Review of Economic Modelling at The Treasury

Report prepared for the Department of the Treasury
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Glossary of Types of Models

This report refers to various types of empirical, economy-wide models. This glossary aims to provide non-modellers with a general idea of the nature and applications of each type of model.

Model Type	Model Description
Input-output (IO)	An IO model depicts inter-industry relationships within an economy. There are quantity and price versions. In the quantity version, industry production is driven by final demands. In the price version, industry prices are driven by unit costs. Input-output models were originally developed for economic planning. The Treasury's PRISMOD.IO is a price version of an IO model.
Computable General Equilibrium (CGE)	CGE models further develop IO models by modelling optimal economic choices, subject to preferences, technologies and budget constraints. They study the impact of permanent policies like the tax system or barriers to trade. Hence the focus is on long-run equilibrium. Medium-term dynamics associated with adjustments in capital stocks and wealth are optionally included. Treasury uses its version of the Independent Economics CGE model to model the economic impacts of tax policies.
New Keynesian DSGE (DSGE)	DSGE models, like CGE models, focus on economic choices. However, while CGE models emphasise industry detail, DSGE models emphasise the dynamics of the economic cycle. These dynamics are based on optimising behaviour in the face of adjustment costs, with businesses and consumers basing their expectations on the forecasts of the model. DSGE models analyse the effects of macro policies and shocks on the economic cycle.
Overlapping Generations (OLG)	OLG models are a type of CGE model that models each successive generation over the periods of life. Like other CGE models, economic choices are based on optimising behaviour, and any dynamics are likely to be in capital stock adjustment and accumulation of wealth and public debt. Introducing multiple generations is a modelling complication that can be justified for policies affecting the allocation of resources across different generations. Hence OLG models are used to study the effects of retirement incomes policies, government debt policies and demographic change.
New Keynesian macro-econometric (macro-econometric)	Macro-econometric models combine theory and data in an eclectic way. Like DSGE models, they assume that businesses maximise profits, but they treat household saving more simply. Dynamics are based more on empirical analysis than theory, and not all expectations are based on model forecasts. These models are used for forecasting and for analysing the effects of macro policies and shocks.
Vector Autoregression (VAR)	VAR models are data based. In their simplest form, they capture the dynamic interdependencies between multiple macro variables, without using economic theory about how the variables inter-relate. VAR models that are fully data based necessarily involve a small number of variables. VAR models provide short-term forecasts.
Microsimulation	A microsimulation model simulates the effects of an economic change on a sample of many individual households. It assesses how different types of households (as defined by income, stage of life, composition, location) are affected differently by the same economic change. At The Treasury PRISMOD.DIST and CAPITA are used for equity analysis, while MARIA is used to model retirement incomes.
Budget	Fiscal authorities use models to project the government budget. These models usually assume the continuation of existing Government policy. Drawing on economic forecasts, budget projections are influenced by projected growth in tax bases and spending bases (populations of benefit recipients and more intensive users of health, education and other government services). Budget modelling may take into account that policy changes can affect the associated tax or spending base and the economy more generally.

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Chris Murphy
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Synopsis

Introduction

While the Australian Department of the Treasury ("The Treasury") provides economic advice across a wide range of issues, economic modelling is a particularly important tool for the advice provided in the key areas of the macroeconomic outlook and policy, tax policy and the budget. Accordingly, The Treasury aims to have an economic modelling capability that is at best practice for a fiscal authority. To assist in achieving that aim, it commissioned Independent Economics (IE) to undertake a review and recommend areas for further developing The Treasury's economic modelling capability.

This review considers economic modelling capabilities at fiscal authorities in other advanced economies and arrives at an international benchmark for the economic modelling capability of a fiscal authority. It then reviews the existing economic modelling capability of The Treasury. Taking into account both the international benchmark and The Treasury's existing capability, it recommends areas for further developing that capability.

Previous related reviews at The Treasury in 2005, 2012 and 2015 have focussed on The Treasury's forecasting capability. This review has a different emphasis. It focusses specifically on modelling. Further, it considers not only forecasting applications of modelling, but also policy applications.

This report reviews The Treasury's economic modelling capability on a group-by-group basis. Three groups in The Treasury use economy-wide models as tools in their forecasting and policy advice work. Those groups are Macroeconomic Group, Revenue Group and Fiscal Group.

In The Treasury's forecasting process, Macroeconomic Group prepares the core forecasts for the economy. It also prepares the forecasts of the economic parameters used by the other two groups in forecasting the Budget. Revenue Group forecasts the revenue side of the Budget. Fiscal Group works with the Department of Finance in forecasting the expenditure side of the Budget. Fiscal Group also calculates the forecast of the Budget balance from the revenue and expenditure projections and forecasts government debt.

For policy analysis, Macroeconomic Group provides advice on macroeconomic policy. Revenue Group analyses taxation proposals, and provides costings, estimated impacts on the economy, and assessments of equity implications. Fiscal Group analyses intergenerational issues including retirement incomes policies and the effects of population ageing on the budget. It also advises on social policy (education, health and benefit payments).

In The Treasury some models are housed in one Group but the results are used in another Group. Here modelling options are reviewed under the Group that does or could use the model results. This perspective was chosen because it is important that modelling activities are well integrated with each group's advisory responsibilities.

Finally, this review discusses the management issues in implementing its recommendations. This includes the organisation of modelling, the development of modelling skills and resourcing modelling priorities.

Table A
Types, Purposes and Features of Models

Type	Main Purpose for Fiscal Authority	empirical-based economic cycle	theory-based economic cycle	capital & wealth accumulation	long run theory	many industries	heterogenous households	fine budget detail
VAR	macro forecasting							
macro-econometric	macro forecasting & policy							
DSGE	macro policy							
IO	tax policy: price impacts							
CGE	tax policy: price & real impacts							
micro-simulation	tax policy: equity impacts							
Budget	budget forecasting							
OLG	retirement incomes, ageing, public debt							

Table B
Models and Main Recommendations

purpose	fiscal authorities	Treasury now	Treasury then	Recommendations
macro forecasting	1) macro-econometric + judgement 2) VAR	3-phase model + judgement	1) Trsy macro-econometric + judgement 2) VAR	M1-M3
macro policy	1) macro-econometric 2) DSGE	AUS-M	1) Trsy macro-econometric 2) RBA DSGE (Trsy)	M4-M5
tax policy: economic impacts	1. CGE 2. OLG	IE CGE (Treasury)	1. like CGETAX 2. KTW OLG (Trsy)	R1
tax policy: equity impacts	IO or CGE -> micro-simulation	IO -> DIST/CAPITA	like CGETAX -> DIST/CAPITA (SR/LR)	R2-R3
budget forecasting	policy -> economy -> budget <- policy	economy -> budget <- policy	policy -> economy -> budget <- policy	R4,F1-F3
retirement incomes	1. micro-simulation 2. OLG	MARIA	1. MARIA 2. KTW OLG (Trsy)	F4

Modelling at Fiscal Authorities

Fiscal authorities in advanced economies use eight main types of economy-wide models. The nature of each of these models is summarised in the Glossary of Types of Model (see page i). The main purposes and features of each type of model are depicted in a stylised way in Table A. Dark shading is used for features that are generally found in a given type of model whereas light shading is used if a feature is optional for that model type.

This review's main recommendations for model development at The Treasury are summarised in Table B. For each main area of Treasury advice where models are an important tool, it compares the recommended modelling approach ("Treasury then") with Treasury's current approach ("Treasury now") and the international benchmark approach ("fiscal authorities").

The following reviews the use of each of the eight types of models at fiscal authorities in advanced economies. For each model type, the nature of the model is considered along with the applications to which it is most suited and the prevalence of its use at fiscal authorities in advanced economies. Each type of model is discussed under the heading of the Group in The Treasury that could or does use it.

Macroeconomic Group

The Macroeconomic Group in The Treasury provides advice on macroeconomic forecasts and macroeconomic policy. In fiscal authorities in advanced economies, the modelling tools that may be used in providing this type of advice include VAR, DSGE and macro-econometric models. These three types of models are now discussed in turn.

Vector Autoregression (VAR) models

Vector Autoregression (VAR) models are based on data rather than theory. In their simplest form, they capture the dynamic interdependencies between multiple macro variables, without using economic theory about how the variables inter-relate. Instead, traditional VAR models allow everything to affect everything[1]. A price for this flexibility is that these models are necessarily small, unless more assumptions are made.

In essence, VAR models provide an empirically-based representation of the economic cycle, as indicated in Table A. They are most suited to providing short-term forecasts for a small number of key variables. However, fiscal authorities require forecasts over varying horizons for a large number of variables. Consequently, the main role of VAR models at fiscal authorities is in providing a cross-check on part of the main forecasts.

Huntley and Miller (2009a) at the US Congressional Budget Office (CBO) provide a good demonstration of how VAR modelling can play this cross-checking role. They use VAR model forecasts as a benchmark in checking the track record of the CBO's main forecasts. Reassuringly, they find that the main forecasts generally match or outperform the main forecasts for accuracy.

Because VAR models play a cross-checking rather than a central role, having a VAR model is a lower modelling priority for a fiscal authority.

[1] This is with the exception of contemporaneous interactions, where a recursive structure may be imposed for the purpose of making shocks orthogonal to each other.

New Keynesian DSGE (DSGE) models

In contrast to VAR models, New Keynesian Dynamic Stochastic General Equilibrium (DSGE) models are based on economic theory. They are mainly concerned with understanding economic cycles and the influence of macroeconomic policy on those cycles. While several types of models emphasise theory in modelling long run outcomes, DSGE models differ in that they also emphasise theory in modelling economic cycles. This can be seen in Table A.

While DSGE models emphasise theory and Structural VAR models emphasise data, they share a common focus in explaining economic cycles by random shocks. Pagan and Robinson (2016) investigate this relationship between the two types of models.

The heavy reliance of DSGE models on economic theory has divided economists concerning their value. Blanchard (2016) finds that DSGE models provide a useful organising structure for discussing macroeconomics, but have serious practical flaws[2]. This view is reflected in how DSGE models are used. They are commonly used in academia and for scenario analysis, where economic reasoning is paramount. They are less commonly used for forecasting, where empirical accuracy is important.

The earlier DSGE models emphasised monetary policy and so DSGE models are now widely used at central banks. Some more recent DSGE models also analyse the influence of fiscal policy on the economic cycle. In an international collaboration, Coenen et al. (2012) use nine different DSGE models to analyse the economic impact of the fiscal stimulus applied around the world in response to the GFC. However, none of the nine DSGE models came from fiscal authorities, where the take-up of DSGE modelling has been more gradual than at monetary authorities or in academia.

At fiscal authorities in the US, UK, Canada, Singapore and New Zealand, DSGE models are either absent, or take a back seat to macro-econometric models. This may reflect the priority given to forecasting, the availability of macro-econometric models as a tool for macro policy analysis, the more recent introduction of fiscal policy to DSGE models or some combination of these factors.

DSGE models, although a higher priority in academia and for monetary authorities, are a lower priority for fiscal authorities.

New Keynesian macro-econometric (macro-econometric) models

Macro-econometric models combine theory and data in an eclectic way. This places them between the data-based VAR models and the theory-based DSGE models. Like DSGE models, macro-econometric models emphasise economic theory in modelling long run outcomes. However, they emphasise empirical analysis in modelling the dynamics of the economic cycle. This can be seen in Table A.

This eclectic approach reflects a balancing act between the two applications of macro-econometric models of macro forecasting and macro policy analysis. The dynamics are data-based to give the strong short-term empirics that are needed for short-term forecasting. The theoretically-based long-run modelling helps provide plausible long-term forecasts and sound macro policy analysis.

Macro-econometric models typically play a major role at fiscal authorities.

- In the US, the CBO (2014) uses simplified versions of three macro-econometric models in estimating demand multipliers.

[2] I would like to thank Adrian Pagan for drawing my attention to this recent article by Blanchard.

- In the UK, the Office for Budget Responsibility (2013) uses a macro-econometric model originally developed by the UK Treasury as a tool in preparing its 5-year forecasts.
- The Department of Finance Canada used its CEFM model to quantify the impacts of Canada's fiscal stimulus instituted in response to the GFC (Conference Board of Canada, 2010).
- In New Zealand, a macro-econometric model occupies the central position in the New Zealand Treasury forecasting process (Ulf D. Schoefisch Economic Consulting, 2007).

In fiscal authorities of advanced economies, macro-econometric models play a substantial role in both macro forecasting and policy analysis, making them a higher modelling priority.

Revenue Group

The Revenue Group in The Treasury provides advice on tax policy. In fiscal authorities in advanced economies, the modelling tools that may be used in providing tax policy advice include IO, CGE and microsimulation models. These three types of models are now discussed in turn.

Input-output (IO) models

An IO model depicts inter-industry relationships within an economy, as indicated in Table A. The price version of an IO model can be used to estimate how changes to indirect taxes affect consumer prices.

For example, at the Office of Tax Analysis at the US Treasury, Horowitz et al. (2017) use such a model to simulate the impact on consumer prices of a US tax on CO2 emissions imposed in 2019 at $49 per tonne. The modelling estimated the price impact for 33 categories of household consumption. Double-digit price rises were 27 per cent for natural gas, 17 per cent for electricity and 12 per cent for gasoline, with the overall increase in consumer prices estimated at 2.6 per cent.

However, input-output models do not allow for behavioural responses, including to price changes. They also ignore long run constraints on the economy, including the budget constraints faced by governments and households and the constraint on labour supply imposed by population. CGE models overcome these problems.

In the fiscal authorities of advanced economies, IO pricing models may be used to estimate the consumer price impacts of changes in indirect taxes if a CGE model is not available.

Computable General Equilibrium (CGE) models

CGE models, like IO models, often distinguish many industries. However, they overcome the above-mentioned problems with IO models by modelling economic choices, and do so taking into account consumer preferences, production technologies, and the constraints imposed by population and budgets.

They share this focus on long run theory with DSGE models, as indicated in Table A. However, DSGE models focus on macro policies and business cycles, whereas CGE models focus on structural policies (such as tax reform) and more elaborated longer run economic responses.

CGE models have been used to analyse the economic efficiency of taxes since the seminal work for the USA by Ballard, Shoven and Whalley (1985). There results show the economic gains that can be made by shifting the tax mix away from more inefficient taxes towards less inefficient taxes.

Some CGE model-based studies of tax reform focus only on long-term effects (e.g. Sørensen, 2014). However, as shown in Table A, CGE models optionally include dynamics that trace the adjustment of capital stocks and wealth accumulation on a year-by-year basis. This is the case in the following tax reform studies conducted at fiscal authorities.

- The Department of Finance Canada (Baylor and Beauséjour, 2004) used a CGE model to estimate economic impacts of corporate, personal income, payroll, consumption and investment taxes.
- In the UK, HM Revenue and Customs and HM Treasury (2013) used HMRC's CGE model to simulate the reduction in the UK corporate tax rate from 28 to 20 per cent.
- In the US, the CBO has used five different types of models, including a CGE model (Foertsch, 2004) to simulate a personal income tax cut (Dennis et al., 2004).

In the fiscal authorities of advanced economies, CGE models are used to simulate the economic impacts of tax reform. This makes them a higher modelling priority.

Household Microsimulation models

A microsimulation model simulates the effects of an economic change on a sample of many individual households. The results are used to assess how different types of households (as defined by income, stage of life, composition, location) are affected differently by the same economic change. In particular, they can be used to assess the distributional effects of tax reform, complementing the assessment of the economic effects provided by CGE models. Table A indicates the emphasis on households.

The two main issues in using microsimulation models are how the economic incidence of taxes on households is assessed and whether equity is measured using current or lifetime incomes.

Microsimulation models are sometimes run in standalone mode. In that case a separate assessment needs to be made about the economic incidence of each tax on households, which can restrict the range of taxes that can be considered. The well-known EUROMOD microsimulation model (Sutherland and Figari, 2013) is generally simulated in that way to assess the equity impacts of changes in personal income tax and government benefit payments.

Linking a microsimulation model to a pricing input-output model means that the equity impacts of changes in indirect taxes can also be assessed. In the US Treasury study of a CO2 emissions tax referred to previously (Horowitz et al., 2017), this approach was taken i.e. a pricing input-output model was linked to the Treasury Distribution Model (TDM).

To cover all taxes and to assess economic incidence in a conventional way, microsimulation models are linked to CGE models. Since 1999 many studies have done this (Colombo, 2010). For example, Vandyck (2013) links the Belgium version of EUROMOD to a CGE model to simulate changes to Belgium oil excises. Linking provides some consistency in the estimates of the economic and equity impacts of tax reform and alternative methods of linking are available (Cockburn et al., 2015)[3].

While traditional studies assess equity according to impacts on *current* real incomes, recent microsimulation studies emphasise the importance of impacts on *lifetime* real incomes (Auerbach et al.,

[3] I would like to thank Robert Ewing and Susie Kluth of the Tax Analysis Division in The Treasury for drawing my attention to this study.

2016; Levell et al., 2016)[4]. They show that effects on lifetime incomes can be very different from effects on current incomes, suggesting that microsimulation models should be extended to cover both.

Fiscal Group

The Fiscal Group in The Treasury prepares fiscal projections and provides advice on intergenerational issues such as retirement incomes policy. At fiscal authorities in advanced economies, budget projection models and OLG models may be used as tools in providing advice in the two respective areas. These two types of models are now discussed in turn.

Budget models and forecasting

Fiscal authorities use budget models to project the Government Budget. These models usually assume the continuation of existing Government fiscal policy. The Budget projections are influenced by projected growth in tax bases and spending bases (populations of benefit recipients and more intensive users of health, education and other government services). Budget models may take into account that policy changes can affect the associated tax or spending base and the economy more generally. As indicated in Table A, budget models emphasise fiscal detail.

Fiscal forecasting is reviewed by Leal et al. (2007) who identify five main issues.

- In deciding where to produce the fiscal projections, there is the trade-off between access to the inside knowledge of a fiscal authority versus the independence of an independent agency.
- Usually economic forecasts are produced first and then used as an input into producing fiscal forecasts, but this ignores feedback effects of fiscal policy on the economy unless there is iteration between the two types of forecasts.
- Fiscal authorities typically base their fiscal forecasts on current government policy, but this can involve judgement and guesswork when policies are not well specified.
- Fiscal forecasts with long-term horizons are usually based on simple economic projections and therefore do not take into account the implications of population ageing for investment and saving rates, but this could be addressed if more sophisticated economic projections were used.
- Fiscal authorities are generally required to produce highly detailed budget projections for public accountability, but it is difficult to ensure that these are consistent with the economic forecasts so top-down consistency checks should be performed.

Overlapping Generations (OLG) models

OLG models are a type of CGE model that models each successive generation over the periods of life. Like other CGE models, economic choices are based on optimising behaviour, and any dynamics (beyond population ageing) are likely to be in capital stock adjustment and the accumulation of household wealth and government debt. Table A indicates that OLG models draw on long run economic theory and that households are heterogeneous (because of the inclusion of multiple generations).

Introducing multiple generations is a modelling complication that can be justified for policies affecting the allocation of resources across different generations. Specifically, OLG models can be used to model

[4] I would like to thank Graeme Davis of the Tax Framework Division in The Treasury for drawing my attention to these studies.

the effects of government policies concerning retirement incomes and the level of government debt on the economy and the government budget. Further, they can be used to analyse the effects of demographic change, including population ageing.

Because of their focus on life cycles and neglect of economic cycles, OLG models are generally used for scenario analysis rather than forecasting. Nishiyama (2013) illustrates the uses of an OLG model in a US CBO working paper. He does not present his baseline forecast but rather simulates alternative scenarios involving intergenerational issues and reports the ensuing deviations from baseline.

In summary, OLG models are mainly used at fiscal authorities for scenario analysis of intergenerational issues in research reports. This makes an OLG model a medium modelling priority for a fiscal authority.

Previous Reviews

The Australian Public Service Commission (2013), in reviewing The Treasury's overall capability, made a general assessment that "Treasury's modelling capability is among the best in the country". This is undoubtedly true. This review assesses The Treasury's modelling capability in greater detail and against the international benchmark for fiscal authorities in advanced economies.

The 2012 Treasury forecasting review noted that the Treasury ceased using a macro-econometric model as a forecasting tool in 2010 when it decided that the TRYM model required a major redesign. The 2012 review recommended that "it is important to embed the redeveloped TRYM model into the economic forecasting process" (Australian Government, 2012a). In practice The Treasury subscribed to AUS-M rather than draw upon a redeveloped TRYM model. AUS-M has been used for scenario analysis, but has not been embedded in the forecasting process. The forecasting process uses a 3-phase approach, with an upgraded national accounting framework (NAFF) in the first phase of two years.

The 2015 forecasting review endorsed the 2012 recommendation to embed a macro-econometric model in the forecasting process. The Treasury subsequently decided to develop a new model.

The Reserve Bank of Australia (RBA) uses a short-term forecasting framework that is similar to The Treasury's upgraded NAFF. The 2014 RBA forecasting review conducted by Pagan and Wilcox (2015) recommended that the RBA develop a macro-econometric model for forecasting, using the RBA's upgraded NAFF as a starting point. The RBA accepted this recommendation (Kent, 2016) and a dedicated team of five macroeconomic modellers is developing the RBA's new macro-econometric forecasting model. This is in addition to its 2-person team who maintain the RBA's existing DSGE model, which is designed primarily for analysing monetary policy and the economic cycle.

Macroeconomic Group

The Macroeconomic Group provides advice on macroeconomic forecasts and macroeconomic policy. As discussed under "modelling at fiscal authorities", in advanced economies the modelling tools that may be used in providing this type of advice include VAR, DSGE and macro-econometric models.

The Treasury uses its upgraded NAFF for preparing its short-term forecasts, as part of a 3-phase approach that extends the forecasting horizon to 40 years. It also has access to a subscription macro-econometric model, AUS-M, for macroeconomic policy analysis.

The Treasury has plans to replace and upgrade these modelling arrangements. These plans include developing a new macro-econometric model, and developing its own version of the RBA DSGE model, referred to here as RBA DSGE (Treasury).

This review considers these current modelling practices and plans in the context of the functions of Macroeconomic Group. The modelling approach to macro forecasting is reviewed first, followed by the modelling approach to macro policy analysis.

Macroeconomic forecasting

The 3-phase approach to forecasting currently used at The Treasury is depicted in Figure A. This involves a 2-year short-term forecast, a 5-year cyclical adjustment phase, and a long-term projection based on potential GDP. These three phases are as follows.

