollar of assessable income above $\underline{y}$. Algebraically, the age pension benefit for the age-eligible households can be written as

$$p^i_{j,t} = \max\left\{\min\left\{p^{\max}, p^{\max} - \theta\left(\widehat{y}^i_{j,t} - \underline{y}\right)\right\}, 0\right\}, \qquad j \geq 65, \tag{4}$$

where the assessable income, $\widehat{y}^i_{j,t}$, consists of interest income, $rA^i_{j-1,t-1}$, and half of labour earnings, $0.5 \times w_t e^i_j ls^i_{j,t}$.[7]

The second pre-funded private pension pillar, known as the Superannuation Guarantee, requires that employers 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, ν, from their gross labour earnings, $w_t e^i_j ls^i_{j,t}$. The contributions net of the contribution tax, $\tau^s \cdot \nu$, are added to the stock of superannuation assets, $\widehat{s}^i_{j,t}$, which earns investment income at the after-tax interest rate, $(1-\tau^r)\, r$. The superannuation asset accumulation can be expressed as

$$\widehat{s}^i_{j,t} = \left[1 + (1-\tau^r)\, r\right] \widehat{s}^i_{j-1,t-1} + (1-\tau^s)\, \nu \cdot w_t e^i_j ls^i_{j,t}, \qquad j \leq 60,\ \widehat{s}^i_{20,t} = 0, \tag{5}$$

where τ^r and τ^s denote the earnings and contribution tax rates paid by the superannuation fund. The superannuation assets must be kept in the fund until households reach age 60 when

[6] The actual means test of the age pension also includes the assets test and it is the binding test (the income or assets tests resulting in a lower pension benefit) that si used to determine the pension payment. The model considers only the income test as it affects the majority of part age pensioners.

[7] This is to approximate the existing preferential treatment of income from employment in the age pension means test.

the accumulation ceases and households are assumed to receive their accumulated balances as lump sum payouts. It is further assumed that working households aged 60 years are paid mandatory contributions directly into their private asset accounts.[8] Therefore, superannuation payouts denoted by $s^i_{j,t}$ in (2) may be expressed as

$$s^i_{j,t} = \begin{cases} 0 & j < 60 \\ \widehat{s}^i_{60,t} & j = 60 \\ (1-\tau^s)\,\nu \cdot w_t e^i_j l s^i_{j,t} & j > 60. \end{cases} \tag{6}$$

Government budget. The government activities are summarized by a budget constraint, which includes an issue of new debt, $\Delta D_{t+1} = D_{t+1} - D_t$, and tax revenues, T_t, that finance government consumption expenditure, G_t, interest payments on current public debt, rD_t, and transfer payments to individuals, TR_t:[9]

$$\Delta D_{t+1} + T_t = G_t + rD_t + TR_t. \tag{7}$$

The transfer payments in (7) contain the age pension expenditure, P_t, and the social transfers, ST_t, which are assumed to paid to households aged $j < 65$. The government collects the total tax revenue, T_t, from household income taxes, T^Y_t, consumption taxes, T^C_t, superannuation taxes paid by the superannuation fund, T^S_t, and other household taxes, T^{LS}_t, as well as from imposing corporate taxes on the firms' profits, T^F_t. The per capita transfer payments and tax receipts in period t are given by

$$\begin{aligned}
P_t &= \textstyle\sum_{i=1}^{5} \omega_i \sum_{j=65}^{90} p^i_{j,t}\ \mu_j \\
ST_t &= \textstyle\sum_{i=1}^{5} \omega_i \sum_{j=21}^{64} st^i_{j,t}\ \mu_j \\
T^Y_t &= \textstyle\sum_{i=1}^{5} \omega_i \sum_{j=21}^{90} t(y^i_{j,t})\ \mu_j \\
T^C_t &= \textstyle\sum_{i=1}^{5} \omega_i \sum_{j=21}^{90} \tau^c_t\ c^i_{j,t}\ \mu_j \\
T^S_t &= \textstyle\sum_{i=1}^{5} \omega_i \sum_{j=21}^{60} \left[\tau^s \nu \cdot w_t e^i_j l s^i_{j,t} + \tau^r r \cdot \widehat{s}^i_{j-1,t-1}\right]\ \mu_j \\
T^{LS}_t &= \textstyle\sum_{i=1}^{5} \omega_i \sum_{j=21}^{90} \overline{t}^i\ \mu_j \\
T^F_t &= \tau^f (Y_t - \delta q_t K_t - (1+\nu) w_t L_t).
\end{aligned} \tag{8}$$

[8] This is consistent with post-July 2007 policy, which allows such contributions by seniors (those aged 60 and over) to be immediately removed from the fund.

[9] Note that the issue of new debt (or the change in net government debt) in period t is equal to the budget deficit in that period.

2.4 Foreign sector

We employ a small open economy framework since that description best fits the Australian economy. In the small open economy model, the domestic interest rate, r, is exogenous and equal to the world interest rate, r^w.[10] Letting A_t^F stand for the (per capita) net foreign assets at the beginning of t, the international budget constraint can specified as

$$(1+n)(1+g)A_{t+1}^F - A_t^F = rA_t^F + X_t, \tag{9}$$

where the left side of (9) represents per capita capital flows and the right side is the current account comprising the per capita net trade balance denoted by X_t, and the per capita interest receipts (payments) from foreign assets (debt), rA_t^F.

2.5 Competitive equilibrium

Given government policy settings for the taxation and pension systems, the demographic structure and the world interest rate, a competitive equilibrium is such that

(a) households make optimal consumption and leisure decisions by maximizing their lifetime utility (1) subject to their budget constraint (2);

(b) competitive firms choose labour and capital inputs to solve their profit maximization problem in (3);

(c) the government budget constraint (7) is satisfied;

(d) the labour, capital and goods markets clear

$$\begin{aligned} L_t &= \textstyle\sum_{i=1}^{5} \omega_i \sum_{j=21}^{90} e_j^i \; ls_{j,t}^i \; \mu_a, \\ q_t K_t &= \textstyle\sum_{i=1}^{5} \omega_i \sum_{j=21}^{90} (a_{j-1,t-1}^i + \widehat{s}_{j-1,t-1}^i)\mu_j + A_t^F - D_t, \\ Y_t &= \textstyle\sum_{i=1}^{5} \omega_i \sum_{j=21}^{90} c_{j,t}^i \; \mu_j + I_t + G_t + X_t. \end{aligned} \tag{10}$$

where μ^i and ω_i denote inter- and intra-generational shares.

[10] The exogenous interest rate assumption is relaxed in Section 5, which examines how sensitive the results are to the imperfect capital mobility assumption with an endogenous interest rate.

(e) the bequest transfers are equal to the sum of the assets left by the deceased agents within each skill type, $b_t^i = \sum_j (1 - \pi_j) (a_{j,t}^i + \widehat{s}_{j,t}^i)\mu_j$.[11]

3 Calibration

We now provide specific details on the calibration procedure that is to replicate or closely approximate the key Australian macro data and fiscal indicators in 2014, including the budget deficit and net government debt to GDP ratios in that year. As already mentioned, Australia has only recently started accumulating public debt, and so the standard assumption of a steady state equilibrium would not do the job in matching these two government indicators, as the current budget deficit to GDP ratio would imply much larger government debt to GDP ratio in a steady state than that observed from the data.[12] We use the following alternative approach that allows for 2014 - the base year for our fiscal policy analysis - to be a non-steady state year.

First, we compute the initial steady state that targets key Australian macro data and fiscal indicators for the period of 2000-08.[13] Given that the Australian government ran small budget surpluses and had literally no debt during that period, we make an assumption of a balanced government budget with zero net public debt in this initial steady state. In addition, we use the actual fiscal policy settings and the policy parameter values as of 2014, as our aim is to calibrate the model to match the budgetary position of the government in that year. We then compute the adjustment parameters for each tax revenue and government expenditure (discussed further below) to match the observed ratio of the given government indicator to GDP averaged over the period of 2000-08. The values of the main parameters used in this initial steady state and the sources are reported in Table 1.

Second, we run the baseline transition from this initial steady state where we re-compute the adjustment parameters to match the observed ratios of the given government revenue and

[11] As mentioned, we assume that accidental bequests are equally redistributed to surviving households of the same income type aged between 45 and 65 years. This means that the bequests received by higher income households are significantly larger than those received by lower income types.

[12] In a steady state, the net government debt to GDP ratio can be derived from the budget constraint in (7) as $\text{Deficit\_GDP} / (n + g + ng)$. Given the rates of population growth and technical progress and the budget deficit of 3.07% of GDP in 2014, the implied steady state net debt would equal to 98.27% of GDP, compared to the actual net debt of only 12.8% of GDP in 2014.

[13] We use the GAMS software to compute this steady state equilibrium (as well as the baseline and fiscal policy transition paths that are discussed later in the text). Details on our algorithm are provided in Appendix A.

expenditure to GDP for the period of 2009-2014. As shown later in this section, this approach generates net government debt that closely approximates the actual net public debt in 2014.

Table 1: Values of main model parameters

Description	Value	Source
Demographics		
Population growth rate	0.016	Data
Intra-generational shares	All 0.2	Data [a]
Conditional survival probabilities	ABS (2014b)	Data
Utility function		
Inter-temporal elasticity of substitution	0.4	Literature [b]
Intra-temporal elasticity of substitution	0.9	Literature [b]
Subjective discount factor	0.99	Calibrated
Leisure parameter	1.5	Literature [b]
Technology		
Productivity constant	0.872	Calibrated
Elasticity of substitution in production	0.778	Calibrated
Capital intensity parameter	0.45	Data
Capital depreciation rate	0.055	Calibrated
Adjustment cost parameter	10	Literature [c]
Technical progress rate	0.015	Data
Policy parameters		
Maximum age pension p.a. (in $100,000)	0.21504	Data
Income test free threshold p.a. (in $100,000)	0.04056	Data
Pension taper (withdrawal) rate	0.5	Data
Mandatory superannuation contribution rate	0.095	Data
Superannuation contribution tax rate	0.15	Data
Superannuation 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 (2007); [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 2013-14 Australian income tax schedule.