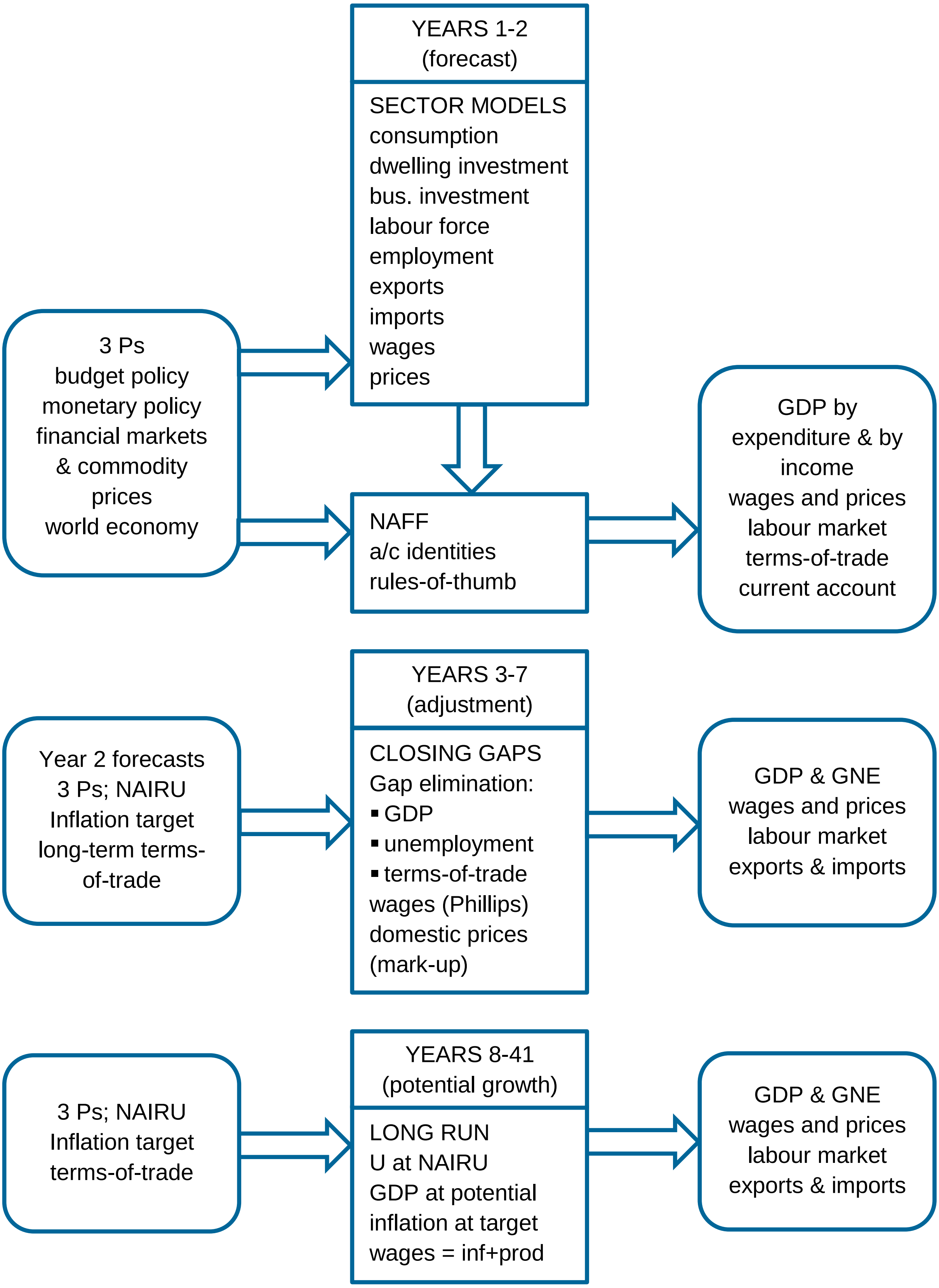
The "forecast" phase, shown in the top of Figure A, extends over the first two years, and uses the upgraded National Accounting Forecasting Framework (NAFF). This combines the traditional national accounting and other identities of the NAFF with around a dozen individual regression equations for forecasting key macro-economic variables. This resembles a macro-econometric model except the individual behavioural equations are separate from each and the accounting identities. In fact, the upgraded NAFF could be described as the precursor to a macro-econometric model. In the forecasting process, besides the NAFF, judgements based upon insights from sectoral experts, partial data, forecasting cross-checks, an understanding of international and financial markets, insights of experienced senior staff and outside liaison are also important.

The forecast phase is followed by an adjustment phase and a potential growth phase. The later phase extends from year eight to year 41, taking it to the end of the horizon of the Intergenerational Report (IGR). This potential growth phase is represented in the bottom panel of Figure A. Potential GDP is projected from the labour supply using the "3Ps" of population, participation and productivity. The short-term and long-term projections are knitted together over a 5-year period of "cyclical adjustment", extending from years three to seven, in which the labour market becomes balanced.

Further details of the 3-phase approach are provided in Bullen et al. (2014). This 3-phase approach can be contrasted with using a macro-econometric model to generate forecasts. As set out in the review of modelling at fiscal authorities, macro-econometric models are widely used at fiscal authorities in advanced economies for generating forecasts.

For forecasting over multiple horizons, macro-econometric models aim to combine strong short-term empirics with well-defined long-term economic properties. They take into account a wide range of imbalances in the economy, not just labour market imbalance. The model uses empirical evidence gained from econometric analysis of past data to model how imbalances are resolved.

Figure A
Macroeconomic Forecasts/Projections Over Different Time Horizons (current approach)



In the case of The Treasury, a macro-econometric model has the following specific advantages compared to the existing 3-phase forecasting approach.

1. Labour market adjustment is based on historical evidence gained from econometric analysis rather than a mechanical assumption.
2. Other imbalances are also taken into account including imbalances in goods markets, business and housing capital stocks, private saving and net assets, and government deficits and debt. By modelling how such imbalances have been resolved historically, a macro-econometric model is more likely to anticipate future swings in the economy.
3. A macro-econometric model can be readily used to draw out key uncertainties in the economic outlook by simulating alternative scenarios.
4. A macro-econometric model can be used for macro-economic policy analysis.
5. A macro-econometric model would be a more effective tool in developing the macroeconomic advisory skills of Treasury officers than the existing simple 3-phase approach.

Thus, this review endorses the recommendation of the 2015 Forecasting Review that an economy-wide forecasting model should be developed and embedded in the wider forecasting process.

The macro-econometric model approach to forecasting is depicted stylistically in Figure B, which can be compared with the existing 3-phase approach shown in Figure A. The forecast is now no longer artificially divided into three phases, the cyclical adjustment takes account of a much wider range of potential imbalances in the economy and the modelling of long run equilibrium is more comprehensive.

Other non-model information should be taken into account by making judgemental adjustments to the model forecasts. This non-model information might include the predictions of other types of models (such as VAR models), expectations surveys, the views of experienced senior staff, and information gained from business liaison. Forecasts from macro-econometric models are readily and routinely adjusted to take into account such information through so-called residual adjustments.

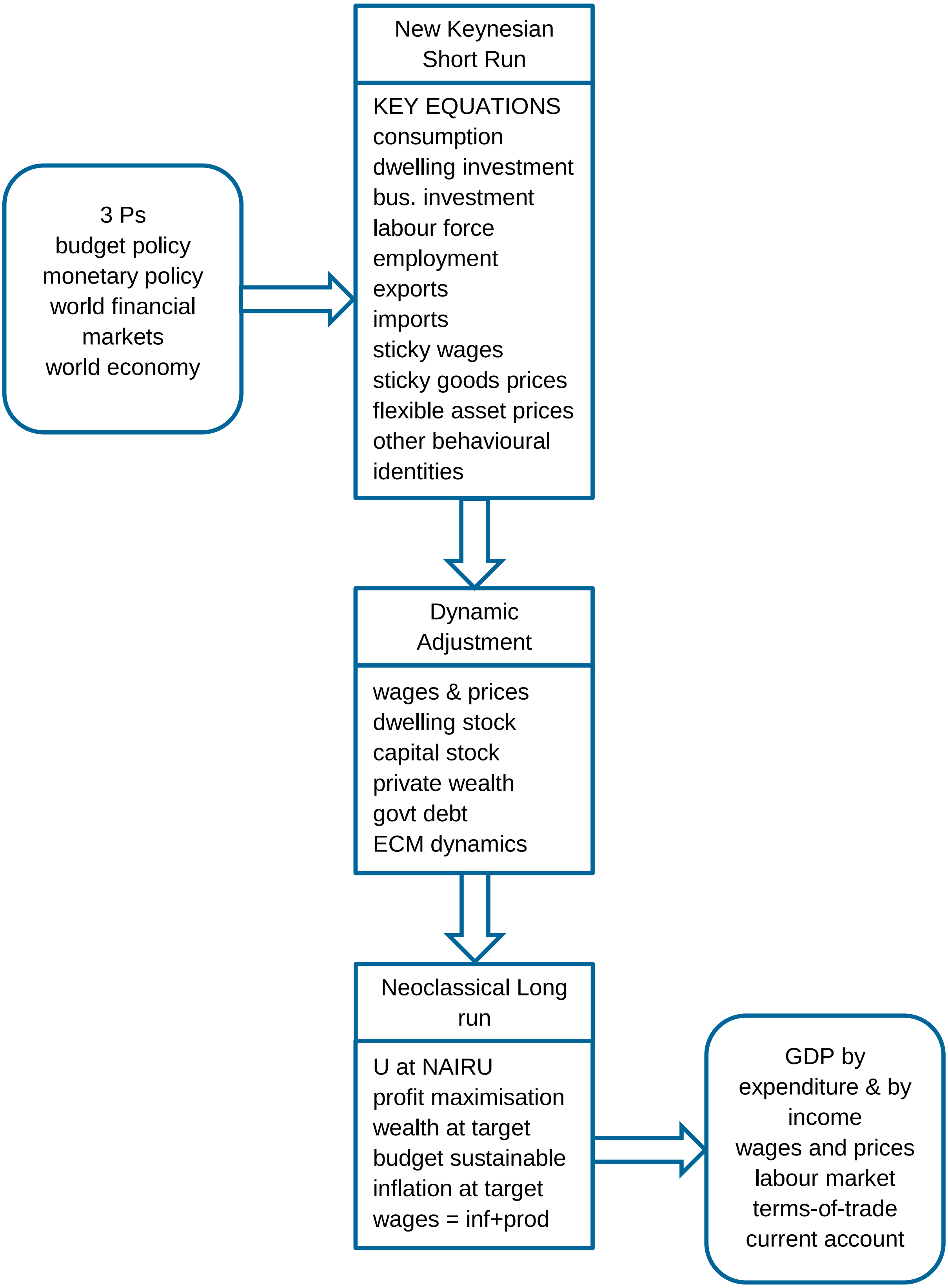
As discussed under "modelling at fiscal authorities", VAR models can play a useful role in cross-checking the key short-term forecasts from a macro-econometric model. This cross-check can be applied both in assessing the forecasting track record of a fiscal authority, as well as in each forecasting round. This review recommends that The Treasury consider using a VAR model for this purpose. It could either use an existing VAR model or develop its own using the latest data.

Macroeconomic policy analysis

Following the retirement of the TRYM model, in recent years The Treasury has not been active in publishing its own model-based analyses of macro policy. For example, The Treasury drew on other types of research in estimating the macroeconomic effects of the fiscal stimulus that was applied in response to the GFC.

This situation may soon change. The Treasury has decided to develop a new macro-econometric model. In addition, The Treasury is working on its own version of the RBA DSGE model, referred to here as RBA DSGE (Treasury). Hence, The Treasury may soon have a choice between two different models for analysing macroeconomic policy.

Figure B
New Macroeconomic Model (recommended approach)



The quarterly RBA DSGE model (Rees et al., 2016) "is intended primarily for use in scenario analysis rather than as a forecasting tool". Hence it is included in this discussion of models and macro policy analysis and was not included in the preceding discussion of models and macro forecasting.

The key innovation of the RBA's New Keynesian DSGE model is that it distinguishes three sectors – a non-tradeable sector, a resources sector and a non-resources tradeable sector. This is so the RBA model can be used to analyse the effects in Australia of shocks to resource prices. RBA DSGE seems generally well suited to the RBA's scenario analysis purposes. Nevertheless, three improvements are proposed in the body of this report.

The RBA is already using its model to analyse monetary policy and the economic cycle. Further development work is required (by the RBA or The Treasury) to use the model to analyse fiscal policy and the economic cycle in the way done by Coenen et al. (2012).

- Introducing multiple categories of government spending.
- Distinguishing some distortionary taxes such as consumption taxes, labour income taxes, and capital income taxes.
- Introducing government deficits and debt and a fiscal rule in which either a labour income tax or a lump sum tax is used to achieve fiscal sustainability by targeting the government deficit or debt.

Informal advice from The Treasury suggests that it may not use the RBA DSGE (Treasury) model to undertake counter-cyclical analysis. Such analysis would be the main reason for The Treasury to be involved in DSGE modelling. Hence, it would be prudent for The Treasury to carefully consider the objectives of this DSGE project before proceeding further.

The Treasury also has the option of building a capability for macro policy analysis into the new macro-econometric model that it is already committed to developing for forecasting purposes. The type of macro-econometric model that The Treasury needs for forecasting is also likely to be readily adaptable to macro policy analysis. The Treasury needs a macro-econometric model with strong short-term empirics and well-defined long-term economic properties because, in different contexts, its forecasting horizon varies from two years to 41 years. This same combination of short-term and long-term strength is also needed when using a macro-econometric model for macro policy analysis.

A simple form of macroeconomic policy analysis is to simulate alternative scenarios for macroeconomic policy. A more sophisticated form is to undertake optimal control. One form of optimal control finds the optimal response of macroeconomic policy to different types of shocks. The other form finds the optimal current stance for monetary and fiscal policy although Pagan (1997) notes this "open loop" use of optimal control is subject to the qualification of potential time inconsistency.

Perhaps the highest profile use of open loop optimal control at present is by the US Federal Reserve. Recent examples are Brayton, Laubach and Reifschneider (2014) and Reifschneider (2016). Both papers use the Fed's macro-econometric model, the FRB/US model (Brayton and Tinsley, 1996).

The main body of this report discusses the broad design parameters for the new macro-econometric model. Some issues that The Treasury would need to consider are as follows:

- the extent to which budget economic parameters should be included in the core model or satellite models;

- the extent to which model consistent expectations should be assumed;
- the degree of industry detail;
- whether the sources of long-term economic growth should be wholly exogenous or partly explained within the model; and
- the degree of household sophistication assumed in modelling household saving behaviour.

Recommendations

Macroeconomic Group – Recommendation 1 (macro forecasting model) – higher priority

Prior to this review, The Treasury decided it would develop a new economy-wide forecasting model. This review recommends that the new model be a macro-econometric model, combining strong short-term empirics with well-defined long-run properties. This is necessary so that the model can be used over the greatly varying time horizons (from two to 41 years) required in The Treasury's forecasting/projections work. The new model should use the existing 3-phase forecasting approach as its starting point so the value of the research used to develop it is preserved and to make it easier for Treasury forecasters to learn the new model.

Macroeconomic Group – Recommendation 2 (macro forecasting judgement) – higher priority

Judgemental adjustments should be applied to the forecasts from the macro-econometric model, especially in the first year or two of the forecast period, to allow for information not already taken into account in the model. This information may include forecasts from other models, insights from sectoral experts, partial data, expectations surveys, the views of experienced senior Treasury staff and intelligence from business liaison. However, this information should be critically assessed. This approach is consistent with research that shows that judgemental adjustments of model-based forecasts tend to improve their accuracy but are overdone.

Macroeconomic Group – Recommendation 3 (macro forecasting cross-check) – lower priority

The Treasury should consider adopting or developing a Vector Autoregression (VAR) model to use as a cross-check on the key short-term forecasts. This cross-check can be applied both in assessing The Treasury's forecasting track record, as well as in each forecasting round.

Macroeconomic Group – Recommendation 4 (primary analysis of macro policy) – medium priority

The Treasury should consider using the new macro-econometric model as its primary model for macroeconomic policy analysis. Such models have significant government budget detail, strong short-term empirics and recognise that consumer spending depends partly on current income, while allowing for the long term constraints on the economy. All of these features are needed so that realistic short and long term policy responses are generated.

Macroeconomic Group – Recommendation 5 (alternative analysis of macro policy) – lower priority

The Treasury should consider adding more fiscal structure to its version of the Reserve Bank's DSGE model so that it can use it as an alternative tool for macroeconomic policy analysis.

Revenue Group

The Revenue Group in The Treasury provides advice on tax policy proposals, including estimates of economic and distributional impacts. As discussed under "modelling at fiscal authorities", the modelling tools that may be used in providing this type of advice include IO, CGE and microsimulation models.

The Treasury broadly follows this international practice. For assessing the economic impacts of tax policy proposals it uses the IE CGE (Treasury) model as its CGE model. For the equity impacts it uses a pricing IO model known as PRISMOD.IO linked to its household microsimulation models known as PRISMOD.DIST and CAPITA. The PRISMOD models only come into play for indirect tax changes.

The Treasury also has plans to develop a Treasury version of the Overlapping Generations (OLG) model of Kudrna, Tran and Woodland (2015). As foreshadowed under "modelling at fiscal authorities", fiscal authorities in advanced economies mainly use OLG models in areas that are covered by Fiscal Group, but The Treasury is also considering using KTW OLG (Treasury) in Revenue Group and that idea is considered here.

This review considers these current modelling practices and plans in the context of the functions of Revenue Group. The modelling approach to estimating the economic impacts of tax proposals is reviewed first. The current use of IE CGE (Treasury) model is discussed first, followed by the planned use of the KTW OLG (Treasury) model. Next, The Treasury's use of microsimulation models to estimate equity effects is reviewed. Finally, other uses of modelling in Revenue Group are discussed.

Economic effects of tax policy with CGE models

CGE models study the impact of permanent policies like the tax system and so the main focus is on long-run outcomes. Medium-term dynamics associated with adjustments in capital stocks and wealth are optionally included. Fiscal authorities in the US, UK and Canada have all used CGE models to simulate the economic effects of tax reform proposals.

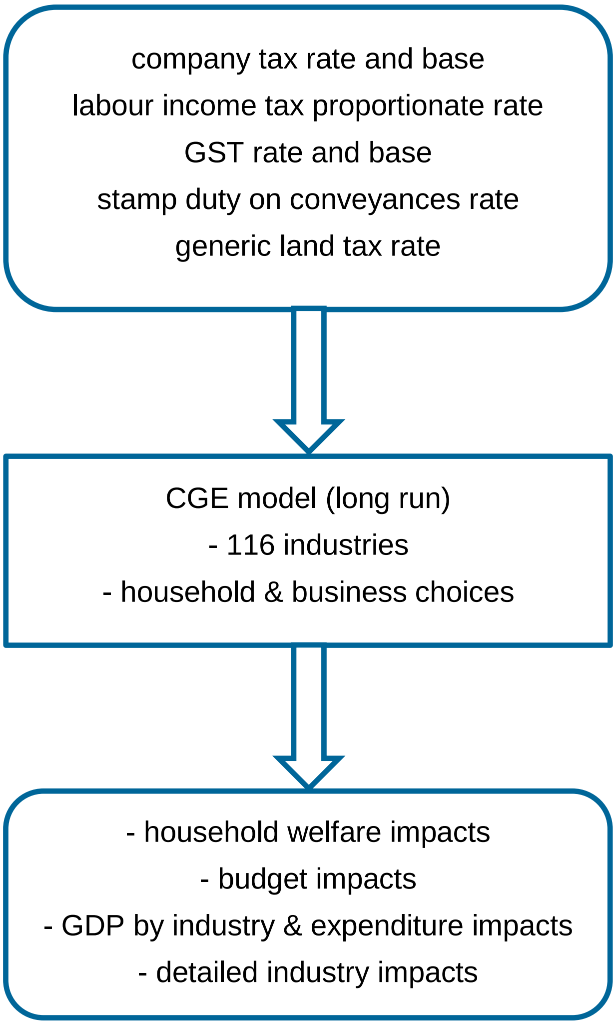
The Treasury has followed a similar approach in several reviews, including the Australia's Future Tax System Review ("Henry Tax Review"), the Business Tax Working Group (BTWG) and the recent Tax Review. The author of this report was involved in all three of these CGE modelling exercises.

In the Tax Review, The Treasury prepared two economic modelling reports. Cao et al. (2015) modelled the economic efficiency of five major taxes, and Kouparitsas et al. (2016) modelled the economic impacts of the proposed cut in the company tax rate from 30 to 25 per cent. The Treasury version of the Independent Economics CGE model was used in this work. This IE CGE (Treasury) modelling is depicted in Figure C.

The IE CGE model is well suited to modelling changes to company tax. It includes detailed modelling of the company tax system including the dividend imputation system, and behavioural responses to company tax including investment disincentive effects and profit shifting by MNCs.

For the Tax Review, The Treasury also commissioned Independent Economics to use its CGETAX model to prepare two economic modelling reports with similar scope to the two Treasury reports. Versions of these two Independent Economics studies have subsequently appeared as ANU Working Papers (Murphy (2016a) and Murphy (2016b)). CGETAX is a further development of the original IE CGE model. Like the original model, CGETAX is well suited to modelling the effects of changes to company tax, as it models company tax in a similar way.

Figure C
IE CGE (Treasury) Model of Long-run Effects of Taxes on the Economy (current approach)



Compared to IE CGE, CGETAX is better able to model changes to personal income tax because it allows for the progressive nature of the personal income tax system and the saving disincentive effect from taxing asset income. Further, CGETAX includes extensions that allow it to model the economic effects of seven other categories of taxes, namely, payroll tax, taxes on alcoholic beverages, cigarette tax, gambling taxes, import duties, insurance taxes and mining taxes.

CGETAX has also been updated to use a more recent ABS input-output table (2012-13 vs 2007-08). Finally, it allows for imperfect competition in some industries via mark-up pricing.

Based on the above further developments, The Treasury may wish to upgrade from its version of the IE CGE model to CGETAX[5].

At the same time, CGETAX could be further developed to further enhance its usefulness for tax policy and other public economics analysis. The number of industries could be slimmed down and the following two features found in the HMRC CGE model of the UK could be added.

- Annual dynamics could be introduced through capital stock adjustment and household wealth accumulation, so that an annual time path is traced towards the long run equilibrium outcome.
- The representative household could be replaced with 50 types of households, distinguished by 10 income levels and 5 household compositions. This would allow for differences in behavioural responses between different types of households and a basic analysis of equity effects.

With these developments, CGETAX would be more highly-featured than CGE models used in other advanced economies for tax policy analysis, including the US, UK and Canada. CGETAX already covers a wider range of taxes and incorporates a fuller set of behavioural responses to those taxes.

Economic effects of tax policy with OLG models

While The Treasury already has access to a CGE model (IE CGE or CGETAX) to estimate the economic impacts of tax policy proposals, it is considering further developing the Overlapping Generations (OLG) model of Kudrna, Tran and Woodland (2015) for the same purpose. The idea of using KTW OLG (Treasury) for analysing the economic effects of tax policy proposals is reviewed here.

As discussed under "modelling at fiscal authorities", OLG models include multiple generations of households to study policies affecting the allocation of resources across different generations. Fiscal authorities in advanced economies use OLG models to study the effects of retirement incomes policies, government debt policies and demographic change. This same emphasis is seen in the six journal articles that KTW have published using their model. Such intergenerational issues are largely the responsibility of Fiscal Group.

Simpler CGE models are preferred to OLG models when modelling tax policies that have less effect on intergenerational equity. In these Ramsey CGE models, there can be a single representative household, or multiple households that may be distinguished by household composition and/or income-earning capacity. Leading examples of Ramsey CGE models at fiscal authorities are the HMRC CGE in the UK and the Department of Finance Canada CGE model. CGETAX is also a Ramsey CGE model. The greater simplicity of Ramsey CGE models compared to OLG models leaves more room to include other

[5] The IE CGE and CGETAX models were developed by Independent Economics. To address the potential conflict of interest in this recommendation, the upgrade from IE CGE to CGETAX is being offered for free.

features useful for tax policy analysis such as fine fiscal detail and associated behavioural responses and the industry detail needed to meaningfully model more narrowly-based taxes.

With its 80 generations of households, KTW OLG only includes three categories of taxes and those taxes are modelled relatively simply. While there would be scope to further develop it, there is a limit to the extent that it would be prudent to add further complexity interacting with the 80 generations.

Overall, KTW OLG (Treasury) has more potential to contribute to the work of Fiscal Group than to the work of Revenue Group.

Equity impacts of tax policy

Microsimulation models are commonly used to estimate the equity or distributional effects of tax policy proposals. The Revenue Group uses microsimulation models to simulate how changes in tax and benefit rates affect the disposable incomes and cost of living of different types of households. This modelling uses unit record data of incomes and expenditures from surveys of thousands of individual households. This modelling approach is depicted in Figure D.

A pricing IO model known as PRISMOD.IO models the effects of changes to GST and other indirect taxes on industry prices to consumers. These price effects are mapped to consumer categories of spending and PRISMOD.DIST, a microsimulation model, simulates the resulting changes in the cost of living for different types of households. Thus, the PRISMOD models only come into play for indirect tax changes. CAPITA, the main microsimulation model, simulates the effects of changes to personal income taxes and benefits on the nominal incomes of different types of households. Combining the results from the two microsimulation models enables a comparison of the effects on real incomes for different household types. Potential household labour supply responses to tax changes are simulated in CAPITA-B.

This type of equity analysis is similar to approaches used elsewhere. Examples are the EUROMOD project (Sutherland and Figari, 2013) and a recent US Treasury study (Horowitz et al., 2017).

At the same time, there is room for improvement to take into account modelling critiques. The Treasury could consider the merit and feasibility of the following potential improvements.

- The CGE modelling of the economic effects of tax policy could be linked to the microsimulation modelling of the equity effects to achieve greater consistency.
- Labour supply responses normally depend on real changes, so in modelling them in CAPITA-B the nominal effects from CAPITA should be adjusted for the price effects from PRISMOD.DIST.
- If feasible, CAPITA should be extended so that it shows impacts not only on current incomes but also lifetime incomes. The CGE model would be run in a short run mode for the current income modelling and a long run mode for the lifetime income modelling.

This recommended approach is depicted in Figure E, which can be compared with the current approach depicted in Figure D.

Revenue Group also uses microsimulation models for costing tax policy proposals.

Other revenue modelling

Besides the equity modelling depicted in Figure D, Revenue Group also undertakes a wide range of other revenue-related modelling. This other modelling is concerned with forecasting, costings and

Figure D
Microsimulation Modelling of Effects of Taxes and Benefits on Household Equity (current approach)

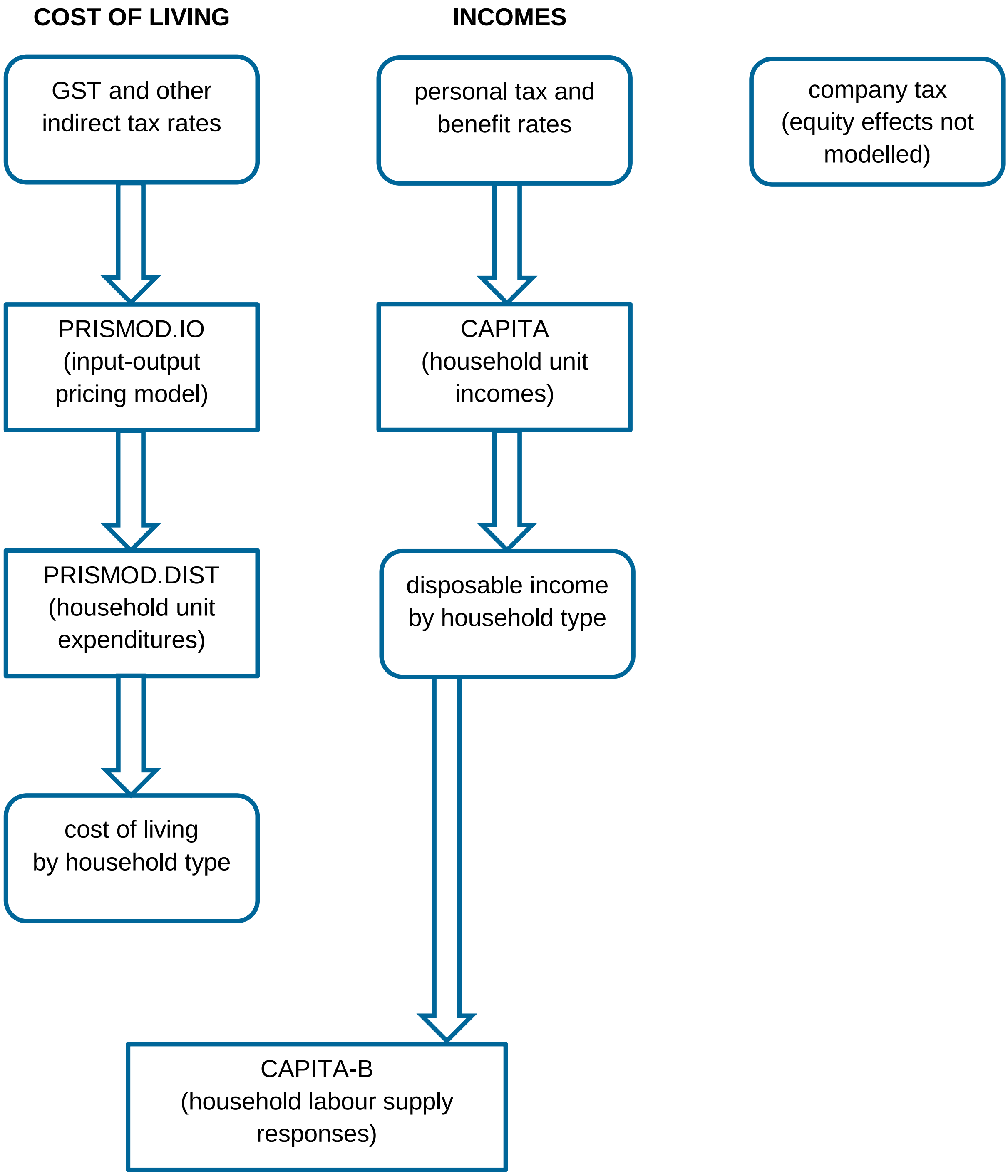
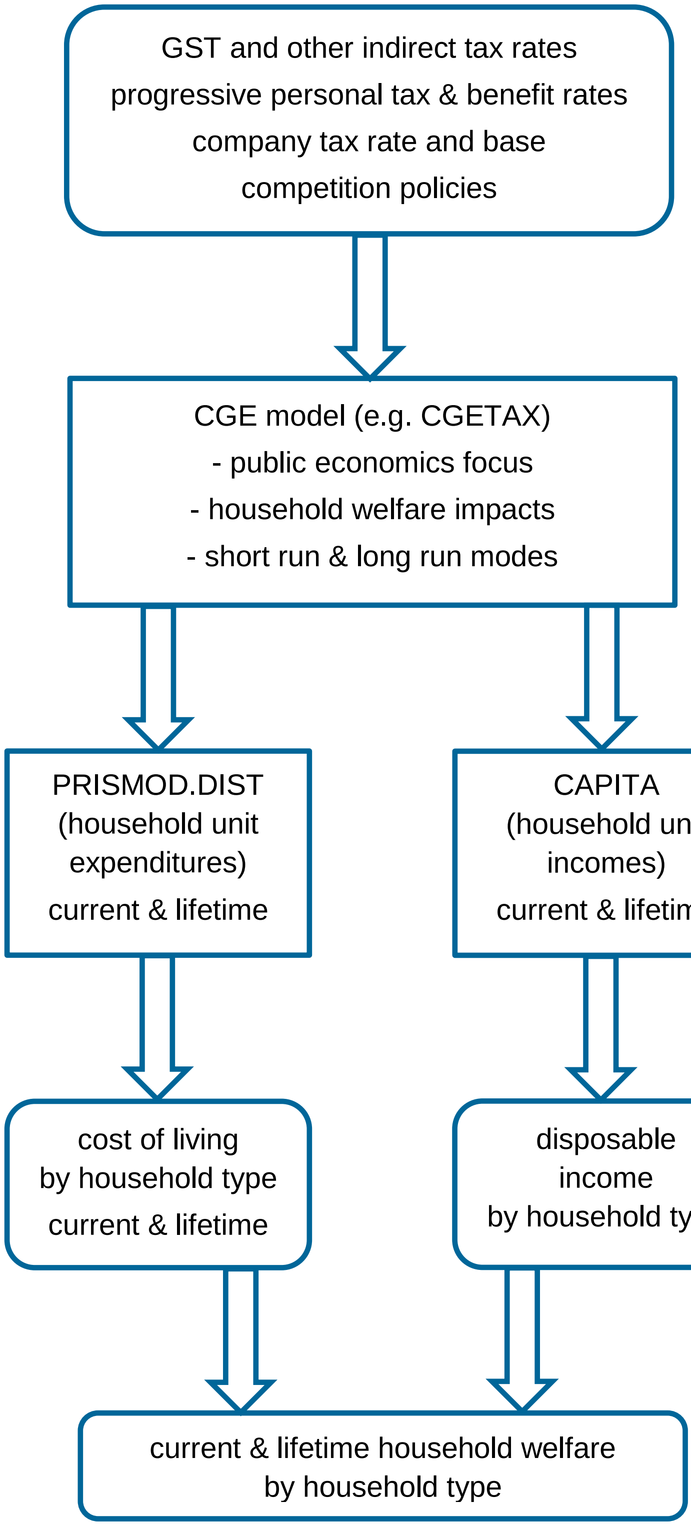


Figure E
Tax and other reform policies: effects on economy & household equity (recommended approach)



cameos (i.e. impacts on a representative household with a given set of characteristics). This review is mainly concerned with economy-wide modelling, which is the focus of its recommendation for further developing the method for costing tax policy proposals.

In costing tax policy changes, The Treasury always takes into account the direct effect on the budget of the change in the tax rate. It may also take into account the indirect effect from any estimated induced change in the tax base. This partial equilibrium approach can be applied if a tax change applies to a single market, such as the cigarette market.

Some tax changes, such as changes to personal or company income tax, may affect GDP and national income. This is likely to affect collections from most taxes. Taking this into account requires a general equilibrium analysis and is known as dynamic scoring (Mankiw and Weinzierl, 2004). This is now required in the US for material tax changes (Hall, 2015)[6] and a similar approach is recommended here.

Recommendations

Revenue Group – Recommendation 1 (Economic impacts of tax policy model) – higher priority

For its CGE model analysis of the economy-wide impacts of tax policy, The Treasury should upgrade from using the IE CGE model to using the CGETAX model[7]. This will increase the depth of the analysis for the five categories of tax that are covered by IE CGE. It will also increase the number of categories of tax that are covered from five to twelve.

Revenue Group – Recommendation 2 (Equity impacts of tax policy model) – higher priority

The Treasury should consider upgrading CAPITA to extend its reporting of the impacts of changes in taxes and benefits on incomes. The existing CAPITA reports impacts on current incomes, but this could be extended to include both current incomes and lifetime incomes. This would give a more complete picture of the equity impacts of changes in taxes and benefits.

Revenue Group – Recommendation 3 (Consistent modelling of impacts) – medium priority

The Treasury should consider linking the modelling of the economy-wide and equity impacts of tax policy to achieve greater consistency. The microsimulation modelling of impacts on individual households in PRISMOD.DIST and CAPITA would then be driven by a CGE model, and PRISMOD.IO would no longer be needed. The CGE model would be run in two modes, a short-run mode for generating impacts on current incomes and a long-run mode for generating impacts on lifetime incomes.

Revenue Group – Recommendation 4 (Tax Costings with dynamic scoring) – medium priority

The Treasury should consider whether, in estimating the budget impact from a tax policy change, it takes into account potential economy-wide effects. Such dynamic scoring is required in the US for costings with a gross budgetary effect of 0.25 per cent of GDP or more in any year over the next 10 years. When taken into account, economy-wide effects on the costings should be separately identified. The size of such effects is important in judging the desirability of a policy and taking them into account should also improve the accuracy of costings.

[6] I would like to thank Robert Ewing and Susie Kluth of the Tax Analysis Division in The Treasury for drawing my attention to this reference.

[7] The IE CGE and CGETAX models were developed by Independent Economics. To address the potential conflict of interest in this recommendation, the upgrade from IE CGE to CGETAX is being offered for free.

Fiscal Group

The Fiscal Group in The Treasury prepares fiscal projections and provides advice on intergenerational issues such as retirement incomes policy. As discussed under "modelling at fiscal authorities", in advanced economies the modelling tools that may be used in providing this type of advice include budget projection models and, less commonly, OLG models.

In advanced economies fiscal authorities typically use budget models to prepare fiscal projections over various time horizons, using their economic projections as inputs. The Treasury also follows this practice, and its use of budget models in preparing projections is reviewed first.

The Treasury does not currently have its own Overlapping Generations (OLG) model, but is in the process of developing a Treasury version of the OLG model of Kudrna, Tran and Woodland (2015). The possible use of this model in Revenue Group has already been discussed. Here the potential uses of KTW OLG (Treasury) in Fiscal Group are reviewed, following the review of budget projections.

Budget Projections

Budget projections in Australia are prepared under the requirements of the Charter of Budget Honesty Act 1998 (Office of Parliamentary Council, 2014). The Charter covers the annual Budget cycle, the pre-election economic and fiscal outlook (PEFO) report, and the Intergenerational report (IGR). Further, Secretaries of the Treasury and the Department of Finance take responsibility for PEFO, while their Ministers take responsibility for the other budget reporting.

As in other advanced economies, budget projection models assume the continuation of existing Government fiscal policy. The budget projections are influenced by projected growth in tax bases and spending bases (populations of benefit recipients and more intensive users of health, education and other government services).

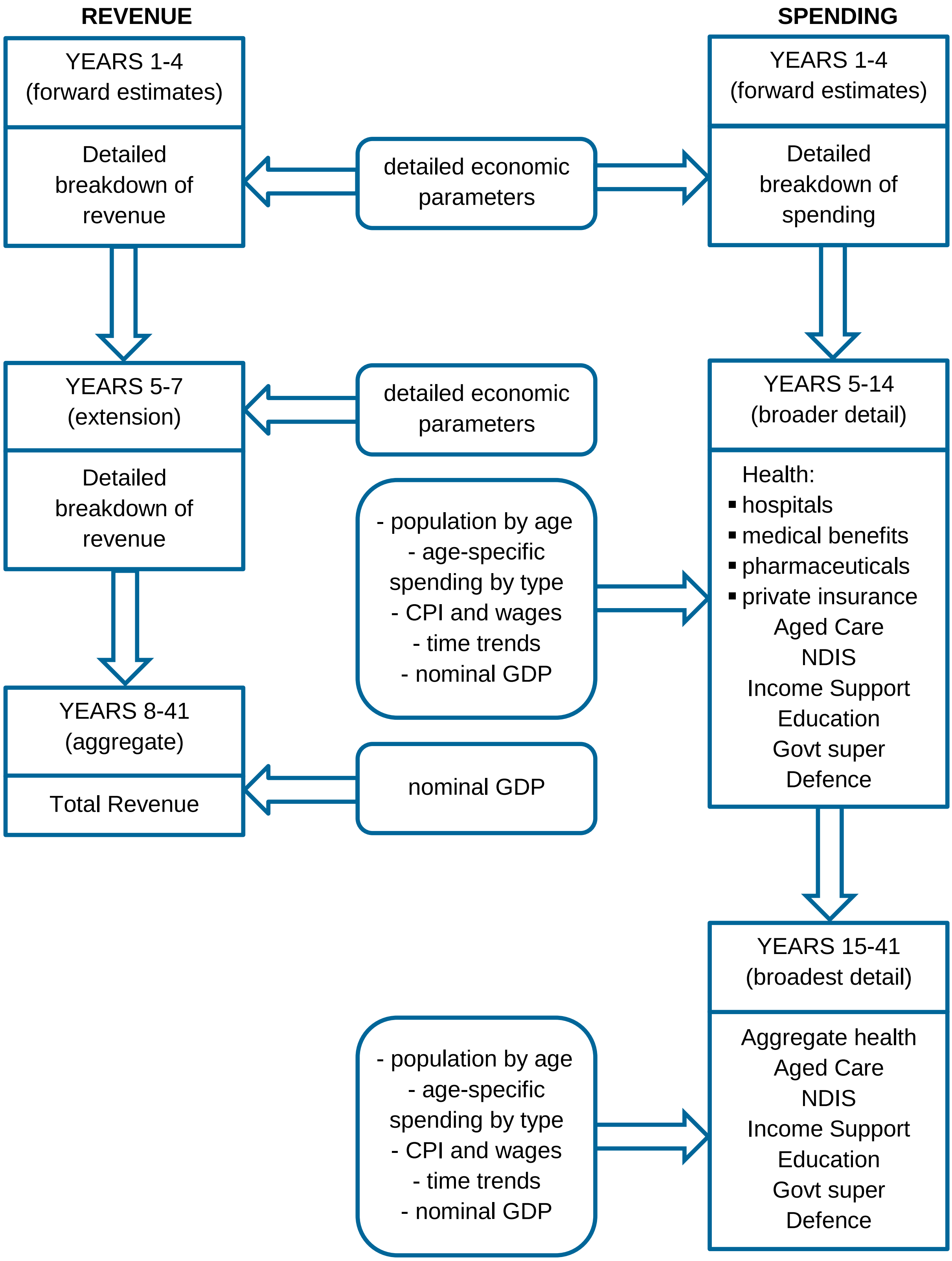
Again similar to fiscal authorities in other advanced economies, the budget projections are prepared following a sequential approach. The economic forecasts are prepared first, and then those economic forecasts are used as an input in preparing the fiscal forecasts.

The horizon for the long-term fiscal projections contained in the IGR is 40 years, as required by the Charter. This can be compared with the horizons used in other advanced economies of 15 years in New Zealand, 30 years in the US, 40 years in Canada and 50 years in the UK.

The Budget outlook modelling approach is depicted in a highly stylised form in Figure F. For a more detailed explanation, see Appendix C of the IGR (Australian Government, 2015a).

- The Forward Estimates, which appear semi-annually in the Budget and MYEFO, cover the first four years of the revenue and expenditure projections. These Forward Estimates are based on detailed modelling, which depends on many government policy settings and an extensive range of economic parameters. See Appendix A for a listing of the budget economic parameters.
- Treasury modelling extends the Budget outlook from the 4-year period used in the Forward Estimates to 41 years. For expenditures, this is done in a simplified way where the key drivers of cost and demand are applied to expenditure from the end of the Forward Estimates. For revenues, the detailed Forward Estimates approach is extended to around year seven.

Figure F
Budget Outlook Modelling (current approach)



Revenue

Bracket creep or fiscal drag, if left unchecked, would lead to ongoing increases in personal income tax as a share of GDP. In the UK, Canada and New Zealand, fiscal drag is switched off after five to seven years of a long-term fiscal projection, resulting in revenue projections that are approximately stable relative to GDP from then on. However, in Australia, the problem of fiscal drag in long-term revenue projections is addressed by holding total tax revenue fixed as a share of GDP, once that share reaches an historical benchmark. What distinguishes this approach from the approaches used elsewhere is the switch in Australia from a bottom up projection of tax revenue, to a top-line projection.

In the advanced economies considered, the long-term economic projections driving the fiscal projections follow a similar, simple pattern. In a potential growth phase, GDP grows smoothly, and all tax bases are growing at similar rates. This does not appear to take account of "the implications of population ageing on consumption, investment and savings decisions" (Leal et al., 2007, p. 27).

This could be addressed by using a macro-econometric model to provide the economic projections, and to incorporate into that model the economics of population ageing. This is shown in Figure G. At the same time, it is acknowledged that this approach is uncommon. As mentioned under "modelling at fiscal authorities", Leal et al. (2007) attribute this uncommonness to economy-wide models being difficult to build and understand, the modelling assumptions being open to debate, and the policy conclusions from them being difficult to communicate to the public.

Expenditure

The long-term projections on the expenditure side of the budget are invariably based on the assumption of unchanged policy. As shown in Figure F, the expenditure projections beyond the Forward Estimates, like the revenue projections, involve two phases, but with different timing. In the decade from years 5 to 14, expenditures are projected using around a dozen categories (most of which are shown in Figure F), the categories being far broader than those used in the Forward Estimates. For years 15 and beyond, the categories used are even broader, with health expenditure aggregated to a single category.

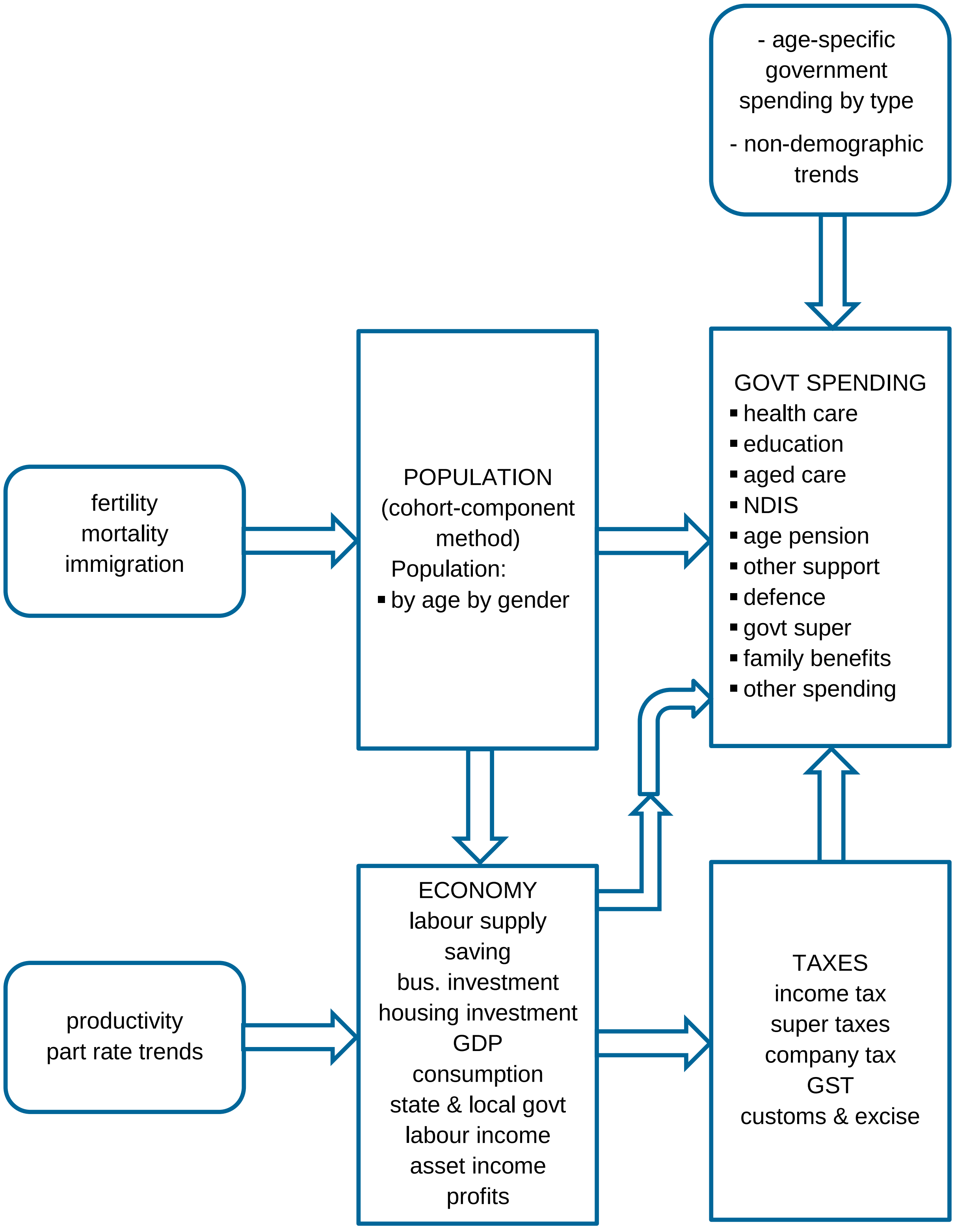
In keeping with practice in other advanced economies, health, aged care and education spending are projected taking into account the effect of population ageing on the demand for government services. Non-demographic-related trends (such are advances in medical technology) are also taken into account.