3.1 Demographics

The demographic parameters include the age-specific survival rates, π_j, and the annual population growth rate, n, which are assumed to be time-invariant, implying constant cohort shares, μ_j. We take π_j as the average survival probability for males and females from the 2011-13 life tables (ABS, 2014b) and set n to 1.6%, which is the annual population growth rate from 2013 to 2014. Given the chosen values for the two demographic factors, the model generates an old-age dependency ratio of 0.22, which is similar to the actual dependency ratio in 2014. The intra-generational shares, ω_i, are equal to 0.2 for each skill or income type of households

in the model, based on the quintiles used by ABS (2007).

3.2 Endowments

There are five skill types (i.e., income quintiles) in each cohort, which differ by their exogenously given earnings ability.[14] The earnings ability (or labour productivity) profiles are constructed using the estimated lifetime wage function taken from Reilly *et al.* (2005) and the income distribution shift parameters derived from ABS (2007). In particular, the earnings ability profile for the third quintile in the model is taken from Reilly *et al.* and is adjusted for technical progress in the same way as in Altig *et al.* (2001).[15] The earnings ability profiles for lower and higher income quintiles are shifted down and up, using the shift parameters, to approximately replicate the private income distribution in Australia.[16] Based on ABS (2007) data, the shift parameter is set to 0.26 for the lowest quintile, 0.55 for the second quintile, 1.0 for the third quintile, 1.52 for the fourth quintile and 2.63 for the highest quintile. Given that Reilly *et al.* (2005) considered only workers aged 15-65, the earnings ability after age 65 is assumed to decline at a constant rate, reaching zero at age 90 for each income class.

3.3 Preferences and technology

The functional forms of the household utility and production technology are standard in related literature. Importantly, the values assigned to the utility and technology parameters are similar to those used by others (see, for example, Auerbach and Kolikoff (1987) and Fehr, 2000). We calibrate the subjective discount factor, β, in the lifetime utility (1) to match the capital to output ratio (= 3.085). Most of the production function parameters are also calibrated to replicate other calibration targets such as the investment rate of 0.085. The wage rate, w, is normalized to one by calibrating the value of the productivity constant, κ, and the exogenous interest rate, r, is set to 4%. The adjustment cost parameter, ψ, is set to 10 as in Auerbach and

[14] Note that there are other two sources of the intra-generational heterogeneity - social transfer payments, $st^i_{j,t}$, and other taxes, $\bar{t}^i$, that are discussed in detail further below.

[15] The growth-adjusted earnings ability profile for the third quintile takes the form: $e_a = \exp(\alpha_0 + (g+\alpha_1)X + \alpha_2 X^2)$, where parameters α_0, α_1 and α_2 are taken from Reilly *et al.* as average estimates for males and females with 12 education years, X represents years of potential experience ($a - 5 -$education years) and g denotes the rate of technical progress.

[16] It is also assumed that the two lower income types have 10 years of schooling and the two higher income types 15 years of schooling, resulting in labour productivity profiles that differ not only by the level but also by the shape among the quintiles (i.e., being relatively flat for lower income types compared to higher income types).

Kolikoff (1987) and the rate of technological progress, g, to 1.5% per year based on Productivity Commission (2013). We also set the equilibrium condition for the capital market to target the net foreign assets to capital ratio of -0.173. This reflects the net foreign ownership of 17.3% of Australia's capital stock averaged over the period of 2000-08 (ABS, 2014a).

3.4 Fiscal policy

We base on the policy settings for the age pension, mandatory superannuation and taxation, and their parameter values in the financial year of 2013-14 to calibrate fiscal policy. We then calculate the adjustment parameters for each of government expenditures and for each of tax revenues, so that we re-produce the exact composition of the government budget in the initial steady state (2000-08) and in each transitional year of the calibration period (2009-14). Details are provided below.

Pensions. The age pension parameters presented in Table 1 relate to those for single pensioners and match the actual values applicable from September 2013 to June 2014. The mandatory superannuation contribution rate of 9.5% of gross earnings is for year 2014.

Transfers. In order to match not only private income but also social welfare and gross total income and to reproduce realistic labour supply profiles for each income quintile, we assume that households receive social transfers (other than the age pension) from the government. These payments denoted by $st^i_{j,t}$ in (2) are assumed to be received by households in the lowest to fourth income quintiles aged $j < 65$. Utilizing the ABS (2007) data, we calculate the share of social welfare in gross total income for each income quintile, which is 0.44 for the lowest quintile, 0.3 for the second quintile, 0.15 for the third quintile and 0.06 for the fourth quintile. One can think that these government benefits include welfare payments such as family benefits, disability support pension and unemployment benefit.

Taxes. The consumption and corporation tax rates are set to their statutory rates of 10% and 30%, respectively. While the consumption, corporation and superannuation tax rates are linear, the income tax rates are nonlinear and progressive. The income tax tax function is estimated to approximate of the 2013-14 progressive income tax schedule.

The five household types also differ in terms of the other taxes, $\bar{t}^i$. Using the ABS (2007) data, we derive the share for each income type in the total taxes paid. These shares are 0.08 for the lowest quintile, 0.1 for the second quintile, 0.15 for the third quintile, 0.22 for the fourth

quintile and 0.45 for the highest quintile. We then adjust the other taxes to match the observed ratio of the non-taxation revenue to GDP (1.53% of GDP averaged over the period of 2000-08) and apply these shares to account for the third exogenous source of heterogeneity among the five skill types of households in our model.

Adjustment factors. As mentioned, the adjustment parameters are introduced to match the exact composition of the government budget in the initial steady state and in the period of 2009-14. The values of these adjustment parameters together with the calibration targets taken from Australian Government (2015) are provided in Table 2.

Table 2: Adjustment parameters and calibration targets for government tax revenues and expenditures

Government indicator	Adjustment parameters [a]				Calibration targets (in % of GDP) [b]			
	2000-08	2010	2012	2014	2000-08	2010	2012	2014
Tax revenue								
Personal income tax	0.82	0.69	0.74	0.77	11.49	9.80	10.50	10.90
Consumption tax	1.28	1.10	1.00	1.13	6.95	6.20	5.70	6.40
Corporation tax	0.92	0.83	0.91	0.90	4.70	4.30	4.70	4.60
Superannuation tax	0.58	0.41	0.41	0.41	0.70	0.50	0.50	0.50
Other tax [c]	1.00	1.25	0.91	0.91	1.53	1.90	1.40	1.40
Transfer payments								
Age pension	0.90	1.00	1.00	1.03	2.50	2.80	2.82	2.93
Other social transfers [d]	1.00	1.07	1.10	1.14	4.00	4.25	4.40	4.59

Notes: [a] Adjustment parameters are computed to replicate calibration target for each revenue and expenditure in % of GDP in initial steady state (2000-08) and during calibration period (2009-2014); [b] Taken from Australian Government (2015); [c] This item represents non-taxation revenues; [d] These payments include family benefits, disability pension and unemployment benefits.

The algebraic description of the model in Section 2 is kept as simple as possible and so it does not explicitly include any of these adjustment parameters. However, it needs to be emphasized that the model description features effective tax rates and transfer payments that are the product of the statutory rate and the given adjustment factor. Let's first consider the adjustment parameter for the age pension. As shown in Table 2, its calibrated value is 0.9 in the initial steady state, implying that the effective age pension payments, $p^i_{j,t}$, in (2) and in (8) are scaled down for each skill type to match the actual pension expenditure of 2.5% of GDP averaged over the period of 2000-08. The reason for this adjustment is because the model assumes the actual pension parameters for 2013-14 (with higher maximum pension benefit than in 2008) and for single pensioners (whereas the couple maximum pension rate is smaller than the rate for single pensioners). Similarly, the progressive income tax, $t(y^i_{j,t})$, is also scaled down with the adjustment parameter of 0.82 in the initial steady state, as the model does not account for any tax offsets available for lower income earners. Given the superannuation tax adjustment factor of 0.58 in the initial steady state, the effective superannuation tax rates on contributions

and fund earnings are lower than the statutory rates. This is because the superannuation system is fully mature in the model (with mandatory contributions at 9.5% of gross earnings made over the entire working lives), whereas it has yet to achieve full maturity in Australia.

Table 2 also indicates that the effective consumption tax rate (i.e., the product of the statutory good and service tax (GST) rate of 10% and the consumption adjustment factor) equals 12.8% initially. This is because the calibration target for the consumption tax revenue (i.e., 6.95% of GDP) includes not only the GST revenue but also receipts from other indirect taxes. The other tax, $\bar{t}^i$, in (2) is assumed to be collected as a lump sum tax within each income type and is to target the government non-taxation revenue, in order for the model to exactly replicate the total revenue of the government budget.

Deficit Path. In addition to matching government tax revenues and expenditures over the period of 2009-2014, we also set the budget deficit to GDP ratios in the model to those observed from the data during that period. This approach then generates net government debt that is close to the actual net public debt in 2014 - the base year for the fiscal policy analysis that is not a steady state year.[17] We further assume that public consumption, G_t, adjusts endogenously to balance the government budget in (7) with a growing public debt over the period of 2009-14.

3.5 Model performance

The benchmark steady-state solution (2000-08) and the solutions in the selected years of the calibration period (2009-14) for the key macroeconomic and fiscal variables are reported in Table 3, which also provides a comparison with Australian data. The comparison of model generated and actual macroeconomic indicators indicates that the model replicates the Australian economy fairly well. Importantly, the model exactly matches the observed budget deficit to GDP ratios over the calibration period of 2009-2014 and closely approximates the net government debt in % of GDP in 2014.[18]

[17] As mentioned, this approach involves solving for the baseline transition path, where we use the parameter values presented in Table 1 and apply the Gauss-Seidel algorithm that is specified in Appendix A.

[18] Our model does also a good job in approximating the lifecycle behavior of Australian households observed from the HILDA surveys (Wooden *at al.*, 2002). The comparison of lifecycle labour supply, labour earnings and pension payments generated by the model for the initial steady state and for selected years of the calibration period with the cross-sectional profiles derived from HILDA is available from authors upon request.