The aggregation of health to a single category for year 15 and beyond appears to be motivated by a desire for greater policy realism. From years 5 to 14, existing government policy leads to steady falls in both the Commonwealth's share of hospital funding and the average rebate rate for private health insurance. The aggregated approach taken from years 15 onwards implicitly assumes that this share and this rate finally stabilise.

The approach to projecting expenditure could be improved in some ways.

- There is a broad-brush element in applying government policy to project spending beyond the Forward Estimates; more policy detail might be used in the medium-term estimates.
- Behavioural responses to different spending scenarios might be introduced. For example, in the medium-term and long-term estimates a shift in government spending from, say, funding of government provision of education or health services to funding of private provision of competing services may cause a shift in consumer demand in favour of the private services.

Figure G
Extending the Budget outlook modelling for private saving & investment (recommended approach)



The KTW OLG model

As indicated previously, The Treasury intends to replicate and then further develop the KTW OLG model for its own uses.

As explained under "modelling at fiscal authorities", OLG models incorporate successive generations over the periods of life. Thus, OLG models are used to study intergenerational issues such as the effects of retirement incomes policies, government debt policies and demographic change. Further, because OLG models focus on life cycles and neglect economic cycles, they are ill-suited to forecasting. In any case, the budget model used in the IGR contains more of the detail needed to support a robust fiscal projection than does KTW OLG, as seen by comparing Figure F for the IGR with Figure H for the KTW OLG model. Instead, OLG models are used for scenario analysis.

These considerations are reflected in research at the US CBO where, in a working paper, Nishiyama (2013) simulates four scenarios involving intergenerational issues. A similar emphasis on intergenerational issues is seen in the six journal publications in which KTW OLG has been used by the model's authors. Those publications cover age pension policy, superannuation policy and the effects of demographic change on the government budget. There is also a similar focus on intergenerational issues in the collection of eight applications of the KTW OLG model (Kudrna and Woodland, 2010) that was commissioned by The Treasury for the AFTS ("Henry") Review.

The existing IGR includes sensitivity analysis of the fiscal projections to some of the assumptions (Australian Government, 2015a, Appendix B). However, this is confined to varying some of the demographic and economic assumptions. KTW OLG (Treasury) may be able to provide additional sensitivity analysis covering some policy assumptions. For that purpose, it has the advantage that it allows for behavioural responses in saving rates, investment rates and labour supply to policy changes.

Retirement Incomes

The Treasury previously used RIMGROUP for long-term modelling of retirement incomes. RIMGROUP was used for assessing the adequacy of retirement incomes and for Budget projections of age-related pension outlays and superannuation income tax revenue in the long term. However, RIMGROUP has been retired[8] from use.

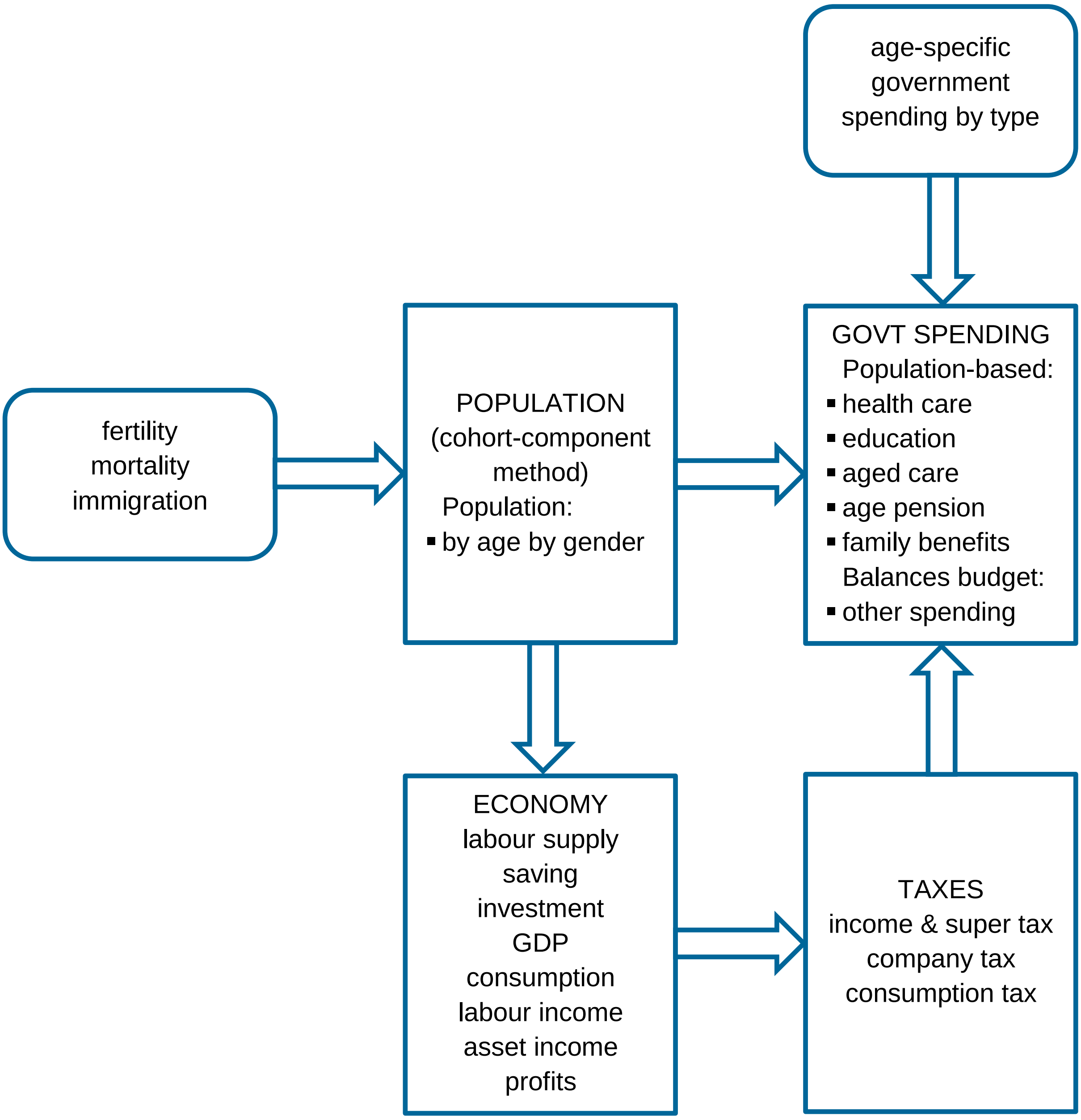
RIMGROUP is now being replaced by the Model of Australian Retirement Income and Assets (MARIA). Like RIMGROUP before it, MARIA models the long term effects of age pension and superannuation policy on retirement incomes. It improves on RIMGROUP by using administrative unit record data in place of data on groups of individuals.

KTW OLG (Treasury) might play a supporting role to MARIA, in the same way that it might for the IGR generally. MARIA, because of its fine level of detail – both the use of unit record data and considerable detail on pension and superannuation policies – is very likely to provide a more credible baseline projection of retirement incomes than KTW OLG (Treasury). However, KTW OLG (Treasury) may provide useful policy sensitivity analysis for that baseline, which takes into account behavioural responses to policy change.

The existing retirement incomes policy levers in KTW OLG provide an indication of the potential scope for policy sensitivity analysis in support of MARIA and the IGR more generally.

[8] no pun intended

Figure H
The KTW Overlapping Generations (OLG) model



- For the age pension there is a maximum pension rate, an income threshold, and a taper rate, but no modelling of the assets test or distinction between singles and couples.
- For superannuation there is a mandatory contributions rate but no voluntary contributions, a contributions tax rate and an earnings tax rate; benefits are assumed to be taken as lump sums.

Compared to other Treasury modelling of retirement incomes this setup is broad brush, but perhaps it could be further developed as part of the Treasury development work on KTW OLG.

Other modelling

Finally, it can be noted that the New Zealand Government has been developing a policy of social investment. The idea is that early investment in intervention with at risk groups to help place them in jobs and improve education and health levels can help avoid long-term dependence on government assistance. Thus, the taxpayer may receive a high rate of return on such early social investments. Estimating rates of return for options for social investments is a potential future area of modelling.

Recommendations

Fiscal Group – Recommendation 1 (IGR framework) – higher priority

In most respects the Australian IGR is developed in a similar way to other countries, except that it is issued in the name of the government rather than the department and it provides only a top-line revenue projection for the long term. This review proposes that consideration be given to the IGR being issued in the name of The Treasury, with revenue projections developed on a bottom up basis.

Fiscal Group – Recommendation 2 (IGR and long-term revenue projections) – medium priority

Like similar exercises in other countries, the IGR currently analyses the long term effects of demographic change on relative growth in spending bases but not tax bases. The Treasury should consider investigating the potential longer term effects of demographic change and other factors on relative growth in the major tax bases.

Fiscal Group – Recommendation 3 (IGR and long-term expenditure projections) – lower priority

The Forward Estimates draw on elaborate modelling of government expenditures conducted by Finance and spending departments. However, expenditure projections from year five onwards rely on more broad-brush modelling conducted by The Treasury. The Treasury could consider further developing the medium-term expenditure estimates to increase the policy detail. In the medium-term and long-term projections it could also potentially incorporate behavioural responses to changes in the spread of government expenditure between the government and private sectors in both health and education.

Fiscal Group – Recommendation 4 (IGR and policy sensitivity) – medium priority

The Treasury is aiming to replicate the Kudrna et al. (2015) Overlapping Generations (OLG) model with a view to further developing it. The Treasury should consider investigating the potential use of the KTW OLG (Treasury) model in producing policy sensitivity analysis for the IGR that allows for behavioural responses to changes in retirement incomes policy.

Management

This review now discusses the management issues in implementing its recommendations. Management aim to ensure that the modelling activities are fully aligned with The Treasury's advisory responsibilities and are executed efficiently.

Organisation

It is a challenge for any government economic agency to keep its modelling activities fully integrated with the agency's functions. The integration issues that can arise if modelling is centralised are discussed in the Department of Finance Canada's review of its modelling activities (DFC, 2012).

For its macroeconomic models, it is understood that The Treasury is proposing to locate the new macro forecasting model in MECD and the new DSGE model in MMPD. This approach of co-locating a model with the associated advisory function minimises integration risks.

At the same time, perhaps due to historical circumstances, there are cross-overs in other cases between the Group that houses a model and the Group with the associated advisory function. The Revenue Group provides tax policy advice and houses modelling of the equity impacts of tax proposals. However, Macroeconomic Group houses the modelling of economic impacts. The Fiscal Group provides advice on retirement incomes policy, but the associated microsimulation model is housed in Revenue Group and the new policy scenario model in Macroeconomic Group.

From an outside perspective, these arrangements seem to carry risk and merit review. However, management would need to also weigh up a range of internal considerations and make their own better-informed judgements.

Modelling Skills

Successful economy-wide modelling requires a range of specialist skills, some technical and some economic. A successful modelling team will bring the full range of required skills together.

Good modellers are mobile in the workforce[9]. The Treasury faces competition for modellers from within government as well as from the private sector. It therefore needs to be able to attract and retain good modellers. This is likely to require a combination of career-developing and financial incentives. The body of the report discusses a range of possible incentives. These including providing development opportunities, creating specialist modelling positions and paying specialist bonuses.

New Modelling Projects

The Treasury has committed to developing a new macro-econometric model, and a team will be needed to devise a detailed blueprint and implement it. The size of the team required is likely to be between three and five FTE.

In management deciding about a new model, there are six important questions to be answered clearly and early to ensure effective integration between the modelling and The Treasury's advisory functions and the efficient progression of the modelling.

[9] I would like to thank the Tax Analysis Division of The Treasury for input into the following discussion, while taking full personal responsibility for the content.

1. Who are the stakeholders?
2. What is the purpose of the model?
3. Where is the design?
4. How many FTE and for how long?
5. Have the stakeholders approved the project and joined the steering committee?
6. Where else can I see a project like this functioning successfully?

Besides the new macro-econometric model, The Treasury is also at the early stages of two other modelling projects, the development of a Treasury version of the RBA DSGE model and a Treasury version of the KTW OLG model. This review considers that it is important that the six questions set out above are asked and satisfactorily answered for all three projects early in their development.

Subject to that, the view of this review concerning these three new modelling projects is that they all have some merit. However, as detailed in this review and indicated in the relevant recommendations, for meeting the needs of The Treasury as a fiscal authority, the macro-econometric modelling project is of the highest importance, followed by the OLG project and then the DSGE project. This ordering would be different for a monetary authority or an academic institution.

The Treasury is already invested in models that provide analysis of the economy-wide and equity impacts of tax reform that is nuanced and competitive with that undertaken at other fiscal authorities. Further investment in those models in the way proposed in the four recommendations for Revenue Group offers a surer and more cost effective way of further developing The Treasury's capability in this area than embarking on alternative modelling approaches.

1 Introduction

The role of the Australian Treasury ("The Treasury"), as set out in its latest corporate plan (Australian Treasury, 2016), is as follows.

> *As Australia's pre-eminent economic adviser, the Treasury serves the Australian people by assisting the Government to manage emerging domestic and international opportunities and pressures. Treasury provides advice across a range of issues: including tax, the Budget, the economy, financial sector, foreign investment, structural policy, small business and international economic policy. The Treasury also works with State and Territory governments on key policy areas as well as managing federal financial relations.*

Economic modelling is important in fulfilling this role, especially in relation to the first three areas of advice listed in the corporate plan - tax, the Budget and the economy. Hence, The Treasury is keen to work towards having a economic modelling capability that is at best practice for a fiscal authority. This is challenging. There are continual developments in the field of economic modelling, skilled economic modellers are mobile in the workforce, model development can take a back seat to shorter-term priorities, and vigilance is needed to keep the modelling effort fully integrated with The Treasury's advisory responsibilities.

Accordingly, The Treasury commissioned Independent Economics (IE) to undertake a review of Treasury's economic modelling capability. It did not want an audit or health check style of review that might be limited to recommending minor changes. Rather, The Treasury sought an independent review of its whole modelling strategy, with a recommended roadmap for the future. The recommended roadmap takes into account both The Treasury's existing modelling capability and the international benchmark provided by the modelling capabilities of fiscal authorities in other advanced economies.

The starting point for this review is the other related reviews that have been undertaken in recent years. There were reviews of economic forecasting at The Treasury in 2005, 2012 and 2015 and at the Reserve Bank of Australia (RBA) in 2014. This review has a different emphasis. It focusses specifically on modelling. Further, it considers not only forecasting applications of modelling, but also policy applications.

Three groups in The Treasury use economy-wide models as tools in this forecasting and policy advice work. Those groups are Macroeconomic Group, Revenue Group and Fiscal Group.

In The Treasury's forecasting process, Macroeconomic Group prepares the core forecasts for the economy. It also prepares the forecasts of the economic parameters used by the other two groups in forecasting the Budget. Revenue Group forecasts the revenue side of the Budget. Fiscal Group works with the Department of Finance in forecasting the expenditure side of the Budget. Fiscal Group also calculates the forecast of the Budget balance from the revenue and expenditure projections and forecasts government debt.

For policy analysis, Macroeconomic Group provides advice on macroeconomic policy. Revenue Group analyses taxation proposals, and provides costings, estimated impacts on the economy, and assessments of equity implications. Fiscal Group analyses social policy (education, health and benefit payments) and retirement incomes policy (superannuation and age-related pensions).

These three Groups also have other functions and there is a Markets Group. However, this other economic advisory work does not draw significantly on economy-wide modelling.

This report approaches its task as follows. First, as an international benchmark, it identifies eight types of economy-wide models (see the Glossary) that are used in fiscal authorities of advanced economies for different purposes. Second, it describes the types of models that are used, or planned to be used, by The Treasury. Third, it proposes a roadmap that takes The Treasury from its current modelling capability to a modelling capability that approaches the international benchmark.

In each of these three steps, the discussion is arranged according to the three Treasury Groups introduced above. This approach was chosen because the three different Groups require different types of models to best suit their needs. Attempting to cover the diverse range of Treasury's economic advisory responsibilities in just one or two models would be ill-advised, because complex, super models take many years to develop, are very difficult to understand and are highly unwieldy to maintain. Further, they ignore the insight that aspects that may be important in analysing some economic issues may be unnecessary complications in analysing other economic issues. The modelling needs of Macroeconomic Group are discussed first, followed by Revenue Group and then Fiscal Group.

In The Treasury some models are housed in one Group but the results are used in another Group. Here models are reviewed under the Group that uses the results. This perspective was chosen because it is important that modelling activities are well integrated with each group's advisory responsibilities.

This broad review raises 13 main questions about the nature and scope of the models that The Treasury should use.

1. The Treasury now uses a 3-phase approach to generate its macroeconomic forecasts over different time horizons, but has recently decided to develop a new economy-wide forecasting model, such as a macro-econometric model. Is it on the right path in deciding to develop and use such a model for forecasting over different time horizons?
2. Should The Treasury apply judgemental adjustments, based on critically assessed information, to the forecasts from its new macro-econometric model, just as it does using the 3-phase approach?
3. Should The Treasury consider using a VAR model as a cross-check on its key short-term forecasts?
4. Should The Treasury consider also using the new macro-econometric model as its primary tool for macroeconomic policy analysis?
5. The Treasury has obtained a copy of the Reserve Bank's DSGE model, which is primarily designed for analysis of monetary policy and the business cycle, with a view to further developing it. Should The Treasury consider following the lead of researchers in other countries by adding more fiscal structure, giving it an alternative tool for macroeconomic policy analysis?
6. For modelling the economy-wide impacts of tax reform, should The Treasury upgrade from the IE CGE model used in the recent tax review to its successor the CGETAX model, with its fuller coverage of the tax system and more complete allowance for behavioural responses?

7. The equity analysis of proposed policy changes currently focusses on how households are affected initially. Should The Treasury consider also modelling how households are affected over their lifetimes?

8. The efficiency and equity of taxes are analysed using separate models at present. Should The Treasury consider linking the analysis of efficiency and equity for greater consistency, and developing the approach so that short and long term results are available?

9. When costing tax policy changes, The Treasury occasionally considers feedback effects on the budget from economy-wide impacts. Could this be done more often for large revenue measures?

10. In most respects the Australian IGR is developed in a similar way to other countries, except that it is issued in the name of the government rather than the department and it provides only a top-line revenue projection for the long term. Should consideration be given to the IGR being issued in the name of The Treasury, with revenue projections developed on a bottom up basis?

11. Like similar exercises in other countries, the IGR currently analyses the long term effects of demographic change on relative growth in spending bases but not tax bases. Should The Treasury consider investigating the potential longer term effects of demographic change and other factors on relative growth in the major tax bases?

12. The IGR's long-range government expenditure projections are based on simpler modelling than the Forward Estimates. Should The Treasury consider upgrading these long-range projections to build in greater policy detail and some behavioural responses to policy change?

13. The Treasury is aiming to replicate the Kudrna et al. (2015) Overlapping Generations (OLG) model with a view to further developing it. Should The Treasury follow the lead of other researchers in focussing on applications where intergenerational issues are important, such as retirement incomes policy, public debt policy and understanding the effects of an ageing population?

This review considers all of the above questions and answers each question in the affirmative. This leads to recommendations that form the core of a roadmap for the future development of modelling at The Treasury.

The roadmap contains proposals for the further development of a suite of economic models and skilled economic modellers. Following this roadmap should help to equip The Treasury with best-practice modelling services to call on in meeting its economic advisory responsibilities as a fiscal authority.

Section 2 discusses the types of economy-wide models that are commonly used at fiscal authorities in advanced economies. This provides an international benchmark that involves eight types of economy-wide models.

Section 3 of this report summarises earlier related reviews. This includes the 2005, 2012 and 2015 forecasting reviews at The Treasury and the 2014 forecasting review at the RBA.

The next three sections review modelling capabilities on a group-by-group basis. For each group, this includes a stocktake of its existing modelling capability against the international benchmark.

- **Section 4** reviews the modelling capability of the Macroeconomic Group.
- **Section 5** reviews the modelling capability of the Revenue Group.

- **Section 6** reviews the modelling capability of the Fiscal Group.

Section 7 discusses the main management issues in implementing the roadmap. The overriding aim is to ensure that The Treasury's modelling effort is fully aligned with The Treasury's advisory responsibilities and is executed efficiently. Topics discussed include the arrangement of modelling activities within The Treasury's organisational structure, developing modelling skills and resourcing modelling priorities.

Appendix A lists the economic parameters needed in preparing Budget estimates.

While all care, skill and consideration has been used in the preparation of this report, the findings refer to the terms of reference of The Treasury and are designed to be used only for the specific purpose set out below. If you believe that your terms of reference are different from those set out below, or you wish to use this report or information contained within it for another purpose, please contact us.

The specific purpose of this report is to provide a review of The Treasury's economic modelling capability.

The findings in this report are subject to unavoidable statistical variation. While all care has been taken to ensure that the statistical variation is kept to a minimum, care should be taken whenever using this information. This report only takes into account information available to Independent Economics up to the date of this report and so its findings may be affected by new information. The information in this report does not represent advice, whether express or inferred, as to the performance of any investment. Should you require clarification of any material, please contact us.