Table 3: Comparison of model generated values for key variables with Australian data

Variable	Model generated [a]				Australian data [b]			
	2000-08	2010	2012	2014	2000-08	2010	2012	2014
Private consumption [c]	54.12	56.42	57.08	56.84	57.71	55.38	53.72	55.47
Public consumption [c]	18.87	19.77	17.50	18.86	17.41	18.01	17.88	17.68
Investment [c]	26.54	26.23	26.33	26.53	26.44	27.76	28.18	27.40
Trade balance [c]	0.47	-2.43	-0.91	-2.23	-1.71	-0.97	-0.13	-0.43
Total tax revenue [c]	25.37	22.70	22.80	23.80	25.37	22.70	22.80	23.80
Budget surplus [c]	0.00	-4.21	-2.92	-3.07	0.74	-4.21	-2.92	-3.07
Net government debt [c]	0.00	2.06	9.25	12.13	3.16	3.30	9.90	12.80
Capital to GDP [d]	3.09	3.06	3.08	3.10	3.09	3.16	3.05	3.22
Investment to capital [d]	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Foreign assets to capital [d]	-0.17	-0.18	-0.20	-0.21	-0.17	-0.18	-0.18	-0.17

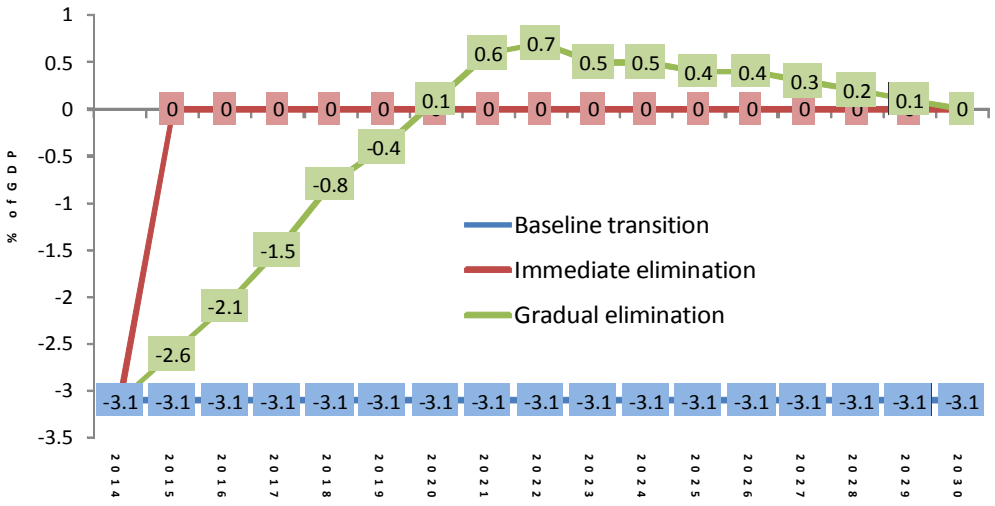
Notes: [a] The model-generated values relate to the initial steady state equilibrium in 2000-08 and to selected years of the calibration period in 2009-14; [b] The values are derived from ABS (2014a) and Australian Government (2015), with the values for 2000-08 being averages over that period; [c] In % of GDP; [d] Ratio.

4 Quantitative analysis

In this section, we report on the implications of several budget repair measures to either immediately or gradually eliminate the 2014 budget deficit. As shown in Figure 1, under the immediate elimination, the budget deficit is set to zero in 2015, whereas the gradual elimination of the 2014 budget deficit follows the projected path to budget surpluses by Australian Government (2015).[19] The results for key macroeconomic variables and for welfare across and within generations are presented with respect to the baseline transition with the deficit path that is also plotted in Figure 1. We first outline some of the key macroeconomic effects of the baseline transition and then we proceed to the discussion of the macroeconomic and welfare implications of the three budget repair measures under the immediate and gradual eliminations of the 2014 budget deficit.

[19]The budget surplus of 0.4% of GDP that the government projected for 2026 is assumed to decline at a constant rate to reach zero in 2030. After 2030, similarly to the immediate fiscal consolidation plan, there is no longer budget surplus or deficit.

Figure 1: Budget deficits/surpluses under different fiscal consolidation plans



Notes: The underlying cash balance (budget deficit/surplus) for 2014 and gradual eliminations of budget deficits are taken from Australian Government (2015).

4.1 Baseline transition

The baseline transition includes the calibration period of 2009-14 (that matches the composition of the government budget as discussed in the previous section) and the remaining period from 2015 to a new steady state in 2150. In that remaining period of the baseline transition, we keep the budget deficits in % of GDP unchanged as observed in 2014 and adjust public consumption to balance the government budget with an increasing net debt and interest payments. From now on, we will concentrate on the implications over the period from 2015 to 2150.

Table 4 reports the macroeconomics effects in the selected years of the baseline transition and in the long run that relates to year 2150. The results are presented as percentage changes in de-trended, per capita variables relative to year 2014, with net government debt expressed in % of GDP. The table also shows the values for the selected variables in 2014, which are reported in units of $\$100,000$ and as per capita for all the monetary variables, as per capita and in efficiency units for labour supply and in % of GDP for net government debt.

Table 4: Macroeconomic implications during baseline transition
(Percentage changes in selected detrended per capita variables from year 2014)

Variable	2014 [a]		2015	2020	2030	2050	Long run
Labour supply	0.356	%	0.00	-0.03	-0.06	-0.08	-0.06
Capital stock	2.351	%	-0.04	-0.22	-0.40	-0.50	-0.51
Domestic assets	1.950	%	-0.05	-0.23	-0.38	-0.44	-0.68
Net foreign assets	-0.485	%	-4.22	-23.34	-53.28	-91.16	-136.51
Net government debt [b]	12.130	-	14.74	26.67	45.65	69.85	98.27
Output (GDP)	0.758	%	-0.02	-0.09	-0.17	-0.22	-0.22
- Private consumption	0.431	%	-0.03	-0.15	-0.30	-0.33	-0.36
- Public consumption	0.143	%	-0.61	-3.38	-7.65	-12.88	-18.94
Age pension costs	0.022	%	0.10	0.49	0.83	0.87	0.94
Total tax revenue	0.180	%	-0.03	-0.16	-0.32	-0.40	-0.43
- Personal income tax	0.083	%	-0.05	-0.26	-0.50	-0.64	-0.69
- Consumption tax	0.049	%	-0.03	-0.15	-0.30	-0.33	-0.36

Notes: [a] The values for monetary variables in 2014 are presented in units of $100,000 and per capita; Labour supply is presented in per capita and efficiency units; Net government debt in 2014 and other selected years of the transition is presented in % of GDP.

The results for the baseline transition in Table 4 can be summarized as follows. First, net government debt increases significantly during the transition despite the reductions in public consumption that is required to keep the budget deficit constant at 3.07% of GDP. In the long run, net government debt reaches 98.27% of GDP and is more than 8 times larger than in the base year of 2014.[20] Second, the large increases in net government debt are shown be funded from abroad through capital imports, which lead to significant decreases in net foreign assets during the baseline transition. As shown in Table 4, net foreign assets decrease by 136.5% in the long run relative to 2014.[21] Third, in our small open economy, these substantial changes in government debt and foreign assets have no impact on the domestic interest rate and so the effects of the baseline transition on the other key macroeconomic and fiscal variables reported in Table 4 are relatively small.[22]

[20] As pointed out before, the steady state debt to GDP ratio is implied by the assumed deficit to GDP ratio and the rates of population growth and technological progress. Note that the higher these growth rates are the smaller government debt to GDP ratio would be for the given budget deficit to GDP ratio.

[21] The negative value for net foreign assets in 2014 implies net foreign debt, which increases significantly during the transition due to capital inflows that finance increased public borrowing depicted by a growing net government debt.

[22] In a small open economy model with the exogenous domestic interest rate, the marginal products of capital and labour as well as the capital labour ratio are unchanged in the long run. Hence, the change in labour supply must be matched by the change in the capital stock in the long run. The observed difference between the long run effects on labour and capital in Table 4 is due to the changes in the effective tax rate on firm's profits (that are to match observed company tax revenues in % of GDP) during the calibration period of 2009-14, which alter the capital labour ratio in the long run.

4.2 Two fiscal consolidation plans

We now consider two fiscal consolidation plans: immediate one in which the government eliminates the 2014 budget deficit immediately in 2015 and gradual one in which the government eliminates the 2014 budget deficit gradually over the period of 15 years (see Figure 1).

4.2.1 Implementation

The government is assumed to have three fiscal measures to finance each of the two consolidation plans: (i) the income tax rates, (ii) the consumption tax rate and (iii) transfer payments.[23] The adjustments in income or consumption taxes or transfer payments are made to balance the government budget constraint in (7) from year 2015 onwards. While it is straightforward to implement the consumption tax adjustments via temporary increases in the effective consumption tax rate, τ_t^c, additional assumptions need to be made for the other two measures. In the case of the income tax adjustments, we assume a proportional increase or decrease in the progressive income tax function through a scalar, λ_t, that is calculated as[24]

$$\lambda_t = \frac{G_t + TR_t + rD_t - \left(\Delta D_t + T_t^C + T_t^S + T_t^{LS} + T_t^F\right)}{\sum_{i=1}^{5} \omega_i \sum_{j=21}^{90} t(y_{j,t}^i)\mu_j}.$$

In the case of the transfer payment measure, a similar scalar is computed to adjust (temporarily cut) the transfer payments ($TR_t = P_t + ST_t$) to finance the deficit reductions.

We assume that the government announces each fiscal consolidation plan (as depicted by Figure 1) at the beginning of 2015 and that both plans are unanticipated by existing households. This means that the existing households of different ages and income types (alive in 2015) unexpectedly learn about the government's fiscal consolidation plans and re-optimize their labour supply, consumption and saving decisions over their remaining lifetimes. Note that these households are endowed with their assets that they accumulated in 2014 prior to the fiscal consolidation. We take these assets from the simulation of the baseline transition. Further note that all the existing and future born households are assumed to have perfect foresight about the future tax or transfer changes required to repair the government budget.

[23] We also consider two alternative tax measures to repair the government budget: (i) temporary levy on labour income and (ii) temporary levy on total assets income. The discussion of the macroeconomic and welfare effects of these two alternative budget repair measures is provided in Appendix B.

[24] Note that under the immediate consolidation plan, the budget deficit is set to zero, $\Delta D_t = 0$ for $t = 2015, ..., \infty$.

4.2.2 The effects of an immediate plan

Macroeconomic effects. The simulation results of the three budget repair measures for the key macroeconomic variables under the immediate fiscal consolidation plan are provided in Table 5. The table shows these effects as percentage changes in the selected per capita variables in the selected years of the transition and in the long run with respect to the baseline results. Recall that the baseline transition assumed the actual budget deficit of 3.07% of GDP in 2014 to stay unchanged during the period of 2015-2150. The long run effects in Table 5 then compare the implications in the new policy and baseline steady states and essentially can be approximated by the results for year 2150.