2 Modelling at Fiscal Authorities

This section provides an introduction to the main types and applications of economic models at fiscal authorities in advanced economies. The aim is to establish an international benchmark for The Treasury's modelling Capability. This international benchmark is used in the Group-by-Group review of The Treasury's modelling capability contained in sections 4 to 6. Accordingly, this section is divided into sub-sections according to the three groups in The Treasury. That is, each type of model is considered under the group in The Treasury that does or could use it.

In all, eight types of economic models are considered. For each model, there is a discussion of its nature, the applications to which it is most suited, and the prevalence of its use at fiscal authorities.

2.1 Macroeconomic Group

One important use of economy-wide models at fiscal authorities is as a tool in providing advice on the macroeconomic outlook and macroeconomic policy. At The Treasury, this advice is provided by the Macroeconomic Group.

There are three main types of economy-wide models that can be used as tools in preparing macroeconomic forecasts and policy advice. These are VAR models, DSGE models and macro-econometric models. An important difference between these models is in the relative emphasis that each model places on economic theory and data analysis.

Vector Autoregression (VAR) models

Vector Autoregression (VAR) models are designed for short-term forecasting and are data based. In their simplest form, they capture the dynamic interdependencies between multiple macro variables, without using economic theory about how the variables inter-relate. Instead, traditional VAR models allow everything to affect everything[10]. This general approach avoids the risk of overlooking some linkages between variables simply because those linkages are not incorporated in economic theory. Sims (1980) describes this as avoiding "incredible" assumptions.

By the same token, because everything can affect everything, there are potentially too many parameters to estimate robustly. Hence, traditional VAR models are restricted to a relatively small number of variables. The original VAR model of Sims (1980) contained just six variables – the money supply, real GDP, unemployment, wages, the price level and import prices. As Sims (1980) puts it, "a six-variable dynamic system is estimated without using theoretical perspectives".

Another limitation is that VAR models are better suited to short term than long term projections. VARs may be able to capture short term dynamics, but their long-term projections can look odd when compared to theory about the long run equilibrium of the economy.

VAR model developers have wrestled with these limitations of using an unrestricted VAR model. Bayesian methods have been introduced to help estimate larger VARs. To improve the long-term

[10] This is with the exception of contemporaneous interactions, where a recursive structure may be imposed for the purpose of making shocks orthogonal to each other.

projections, some structural assumptions may be made. However, to some extent these developments represent a move away from the original VAR aim of applying an unrestricted model to the data.

It is reasonable to conclude that there are limitations of VAR models when it comes to long term projections or projecting a large number of variables. At the same time, one can agree with Stock and Watson (2001) that "VARs are powerful tools for describing data and for generating reliable multivariate benchmark forecasts". For a handful of key variables over a short-term horizon, they can provide a useful cross-check to the more complete forecasts prepared using other methods such as a large scale macro-econometric model.

The Congressional Budget Office (CBO) study of Huntley and Miller (2009a) illustrates how a VAR model can play this cross-checking role at a fiscal authority. In particular, the study develops a small VAR model and uses it as a benchmark in evaluating the CBO's forecasting track record. Reassuringly, it finds that "most variables generated endogenously by macroeconomic forecasters at the agency have MSEs (mean square errors) that are roughly comparable to or better than the VAR counterparts".

For a fiscal authority, using a VAR model is a lower modelling priority, because a VAR model plays a cross-checking role rather than a core role.

New Keynesian DSGE (DSGE) models

In contrast to VAR models, Dynamic Stochastic General Equilibrium (DSGE) models emphasise economic theory. Economic theory is used not only in formulating equilibrium relationships, but also in modelling the dynamic path to that equilibrium.

DeJong and Dave (2011) refer to three types of DSGE models. The first type, real business cycle models, emphasise stochastic movements in technological progress or productivity as a driver of economic cycles. The second type, asset price models, use stochastic variation in income from asset holdings to explain asset prices. The third type, New Keynesian DSGE models, allow for stickiness in prices, so that economic cycles are partly driven by demand shocks.

Of these three types of DSGE models, New Keynesian DSGE models are of most interest to fiscal authorities, so the other two types of DSGE models are not discussed further here. When "DSGE models" are referred to in the remainder of this report, it should be understood as a shorthand for New Keynesian DSGE models only.

While DSGE models emphasise theory and Structural VAR models emphasise data, they share a common focus in explaining economic cycles by random shocks. Pagan and Robinson (2016) investigate this relationship between the two types of models.

Computable general equilibrium (CGE) models use economic theory to model an equilibrium in which businesses and households make optimal economic choices based on technology, preferences and budget constraints. DSGE models also model economic equilibrium in this optimising way. In addition, DSGE models use economic theory to model a dynamic path to equilibrium. They are particularly concerned with analysing economic cycles.

The simplest 3-equation DSGE model is designed to analyse the effects of monetary policy. Hence, it focusses on aggregate demand, inflation and a monetary policy rule. In keeping with the emphasis on theory, businesses and consumers are assumed to base their expectations for the economy on the forecasts of the model itself.

Smets and Wouters (2007), in their famous DSGE model of the US economy, add more structure and dynamics. The number of stochastic variables rises from three to seven – exogenous demand, the monetary policy interest rate, the risk premium, investment, total factor productivity, the wage mark-up and the price mark-up. With this additional structure, Smets and Wouters (2007) analyse how the business cycle is driven by the seven main types of economic shocks associated with the seven stochastic variables. Hence their DSGE model can be used not only to analyse the effects of monetary policy, but also to obtain a general understanding of the causes of cyclical fluctuations.

The heavy reliance of DSGE models on economic theory has divided economists concerning their value. Blanchard (2016), a distinguished macroeconomist and former director of the Research Department at the IMF, offers an authoritative and balanced perspective[11]. "DSGE models can fulfil an important need in macroeconomics, that of offering a core structure around which to build and organize discussions." However, improvement is needed because he sees "the current DSGE models as seriously flawed". Blanchard (2016) identifies five flaws.

1) The implication that consumers "are infinitely lived and foresighted"[12] and twist their planned consumption paths in response to interest rate changes conflicts with empirical evidence.

2) The forward-looking modelling of price adjustment does not capture the inertia of inflation.

3) The estimation procedure relies heavily on the views of the researcher (through calibration and tight Bayesian priors) to set values for parameters of which our knowledge is fuzzy.

4) DSGE models aim for welfare analysis based on utility theory, but "the problem in practice is that the derivation of welfare effects depends on the way distortions are introduced in the model" (Blanchard, 2016). Blanchard prefers the traditional assumption in macroeconomics that welfare depends on deviations in output from potential and inflation from target.

5) "DSGE models are bad communication devices" because for non-DSGE modellers they are "often extremely hard to understand".

Blanchard's view of DSGE models, that they provide a useful organising structure for discussing macroeconomics, but have serious practical flaws, is generally reflected in how they are used. They are commonly used in academia and for scenario analysis, where economic reasoning is paramount. They are less commonly used for forecasting, where empirical accuracy is important.

The use of models at the Reserve Bank illustrates this point. In presenting the Reserve Bank's DSGE model, Rees, Smith and Hall (2016) state that "the model described in this paper is intended primarily for use in scenario analysis rather than as a forecasting tool". The Reserve Bank is developing a separate macro-econometric model for forecasting (Kent, 2016).

The RBA DSGE model (Rees et al., 2016) can be characterised as a version of the Smets and Wouters (2007) model of the US that has been customised by the RBA to Australia. These customisations

[11] I would like to thank Adrian Pagan for drawing my attention to this recent article by Blanchard.

[12] Because DSGE models are stochastic and hence allow for uncertainty, it is more accurate to suggest that consumers are assumed to have model consistent expectations rather than perfect foresight.

recognise the importance of the rest-of-the-world and the resources sector to the Australian economy, and are the main factor lifting the number of observed variables from seven in Smets and Wouters (2007) to 17 in Rees et al. (2016).

With this customisation to Australia, the RBA DSGE can be used in Australia for the same purposes as the Smets and Wouters (2007) model in the US. That is, it can be used for monetary policy analysis and to provide an economic interpretation of cyclical fluctuations. These uses have made DSGE models popular at central banks in advanced economies. Central banks with DSGE models include the US Federal Reserve, the Bank of England, the Bank of Canada and, closer to home, the Monetary Authority of Singapore, the Reserve Bank of New Zealand and the Reserve Bank of Australia (RBA).

All (New Keynesian) DSGE models can analyse the use of monetary policy in countering economic cycles. At some institutions, DSGE models have been extended so that they can also be used to model the use of fiscal policy for the same purpose. Coenen, Erceg, Freedman, Furceri, Kumhof, Lalonde, Laxton, Lindé, Mourougane, Muir, Mursula, Resende, Roberts, Roeger, Snudden, Trabandt and Veld (2012) collaborate to use a range of DSGE models to simulate fiscal stimulus. Four key points emerge from this study, which was prompted by the GFC-motivated fiscal stimulus programs.

1) The DSGE models used are not based in fiscal authorities, even though the models are being used to analyse fiscal stimulus. Rather, the DSGE models (Coenen et al. (2012), p. 32) are sourced from four monetary institutions (the Bank of Canada, the US Federal Reserve, the European Central Bank and the IMF), two more generalist international agencies (the OECD and the European Commission), and two academic institutions.

2) The amount of development work involved before a DSGE model can be used to simulate fiscal stimulus (or contraction) is extensive (Coenen et al. (2012), pp. 35, 38-39). So that tax cuts can be effective as a stimulus, Ricardian equivalence is relaxed by assuming that 20 to 50 per cent of households are financially constrained. Multiple categories of government spending are recognised, which can include productive government investment, transfer payments and government consumption. Some distortionary taxes are distinguished, the main examples being consumption taxes, labour income taxes, and capital income taxes. There is a fiscal rule in which either a labour income tax or a lump sum tax is used to achieve fiscal sustainability by targeting the government deficit or debt.

3) To dampen the considerable, unrealistic twisting of consumption paths that is highlighted by Blanchard (2016), the elasticity of intertemporal substitution in the government agency DSGE models ranges from 0.24 to 0.5 (Coenen et al. (2012), p. 37), well below the value of 1 that is often assumed in academic work with DSGE models.

4) The main policy conclusions of the study are as follows. A fiscal stimulus that is temporary provides a bigger short-term boost to the economy than a stimulus that is permanent. It also avoids the negative, long-term impact of a permanent stimulus, arising from higher government spending and taxes generating disincentive effects. A fiscal stimulus is less effective in a more open economy because of a greater leakage into net imports. To the extent that consumers are forward looking, increases in government spending on goods and services provide a larger economic stimulus than tax cuts.

While Coenen et al. (2012) demonstrate that DSGE models, after extensive further development, can be used to simulate counter-cyclical fiscal policy, their use at fiscal authorities is limited. This can be seen by taking the USA, UK, Canada, Singapore and New Zealand as examples. In all five advanced economies, the Central Bank uses a DSGE model, whereas the fiscal authority makes limited or no use of a DSGE model. In the cases where a fiscal authority does use a DSGE model, it is for policy simulation rather than forecasting.

In the US, the Congressional Budget Office (CBO) explains its current use of macro models for fiscal policy analysis in a recent report on "How CBO Analyzes the Effects of Changes in Federal Fiscal Policies on the Economy" (CBO, 2014). The CBO (2014, p. 4) uses a range of models to estimate the short-term effects of changes in fiscal policy on the economy.

> *In estimating demand multipliers, CBO draws heavily on macroeconomic forecasting models…CBO's estimates of demand multipliers are also influenced by evidence from time-series models and dynamic general-equilibrium models.*

From this explanation, it appears that macro-econometric models play a more important role than DSGE models in the CBO's fiscal policy analysis. That said, the CBO does have an interest in DSGE models, as seen in a staff working paper "assessing the capacity for the approach to be used" (Huntley and Miller, 2009b).

In the UK, there are three main fiscal authorities, HM Revenue & Customs, HM Treasury and, within HM Treasury, the Office of Budget Responsibility (OBR). HM Treasury and OBR jointly maintain and develop a "large scale macro-econometric model" (OBR, 2013, p. 5) that was originally developed by HM Treasury and is used for forecasting. Separately, the Bank of England maintains a DSGE model that is known as COMPASS and "is at the centre of a suite of models" (Fawcett, Körber, Masolo and Waldron, 2015).

The OBR also has its own rather small "DSGE model" used for scenario analysis (Murray, 2012). However, this 5-equation model cannot be used to model fiscal policy as there are no linkages from the budget to the economy; there are only linkages in the opposite direction, from the economy to the budget. Further, this model does not fully accord with the usual description of a DSGE model. In particular, to forecast better, there are no model consistent expectations in modelling either consumption or inflation.

In Canada, the Department of Finance Canada (DFC) maintains six economy-wide models (Department of Finance Canada, 2012). Not much public information could be found on these models, including whether they include a DSGE model. However, DFC modelling of the fiscal stimulus undertaken in response to the GFC (Conference Board of Canada, 2010) was undertaken using the DFC's Canadian Economic and Fiscal Model (CEFM). The CEFM is a macro-econometric model, not a DSGE model.

In Singapore, the Ministry of Finance (MoF) houses the Medium-term Fiscal Model of Singapore (MFMS), which was developed by the author of this report. The MFMS is a macro-econometric model of the economy and the budget. There is no indication that the MoF has a DSGE model.

The New Zealand Treasury publishes extensively on its use of economic modelling, including a macro-econometric model. A review of these publications could not find any evidence that it uses a DSGE model.

Given that Coenen et al. (2012) demonstrate that DSGE models can be used for analysing a fiscal stimulus (or contraction), then why is the use of DSGE models at fiscal authorities rather limited? This is unclear, but two plausible reasons can be suggested. First, fiscal authorities need to provide detailed economic and budget forecasts that require macro-econometric models, and this work may take precedence over using models for macroeconomic policy analysis. Second, when fiscal authorities do undertake macroeconomic policy analysis, they can use their macro-econometric models and so perhaps don't see a need to embrace DSGE models for the same purpose.

There is also another possible explanation. (New Keynesian) DSGE models were first developed to analyse monetary policy with fiscal policy coming later. So perhaps it is a matter of time before DSGE models spread from central banks to fiscal authorities. If this is so, it seems to be a slow process.

In summary, DSGE models are commonly used in academia and at central banks for monetary policy analysis. With major extensions, they can also be used for analysis of fiscal expansion/contraction as illustrated by Coenen et al. (2012). However, to date there has been limited use of DSGE models at fiscal authorities.

Overall, using a DSGE model is a lower modelling priority for fiscal authorities, probably because of the priority given to forecasting and the availability of macro-econometric models for macroeconomic policy analysis.

New Keynesian macro-econometric (macro-econometric) models

Macro-econometric models combine theory and data in an eclectic way. In broad terms, like DSGE models, macro-econometric models emphasise economic theory in modelling the economy's long run equilibrium. However, macro-econometric models differ from DSGE models by relying more on data analysis, and less on economic theory, to model the dynamic adjustment process to that equilibrium.

Pagan and Wilcox (2015) make a closely related distinction between ECO and ECS models. Both types of models use economic theory to model long run equilibrium. ECO ("economic optimisation") models also use economic theory to obtain dynamic structures. ECS ("error correction systems") models allow evidence from the historical data to flexibly determine the trajectory that a macro variable follows to its long run equilibrium. This distinction between ECO and ECS models captures the main distinction between DSGE and macro-econometric models.

Despite this conceptual difference in formulating dynamics, in practice there can be similarities in the dynamic properties of DSGE and macro-econometric models. Both types of models generally have a Keynesian short run because of stickiness in prices, and a supply-driven long run once prices and capital stocks have fully adjusted. The main difference here lies in the balance between theory and data analysis in modelling the price and capital stock adjustments.

Further, because of their eclectic approach, macro-econometric models fit the definition of an ECS model somewhat loosely. That is, there are exceptions to the rules of using optimisation theory to model long run equilibrium and of using data analysis to model dynamics.

In modelling long run equilibrium, most macro-econometric models follow optimisation theory by assuming that businesses maximise profits subject to a production technology. However, rather than assuming that household consumption is based on intertemporal optimisation, they usually avoid the problem of twisting consumption paths highlighted by Blanchard (2016) by instead relating consumption to current and/or permanent income.

In modelling dynamics, most macro-econometric models apply regression analysis to the data to estimate the parameters of error correction models. However, economic theory may also play a role in formulating dynamics. For example, there may be selective use of model consistent expectations, especially in financial markets where it helps to account for jumps in asset prices in response to new information about the future.

This eclectic approach reflects a balancing act between the two applications of macro-econometric models, namely, providing economic forecasts and macroeconomic policy analysis. The dynamics are data-based to give the strong short-term empirics that are needed for short-term forecasting. In that sense (but not more generally) macro-econometric resemble time series models such as VARs. The theoretically-based long-run equilibrium helps provide plausible long-term forecasts. It is even more important in enabling economically-interpretable macroeconomic policy analysis.

Macro-econometric modellers at the Department of Finance Canada explain the rationale behind macro-econometric models in a way that foreshadows the Pagan and Wilcox (2015) description of an ECS model.

> *The design of the model is constrained by the fact that it must serve two purposes: forecasting and policy analysis…Given these objectives, we have adopted a strategy in which the determination of the equilibrium long-run value for key economic variables is treated separately from the dynamic adjustment or determination in the short run. As a result, we can model key choice decision variables within an error correction structure since such a framework appears ideally suited for that purpose. This framework allows us to test or impose long-run relationships between economic variables, as often suggested by economic theory, without imposing these relationships on short-term dynamics. (Robidoux and Wong, 1998)*

In contrast to DSGE models, macro-econometric models typically play a major role at fiscal authorities. This can be seen by again taking the USA, UK, Canada, Singapore and New Zealand as examples.

In the US, the Congressional Budget Office (CBO) undertakes both forecasting and fiscal policy analysis. Its uses of models in these two applications are discussed in turn.

The CBO (1998) takes an eclectic approach in preparing its short-term forecasts.

- "CBO analysts look at many economic indicators to develop a view about the near-term growth prospects of the economy."
- "CBO also uses statistical methods to better understand recent economic developments."
- "CBO also looks at developments on the economic horizon that have not yet affected the economy but are expected to come into play in the near future."

- “An important part of CBO's forecast involves assumptions about the policy reactions of the Federal Reserve.”

More weight is placed on modelling in preparing the CBO’s projections over a long-term horizon of five years and beyond. A “neoclassical model of economic growth” (CBO, 1998) is used in which potential GDP is forecast based on projections of inputs to a production function. The inputs are labour, capital, land and total factor productivity (CBO, 2001). Labour input is projected from the supply side of the labour market, and this involves applying projections of participation rates, NAIRUs and average hours worked to projections of the working age population. This is similar to how GDP is determined in the medium to long run in a typical macro-econometric model. The CBO’s neoclassical growth model distinguishes several industries, including farming, government services, housing services and non-farm business services.

Turning to fiscal policy analysis, the CBO (2014) makes a distinction between the short-term and long-term. For the short-term, it estimates “demand multipliers”.

> *In estimating demand multipliers, CBO draws heavily on macroeconomic forecasting models. CBO’s analyses incorporate simplified versions of three such models—two created by private forecasting companies (Macroeconomic Advisers and IHS Global Insight) and one developed by the Federal Reserve (FRB-US).*

“CBO’s estimates of the long-term economic effects of changes in fiscal policies rely on models of potential output” (CBO, 2014). Two alternative models are used.

> *One model that CBO uses to estimate the effects of fiscal policy changes over the long term is a Solow-type growth model, which is an enhanced version of a widely known model developed by Robert Solow. The other model that CBO uses to estimate the long-term effects of changes in fiscal policies is a life-cycle growth model.*

The Solow growth model referred to here is the neoclassical model of growth, focussed around potential GDP, which is used in generating the CBO’s long-term forecasts. The life-cycle growth model is an overlapping generations (OLG) model.

In practice, it appears that the neoclassical growth model, rather than the OLG model, is the primary model used in estimating the long-term effects. The neoclassical growth model is used in the long-term analysis of alternative fiscal policies contained in the 2016 Long-term Budget Outlook (CBO, 2016, p. 67). More generally, it is the only model mentioned in the CBO explanation of how its estimates of short-term and long-term economic effects are knitted together (CBO, 2014, p. 11).

> *During a transitional period, CBO uses a weighted average of the estimated short-term effects of changes in fiscal policies … and the estimated long-term effects of changes in fiscal policies as derived from the Solow-type growth model.*

In the UK, HM Treasury and the Office of Budget Responsibility (OBR) jointly maintain and separately use the macro-econometric model originally developed by HM Treasury (Office for Budget Responsibility, 2013). This model is used in generating 5-year ahead projections of the economy and the budget, which are updated every six months.

In Canada, “the Canadian Economic and Fiscal Model (CEFM) is used by the Department of Finance to forecast key economic and fiscal indicators and to simulate the economic and fiscal impacts of policy or economic changes” (Cao and Robidoux, 1998). CEFM was updated in 2006 to better represent the role of monetary policy in targeting inflation (Hamalainen, 2006).

An unusual feature of Canada’s economic and fiscal forecasting process is that the core economic forecasts are based on a survey of private sector forecasts (Office of the Parliamentary Budget Officer, 2008). The Department of Finance Canada then develops the more detailed economic forecasts that are required as budget parameters. In 2009, CEFM was used to model the fiscal stimulus undertaken in response to the GFC, and this model-based assessment was then reviewed by the Conference Board of Canada (2010).

In Singapore, the author of this report has developed two macro-econometric models. The Monetary Model of Singapore (MMS) was developed for use by the Monetary Authority of Singapore (MAS), and the Medium-term Fiscal Model of Singapore (MFMS) was developed for use by the Ministry of Finance and the Ministry of Manpower.

- Since its development in 1998, “MMS has been used by the MAS to develop official economic forecasts every quarter, generate alternative scenarios, and conduct macroeconomic and industry policy analysis” (MAS, 2014). MMS uses quarterly data.
- MFMS is an annual, macro-CGE model of the Singapore economy with a special focus on the interactions between the economy and the budget. Originally developed in 2012 for the Singapore Ministry of Finance, in 2015 it was extended for the Singapore Ministry of Manpower to include a labour market module. It was updated in 2016-17 and uses annual data.

In New Zealand, macro modelling at the Treasury is centred on a macro-econometric model known as the New Zealand Treasury model or NZTM (Szeto, 2002 and Ryan and Szeto, 2009). The original version of this model, known as NZM, was developed in the 1990s by the author of this report (Econtech, 1995). Ulf D. Schoefisch Economic Consulting (2007) reports that NZTM occupies the central position in the New Zealand Treasury forecasting process.

In summary, in the fiscal authorities of the advanced economies considered here, macro-econometric models play a major role in forecasting and, to a lesser extent, macroeconomic policy analysis. This makes having and using a macro-econometric model a higher modelling priority for fiscal authorities in advanced economies.

2.2 Revenue Group

Another important use of economy-wide models at fiscal authorities is as a tool in analysing tax proposals. The models are used to provide costings, estimate impacts on the economy and assess equity implications. Models are also used to project government revenue, but that is considered in section 2.3 under the broader topic of projecting the government budget. At The Treasury, tax proposals are assessed by the Revenue Group.