Table 5: Macroeconomic effects of immediate elimination of budget deficit with different policy instruments (Percentage changes in selected variables from baseline results with unchanged 2014 budget deficit to GDP ratio)

Variable	(i) Temporary income tax hikes				(ii) Temporary consumption tax hikes				(iii) Temporary transfer payment cuts			
	2015	2020	2030	Long run	2015	2020	2030	Long run	2015	2020	2030	Long run
Labour supply	-6.55	-5.06	-2.48	0.66	-0.26	-0.13	0.05	-0.11	2.54	1.96	1.28	-0.74
Capital stock	0.00	-1.26	-1.53	0.66	0.00	-0.01	0.04	-0.11	0.00	0.55	0.82	-0.74
Domestic assets	0.00	-6.00	-12.79	7.88	0.00	-0.85	-1.71	-0.06	0.00	-0.16	-0.76	-3.08
Net foreign assets	14.27	8.00	7.39	76.82	0.26	14.98	32.25	64.98	-5.92	12.76	32.43	61.19
Government debt [a]	15.42	13.15	9.51	0.00	14.77	12.66	9.30	0.00	14.50	12.47	9.21	0.00
Output (GDP)	-4.42	-3.80	-2.16	0.66	-0.17	-0.09	0.05	-0.11	1.67	1.48	1.12	-0.74
- Consumption	-4.11	-4.61	-4.50	2.65	-4.69	-3.94	-2.68	1.38	-3.41	-2.45	-1.18	0.47
Age pension costs	0.40	0.84	2.02	-2.14	0.00	0.06	0.17	0.04	-42.60	-34.34	-21.99	11.08
Total tax revenue	12.95	10.65	7.05	-3.89	12.90	10.56	6.82	-3.62	-0.04	0.18	0.30	-0.58
- Income tax	34.32	28.88	19.63	-10.40	-0.20	-0.29	-0.31	-0.14	0.60	0.78	0.64	-1.19
- Consumption tax	-4.11	-4.61	-4.50	2.65	48.59	39.91	25.87	-13.13	-3.41	-2.45	-1.18	0.47
Policy instrument [b]	42.42	37.64	26.93	-12.67	55.90	45.65	29.34	-14.31	-39.84	-31.67	-19.42	8.60

Notes: [a] Net government debt presented in % of GDP; [b] The fiscal policy measure to eliminate the 2014 budget deficit immediately in 2015 is either (i) income taxation or (ii) consumption tax rate or (iii) transfer payments.

As expected, the immediate fiscal consolidation leads to either significant tax hikes or transfer payment cuts initially. For instance, in 2015 (when the budget deficit is completely eliminated), the required tax hike is 42.42% in progressive income tax rates or 55.9% in the consumption tax rate. Alternatively, the required cut in transfer payments to households in 2015 amounts to almost 40%. In the subsequent transitional years, the required tax hikes or transfer payment cuts start to moderate. Eventually, all three fiscal adjustments result in the reduced tax rates or increased transfer payments. As shown in Table 5, the immediate (as well as the gradual) fiscal consolidation leads to a reduction of 14.3% in the consumption tax rate or an increase of 8.6% in the transfer payments in the long run. This long run result of lower tax rates or higher transfer payments is due to reduced net government debt, which initially further increases from 12.8% of GDP in 2014 to around 15% of GDP in 2015. However, as the government eliminates the budget deficit and then pays off interest payments and the princi-

ple, net government debt starts to decline, converging to zero in the new steady state of each fiscal policy measure.[25] The results also indicate that reduced government debt leads to large increases in net foreign assets (i.e., reductions in net foreign debt).

Table 5 reveals quite distinct impacts on key macroeconomic variables such as per capita labour supply among the three fiscal policy adjustments. Let's first consider the two tax measures to finance this immediate fiscal consolidation plan. Both tax measures has negative effects on per capita labour supply initially, but the negative impact effect of the distortive, income tax hikes is much greater (6.55% decline) than that due to the less distortive, consumption tax hikes (0.26% decline). Similarly, in the medium run the progressive income tax hikes generate significant declines in per capita labour supply, output and domestic assets, whereas the impact of the consumption tax hikes on the economy is relatively modest. In the long run, however, zero government debt allows for a reduction in income tax rates (by 12.67% relative to the baseline transition), providing labour supply and saving incentives and leading to higher per capita labour supply and domestic assets.

The implications of the temporary cuts to transfer payments are positive for per capita labour supply on impact (in 2015) as well as in the medium run. This is due to the reduced income effect on household labour supply that these payments (i.e., social transfers to households aged $j < 65$ and age pension payments to households aged $j \geq 65$) generate. In the long run, the implications for most macro variables are opposite as is the adjustment in transfer payments (8.6% increase). For example, the long run decreases in per capita labour supply and domestic assets from higher transfer payments are 0.74% and 3.08%, respectively.

Table 5 also shows that while the aforementioned effects on net government debt are very similar across the three budget repair policies, the effects on other selected fiscal variables (e.g., income and consumption tax revenues and pension expenditure) differ greatly, depending on the underlying fiscal policy instrument that finances the fiscal consolidation. For example, the consumption tax hike in 2015 raises the consumption tax revenue by 48.6% in the same year. In the long run when the tax rate is lower, the consumption tax revenue declines by 13.1% relative to the baseline result with the unchanged consumption tax rate.

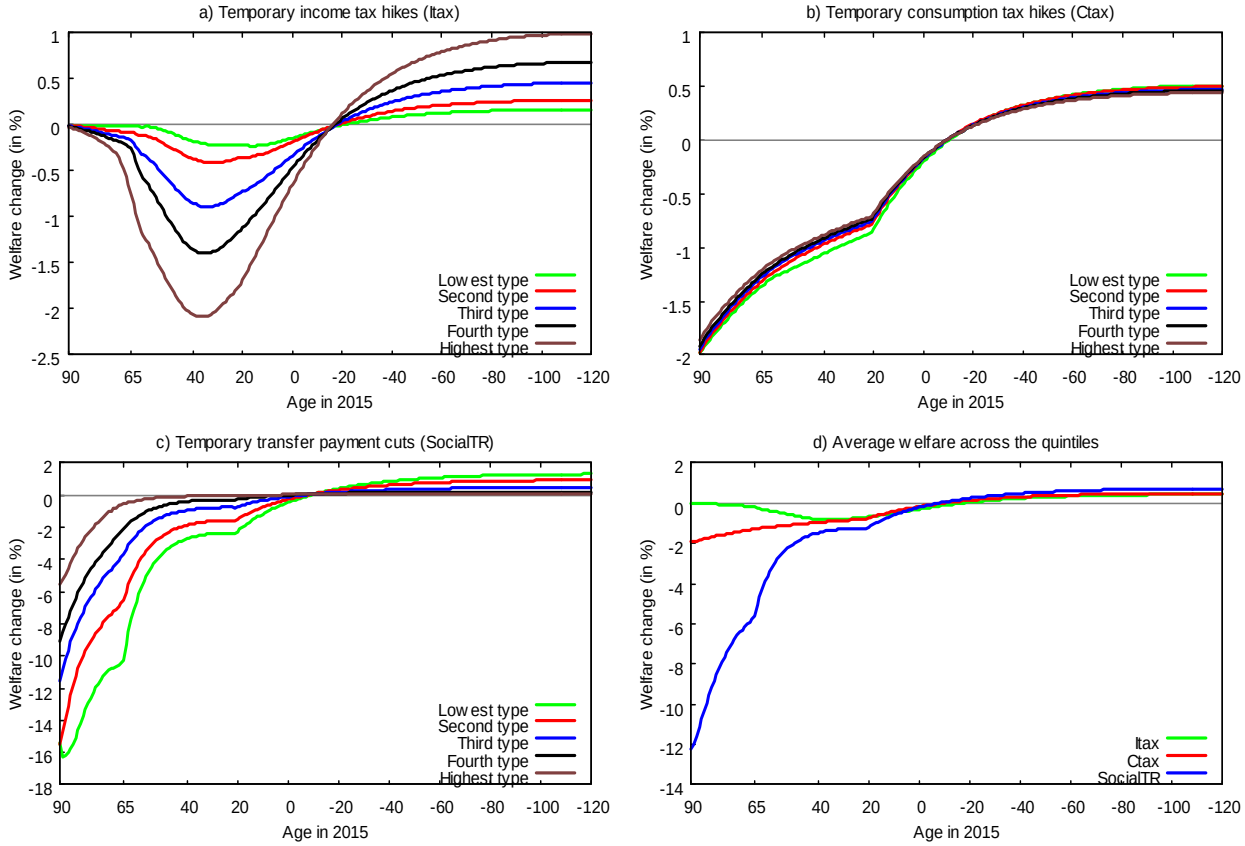
Welfare effects. We calculate standard equivalent variations to measure the effects of the three examined budget repair measures on welfare across generations and skill types. These

[25] Recall that the net government debt to GDP ratio reaches almost 100% of GDP in the new steady state of the baseline transition with the budget deficit of 3.07% of GDP.

calculations measure the proportional percentage increase/decrease in consumption and leisure for each generation (over the remaining life span) that is needed during the baseline transition with the constant deficit to GDP ratio (as in 2014) to produce the realized remaining lifetime utility in each reform scenario (for more detailed information, see Auerbach and Kotlikoff (1987), p.87).

Figure 2 depicts the distributional and average welfare effects of the immediate fiscal consolidation plan. Panels 2a-2c present percentage changes in the remaining utility for each income quintile of every generation relative to the remaining utility level under the baseline transition. In order to compare the three fiscal adjustments, Panel 2d plots the intergenerational welfare effects averaged over the five skill classes.[26]

Figure 2: Welfare implications of immediate elimination of budget deficit with different policy instruments (Percentage changes in welfare relative to baseline transition with unchanged 2014 budget deficit to GDP ratio)



Notes: Equivalent variation measures in %; Oldest (youngest) household in 2015 when the immediate elimination of the 2014 budget deficit is adopted is 90 years (21 years) old. All generations younger than 21 years are born in the subsequent periods of the transition.

Several observations can be drawn from these welfare results. First, all existing generations alive in 2015 (i.e., cohorts aged 21-90 years) when the deficit is eliminated attain welfare losses.