Three main types of models are used to estimate economic and equity impacts of tax proposals. Economic impacts can be estimated using input-output (IO) models or computable general equilibrium

(CGE) models. The modelling of economic impacts may be linked to a microsimulation models of individual households to assess equity impacts.

The following discussion takes each of these three types of models in turn. For each model, there is a discussion of its nature, the applications to which it is most suited, and the prevalence of its use at fiscal authorities.

Input-output (IO) models

An IO model depicts inter-industry relationships within an economy. There are quantity and price versions. In the quantity version, industry production is driven by final demands. In the price version, industry prices are driven by unit costs. Input-output models were originally developed for economic planning.

The price version of an input-output model can be used to estimate how changes to indirect taxes affect prices paid by consumers. For taxes applied on sales to consumers, calculating consumer price impacts is generally straightforward and a model may not be needed. However, for taxes applied on sales to businesses or on business inputs, modelling is needed to take into account industry interrelationships in estimating the final impacts on different consumer prices.

At the US CBO, Perese (2010) uses the price version of an input-output model to simulate the impact on consumer prices of a hypothetical US tax on CO2 emissions imposed in 2006 at $20 per tonne. The modelling estimated that this would add 12 per cent to natural gas prices, 9 per cent to electricity prices, 5 per cent to prices for both fuel oil and gasoline, and between 0.14 and 0.79 per cent to prices for the remaining 15 categories of consumer spending.

Similarly, at the Office of Tax Analysis at the US Treasury, Horowitz, Cronin, Hawkins, Konda and Yuskavage (2017) use the price version of an input-output model to simulate the impact on consumer prices of a US tax on CO2 emissions imposed in 2019 at $49 per tonne. The modelling estimated that this would add 27 per cent to natural gas prices, 17 per cent to electricity prices, 12 per cent to prices for both home heating oil and gasoline, and 7, 6 and 4 per cent to prices for air, mass transit and water transport. Price rises for the remaining 26 consumption categories are under 2 per cent while the overall rise in consumer prices is 2.6 per cent.

Perese (2010) notes that "to the extent that production substitution is able to lower the initial cost of the policy, the estimated effects presented here are likely to be upper bounds beyond the short term". CGE models (discussed below) aim to take into account such substitution effects and thus may provide better estimates of long-term price effects.

Input-output models do not allow for behavioural responses, including to price changes. Thus, Perese (2010) and Horowitz et al. (2017) are not able to use their input-output models to estimate the extent to which the hypothetical carbon tax would reduce emissions. Such behavioural responses are a key consideration in assessing tax policy proposals, so an input-output model provides only a partial perspective on economic impacts.

The quantity version of an input-output model can be used to estimate the boost to the economy from an increase in final demand, such as an increase in government final demand. However, it ignores long run constraints on the economy, including the budget constraints faced by governments and households and the constraint on labour supply imposed by population. Consequently, the quantity version of an input-output model is only suitable for short-term economic analysis.

Overall, input-output models, when used for tax policy analysis, provide short-term estimates of impacts on consumer prices, and no estimates of behavioural responses. However, CGE models address these limitations by allowing for behavioural responses and long-term constraints on the economy.

Computable General Equilibrium (CGE) models

CGE models further develop IO models by modelling optimal economic choices, subject to preferences, technologies and budget constraints. DSGE models also model optimal choices in this way. HMRC (2013) explain the similarities and differences between CGE and DSGE models as follows.

> *CGE models are similar to DSGE models in that both model classes are based on microeconomic foundations rather than historical relationships. The main difference between the two types of model is DSGE models attempt to capture fluctuations in business cycles whereas CGE models tend to focus more on medium-run and long-run macroeconomic analysis. Standard DSGE models also tend to have less detailed representations of firms and households than CGE models. On the other hand, DSGE models allow for random variations to account for uncertainty whereas CGE models are deterministic, with agents facing no uncertainty about the future.*

One way in which DSGE models have less detailed representations of firms is that they typically only distinguish somewhere between one and five industries, because only limited industry detail is needed to capture fluctuations in business cycles. In contrast, CGE models may have 100 industries or more, which can help in modelling structural policies.

The focus of DSGE models on macroeconomic policy and business cycles leads to the inclusion of substantial short and medium term dynamics. However, because CGE models instead focus on the impact of permanent policies like the tax system or barriers to international trade, the focus is on long-run equilibrium and dynamics are less important. In fact, CGE models may be static, representing the economy only after it has converged to a long run equilibrium. Alternatively, CGE models may include medium-term dynamics, typically for capital stock adjustment and household asset accumulation.

CGE models have been used to analyse the economic efficiency of taxes since the seminal work for the USA by Ballard, Shoven and Whalley (1985). They estimated marginal excess burdens (MEBs) for the major US taxes.

The MEB shows the consumer loss per dollar of improvement in the government budget from a small tax rise. This loss is measured over and above the amount of the revenue that is raised[13]. Thus, the MEB provides a pure measure of the costs to consumers of the disincentive effects from a tax. These disincentive effects may include disincentives to work, save or invest, or to the patterns in the same areas. More narrowly-based taxes may also distort more specific economic choices e.g. between different alcoholic beverages.

Ballard et al. (1985) reached two major conclusions.

[13] The income effect on consumers from raising revenue from them is neutralised by assuming the revenue is returned as a lump-sum transfer, leaving only the disincentive effects.

"There is growing evidence that MEBs may be in the range of 15 to 50 cents for an economy like that of the United States." Such a wide range means that there is a large potential for consumers benefiting by the US Government relying more on taxes with low MEBs and less on taxes with high MEBs. In principle, tax efficiency would be optimised by shifting the tax burden in this way until MEBs are equalised across all taxes.

"We hope that the large estimates we report will contribute to … a discussion of possibly modifying the cost-benefit criterion for public goods evaluation." For example, if a government spending program is to be funded with a tax with a typical MEB of say 25 cents per dollar, each four dollars of program spending would need to provide consumers with benefits of at least five dollars for the program to be worthwhile. This is so the program covers the direct cost to taxpayers of $4, plus the additional cost from disincentive effects of one dollar (or 25 cents per dollar of additional revenue).

When developing a CGE model for estimating the economic impacts of tax proposals, the standard assumptions include economic optimising behaviour, with firms maximising profits and consumers maximising utility. However, three significant choices need to be made regarding foreign investment, household saving and economic dynamics.

- The Ballard et al. (1985) CGE model ignores foreign investment, so that domestic investment and domestic saving are tied together. This closed economy assumption may have been a reasonable assumption for the US economy of the early 1980s, but not for an advanced, small open economy such as Australia today. For such economies, perfect capital mobility is often assumed, so that at the margin investment is funded from abroad under a given world post-company tax required rate of return e.g. Sørensen (2014). The assumption of perfect capital mobility severs the link between domestic saving and domestic investment. This separation means that corporate tax acts as a disincentive for domestic investment, while asset income taxes act as a disincentive for future consumption.
- The disincentive effects of taxes on asset income depend on how the choice between present and future consumption (household saving) is modelled. One option is to set the elasticity of intertemporal substitution to zero. This assumes away the disincentive effects from asset income taxes, but such a model can still be suitable for analysing other changes to the tax system. Alternatively, the elasticity of asset substitution can be set to a positive value, allowing meaningful analysis of asset income taxes.
- As noted above, CGE models used to analyse the economic impacts of the tax system may be either static or dynamic. Tax studies using static CGE models include Bettendorf, Devereux, van der Horst, Loretz and de Mooij (2009) and Sørensen (2014), while a tax study using a dynamic CGE model is Baylor and Beauséjour (2004). Their dynamics arise from household asset accumulation and capital stock adjustment, and they abstract from the business cycle.

CGE models have been used from time to time by fiscal authorities in advanced economies to estimate the economic impacts of tax proposals.

In the US, Foertsch (2004) uses a simple CGE model to estimate the economic impacts of a personal income tax cut for the CBO Technical Paper series. Accumulation of household wealth and government debt are both modelled. However, this model distinguishes only two types of distorting taxes and there is no industry detail. Further, the model is of a closed economy, and hence abstracts from world capital markets, limiting its direct interest from an Australian perspective.

This CGE modelling of a personal income tax cut is also included in another CBO Technical Paper. Dennis, Hamilton, Arnold, Demiroglu, Foertsch, Lasky, Nishiyama, Ozanne, Peterson, Russek, Sturrock and Weiner (2004) model the same personal income tax cut using five alternative models. The five models are the CGE model of Foertch (2004), two macro-econometric models, an OLG model and the CBO's neoclassical growth model. This research subsequently appeared in a more accessible form as a CBO (2005) report.

In the UK, HM Revenue and Customs and HM Treasury (2013) used HMRC's CGE model to simulate the reduction in the UK corporate tax rate from 28 to 20 per cent. This was the major tax reform in the UK in recent years. In HMRC's CGE model, the dynamics are confined to capital stock adjustment and household wealth accumulation. There are 110 industries and 50 types of households, which are differentiated by household formation and income.

In Canada, the Department of Finance Canada (Baylor and Beauséjour, 2004) has undertaken CGE model-based analysis of the economic efficiency of major taxes. They estimated MEBs for seven tax changes involving corporate tax, personal income tax, payroll tax, consumption tax and investment tax. Similar to the UK study, a CGE model is used, with the dynamics confined to capital stock adjustment and household wealth accumulation. However, there are only four industries and one type of household.

To summarise, fiscal authorities in the US, UK and Canada have all used CGE models to simulate the economic effects of tax reform proposals. Dynamics are annual and are typically confined to capital stock adjustment and household wealth accumulation. DSGE models are not used for this purpose; their focus is on macroeconomic policy and the business cycle, with less detail concerning long run behavioural responses and industries.

Household Microsimulation models

While a CGE model can provide estimates of the economic impacts of a tax proposal, the impacts on equity between households are also important. These equity impacts are commonly assessed using household microsimulation models.

Such a microsimulation model simulates the effects of an economic change on a sample of many individual households. It assesses how different types of households (as defined by income, stage of life, composition) are affected differently by the same economic change.

The set of economic changes can be generated using a CGE model and fed into a microsimulation model. These economic changes typically include impacts on the full range of consumer prices and factor prices. These economic changes are applied to individual households in the microsimulation model.

Different households may be affected differently by the same economic changes for two reasons. A set of changes in consumer prices applied to different household spending patterns can lead to different percentage changes in the cost of living. A set of changes in factor prices applied to different household income patterns (between labour income, asset income and government benefits) can lead to different percentage changes in nominal incomes.

Once the effect on the cost of living and nominal income of each individual household has been assessed, each household is categorised. Households within the same category are then aggregated to estimate average impacts on real incomes for each household category. Categories are often defined in terms of income level, household composition and stage of life.

Colombo (2010) notes that the literature on linking CGE and microsimulation models has flourished since 1999. He distinguishes three different methods of linking, namely fully-integrated, top-down and iterative. Cockburn, Savard and Tiberti (2015)[14] identify some additional methods and sub-methods.

In the fully-integrated (FI) approach, there is no separate microsimulation model. Rather, individual households appear in the CGE model in place of a representative household. This approach is conceptually attractive but has two drawbacks that mean it is rarely used.

- Methods used to simulate CGE models do not generally cope with the discrete decision making that occurs at the level of individual households e.g. a decision to participate or not participate in the labour force. It is more practical in a CGE model to model behaviour of groups of households.
- The fully-integrated model will be very large.

In the top-down (TD) approach, a policy change is simulated in the CGE model and the effects on consumer prices and factor prices are then passed to the microsimulation model for the equity analysis. Cockburn et al. (2015) identify two options within the microsimulation model.

- Under a TD-MA (top-down micro accounting) approach, the behaviour of individual households is assumed to be unaffected by the changes in product and factor prices.
- Under a TD-WB (top-down with behaviour) approach, individual households may respond to changes in product and factor prices by changing their spending patterns and labour supply decisions.

Under either approach, there is potential inconsistency between the behavioural response of the representative household in the CGE model and the aggregated responses of individual households in the microsimulation model. The TD-MA approach has the advantage of simplicity. Under the TD-WB approach, there is the potential to adjust parameters in either the CGE model or the microsimulation model to obtain an approximate matching of behavioural responses between the two models. The TD approaches appear to be the most popular.

Cockburn et al. (2015) also refer to a bottom-up (BU) approach. A policy change is simulated in the microsimulation model, which incorporates behavioural responses. The aggregated, induced changes in consumption of each good and service and labour supplies are then fed into the CGE model. This approach may seem attractive when a policy change impacts very differently on different types of households. However, there are two drawbacks.

[14] I would like to thank Robert Ewing and Susie Kluth of the Tax Analysis Division in The Treasury for drawing my attention to this study.

- The BU approach can only be used for policies that impact directly, rather than indirectly, on households, because the shock must be applied to the microsimulation model. This restricts the policy applications.
- The CGE model must be modified to exogenise its consumption and labour supply responses. This would mean maintaining two versions of the CGE model, the original version for standalone simulations and the modified version for simulations with the microsimulation model.

The final approach is the iterative approach (IA), which combines the TD and BU approaches. The CGE model passes product and factor price effects to the microsimulation model and the microsimulation model passes consumption and labour supply effects to the CGE model. The process iterates until the CGE model's estimates of the product and factor price effects stop changing. This approach has two issues.

- The simulation setup may be complex and the requirement to iterate cumbersome.
- There is no guarantee of convergence.

Fortunately, the simulation experiments of Colombo (2010) suggest that most results tend to be fairly insensitive to the choice of linking method. Hence, it is probably reasonable to start with the simplest method, namely TD-MA. With time, this could be developed to the TD-WB method, and the two models tweaked until their behavioural responses are broadly comparable.

Another issue is the timeframe of the analysis. Traditional microsimulation models are based on the current incomes and spending patterns reported in a survey of households. However, as Auerbach, Kotlikoff and Koehler (2016)[15] point out, the welfare of a household depends on its expenditures over its lifetime, rather than its current income.

For households with ready access to credit markets, expenditures over their lifetimes will be constrained by their lifetime incomes, making it the relevant determinant of their living standards. However, households with more restricted access to credit markets may not be able to borrow against future income. For "hand-to-mouth" consumers, lifetime income is still important, but so too is current income.

Thus, for a fuller equity analysis, information is needed on both the current and lifetime impacts on households. Hence, Levell, Roantree and Shaw (2016)[16] "view the two approaches as complementing one another".

Current incomes are distributed more unequally than lifetime incomes. This is because the current income of a household can fluctuate considerable over its lifetime. Part of this fluctuation reflects the normal variation in income between the different phases of working life and retirement. Part of it also reflects random variation as households transition between employment and unemployment and between better and worse paying jobs. These fluctuations in current income over a lifetime are abstracted from when making equity assessments based on the distribution across households of lifetime incomes.

[15] I would like to thank Graeme Davis of the Tax Framework Division in The Treasury for drawing my attention to this study.
[16] ibid.

Levell et al. (2016) investigate whether making the distinction between current and lifetime incomes also matters for the conclusions drawn about the equity implications of different policies. They find that it does.

Out-of-work benefits have a more favourable effect on equity than in-work benefits if equity is assessed from impacts on current incomes. This is because being out-of-work is likely to mean having a low current income. However, this is not true if equity is assessed from impacts on lifetime incomes. Being out-of-work is often transitory and so is not necessarily a good indicator of a low lifetime income.

Increasing the rate of VAT is "strongly regressive" if equity is assessed from impacts on current real incomes. This is because the expenditure of low income households often exceeds their incomes, making their current VAT liability high relative to their current income. However, if equity is assessed from impacts on lifetime real incomes, increasing the VAT is "close to being neutral in distributional terms". "Households spending a lot relative to their income at any given point in time are often those experiencing only temporarily low incomes." Over a lifetime expenditure and income are more nearly in balance.

The equity analysis of Levell et al. (2016) focusses on income, both current and lifetime. This is because their concern is with vertical equity. However, equity analysis is also concerned with comparisons between smaller and larger households and younger and older households.

Levell et al. (2016) calculate household income relative to household size by measuring household size using the modified OECD scale[17]. After this size adjustment, household income provides a better measure of household living standards, but the comparative impact of policy changes on households of different size is left unreported.

Levell et al. (2016), in calculating lifetime income, consider the entire lifetime of a household. This provides a more complete perspective on how government policy affects a household, because it takes into account how the same household may be affected by different policies at different periods of life. However, it also means that the analysis is silent on the comparative impact between younger and older households i.e. intergenerational equity.

Auerbach et al. (2016) also undertake an equity analysis that stresses lifetime rather than current incomes. However, they model impacts on "remaining expected future lifetime expenditures", including bequests. By considering remaining lifetimes rather than full lifetimes, it is possible to make two types of equity comparisons. First, in "intragenerational accounting" vertical equity comparisons can be made within an age cohort between households with different living standards (as measured by remaining lifetime expenditures). Second, in "intergenerational accounting" comparisons can be made between age cohorts for households with similar economic characteristics.

The microsimulation models of Levell et al. (2016) and Auerbach et al. (2016) are interesting. However, to be more useful for a fiscal authority, they need to be linked to a CGE model. As seen in the studies of Colombo (2010) and Cockburn et al. (2015), the CGE model then provides the estimates

[17] The modified OECD scale assigns a value of 1 to the household head, of 0.5 to each additional adult member and of 0.3 to each child.

of the economic effects of a tax policy proposal, while the microsimulation model uses those economic effects in generating its equity effects.

The microsimulation models of Levell et al. (2016) and Auerbach et al. (2016) do not include behavioural responses. Thus, if a CGE model were linked top-down to one of these microsimulation models, it would be an example of the TD-MA linking approach.

The most straightforward link to establish would be between a standard CGE model and a microsimulation model in the style of Levell et al. (2016). The CGE model would need to provide both short run and long run estimates of economic effects for use in the microsimulation model. The short run economic effects would be applied to information on current income sources and spending patterns of individual households, to estimate impacts on current real incomes. The long run economic impacts would be applied to estimates of lifetime income sources and spending patterns of individual households, to estimate impacts on lifetime real incomes.

The alternative pairing would be between an overlapping generations (OLG) style of CGE model and a microsimulation model in the style of Auerbach et al. (2016). OLG models, which share the focus of the Auerbach et al. (2016) modelling on tracking multiple generations, are discussed in a separate section below. Such a linking would be complex, as it would be matching up two sets of modelling of households that are differentiated by both income-earning capacity and stage of life. This does not appear to have been attempted. Rather, Auerbach and Kotlikoff have investigated OLG and microsimulation modelling separately in the OLG modelling of Altig, Auerbach, Kotlikoff, Smetters and Walliser (2001) and the microsimulation modelling of Auerbach, Kotlikoff and Koehler (2016).

Household microsimulation models linked to CGE models have been used widely to jointly analyse the efficiency and equity impacts of policy options in developing countries. This can be seen from the survey of applications in Cockburn et al. (2015).

At the same time, there seems to be less evidence of microsimulation models being linked with CGE models in studies in advanced economies. This can be illustrated by considering the use of two prominent microsimulation models.

Based at the University of Essex, EUROMOD is a tax-benefit microsimulation model for the European Union with EU funding. Sutherland and Figari (2013) describe the structure of EUROMOD, which is relatively simple. EUROMOD is generally simulated in standalone mode, unlinked to a model of the economy. This means it is only provides equity effects not economic effects. Further, the incidence of a tax or transfer needs to be assumed because it is not being simulated in a CGE model.

In an exception to this standalone use of EUROMOD, Vandyck (2013) links the Belgium version of EUROMOD to a CGE model, using the TD-MA approach. He then simulates the equity and efficiency aspects of two scenarios involving changes to Belgium oil excises.

In the US Treasury study referred to previously, Horowitz et al. (2017) take a different approach to linking. They take the Treasury Distribution Model (TDM), which is a microsimulation model and, in effect, link it to an IO pricing model rather than a CGE model. As discussed earlier, using the IO pricing model, they estimate that a US tax on CO2 emissions imposed in 2019 at $49 per tonne would add 2.6 per cent to consumer prices. They then use TDM to simulate the equity impacts of three alternative methods of recycling the CO2 tax revenue back to households, namely, a personal income tax rebate, a payroll tax cut or a corporate tax cut. The distributional impact of the CO2 tax is then combined with the distributional impact of the alternative revenue recycling options to arrive at an overall equity assessment.

The US Treasury study shows how IO-microsimulation linking can be used to estimate equity impacts. However, this does not provide the broadly consistent estimates of real economic effects that are available from CGE-microsimulation linking.

To summarise, household microsimulation models can play a useful role in modelling tax policy proposals. These microsimulation models are more useful when linked to an economy-wide model that provides estimates of economic changes that result from tax proposals. With IO-microsimulation linking, estimates of equity effects can be obtained for many tax proposals. With CGE-microsimulation modelling, broadly consistent estimates of real economic effects can be obtained as well. To provide a more complete perspective on equity effects, the CGE-microsimulation modelling should aim not only to provide estimates of effects on current real incomes, but also on lifetime real incomes.

2.3 Fiscal Group

An important responsibility of fiscal authorities is preparing projections of government budgets. The role of budget models in these projections over short-term, medium-term and long-term horizons is discussed here.

Long-term budget projections often highlight the future pressure on the government budget arising from population ageing. Further, the extent of this future pressure is influenced by the nature of retirement incomes policies. Budget pressures also raise the issue of what is an acceptable or appropriate level of public debt. In part, these are intergenerational issues, which can assessed using over-lapping generations (OLG) models as a tool.

This section first discusses the role of budget models in preparing projections of government budgets. It then discusses the use of OLG models is analysing the inter-generational issues raised by long-term budget projections. For each of these two types of models, there is a discussion of its nature, the applications to which it is most suited, and the prevalence of its use at fiscal authorities.

Budget models and forecasting

Fiscal authorities use budget models to project the Government Budget. These models usually assume the continuation of existing Government fiscal policy. The Budget projections are influenced by projected growth in tax bases and spending bases (populations of benefit recipients and more intensive users of health, education and other government services). Budget models may take into account that policy changes can affect the associated tax or spending base and the economy more generally.

Fiscal forecasting is reviewed in an informative and balanced paper by Leal, Pérez, Tujula and Vidal (2007) from the European Central Bank. They identify five main issues.

The first issue is independence. Some researchers have claimed that fiscal projections "should be produced by independent authorities to avoid politically motivated forecast biases". On the other hand, the fiscal authority is likely to have access to inside knowledge that is useful in preparing fiscal projections.

One way of balancing these two considerations is for a fiscal authority to prepare the fiscal projections to take advantage of its inside knowledge, but then issue them in its own name rather than the name of the government to improve independence. The case for this seems stronger for long-term fiscal projections, because of the importance of the public receiving objective information about long-term fiscal sustainability. Short-term fiscal projections will be more heavily dependent of the policies of the government in power and so there is a stronger case for them to be issued in the name of that government.

The second issue is forecasting procedure. Under one approach, fiscal projections are generated from within the macro-econometric model that is also used to forecast the economy. This guarantees full consistency between the economic and fiscal forecasts, including allowing for the effects of fiscal policy on the economy.