[26] The numerical values for the welfare effects of these budget repair measures on selected generations are displayed in Table B2 in Appendix B. That table also provides a comparison with the welfare effects under the gradual consolidation plan and of two alternative budget repair measures.

Figure 2d shows that the welfare losses are particularly large in the case of temporary transfer payment cuts, with some older cohorts loosing, on average, up to 12% of remaining resources due to reductions in their pension payments. The temporary increases in the consumption tax rate have also negative effects on the welfare of older generations. Although the magnitude of these effects is much smaller than those observed for the transfer payment cuts, the consumption tax hikes are more negative for the welfare of older households than the income tax hikes. This is simply because all cohorts pay the consumption tax, whereas the income taxes are predominantly paid by the working-age cohorts.

Second, while all the existing generations bear the welfare costs of this immediate fiscal consolidation due to required tax hikes or transfer payment cuts, future generations experience welfare gains. As shown in Figure 2d (and Table B2 for the average welfare), in the long run, generations gain, on average, 0.76% or 0.51% in their lifetime resources as a result of the transfer payment adjustments or the tax adjustments, respectively. Note that the tax hikes or transfer payment cuts to fund the fiscal consolidation are only temporary, with the long run elimination of public debt resulting in reverse changes in these policy instruments. Consequently, the long run tax cuts or transfer payment increases have positive effects on the welfare of future generations.

Third, Figures 2a-2c display interesting differences in the intra-generational welfare effects across the three fiscal policy measures. The consumption tax hikes and in particular the transfer payment cuts are more negative for the welfare of lower income types of the existing cohorts. This is due to the regressive nature of the flat consumption tax rate and because reduced transfer payments represent an important income source for low income households. For instance, in the case of the transfer payment cuts, some older cohorts in the lowest quintile experience welfare losses of 13.3% in their remaining resources, while the welfare losses for the same age cohorts in the highest quintile do not exceed 2.7% (see the results for the cohort aged 80 in 2015 in Table B2).

Conversely, the temporary increases in the income tax rates, which are progressive, reduce the welfare of higher income types more than the welfare of lower income types. Panel 3a shows welfare losses in excess of 2% in remaining utility for some young and middle age cohorts in the highest quintile but only less than 0.2% welfare losses for the same age generations in the lowest quintile. In the long run, the reverse effects on each of the fiscal policy instruments (i.e., either tax cuts or transfer payment increases balancing the government budget with no public

debt) produce opposing distributional welfare effects to those during the fiscal consolidation. Specifically, the highest income households of future generations born after the fiscal consolidation benefit the most from the income tax cuts (with long run welfare up by almost 1.1% in lifetime resources), whereas future generations in the lowest quintile attain the highest welfare gain (almost 1.4% in the long run) under the transfer payment policy.

4.2.3 The effects of a gradual plan

Macroeconomic effects. Table 6 reports the macroeconomic effects of the three budget repair measures under the gradual elimination of the 2014 budget deficit, as projected by Australian Government (2015). Similarly to the results for the immediate consolidation plan, the effects are presented as percentage changes in the selected per capita variables in the selected years of the transition and in the long run with respect to the baseline results.

Table 6: Macroeconomic effects of gradual elimination of budget deficit with different policy instruments (Percentage changes in selected variables from baseline results with unchanged 2014 budget deficit to GDP ratio)

Variable	(i) Temporary income tax hikes				(ii) Temporary consumption tax hikes				(iii) Temporary transfer payment cuts			
	2015	2020	2030	Long run	2015	2020	2030	Long run	2015	2020	2030	Long run
Labour supply	2.07	-6.64	-2.96	0.66	0.63	-0.28	0.02	-0.11	1.91	2.02	1.29	-0.74
Capital stock	0.00	-1.61	-2.04	0.66	0.00	-0.04	0.00	-0.11	0.00	0.56	0.85	-0.74
Domestic assets	0.00	-1.61	-12.82	7.88	0.00	0.14	-1.61	-0.06	0.00	1.80	-0.42	-3.08
Net foreign assets	11.25	18.63	5.95	76.82	-0.08	10.24	30.48	64.98	-5.62	10.46	31.18	61.19
Government debt [a]	14.55	20.24	11.78	0.00	14.68	19.30	11.35	0.00	14.56	19.05	11.23	0.00
Output (GDP)	1.34	-4.98	-2.65	0.66	0.42	-0.20	0.01	-0.11	1.26	1.52	1.14	-0.74
- Consumption	-1.05	-4.68	-4.77	2.65	-1.25	-4.35	-2.79	1.38	-2.87	-2.41	-1.18	0.47
Age pension costs	0.08	0.63	1.85	-2.14	-0.08	-0.11	0.12	0.04	-7.15	-39.15	-23.06	11.08
Total tax revenue	1.84	12.14	7.39	-3.89	1.92	12.07	7.16	-3.62	-0.09	0.32	0.34	-0.58
- Income tax	2.16	32.88	20.86	-10.40	0.44	-0.21	-0.34	-0.14	0.59	1.05	0.71	-1.19
- Consumption tax	-1.05	-4.68	-4.77	2.65	5.60	45.53	27.21	-13.13	-2.87	-2.41	-1.18	0.47
Policy instrument [b]	0.21	42.61	29.22	-12.67	6.93	52.15	30.86	-14.31	-5.42	-35.89	-20.33	8.60

Notes: [a] Net government debt presented in % of GDP; [b] The fiscal policy measure to eliminate the 2014 budget deficit gradually is either (i) income taxation or (ii) consumption tax rate or (iii) transfer payments.

Table 6 indicates that while the long run macroeconomic effects are the same irrespective of the budget deficit being eliminated immediately or gradually, the short run and transitional effects differ greatly between the two fiscal consolidation plans. For instance, under the gradual consolidation plan, the required 2015 tax hike is only 0.21% in progressive income tax rates and 6.93% in the consumption tax rate (compared to the same year tax hikes of 42.4% and 55.9% under the immediate fiscal consolidation plan reported in Table 5). However, in 2020 when the government budget returns to a surplus under the gradual plan, the required tax hikes are 42.61% in average income tax rates or 52.15% in the consumption tax rate, which are significantly higher tax hikes than those under the immediate plan in 2020. Similarly, the

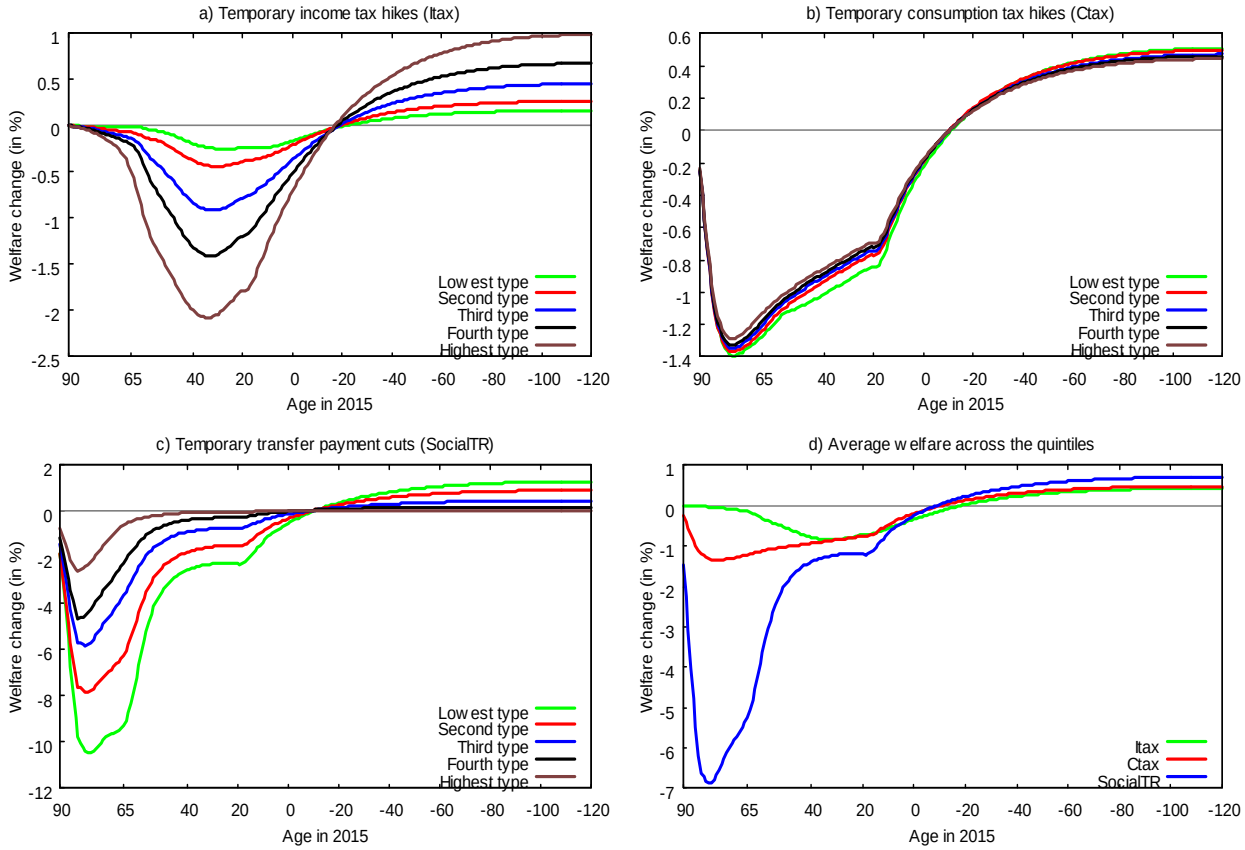
required cut in transfer payments under the gradual plan is only 5.42% in 2015, whereas the cut in 2020 amounts to almost 36%.

The results for this gradual plan indicate that there are important announcement effects as households foresee significant future tax hikes and adjust their lifecycle behaviour accordingly. This is particularly apparent in the case of the income tax adjustments, which result in a 2.07% increase in per capita labour supply in 2015 (compared to a 6.55% decline in per capita labour supply under the immediate plan). As mentioned, the households alive in 2015 foresee significant income tax hikes to be implemented in the near future (e.g., in 2020) and so they increase their labour supply (and savings) initially when the tax rates are still relatively low. However, when the large increases in the progressive income tax rates are actually adopted, households work less, resulting in a decline in per capita labour supply of 6.64% in 2020 under the gradual consolidation plan.