The main problem with this approach is that macro-econometric models fall short of the needs of fiscal authorities in both their fiscal detail and fiscal information. Fiscal authorities require detailed fiscal forecasts. Further, those forecasts need to take into account the latest monthly budget data and detailed knowledge of changes in tax policies and spending programs, whereas macro-econometric models typically use quarterly data and represent fiscal policies in broad rather than detailed ways.

At the same time, budget forecasts are not prepared in isolation from economic forecasts because the economy is a key driver of tax and spending bases. To take this into account, “a widely accepted solution” (Leal et al., 2007) is to generate the economic forecasts first, and then use those forecasts in preparing the budget forecasts using separate procedures. This compromise has two potential shortcomings.

First, because the fiscal forecasts are produced using a separate procedure, there is no guarantee that the fiscal forecasts effectively use all of the information contained in the economic forecasts. One way of guarding against this is to use the more aggregate fiscal forecasts from the macro-econometric model as a cross-check on the more detailed fiscal forecasts produced by the fiscal specialists.

Second, a forecasting approach that operates in one direction, from the economy to the budget, ignores the fact that, in the opposite direction, the budget affects the economy. To address this, Leal et al. (2007) note that in practice an iterative approach may be followed. In this iterative approach, the fiscal experts produce initial fiscal forecasts based on previous economic forecasts, the economic forecasts are updated to take into account the initial fiscal forecasts, these updated economic forecasts are used to produce updated fiscal forecasts and so on until there is convergence.

The third issue is fiscal policy assumptions. Fiscal authorities typically base their fiscal forecasts on current government policy. However, “very often policy measures are not well-specified in the relevant governmental documents” which means “exerting a high degree of judgement and guess-work” (Leal et al., 2007, p.21). This may be more of a problem in the EU experience reviewed by Leal et al., than in Australia. In any case, the need for judgement is likely to be greater, the longer the projection horizon.

The fourth issue is the fiscal forecasting horizon. Leal et al. (2007) distinguish between short-term, medium-term and long-term horizons.

Within-year fiscal forecasts may be heavily influenced by monthly budget data showing the budget outcome in the year to date.

Medium-term fiscal forecasts are defined as covering a period of two to five years (similar to the "Forward Estimates" period in Australia). Such forecasts will be strongly influenced by the underlying economic forecasts. These fiscal forecasts will also be significant for deliberations on macroeconomic policy, including both fiscal and monetary policy.

Long-term fiscal forecasts are defined as covering the period beyond five years and up to several decades (similar to the Intergenerational Report or IGR in Australia). They provide an assessment of fiscal sustainability in the face of an ageing population. Leal et al. (2007) identify three approaches to making these long-term assessments.

- The first approach, which is taken by the IGR in Australia, is to report sustainability gap indicators showing how much taxes should be increased or expenditures reduced to fulfil the government intertemporal budget constraint.
- The second approach uses "generational accounting" to estimate the financial burden imposed by government on different generations.
- The third approach uses either a general equilibrium or macro-econometric model to make long-term budget projections. This has the advantage of taking into account "the implications of population ageing on consumption, investment and savings decisions" (Leal et al., 2007, p. 27).

Leal et al. (2007) report that the third approach, of using an economy-wide model, is the least popular. They attribute this to such models being difficult to build and understand, the modelling assumptions being open to debate, and the policy conclusions from them being difficult to communicate to the public.

The sustainability gap approach is followed in Australia and many other countries. It involves separately projecting expenditures and revenues to arrive at a projection of the fiscal gap.

The approach followed in making long-term projections of the expenditure side of the budget is generally similar between countries. Drawing on long-term population projections, spending bases are projected including populations of benefit recipients and more intensive users of health, education and other government services. The assumption of unchanged government policy is then applied to these spending bases to project government expenditure.

There are more differences in the approach followed in making long-term projections of the revenue side of the budget.

In the US, the CBO (2016) projects the budget, including revenue, to 2046, a 30-year horizon. Revenue projections are made bottom up. The policy assumption is "that the rules governing all tax sources will evolve as specified under current law" (CBO, 2016, p. 53). Total revenue is forecast to be 18.2 per cent of GDP in 2026, unchanged from 2016, but then to rise to 19.4 per cent by 2046. This rise is mainly due to "real bracket creep". Personal income tax brackets are indexed to prices in the US, but real bracket creep occurs because wages are projected to rise faster than prices based on productivity growth.

In 2016 the CBO (2016, p.22) began to take into account the effects of fiscal policy on the economy throughout the 30-year projection period. In effect, the CBO allows not only for the economy to affect the budget, but also for the budget to affect the economy.

In the UK, the Office for Budget Responsibility (OBR) prepares a fiscal sustainability report on an annual basis. In the latest report, the OBR (2017) projects the budget to 2066-67, a 50-year horizon. Revenue projections are made bottom up. The most significant policy assumption made in projecting revenue is "that allowances and thresholds rise in line with earnings rather than prices beyond the medium-term horizon, turning off fiscal drag after five years" (OBR, 2017, pp. 36-37). The effect of this assumption is total revenue is projected at 36.6 per cent of GDP in 2066-67, unchanged from its projected level in 2021-22.

In Canada, the Department of Finance Canada (2016) projects the budget to 2055-56, a 40-year horizon. Revenue projections are made bottom up. After 2022-23, "all tax revenues, including personal income tax, corporate income tax and Goods and Services Tax revenues, as well as other revenues, are assumed to grow in line with nominal GDP". This rules out both bracket creep and the potential for tax bases to grow at different rates from GDP.

In Singapore, the Ministry of Finance does not appear to publish long-term budget projections. However, the author of this report has constructed an unpublished Long-term Model of Singapore (LTMS) for the Monetary Authority of Singapore (MAS). The LTMS is an OLG model. While Singapore has an ageing population, it is generally recognised that this is not leading to the same government budget pressures that it is in other advanced economies. This is because retirement incomes and retirement health expenses are largely pre-funded through employer and employee contributions to the Central Provident Fund.

In New Zealand, the New Zealand Treasury (2016) projects the budget to 2030-31, a 15-year horizon. Revenue projections are made bottom up. However, after five years, all tax categories are gradually transitioned to "percentages of GDP that are neither higher nor lower than would be expected when the economy is performing at its potential".

In all four advanced economies identified above as publishing long-term budget projections, these projections are issued under the name of the fiscal authority. Expenditure projections are invariably based on the assumption of unchanged policy. However, only at the CBO are long-term revenue projections made under the same assumption. In the UK, Canada and New Zealand, fiscal drag is switched off after five to seven years, resulting in revenue projections that are approximately stable relative to GDP from then on.

In all four countries, there does not seem to be allowance for the possibility that population ageing will result in tax bases growing at different rates. This reflects the simple nature of the underlying long-term economic projections, which appear to invariably assume stable household saving rates, so that consumption expenditure grows in line with income. In reality, population ageing might be expected to have substantial effects on household saving.

The fifth issue is the level of disaggregation. Fiscal authorities are generally required to produce highly detailed budget projections for public accountability. However, it is difficult to ensure that highly disaggregated budgetary projections are consistent with the economic forecasts. For this reason, if a very detailed approach is followed, top-down consistency checks should be performed.

Overlapping Generations (OLG) models

OLG models are a type of CGE model that models each successive generation over the periods of life. Like other CGE models, economic choices are based on optimising behaviour, and any dynamics (beyond population ageing) are likely to be in capital stock adjustment and the accumulation of household wealth and government debt. Introducing multiple generations is a modelling complication that can be justified for policies affecting the allocation of resources across different generations.

Specifically, OLG models can be used to model the effects of government policies concerning retirement incomes and the level of government debt on the economy and the government budget. Further, they can be used to analyse the effects of demographic change, including population ageing.

In contexts where intergenerational issues are not so prominent, another type of CGE model, known as the Ramsey model, can be used. The Ramsey model uses a representative household with a notionally infinite life. The more complex overlapping generations (OLG) model allows for finite lives and focusses on each successive generation over the periods of life.

While the Ramsey model and the OLG model are both types of CGE models, this report follows the convention of referring to the OLG type of CGE model as an OLG model. When the more generic term of CGE model is used, it should be read as a reference to the Ramsey type of CGE model.

Because of their limited attention to short-term dynamics, OLG models are generally used for scenario analysis rather than forecasting. Nishiyama (2013) well illustrates the uses of an OLG model in a US CBO working paper. He implicitly recognises the forecasting limitations of OLG models by not presenting his baseline projection. Rather, he simulates a number of alternative scenarios and reports the ensuing deviations from baseline. These scenarios, which all analyse intergenerational shifts, investigate the effects on the economy and budget of:

- an ageing population;
- shifting the tax burden away from future generations through a permanent reduction in public debt achieved by a tax increase that is maintained for 10 years;
- an intergenerational redistribution from retired households to working-age households through a personal income tax cut that is funded by a cut to government benefits that are partly received by retired households; and
- a related scenario in which a payroll tax cut is funded by a cut to old age benefits.

In summary, OLG models can be used at fiscal authorities to investigate intergenerational issues. Their main use is for scenario analysis and they are predominately used in research reports.

3 Previous Reviews

This section summarises related reviews that have been undertaken previously. These previous reviews generally concerned economic forecasting. Reviews of forecasting at The Treasury were conducted in 2005, 2012 and 2015. A review of forecasting at the Reserve Bank of Australia (RBA), which faces some similar forecasting issues to The Treasury, was conducted in 2014.

The previous forecasting reviews are in broad agreement. When generating economic forecasts, they stress the importance of combining mainstream economy-wide modelling with informed judgement gained from a wide perspective. This review takes a similar view. Thus, this review avoids unnecessary duplication by summarising the findings of the previous reviews, rather than re-considering the same issues in detail.

Where this review mainly differs from the previous reviews is in its scope. This review focusses specifically on modelling. Further, this review considers not only forecasting applications of modelling, but also policy applications.

3.1 Treasury Forecasting Reviews

2005 Review

The 2005 Review of forecasting led to a strengthening of the linkages from the economic forecasts to the Budget revenue forecasts. As a result, the revenue forecasts now more fully reflected the likely effects of fluctuations in nominal GDP on taxation revenue.

The 2005 Review also saw a team established to implement the review's recommendations that were designed to overhaul the data and methodology used to forecast taxation revenue. The team subsequently made major investments in the quality of revenue data sets and forecasting methodology.

2012 Review

The 2012 Review was a "health check" conducted by Treasury with an external advisory panel. It found that the weights placed on the three forecasting methodologies – modelling, business liaison and judgement – were broadly appropriate. Similarly, it found that "Treasury's macroeconomic forecasts have been reasonably accurate" and that "Treasury's revenue forecasts are comparable with, or better than, those of official agencies overseas over the past decade". That said, the Review also made 11 recommendations to improve Treasury's forecasting approach.

In 2013-14 Budget Paper No. 1, Treasury responded to some of these recommendations. In Statement No. 2 Appendix A, it responded to recommendation 5 by providing a review of the economic forecasting errors from the previous Budget. In Statement No. 5 Appendix D, it responded to the four recommendations (numbered 1, 3, 9 and 11) that related specifically to revenue forecasting. This increased emphasis on assessing and learning from forecasting performance and acknowledging forecasting uncertainties has continued. For example, beginning from the 2015-16 Budget, Budget Paper No. 1, Statement 7 covers "Forecasting Performance and Scenario Analysis".

The 2012 Review also noted that while the Treasury has used a macro-econometric model of the Australian economy as a forecasting tool since 1970, this practice ceased in 2010. The NIF model was the first model developed in The Treasury and it was used for forecasting from 1970. This was followed by the TRYM model (Australian Treasury, 1996), which was developed and used from 1993. Then, in 2010 The Treasury decided that TRYM required a major redesign and (at the time of the 2012 forecasting review) it was expected that the redeveloped TRYM model would be back in service in 2013.

The 2012 Review considered that an economy-wide model should play an important role in preparing The Treasury's economic forecasts. Hence, recommendation 2 stated that "it is important to embed the redeveloped TRYM model into the economic forecasting process" (rather than only using it as a consistency check). Similarly, recommendation 4 called for documentation to be published on the models used for economic and revenue forecasting.

In practice Treasury has subsequently subscribed to AUS-M rather than draw upon a redeveloped TRYM model. It has used AUS-M for scenario analysis, but has not embedded it in the forecasting process.

The last complete publication of TRYM was in 2001 and public dissemination of a working version of the model through the ABS was discontinued in October 2011. It appears that The Treasury had lost some of its previous skills and experience in economy-wide modelling and was wary of seeking outside assistance. In any case, The Treasury turned to relying heavily on a more piecemeal approach to applying modelling to its economic forecasting.

For a long time, The Treasury had used two alternative methods for generating short-term forecasts – TRYM and the National Accounts Forecasting Framework (NAFF). The NAFF used rules-of-thumb and judgement to forecast macro variables over a short-term horizon (of about two years), while enforcing accounting identities. The NAFF and TRYM were used in parallel.

With TRYM put to one side, The Treasury shifted its modelling effort to upgrading the NAFF. Econometric equations were overhauled and in some instances developed to forecast around a dozen individual key macroeconomic variables. These variable-by-variable forecasts were then fed into the NAFF to improve its empirical foundations. Thus, the overall effect is that the forecasts rely on a combination of unconnected regression equations, judgement and rules-of-thumb. These judgements are based upon insights from sectoral experts, partial data, forecasting cross-checks, an understanding of international and financial markets, insights of experienced senior staff and outside liaison.

The upgraded NAFF assisted in meeting The Treasury's need for short-term forecasts, but The Treasury also requires economic projections well beyond a two year horizon. For example, economic parameters are required for the Budget Forward Estimates, which extend four years ahead, and for longer-range Budget estimates, which have an 11-year horizon. In addition, the Intergenerational Report (IGR), which is produced less frequently, requires economic projections out to a 41-year horizon.

To generate these medium to long term projections, Treasury developed a "Medium-term Economic Projection Methodology" (Bullen, Greenwell, Kouparitsas, Muller, O'Leary and Wilcox, 2014). This 3-phase projections methodology is reviewed in section 4.

2015 Review

The 2015 Treasury forecasting review (Tease, 2015) re-iterated the recommendation of the 2012 review that an economy-wide model should be embedded in the forecasting process. More generally, the 2015 Review emphasised the benefits that would be obtained by diversifying the forecasting process so that it is not so reliant on the single equation models that feed into the upgraded NAFF. It made recommendations that can be summarised as follows.

- **Economy-wide model**: as recommended by the 2012 forecasting review, an economy-wide model should be embedded in the forecasting process.
- **Forecasting cross-checks**: leading economic indicator models and a small Vector Auto Regression (VAR) model should be used to forecast major macroeconomic indicators as a cross-check on the main forecasts.
- **Stronger macro context**: the forecasting process needs to more fully reflect the role of international and financial market developments in driving the Australian economic outlook.
- **Economic insights**: more senior staff should have a greater role in the forecasting process, so that it reflects their deeper economic expertise and experience.
- **Outside experts**: private sector experts on commodity markets and central bank experts on financial markets should have a greater input into the forecasting process.
- **Staff**: stronger skills are needed in macroeconomic analysis, developing VAR and leading indicator models and in using and interpreting economy-wide models.
- **Model maintenance**: more attention needs to be paid to ensuring that the sectoral models that are used are maintained in good condition in the face of new economic developments and data.
- **Software**: consideration should be given to migrating the forecasting tools from Excel to EViews to improve robustness and transparency.
- **Margins of error**: make the assessment in Budget Statement No. 7 of the risks surrounding the forecasts more comprehensive by allowing for a broader range of uncertainties.

Treasury accepted all of the recommendations of the 2015 forecasting review. It also appointed a panel of external experts to provide advice on forecasting methodologies.

Regarding macro-econometric modelling, The Treasury decided explicitly to "embed an economy-wide model early in the process for the 2016-17 and subsequent budgets". After earlier subscribing to the AUS-M model, more recently The Treasury has decided to build a new macro-econometric model, tailored to its needs and well understood in-house. In section 4 this review considers the options for such a model and makes recommendations.

3.2 Other Reviews

2014 Reserve Bank Forecasting Review

Besides the reviews at The Treasury, a review of forecasting at the Reserve Bank was conducted in 2014. That review (Pagan and Wilcox, 2015) and the Reserve Bank's response (Kent, 2016) are also summarised here. The RBA review is of particular interest to this review because the RBA uses a short-term forecasting framework that is similar to The Treasury's upgraded NAFF, although it appears that the two frameworks were developed independently.

The RBA review (Pagan and Wilcox, 2015), similar to the 2012 and 2015 Treasury forecasting reviews, recommended that the RBA develop an economy-wide forecasting model to strengthen its forecasting process. This model would draw on ideas from the Reserve Bank's existing short-term forecasting framework and from existing macro-econometric models, such as the US Federal Reserve's FRB/US model (Brayton and Tinsley, 1996). This was part of seven recommendations, which are now summarised.

1. **Economy-wide model**: this full-system forecasting model would be developed in steps. In the first step, the existing spreadsheet models used in forecasting at the RBA would be merged together as a single model in a modelling software environment, of which EViews and Dynare are examples that are already in use at the Reserve Bank. Then, ideas from existing macro-econometric models, such as the Fed's FRB/US model, would be used to strengthen the long run properties of the model. Equation dynamics would be further developed by using error correction formulations. The emphasis in the model would be customised to the RBA's forecasting requirements. By comparison, more theoretically based models, such as the RBA's existing DSGE model, are more suited to medium-term analysis than short-term analysis such as short-term forecasting. In short, in terms of the modelling terminology of Pagan and Wilcox (2015) explained in section 2, the new forecasting model should be an ECS model, rather than an ECO model.

2. **Structural change**: structural change in the economy should be taken into account in the modelling drawing on the range of available techniques for doing so.

3. **Improve forecasting process** through these eight sub-recommendations.

    a) *Modelling team*: establish a small dedicated modelling section.

    b) *Extend forecast horizon*: extend the forecast horizon from the short term (two and half years) to the medium term so the current economic cycle runs its course to provide a fuller backdrop for monetary policy formulation.

    c) *Cash rate*: replace the forecasting assumption of an unchanged cash rate with a forecasting assumption that is viable in the medium term e.g. market-consistent forecast, a policy rule or an RBA forecast.

    d) *Unemployment rate*: add the unemployment rate to the published forecasts.

    e) *Forecast risks*: extend the discussion of forecast risks so that it allows more comprehensively for uncertainties.

    f) *Forecast co-ordinator*: appoint a forecast co-ordinator to achieve greater consistency both in the underlying assumptions made in different areas of a forecast as well as in the approach from one forecasting round to the next.

    g) *Examine past errors routinely:* forecast errors should be systematically examined at regular intervals and lessons drawn, rather than examined as a one-off exercise.

h) *More debate:* forecasts and policy positions should be openly debated with opposing sides arranged, so that issues can be thoroughly canvassed, rather than positions imposed by senior management.

4. **Skilled, experienced modellers**: to strengthen modelling it was important to recruit more highly trained graduates and to refrain from rotating such staff out of modelling after a short period such as eighteen months.

5. **Re-prioritise resources in favour of forecasting**: if the recommended resources for modelling and forecasting were not currently available, perhaps some resources could be redirected from International and Asian Economies area and/or the Business Liaison Program, which are both large areas. The high quality and benefit of the work performed by these other areas was acknowledged.

6. **Scholarly activity**: place more emphasis on scholarly activity to improve the independence, quality and visibility of Reserve Bank research.

7. **Better data quality for better forecasts**: advocate for improvements in data quality to help forecasting improvements, including a switch to a monthly CPI, an establishment-based employment survey and more timely quarterly national accounts.

The Reserve Bank (Kent, 2016) has responded to some of these recommendations.

It has accepted parts of recommendation three for improving the forecasting process. In particular, from recommendation three, it has adopted parts (a), (c), (d) and (e). It does not intend to pursue recommendation (5).

Importantly for this review, the Reserve Bank has largely adopted recommendation one, to develop and use a macro-econometric/ECS model for forecasting. To develop its new model the RBA has established a dedicated team of five macroeconomic modellers. This is in addition to its 2-person team who maintain the RBA's existing Dynamic Stochastic General Equilibrium (DSGE) model, which is designed primarily for analysing the cyclical effects of changes in monetary policy, commodity prices and other macroeconomic shocks, rather than for forecasting.

Pagan and Wilcox saw the new macro-econometric model as a further development of the existing forecasting framework. However, the RBA intends to still maintain its forecasting framework and keep it at the centre of the forecasting process.

> *Our forecasts will still be generated by a range of analysts and will feature a degree of judgement, rather than be mechanical, model based forecasts. However, the forecasts will be usefully informed by the insights and analysis that full system models can provide. (Kent, 2016)*

Interestingly, this RBA view appears to assume that judgement cannot be applied to model-based forecasts, which are characterised as "mechanical". In reality, judgement is routinely applied to model-based forecasts through so-called residual adjustments, also known as add factors or z-adjustments.

Skilful economy-wide model-based forecasters recognise the value added from superimposing judgement on their forecasts rather than using models in a mechanical fashion. As McNees (1990) notes “it is difficult to imagine that anyone could seriously expect them (models) to incorporate all information with predictive content”.

Historical experience at both the RBA and The Treasury indicates that having separate forecasting frameworks and macro-econometric models carries risks. The model-based forecasts may not be influential if they are not well understood by those using a forecasting framework to generate the official forecasts. The model-based forecasts may even be mistakenly perceived as a threat.

An integrated strategy, such as that recommended by Pagan-Wilcox in their forecasting review for the RBA, may be more successful. This places the economy-wide model at the centre of a wider forecasting process. That wider process draws on sectoral experts, senior staff and outside liaison to inform judgemental adjustments. The modellers and sectoral experts work closely together.

2013 Capability Review of The Treasury

While the reviews discussed so far have concerned forecasting, this review is concerned with the overlapping topic of modelling capability. The Treasury’s modelling capability was briefly considered as part of a 2013 review of the capability of the entire department. The comments of that review (Australian Public Service Commission, 2013) on The Treasury’s modelling capability were as follows.

> *Treasury’s modelling performance has been the subject of extensive public and media attention. Knowledgeable and respected external parties contacted as part of the review expressed the view that Treasury’s modelling capability is among the best in the country, and respected internationally. External review has supported its quality, and Treasury continually aims to refresh its models to reflect new perspectives. Treasury is an intensive user of data from the Australian Bureau of Statistics and a range of other sources to maintain currency. Documentation of models has been less thorough than would be desirable. There is opportunity to build on work underway in the Domestic Economy Division to ensure models are documented and maintained.*

This review agrees with the above general statement. This review gives a more detailed assessment of The Treasury’s modelling capability against best practice for a fiscal authority in an advanced economy and makes specific recommendations to achieve that best practice.

4 Macroeconomic Group

The main types of economic models used at fiscal authorities in other advanced economies were introduced in section 2 as an international benchmark. There, each type of model was classified according to the group in The Treasury that could potentially use it. This report now reviews the models that each group in The Treasury actually does use or plans to use, against the international benchmark.

This section reviews Macroeconomic Group, followed by Revenue Group in section 5 and finishing with Fiscal Group in section 6. The fourth Group with advisory responsibilities is Markets Group, but it does not currently use economic modelling. The four advisory Groups are supported in Treasury by the fifth Group, which is Corporate Group.