Welfare effects. The distributional and average welfare effects of the three budget repair measures financing this gradual fiscal consolidation plan are displayed in Figure 3. The results measure equivalent variations (comparing each reform scenario with the baseline transition) for households of different ages in 2015 and of different skill types.

The comparison of Figures 2 and 3 indicates that, while the welfare effects on future generations are similar (the same in the long run) for the two fiscal consolidation plans, there are some important differences in relation to the welfare effects on the existing households. These differences are particularly significant for some older households under the consumption tax and transfer payment policy measures. As shown in Figure 3d, the transfer payment cut generates an average welfare loss of 1.5% for the oldest generation (aged 90 in 2015). This welfare loss is significantly smaller compared to the average loss of 12% reported in Figure 2d for the same age cohort with the transfer payment cut funding the immediate fiscal consolidation plan. Similarly, the consumption tax hikes reduce the average welfare of the oldest generation by 0.2% under the gradual plan and by 2% under the immediate plan. Therefore, the gradual elimination of the 2014 budget deficit helps to mitigate the negative welfare effects that especially cuts in transfer payments and consumption tax hikes have on some very old cohorts and lower income classes.

Figure 3: Welfare implications of gradual elimination of budget deficit with different policy instruments
(Percentage changes in welfare relative to baseline transition with unchanged 2014 budget deficit to GDP ratio)



Notes: Equivalent variation measures in %; Oldest (youngest) household in 2015 when gradual reductions of the 2014 budget deficits are phased in is 90 years (21 years) old. All generations younger than 21 years are born in the subsequent periods of the transition.

5 Sensitivity analysis

This section provides a sensitivity analysis of the long run steady state results for key macroeconomic aggregates reported in Section 4 to alternative assumptions of the model. The modifications of our base model include: (*i*) imperfect capital mobility with an endogenous domestic interest rate; (*ii*) an economic slowdown via a reduced rate of technical progress; and (*iii*) an ageing demographic environment with improved survival probabilities and reduced population growth. Given the focus of this section on the lung run effects, we do not distinguish between the immediate and gradual eliminations of the 2014 budget deficit, as the results of the two consolidation plans are the same in the long run.

5.1 Endogenous interest rate

Our base model described in Section 2 made the assumption that the domestic interest rate was equal to the exogenously given world interest rate and was unaffected by the changes in net government debt. We now relax this small open economy assumption and examine the effects of the three budget repair measures by assuming imperfect capital mobility with an endogenous domestic interest rate. In this setting, the domestic interest rate, r_t, is determined as

$$r_t = \overline{r} - \gamma \left(A_t^F / Y_t - A_{2014}^F / Y_{2014} \right),$$

where $\overline{r}$ is the exogenous world interest rate ($= 4\%$), A_t^F / Y_t is the ratio of net foreign assets to GDP and the parameter $\gamma > 0$ gives responsiveness to the changes in A_t^F / Y_t. Following Guest (2006), we set γ to 0.02. Under this specification, the domestic interest rate will fall (increase) if the ratio of net foreign assets to GDP increases (decreases). In contrast to the small open economy assumption, this imperfect capital mobility framework implies that the capital labour ratio and the total wage rate faced by firms will also change in the long run, and so the long run changes in the capital stock, labour supply and output will differ. The effects that we discuss below may be thought of as being similar to those derived from a closed economy model.

Table 7 shows the sensitivity of the long run macroeconomic effects by comparing the effects derived from this endogenous interest rate framework with the long run effects from our base model discussed in Section 4. The table also compares the two interest rate frameworks under the baseline transition assumption with the 2014 budget deficit to GDP ratio. The results for this baseline transition assumption indicate a long run increase of 13.77% in the domestic interest rate, which is due to reduced net foreign assets (or higher net foreign debt that funds an increasing government debt). However, relative to the small open economy results, Table 7 indicates that net foreign assets increase significantly as the higher interest rate leads to larger domestic assets and lower capital stock. Per capita labour supply is shown to further decline in the endogenous interest rate framework, which is due to work disincentives from the reduced wage rate. Consequently, as both inputs to production fall, the effect on GDP per capita is more negative than in the small open economy. The long run debt amounts to 98.27% of GDP in both economies, and thus the displayed difference for net government debt in Table 7 is zero.[27]

[27] Recall that the net government debt to GDP ratio in the long run is implied by the given deficit to GDP ratio (3.07% of GDP) and by exogenous rates of population growth and technical progress.

Table 7: Sensitivity of long run macroeconomic effects to imperfect capital mobility
(% point differences between long run results with endogenous and exogenous interest rates)

Variable	Baseline transition [a]	Policy instrument to eliminate budget deficit [b]		
		(i) Income tax rates	(ii) Consumption tax rate	(iii) Social transfers
Labour supply	-0.88	1.54	0.99	0.53
Wage rate	-3.39	5.14	4.01	3.61
Capital stock	-8.35	13.93	10.46	8.92
Domestic assets	13.14	-14.26	-12.94	-12.81
Net foreign assets	98.75	-37.20	-33.46	-32.15
Net government debt [c]	0.00	0.00	0.00	0.00
Interest rate	13.77	-17.36	-13.73	-12.39
Output (GDP)	-3.51	5.60	4.12	3.32
- Private consumption	-1.26	3.43	2.42	1.69
Age pension costs	-2.58	2.40	2.70	9.74
Total tax revenue	-0.34	-1.79	-1.76	0.12
- Personal income tax	-1.91	-3.33	2.34	1.45
- Consumption tax	-1.26	3.43	-6.85	1.69
Policy instrument	-2.63	-6.56	-8.60	5.42

Notes: [a] Deficit of 3.07% of GDP kept unchanged with adjustments in public consumption reported under "Policy instrument"; [b] Long run deficit of 0% of GDP with adjustments in (i) income taxation, (ii) consumption tax rate or (iii) social transfers; [c] Deviation in net debt to GDP ratio.

The effects of the examined budget repair measures are positive for most macroeconomic variables relative to those derived from the small open economy model. For example, the long run capital stock, labour supply, GDP and consumption per capita all increase in this imperfect capital mobility framework. These positive effects are due to improved net foreign assets that cause the domestic interest rate to decline. The reduced interest rate increases investment demand and leads to a larger capital stock. The resulting capital deepening then generates a positive effect on the wage rate, which provides further incentives for households to increase their labour supply. Consequently, both labour supply and GDP per capita increase. The reduced interest rate, however, implies a lower rate of return on assets, leading to smaller domestic assets than in our base model. The relative net foreign assets (i.e., difference between the results in endogenous and exogenous interest rate economies) are then shown to decline as more capital inflows are needed to support the increased capital stock.[28] The long run results in Table 7 also indicate a larger tax cut or a larger transfer payment increase resulting from budget deficit and government debt eliminations when the domestic interest rate is endogenous.

[28] Note that in both economies all three budget repair measures lead to increased net foreign assets in the long run. However, the long run improvements are larger in the small open economy. Hence the difference in the long run effects on net foreign assets reported in Table 7 is negative. This is because the reduced government debt has no impact on the domestic interest rate and so it has much smaller impacts on domestic assets and the capital stock than in this modified model with an endogenous interest rate.

5.2 Economic slowdown

Recent economic projections for Australia indicate that the economy could stay in unfavourable macroeconomic conditions for quite a while (International Monetary Fund [IMF], 2015). How would economic slowdown affect key macroeconomic and fiscal variables, including the level of net government debt in the long run? And how would the macroeconomic effects of the examined budget repair measures presented in Section 4 alter in a situation when the economy experiences a slowdown? This subsection aims to provide answers to these questions. Specifically, we consider a scenario in which the economy has a lower annual rate of technical progress set to 1% compared to the technical change of 1.5% assumed in our base model.

Table 8 compares the long run macroeconomic results for the baseline transition (with the 2014 budget deficit of 3.07% of GDP) and the three budget repair measures (with zero budget deficit) generated by the modified model with lower technical progress with those derived from the base model. In our model, altering technical progress rate, g, affects household behaviour through changes in (i) earning ability (labour productivity) profile, e^i_j, and (ii) time endowment, $h^i_{j,t}$. Any reduction in g flattens the earning ability profile, thus reducing the effective wage rate for each quintile over the lifecycle, as well as making younger households relatively less productive than older households.

Table 8: Sensitivity of long run macroeconomic effects to economic slowdown
(% point differences between long run results with technical change of 1% and 1.5%)

Variable	Baseline transition [a]	Policy instrument to eliminate budget deficit [b]		
		(i) Income tax rates	(ii) Consumption tax rate	(iii) Social transfers
Labour supply	-7.01	0.31	-0.09	-0.47
Capital stock	-6.98	0.31	-0.09	-0.47
Domestic assets	8.41	7.65	-0.04	-2.01
Net foreign assets	50.78	48.79	26.96	21.59
Net government debt [c]	19.08	0.00	0.00	0.00
Output (GDP)	-7.00	0.31	-0.09	-0.47
- Private consumption	-2.82	2.33	1.12	0.47
Age pension costs	20.38	-1.76	0.02	7.10
Total tax revenue	-5.31	-3.44	-3.09	-0.35
- Personal income tax	-6.76	-9.44	-0.11	-0.89
- Consumption tax	-2.82	2.33	-10.59	0.47
Policy instrument	-12.72	-11.07	-11.27	5.95

Notes: [a] Deficit of 3.07% of GDP kept unchanged with adjustments in public consumption reported under "Policy instrument"; [b] Long run deficit of 0% of GDP with adjustments in (i) income taxation, (ii) consumption tax rate or (iii) social transfers; [c] Deviation in net debt to GDP ratio.

The "baseline transition" results in Table 8 show significant declines in long run per capita labour supply, capital stock, GDP and consumption due to lower g. Notice that we report

the impact on effective labour supply, which decreases directly due to the reduced labour productivity and indirectly because of the dominating substitution effect on households' hours of work from the reduced labour productivity. Interestingly, the stock of domestic assets is shown to increase compared to our base model. The intuition behind this result is that younger households save more due to lower expected future earnings, generating higher average domestic assets. In retirement, however, total assets are smaller compared to the economy with higher g, resulting in the increased expenditure on the means tested pension.

Economic slowdown modeled through reduced g directly affects net government debt that is found to increase by additional 19 percentage points of GDP relative to the base model simulation of the baseline transition.[29] The reduced tax revenues and increased expenditures on pensions and interest payments require further cuts in government consumption that is assumed to clear the government budget constraint during the baseline transition.

The comparison of the long run effects of eliminating the budget deficit and net debt reveals that these effects vary greatly across the three fiscal measures. Nevertheless, there are two results that are common for each fiscal policy measure. First, the elimination of larger government debt in the economy with reduced growth allows for a more significant tax cut or transfer payment increase in the long run. As a result, positive long run effects on consumption per capita are larger than those obtained from our base model. For instance, Table 8 shows that the additional 5.95 percentage point increase in transfer payments generates a further 0.47 percentage point increase in per capita consumption. Second, the elimination of larger government debt (relative to net debt in the economy with higher g) leads greater improvement in foreign investment position, as indicated by the further increase in net foreign assets. As for the differences in relative macro effects between the two tax measures, the long run reduction in distortive, income tax rates has positive and significant effects on labour supply and especially domestic assets, while the additional long run consumption tax cut leads to insignificant macro effects and the additional long run transfer payment increase reduces per capita labour supply and domestic assets in comparison with the results reported in Section 4.

[29] In the long run steady state, the net government debt to GDP ratio equals to $\text{Deficit\_GDP}/(n+g+ng)$, which with $g = 1\%$, $n = 1.6\%$ and $\text{Deficit\_GDP} = 3.07\%$ implies net government debt of 117.35% of GDP, compared to 98.27% of GDP reported in Section 4.

5.3 Ageing demographic

Similarly to other developed countries, population ageing in Australia is expected to accelerate in the next several decades, reducing population growth and generating a significantly higher proportion of the elderly in the total population. In this subsection, we examine the long run macroeconomic effects of keeping the existing budget deficit to GDP ratio unchanged (as under the baseline transition) and of the three fiscal policy measures (with zero budget deficit) in an ageing environment. Specifically, we set the age-specific survival probabilities, π_j, to those from the medium population projections by Productivity Commission (2013) for year 2050. We then calculate the annual rate of population growth, n, to generate an old-age dependency ratio of 0.40 taken from their projections for 2050. The implied annual population growth rate is about 0.67% - less than half of the growth rate in our base model.

Table 9: Sensitivity of long run macroeconomic effects to ageing demographic
(% point differences between long run results in ageing and non-ageing economies)

Variable	Baseline transition [a]	Policy instrument to eliminate budget deficit [b]		
		(i) Income tax rates	(ii) Consumption tax rate	(iii) Social transfers
Labour supply	-4.57	0.56	-0.19	-1.16
Capital stock	-4.55	0.56	-0.19	-1.16
Domestic assets	34.94	14.66	-0.09	-4.69
Net foreign assets	105.46	172.51	96.14	74.22
Net government debt [c]	43.11	0.00	0.00	0.00
Output (GDP)	-4.56	0.56	-0.19	-1.16
- Private consumption	2.77	5.43	2.49	0.73
Age pension costs	47.05	-4.18	0.06	16.40
Total tax revenue	1.20	-7.51	-6.63	-1.02
- Personal income tax	3.01	-19.43	-0.23	-2.13
- Consumption tax	2.77	5.43	-23.51	0.73
Policy instrument	-12.46	-22.34	-24.69	12.29

Notes: [a] Deficit of 3.07% of GDP kept unchanged with adjustments in public consumption reported under "Policy instrument"; [b] Long run deficit of 0% of GDP with adjustments in (i) income taxation, (ii) consumption tax rate or (iii) social transfers; [c] Deviation in net debt to GDP ratio.

We report the results in Table 9 as the percentage point deviations in selected macro variables in the long run steady states with ageing from those derived from our base model with the current demographic structure. The "baseline transition" results indicate that in an ageing environment, domestic assets increase significantly (due to increased longevity and proportion of older households with large asset holdings) but labour supply and output declines (due to a reduced proportion of the working age population).[30] The decline in the population growth rate implies a higher net government debt to GDP ratio, which increases to over 140% of GDP

[30]For a detailed analysis of the economic effects of demographic transition in Australia see Kudrna *et al.* (2015).

in the long run (43.11 percentage point increase relative to the long run baseline transition result reported in Table 4). The increased interest payment on government debt and especially the increased government expenditure on the age pension require further cuts in public consumption, which is shown to decline by additional 12.46 percentage points to balance the government budget in this ageing economy.

Table 9 also indicates that in the ageing economy, the elimination of the budget deficit and of the greater government debt leads to (*i*) a further (significant) increase in net foreign assets and (*ii*) an additional long run tax (transfer payment) cut (increase), which has positive impact per capita consumption. These long run effects are qualitatively similar to those reported in Table 8 for the reduced economic growth scenario, as are the effects of additional tax cuts (or additional transfer payment increases) on per capita labour supply and domestic assets in this ageing economy.

5.4 Summary of sensitivity results

This section has examined the sensitivity of the long run macroeconomic effects derived from our base model to (*i*) alternative market structure (i.e., imperfect capital mobility with an endogenous interest rate), (*ii*) alternative economic growth (i.e., economic slowdown with a reduced rate of technical change), and (*iii*) alternative demographic structure (i.e., ageing demographic environment with reduced population growth and improved age-specific survival rates). Although we show that these alternative assumptions of the model generate some differences in the magnitude of the long run macroeconomic effects, the general thrust of the examined budget repair measures remain intact (at least in the long run). In other words, the robustness tests undertaken in this section have revealed that the direction of long run macroeconomic impacts of the examined fiscal policy options was largely unaffected.

6 Concluding remarks

In this paper, we have quantified and compared the macroeconomic and welfare effects of the immediate and gradual fiscal consolidation plans funded by either temporary tax hikes or transfer payment cuts in the context of a small open economy. Using a computable, general equilibrium OLG model calibrated to match both the macroeconomic and household lifecycle data in Australia, we find that, while all the examined budget repair options achieve the

same fiscal goal, the macroeconomic and welfare outcomes differ significantly. Specifically, the current generations would not support any fiscal austerity measures because they are worse off by having their transfer payment cut or having to pay higher taxes. Our results suggest interesting outcomes when choosing between temporary transfer payment cuts or tax increases to fund the fiscal consolidation. Cutting transfer payments results in the worst welfare losses for the current generations (especially older and low skill households), but generates the highest welfare gain for the future generations.

Our results carry implications for designing a feasible fiscal consolidation strategy for Australia. Even though the long-run benefits of the budget repair strategies examined in this paper are undeniable, the transitional costs to the economy and welfare are significant and unavoidable. The budget repair measures are indeed challenging policy choices for a better future in Australia. Our results consistently suggest that none of the examined fiscal austerity measures are politically feasible as they will likely fail to gain the political support of current generations. The conflict of interest between the current and future generations suggests political infeasibility for any structural fiscal reforms.

Our dynamic general equilibrium framework with overlapping generations can be applied to study the effects of structural tax reforms proposed by the recent Henry Taxation Review (AFTS, 2010). Notice that, in our paper we abstract from altruistic motives, so that there are no intended bequests and other forms of intergenerational transfers through family line. Introducing this type of intergenerational transfers creates a new channel that links the welfare of current generations to that of future generations, which might affect welfare outcomes and increase political support by current generations for the fiscal consolidation plan. It also needs to be pointed out that our analysis only considers the examined budget repair strategies separately, while the government may implement a combination (mix) of such fiscal policy options designed to ensure that no generation is worse off from the fiscal consolidation. We leave these extensions for future research.

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Appendix A: The solution method

The steady state equilibria (i.e., initial and final steady states) and the transition paths (i.e., baseline and policy paths) of our nonlinear model are computed, using the GAMS software. We apply the Gauss–Seidel iterative method suggested by Auerbach and Kotlikoff (1987), which involves choosing initial values for some endogenous variables and then updating them by iterating between the production, household and government sectors until convergence.

Steady state. The following steps are carried out to solve for our initial steady state equilibrium.

1. Choose initial values for the accidental bequest, b, the government consumption, $\overline{G}$, and the labour input, L.[31]

2. Given L, calculate the market clearing wage rate, w, capital stock, K, output, Y, capital price, q, and investment, I, using the first order necessary conditions derived from the profit maximization problem (3).[32]

3. Given w and b, solve the household optimization problem that involves maximizing lifetime utility (1) subject to budget constraint (2) for each skill type, using Nonlinear Programming with Discontinuous Derivatives (DNLP) solver CONOPT, to obtain household optimal consumption, labour supply and assets profiles.

4. Given these household solutions, update values of b, L and $\overline{G}$, using the bequest allocation rule, the government budget constraint and the labour market clearing condition.

5. The second through fourth steps are iterated until the solutions for b, L and $\overline{G}$ converge.

[31] When we examine the tax hikes or transfer payment cuts to eliminate the 2014 budget deficit, $\overline{G}$ becomes exogenous and we adjust/endogenize the given tax rate or transfer payment to balance the government budget constraint in (7).

[32] The production sector includes the following five equations to solve for Y_t, w_t, q_t, I_t and K_t:

$$\begin{aligned} Y_t &= F(K_t, L_t) - C(I_t, K_t), \\ w_t &= F_L(K_t, L_t)/(1+\nu), \\ q_{t+1} &= 1 + (1-\tau^f)C_I(I_t, K_t), \\ rq_t &= (1-\tau^f)[F_K(K_t, L_t) - C_K(I_t, K_t) + (1-\delta)\Delta q_t - \delta q_t], \\ K_{t+1} &= [(1-\delta)K_t + I_t]/(1+n)(1+g). \end{aligned}$$

Note that in a steady state, the prices and de-trended per capita variables are constant, e.g., $K_{t+1} = K_t = K$. In addition, there are no adjustment costs, and so the price of capital is one ($q = 1$) and the gross investment becomes $I = (n + g + n \cdot g + \delta)K$. This system of non-linear equations is numerically solved in GAMS, using Mixed Complementarity Problem (MCP) solver, PATH.

Transition path. We compute the baseline transition (2009-2150) and several fiscal policy transition paths (2015-2150). In addition to the steps carried out to solve for a steady state, there are the following two important differences that make the computation of the transition path more involved:

1. On the household side, the generations of the five skill classes alive at the time of the policy change must be treated differently from the steady state simulation. Specifically, the transition path program requires the solution of household optimization problems of those households already alive in the first year of the transition (over their remaining life spans) and of all future born generations (over their whole lifecycle). At the time of the policy change, existing generations solve their optimization problems again but over shorter lifetimes given their ordinary private and superannuation assets accumulated prior to the policy change. In case of the baseline transition, the initial distribution of assets (in 2009) is obtained from the initial steady state simulation, whereas in case of each of the fiscal policy transitions, the initial distribution of assets (in 2015) is taken from the baseline transition simulation.

2. On the production side, capital adjustment costs can occur during the transition path. This implies that the capital price, the wage rate as well as the capital-labour ratio can differ from their initial steady state values.

Appendix B: Alternative budget repair measures

The government has a wide range of policy measures to repair its budget. In this appendix, we consider two alternative tax measures: a special levy on labour income (i.e., temporary introduction of a flat payroll tax rate) and a special levy on total assets income (i.e., temporary introduction of a flat capital income tax rate).[33] The effects of these two alternative budget repair measures and the comparison with the effects of the three policy measures examined in Section 4 are presented and discussed below.

Table B1 reports the macroeconomic effects of the two alternative policy measures that are presented for key macroeconomic variables as percentages changes in selected transitional years and in the long run relative the baseline results. As expected, the two budget-equilibrating

[33] Although Australia does not have any payroll tax (paid by workers) and a flat capital income or interest tax, many countries (e.g., Germany) have such taxes, which motivate the present analysis.

tax instruments increase to finance deficit reductions in the short and medium run. The table below shows significant differences both between the two tax hikes as well as between the two consolidation plans within each tax hike. While the special levy on labour income is relatively small (e.g., 9% levy in 2020 under the gradual plan), the capital income levy is significantly higher (37% levy in 2020 under the gradual plan). This difference is due to (*i*) total assets income being smaller than labour income and (*ii*) more distortive nature of the capital income tax (leading to large short run decreases in domestic assets and assets income). Comparing the two consolidation plans, the immediate plan requires a high levy in 2015 (a 10% levy on labour income or a 34% levy on assets income), whereas under the gradual plan, each of these two alternative tax rates is initially modest but increases significantly by 2020. Similarly to the main tax measurers in Section 4, the transitional effects of the two alternative tax measures on net public debt are much the same.

Table B1: Macroeconomic effects of eliminating budget deficit with alternative policy instruments
(Percentage changes in selected detrended variables from baseline results with 2014 budget deficit to GDP ratio)

Variable	(i) Temporary labour income levy						(ii) Temporary capital income levy					
	Immediate elimination			Gradual elimination			Immediate elimination			Gradual elimination		
	2015	2020	LR	2015	2020	LR	2015	2020	LR	2015	2020	LR
Labour supply	-3.59	-2.28	0.03	2.81	-3.41	0.03	-4.14	-1.97	-0.74	-4.34	-2.77	-0.74
Capital stock	0.00	-0.44	0.03	0.00	-0.70	0.03	0.00	-0.08	-0.74	0.00	-0.18	-0.74
Domestic assets	0.00	-4.80	2.34	0.00	0.39	2.34	0.00	-10.51	16.91	0.00	-9.18	16.91
Net foreign assets	5.98	5.19	68.85	3.66	17.21	68.85	3.75	-16.98	94.94	4.94	-20.16	94.94
Government debt [a]	15.10	12.86	0.00	14.48	19.80	0.00	15.16	12.82	0.00	15.18	19.44	0.00
Output (GDP)	-2.40	-1.66	0.03	1.84	-2.50	0.03	-2.77	-1.33	-0.74	-2.90	-1.90	-0.74
- Consumption	-4.96	-4.59	1.76	-2.32	-4.93	1.76	3.03	0.94	1.27	3.20	1.59	1.27
Age pension costs	0.50	0.75	-0.83	0.10	0.64	-0.83	-0.14	1.45	-3.87	-0.10	0.93	-3.87
Total tax revenue	12.96	10.64	-3.73	1.78	12.16	-3.73	12.88	10.73	-1.90	2.28	12.16	-1.90
- Income tax	-15.48	-13.21	3.13	1.85	-14.86	3.13	-2.91	-2.97	1.69	-3.06	-3.55	1.69
- Consumption tax	-4.96	-4.59	1.76	-2.32	-4.93	1.76	3.03	0.94	1.27	3.20	1.59	1.27
Policy instrument [b]	0.10	0.08	-0.02	0.00	0.09	-0.02	0.34	0.33	-0.10	0.09	0.37	-0.10

Notes: [a] Net government debt presented in % of GDP; [b] The fiscal policy instrument to eliminate the 2014 budget deficit is temporary levy on either (i) labour income or (ii) capital (total assets) income.

The effects on effective labour supply, domestic assets, GDP and consumption differ significantly between the two alternative tax measures, as shown in Table B1. While the gradual fiscal consolidation plan with the temporary labour income levy initially increases per capita labour supply (due to the announcement effects already discussed in relation to progressive income tax hikes), the temporary capital income levy has a significantly negative effect on labour supply (4.34% decline in 2015 relative the baseline result). As a result of introducing this capital income levy, households demand not only more leisure and also more consumption, with per capita consumption increasing by 3.2% in 2015. These two adjustments in households' behaviour have a very negative impact on total assets accumulation, resulting in large reductions in domestic assets in the medium run (9.18% decline in 2020 under the gradual plan). Implied

decreases in total assets earnings then require further increases in the capital income levy. The results for net foreign assets also vary greatly between these two fiscal measures. In case of the temporary labour income levy, net foreign assets are positively impacted by gradual reductions in government debt. In contrast, the temporary assets income levy leads to significantly lower net foreign assets in the short and medium run, as increased capital imports replace reduced domestic savings in funding the capital stock.

The welfare effects of the two alternative measures and of the three main measures are displayed in Table B2. These effects are presented for the selected skill type (income quintile) and for average welfare of four selected cohorts. These cohorts include two existing generations (aged 80 and 40 years in 2015) and two future generations (aged 0 and -150). The results for the generation aged -150 in 2015 represent the long run welfare effects.

Table B2: Welfare implications of eliminating budget deficit with different policy instruments

Policy instrument	Age in 2015	Immediate elimination				Gradual elimination			
		Lowest quintile	Third quintile	Highest quintile	Average welfare	Lowest quintile	Third quintile	Highest quintile	Average welfare
Temporary income tax hikes	80	-0.01	-0.06	-0.14	-0.06	0.00	-0.04	-0.07	-0.03
	40	-0.18	-0.85	-2.06	-0.80	-0.19	-0.83	-2.00	-0.78
	0	-0.14	-0.33	-0.64	-0.30	-0.16	-0.36	-0.70	-0.33
	-150	0.18	0.50	1.09	0.47	0.18	0.50	1.09	0.47
Temporary consumption tax hikes	80	-1.69	-1.62	-1.54	-1.63	-1.35	-1.31	-1.26	-1.31
	40	-1.05	-0.93	-0.88	-0.96	-1.01	-0.90	-0.85	-0.93
	0	-0.20	-0.17	-0.15	-0.17	-0.22	-0.19	-0.17	-0.20
	-150	0.54	0.50	0.47	0.51	0.54	0.50	0.47	0.51
Temporary transfer payment cuts	80	-13.33	-6.96	-2.61	-8.49	-10.41	-5.81	-2.41	-6.87
	40	-2.72	-0.95	-0.07	-1.48	-2.56	-0.89	-0.06	-1.39
	0	-0.45	-0.10	0.02	-0.21	-0.51	-0.12	0.02	-0.24
	-150	1.38	0.50	0.02	0.76	1.38	0.50	0.02	0.76
Temporary labour income levy	80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	40	-1.04	-1.23	-1.47	-1.19	-0.96	-1.16	-1.40	-1.12
	0	-0.35	-0.41	-0.44	-0.38	-0.39	-0.46	-0.49	-0.43
	-150	0.46	0.55	0.63	0.53	0.46	0.55	0.63	0.53
Temporary capital income levy	80	-0.09	-0.93	-1.60	-0.77	-0.06	-0.67	-1.18	-0.56
	40	-0.93	-1.63	-2.03	-1.44	-0.94	-1.69	-2.12	-1.48
	0	-0.08	-0.02	0.02	-0.03	-0.10	-0.05	-0.01	-0.06
	-150	0.39	0.70	0.87	0.61	0.39	0.70	0.87	0.61

Notes: Standard equivalent variation measures (in %) for selected quintiles and average welfare relative to baseline transition with the government deficit to GDP ratio kept constant as in 2014; Age -150 in 2015 shows long run welfare effects.

The comparison of the two alternative tax measures in Table B2 indicates that while the labour income levy has no effect on older cohorts (see the impact on those aged 80 years in 2015) as these households already retired from work, the capital income levy results in significant losses for older cohorts (especially under the immediate consolidation plan). Specifically, the cohorts aged 80 years loose, on average, 0.56% (0.77%) of their remaining resources as a result of the capital income levy funding the gradual (immediate) elimination of the 2014 budget deficit. The welfare losses attained by existing generations are greater for higher income quintiles as

they hold larger assets relative to the assets held by lower income types. In the long run, the government debt elimination generates a subsidy (rather than levy) on either labour or capital income. These subsidies produce gains in average welfare and in welfare of more affluent households, with the long run welfare gains being relatively higher in case of capital income (subsidy) adjustments

Table B2 also compares all five budget repair measures in terms of the inter-generational effects (on average welfare across different cohorts) and the intra-generational effects (on welfare of different income quintiles). Starting with the intergenerational effects (see the results for average welfare), the budget repair measure with transfer payment adjustments results in the highest welfare gains in the long run, followed by the capital income tax/subsidy adjustments. The two fiscal measures, however, produce by far the worst welfare losses for the current generations who face welfare cuts and special levy on their capital income. The comparison of the intra-generational effects reveals that while temporary consumption tax hikes and particularly transfer payment cuts hurt especially the poor, the other tax hikes (progressive income tax hikes in particular) generate larger welfare losses for the rich. In the long run, however, the intra-generational effects reverse as the elimination of government debt allows for either tax cuts or special subsidies on labour and capital income or a transfer payment increase.

In sum, these welfare trade-offs between current and future generations, as well as between the rich and poor, highlight key political constraints and point to challenging policy choices for the wellbeing of future generations.