In some cases in The Treasury, a model is housed in one Group but is used in another Group. This raises the issue of whether such models should be reviewed under the Group that houses the model or under the Group that uses the results. Here models are reviewed under the Group that uses the results. This perspective was chosen because it is important that modelling activities are well integrated with each Group's advisory responsibilities.

Macroeconomic Group is responsible for monitoring and forecasting the Australian economy. It also provides advice on domestic macroeconomic policy and international economic policy issues. Within Macroeconomic Group, the Macroeconomic Conditions Division (MECD) provides advice in relation to the Australian economy. The International Policy and Engagement Division (IPED) provides the advice on international economic policy issues. Macroeconomic Modelling and Policy Division (MMPD) provides the macroeconomic policy advice and undertakes economy-wide modelling, including for Revenue Group.

This review of Macroeconomic Group starts in section 4.1 with a stocktake of its existing macroeconomic modelling capability against the international benchmark established in section 2.1 (which should be read before this section). This is followed in section 4.2 by proposals for approaching that international benchmark. The main recommendations for further developing the modelling capability of Macroeconomic Group are in section 4.3.

4.1 Modelling Capability Stocktake

For Macroeconomic Group, the two most obvious applications for economy-wide modelling are macroeconomic forecasting and macroeconomic policy analysis. As discussed in section 2.1, the model types used for these purposes at other fiscal authorities are VAR (forecasting), DSGE (policy) and macro-econometric (forecasting and policy).

In practice, as discussed in section 3, The Treasury uses its upgraded NAFF for forecasting, and a subscription macro-econometric model, AUS-M, for macro policy analysis. However, The Treasury has plans to upgrade the modelling capability of Macroeconomic Group. These plans include developing a new macro-econometric model, and developing its own version of the RBA DSGE model.

This review considers these current modelling practices and plans in the context of the functions of Macroeconomic Group. The modelling approach to macro forecasting is reviewed first, followed by the modelling approach to macro policy analysis.

The development of the new macro-econometric model was recommended by the 2015 Forecasting Review (Tease, 2015). Hence, the primary purpose of the new model is macro forecasting. However, because macro-econometric models can also be used for macro policy analysis, the new macro-econometric model is included below in both the macro forecasting and macro policy discussions.

The idea of developing a Treasury version of the quarterly RBA DSGE model is set out in a development plan provided by MMPD (2016). Because DSGE models are usually used for analysis of macro policy and the economy cycle, the MMPD proposal is discussed below under macro policy.

Uncommonly, MMPD has a different function in mind for the RBA DSGE (Treasury) model. It does not intend to use the RBA DSGE (Treasury) model "to undertake counter-cyclical analysis". Instead, it intends to model permanent economic reforms, including "major reforms to tax policy, social policy". As discussed in section 2, such permanent reforms are usually analysed using models that focus primarily on the structure of the economy and long run behaviours, particularly CGE models, rather than models that focus primarily on the economic cycle, such as DSGE models. The Treasury's existing capabilities and options for modelling permanent reforms are assessed in sections 5 and 6.

Besides developing its own version of the RBA DSGE model, MMPD is also developing its own version of the Overlapping Generations (OLG) model of Kudrna, Tran and Woodland (2015) or KTW OLG. As discussed in section 2, fiscal authorities use OLG models in areas that are covered by Fiscal Group and, to a lesser extent, Revenue Group. Thus, the potential uses of KTW OLG (Treasury) are reviewed in sections 5 and 6.

In recent years MMPD (including its predecessor MMD) has undertaken economy-wide modelling for some major government reviews. It undertook the 2008 modelling for an emissions trading scheme and the related 2011 modelling for a carbon tax. This carbon price modelling is reviewed following the discussion of macro policy modelling. MMPD also undertook the economy-wide modelling for the recent tax review process. As this modelling was in support of Revenue Group, it is reviewed in section 5.

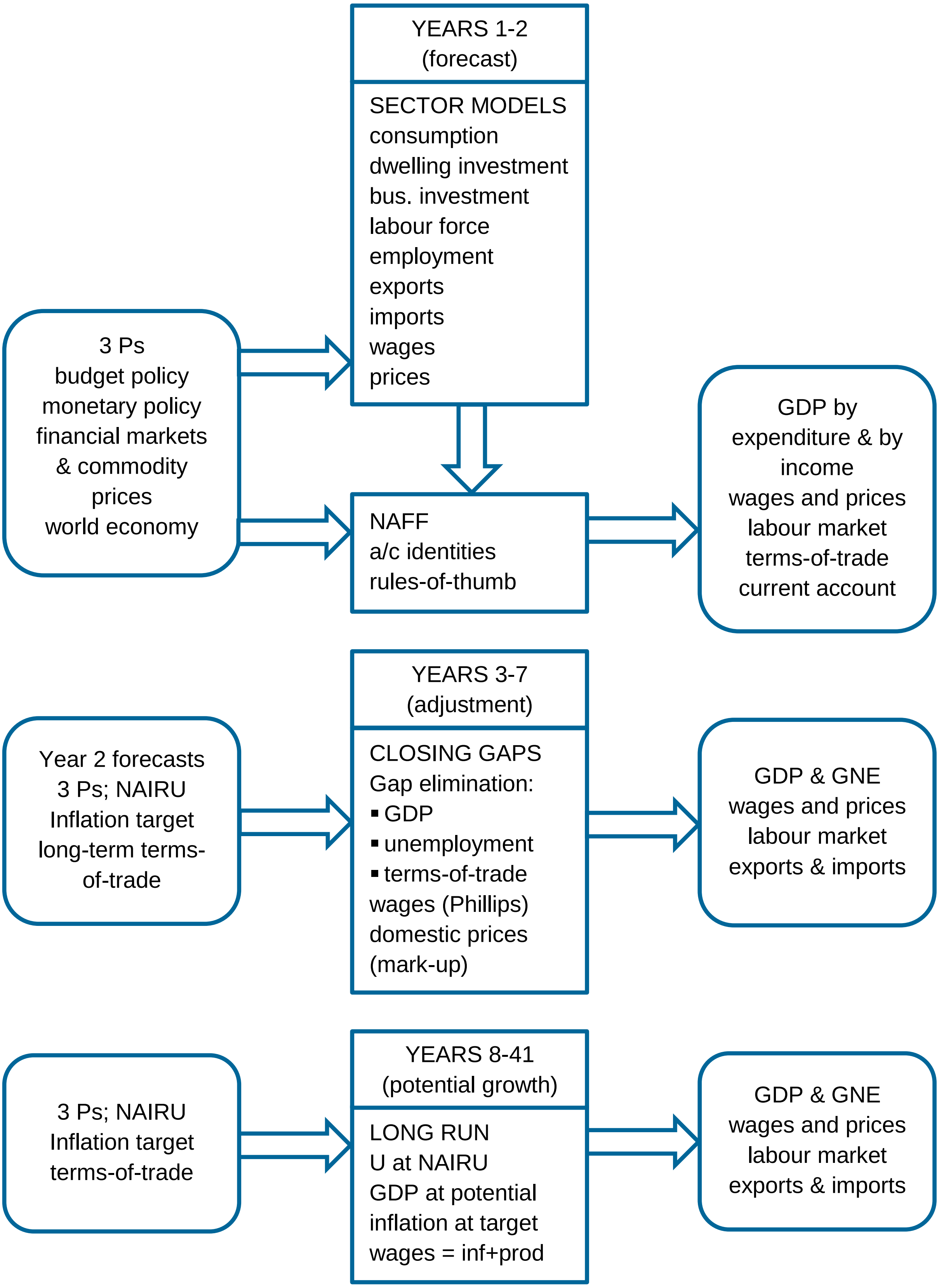
Macroeconomic forecasting

As previously discussed, The Treasury currently employs a 3-phase approach to generating its economic forecasts, but has recently decided to follow fiscal authorities in other advanced economies by using a macro-econometric model. VAR models can also contribute to the forecasting process. The potential contribution to forecasting at The Treasury of the 3-phase forecasting approach, a new macro-econometric model and a VAR model are now discussed in turn.

3-phase forecasting approach

As foreshadowed in section 3.1, rather than using a macro-econometric model, The Treasury currently employs a 3-phase approach to forecasting. This involves a 2-year short-term forecast, a 5-year cyclical adjustment phase, and a long-term projection. This is depicted in Figure 4.1. These three phases are now discussed in turn.

Figure 4.1
Macroeconomic Forecasts/Projections Over Different Time Horizons



The "forecast" phase, which extends over the first two years, is represented in the top panel of Figure 4.1. In this phase an upgraded National Accounting Forecasting Framework (NAFF) is used. This combines the traditional NAFF with around a dozen individual regression equations for forecasting key macro-economic variables. These equations, which are estimated in EViews, cover the following macro-economic variables:

- household consumption (divided into housing services and other);
- dwelling investment;
- business investment (divided into non-dwelling construction and other);
- labour supply (distinguishing trend and cyclical effects);
- employment (in heads and hours);
- exports (divided into rural, mining and other);imports;
- wages; and
- prices.

These single equation forecasts are fed into the National Accounting Forecasting Framework (NAFF), strengthening its empirical foundations. The NAFF itself enforces national accounting and other identities, and uses various forecasting rules-of-thumb. Thus, the overall effect is that the forecasts rely on a combination of unconnected regression equations, rules-of-thumb and judgement. These judgements are based upon insights from sectoral experts, partial data, forecasting cross-checks, an understanding of international and financial markets, insights of experienced senior staff and outside liaison. Because the regression equations are partly driven by variables determined within the NAFF, there is an informal process of iteration between running the regression equations and running the NAFF to achieve a reasonable level of consistency.

The forecast phase is followed by an adjustment phase and a potential growth phase. The later phase extends from year eight to year 41, taking it to the end of the horizon of the Intergenerational Report (IGR). This phase of assumed long-run equilibrium is represented in the bottom panel of Figure 4.1. In this phase, unemployment is set to equal its sustainable rate or NAIRU. GDP is projected simply from the labour supply using the "3Ps" of population, participation and productivity. Price inflation is steady at the 2.5 per cent midpoint of the Reserve Bank's target band. Wage inflation is higher at 4 per cent, reflecting trend productivity growth of 1.5 per cent.

These short-term and long-term projections need to be knitted together. To achieve this, the short-term forecast from the upgraded NAFF is joined to the long-term path from the potential growth phase over a five-year period of "cyclical adjustment", extending from years three to seven. In this adjustment period, unemployment converges linearly from its level at the end of the forecast period to the assumed NAIRU. This is associated with actual GDP converging to potential GDP. This "cyclical adjustment" phase is shown in the middle panel of Figure 4.1.

This 3-phase approach recognises that the resolution of any initial disequilibrium in the labour market will affect the economic outlook. However, this resolution occurs through a mechanical assumption applied over a 5-year adjustment period, extending from year three to year seven of the forecast.

Further details of the 3-phase approach are provided in Bullen et al. (2014).

macro-econometric model

This 3-phase approach can be contrasted with using a macro-econometric model to generate forecasts. As set out in section 2.1, macro-econometric models are widely used at fiscal authorities in advanced economies for generating forecasts.

For forecasting over multiple horizons, macro-econometric models aim to combine strong short-term empirics with well-defined long-term economic properties. As discussed further later, whatever forecasting model is used, judgemental adjustments will always be important, especially in the first year or two of the forecast. They are needed to allow for factors not already taken into account in the model.

A macro-econometric model aims to represent a wide range of imbalances in the economy. These include not only labour market imbalance, but also imbalances in goods markets, business and housing capital stocks, private saving and net assets, and government deficits and debt. The model then uses empirical evidence gained from econometric analysis of past data to model how these and other imbalances are resolved.

Fiscal authorities find macro-econometric models attractive for several general reasons. Such models take a consistent, seamless approach over the full projection period, have strong empirical foundations, incorporate solid macroeconomic analysis, and can be readily used to generate alternative scenarios.

In the case of The Treasury, a macro-econometric model has the following specific advantages compared to the existing 3-phase forecasting approach.

1. In a macro-econometric model the labour market adjustment process, like other adjustment processes, is based on the historical evidence gained from econometric analysis of past data. This is superior to the mechanical assumption used in the 3-phase approach of linear adjustment over five years.
2. A macro-econometric model takes into account that other imbalances in the economy, beyond the labour market, also influence the economic outlook. As mentioned above, this includes any initial imbalances in goods markets, business and housing capital stocks, private saving and net assets, and government deficits and debt. Such imbalances are not taken into account in the second and third phases of the 3-phase approach.
3. More generally, a macro-econometric model adds robustness to the forecasts. All methodologies can forecast an economy growing smoothly and can be upset by highly unusual shocks such as the GFC. However, a macro-econometric model, by capturing a range of economic imbalances and how they have been resolved historically, is more likely to anticipate swings in the economy than the 3-phase approach.
4. A macro-econometric model can be readily used to draw out key uncertainties in the economic outlook. This can be done by simulating alternative scenarios for the world economy, the 3Ps and other factors feeding into the forecast. Simulating alternative scenarios is somewhat problematic using the 3-phase approach. There is the need to iterate between the individual regression equations and the NAFF to achieve consistency. Economic responses across the three phases are unlikely to be fully consistent. Finally, the 3-phase approach captures a more limited range of economic responses; a macro-econometric model represents behavioural responses in a more comprehensive and integrated way.

5. A macro-econometric model can also be used for macro-economic policy analysis. In one form, scenario analysis is used to examine the economic impacts of shifts in macroeconomic policy and non-policy shocks. In another form, optimal control is applied to assess the optimal response of macro policy to different shocks or to generate optimal policy settings. In contrast, the 3-phase approach is not designed for macro-economic policy analysis. The use of models in macroeconomic policy advice is considered further in the next sub-section.

6. A macro-econometric model would be a more effective tool in developing the macroeconomic advisory skills of Treasury officers than the existing 3-phase approach. Macroeconomic analysis is about more than the closing of output gaps, as reflected in points 2-5 above. Macro-econometric modelling helps develop a good understanding of the Australian macro-economy, enhancing the capability of Treasury officers to provide expert advice on macroeconomic forecasts and policy. The modelling process also helps develop general analytical skills.

Giving these advantages, it is unsurprising that the 2012 and 2015 Treasury Forecasting Reviews recommended that an economy-wide model be embedded in The Treasury forecasting process and this review concurs.

Equally, the 2015 Review recognised that an economy-wide model should be viewed as part of a wider forecasting process. That wider process includes input, which currently informs judgement incorporated into the upgraded NAFF, such as from sectoral experts, forecasting cross-checks, an understanding of international and financial markets, insights of experienced senior staff and outside liaison. This raises the issue of how these non-model sources of information should be taken into account when forecasting with a model.

Some non-model information concerns the international economic environment, the 3Ps and government policy. This type of information is covered by the exogenous variables or inputs to a national macroeconomic model. These inputs should always be set based on the best information available from all sources.

Other non-model information concerns endogenous variables or outputs of a macro-econometric model. This information might include the predictions of other types of models (such as Vector Auto Regression (VAR) models), expectations surveys, the views of experienced senior staff, and information gained from business liaison. Forecasts from macro-econometric models are readily and routinely adjusted to take into account such information through so-called residual adjustments, also known as add factors or z-adjustments.

While it is reasonably straightforward to adjust model-based forecasts using judgement, the question arises as to how readily this should be done. The value of judgemental adjustments in macroeconomic forecast accuracy has been analysed by McNees (1990), who finds as follows.

> *The best forecasts are made, not by abandoning models or by abandoning judgment, but by blending both sources of information.*

That model-based forecasts can be made more accurate by applying judgement to them is unsurprising. As McNees (1990) notes “it is difficult to imagine that anyone could seriously expect them (models) to incorporate all information with predictive content”.

At the same time, McNees (1990) finds that, in practice, adjustments are overdone.

> *Judgements usually enhance forecast accuracy…(but) the adjustments that were made were typically too large…(reflecting) the prevailing tendency to place too much weight on the specific circumstances and too little on the model.*

This leads McNees (1990) to the following conclusion.

> *While it would be a mistake to ask forecasters to refrain from adjusting their models, it is also a mistake to accept the adjustments that are made at face value, especially when the adjustments appear without any explanation of the reasoning behind them.*

In short, the evidence indicates that the most accurate forecasting requires a well-developed model supported by carefully analysed judgements.

Forecasting with a macro-econometric model also has another advantage, besides greater accuracy. A macro-econometric model automatically provides the forecasts with an economic interpretation, because the model is based on economic behaviour. Such an interpretation can be more elusive when forecasts are generated using a forecasting framework such as the upgraded NAFF.

VAR model

In section 2.1 it was found from the experience of fiscal authorities in advanced economies, including at the US CBO, that Vector Autoregression (VAR) models can play a useful role in cross-checking the forecasts from a macro-econometric model. In particular, a VAR can provide benchmark forecasts for a handful of key variables over a short-term horizon. This cross-check can be applied both in assessing the forecasting track record of a fiscal authority, as well as in each forecasting round.

Early Australian examples of VAR models include Smith and Murphy (1994) and Dungey and Pagan (2000). It is understood that The Treasury has used the Dungey and Pagan VAR model in the past for cross-checking its forecasts. There would be merit in keeping to that practice or developing its own VAR model from the latest data for the same purpose.

Macroeconomic policy analysis

Following the retirement of the TRYM model, in recent years The Treasury has not been active in publishing its own model-based analyses of macro policy. For example, The Treasury drew on other types of research in estimating the macroeconomic effects of the fiscal stimulus that was applied in response to the GFC.

This situation may soon change. The Treasury has decided to develop a new macro-econometric model. In addition, The Treasury is working on its own version of the RBA DSGE model. Hence, The Treasury may soon have a choice between two different models for analysing macroeconomic policy.

RBA DSGE (Treasury) model

The Treasury is working towards developing its own version of the RBA DSGE model.

As discussed in section 2.1, the quarterly RBA DSGE model (Rees et al., 2016) can be characterised as a version of the Smets and Wouters (2007) model of the US that has been customised to Australia. It "is intended primarily for use in scenario analysis rather than as a forecasting tool". Hence it is included in this discussion of models and macro policy analysis and was not included in the preceding discussion of models and macro forecasting.

The key innovation of the RBA's New Keynesian DSGE model is that it distinguishes three sectors – a non-tradeable sector, a resources sector and a non-resources tradeable sector. This is so the RBA model can be used to analyse the effects in Australia of shocks to resource prices. The RBA has long experience with highly-qualified staff in DSGE modelling, and this is reflected in the sophisticated design and applications of its current DSGE model.

Comparing the RBA DSGE model to the DSGE models that are used at government agencies and described in Coenen et al. (2012), two possible improvements can be suggested.

- The elasticity of intertemporal substitution could be reduced from the value of 1 sometimes assumed in academic studies, to a value between 0.24 and 0.5. This range is based on the DSGE models from government agencies used in Coenen et al. (2012). It is also consistent with Havranek (2015), who estimates a value of 1/3 from an analysis of many empirical studies. Lowering the elasticity of intertemporal substitution would also reduce the problem highlighted by Blanchard (2016) of unrealistic twisting of consumption paths in response to interest rate changes.
- Financial frictions might be introduced, to help account for an episode such as the GFC. Some of the DSGE models referred to in Coenen et al. (2012) do this, and it is taken further in Benes, Kumhof and Laxton (2014)[18] who introduce a banking sector.

The RBA can use its DSGE model to simulate 17 different shocks to the macroeconomy, including shocks to monetary policy, the exchange rate (via the risk premium) and resource prices, as demonstrated in Rees et al. (2016). It seems generally well suited to the RBA's scenario analysis purposes.

The RBA is already using its model to analyse monetary policy and the economic cycle. This raises the question of whether The Treasury could further develop the RBA's model to analyse fiscal policy and the economic cycle. This application of DSGE models was discussed in section 2.1.

The existing RBA model has a simple treatment of fiscal policy that can be summarised in four points.

1) There is a single category of government spending (public final demand).
2) There is a single category of tax, which is assumed to be "lump sum" and therefore non-distortionary.
3) "Ricardian equivalence holds" (Rees et al., 2016, p. 379), so the scope for counter-cyclical fiscal policy through changes to taxes and/or benefits is essentially assumed away.
4) There is always a balanced budget through automatic adjustment of the lump sum tax, and hence there is no government debt.

[18] I would like to thank Adrian Pagan for drawing my attention to this IMF study.

For The Treasury to use the RBA DSGE model to meaningfully analyse fiscal policy and the economic cycle, it would need to incorporate the standard features that are included in DSGE models that are used for that purpose. As discussed in section 2.1, these features can be identified from the DSGE models used in the Coenen et al. (2012) study of fiscal stimulus. Incorporating these features changes the four points used to describe fiscal policy in the existing RBA model to the following.

1) Multiple categories of government spending are recognised, which can include productive government investment, transfer payments and government consumption.
2) Some distortionary taxes are distinguished, the main examples being consumption taxes, labour income taxes, and capital income taxes.
3) Ricardian equivalence is relaxed by assuming that 20 to 50 per cent of households are financially constrained, introducing a link from current income to consumption.[19]
4) There is a fiscal rule in which either a labour income tax or a lump sum tax is gradually adjusted to achieve fiscal equilibrium in the long term rather than in every quarter.

A comparison of the two 4-point lists shows the substantial model development program that would be needed. Further, the use of DSGE models in advanced economies is common at monetary authorities, but is limited at fiscal authorities, who rely more on macro-econometric models. It is significant that four of the DSGE models used in the Coenen et al. (2012) study of fiscal stimulus were sourced from monetary authorities, but none were sourced from fiscal authorities.

MMPD advise that they do not intend to use the RBA DSGE (Treasury) model "to undertake counter-cyclical analysis". The reason for this is unknown, but it would remove the main rationale for The Treasury to be involved in DSGE modelling.

macro-econometric model

The Treasury has a second option for developing a modelling capability for macroeconomic policy analysis. It could build this capability into the macro-econometric model that it is already committed to developing for forecasting purposes.

Fortunately, the type of macro-econometric model that The Treasury needs for forecasting is also likely to be readily adaptable to macro policy analysis. As discussed in the macroeconomic forecasting section, The Treasury needs a macro-econometric model with strong short-term empirics and well-defined long-term economic properties. This is because, in different contexts, its forecasting horizon varies from two years to 41 years. This same combination of short-term and long-term strength is also needed when using a macro-econometric model for macro policy analysis.

Macro-econometric models obtain this strength over multiple horizons by employing suitable macro-economic and econometric approaches. On the macro-economic side, they assume sticky prices and profit maximisation, while allowing for slow adjustment of capital stocks. This results in a transition from a Keynesian short run in which economic activity is demand determined, to a neoclassical long run in which it is supply determined. This conforms to the mainstream paradigm for macro policy

[19] For example, the MSG model (McKibbin and Sachs, 1989) and the Bank of Canada ToTEM II DSGE model (Dorich, Johnston, Mendes, Murchison and Zhang, 2013) introduce "Keynesian" or "current-income consumers", alongside inter-temporally optimising "life cycle" or "unrestricted lifetime-income consumers".

analysis. On the econometric side, they adopt error correction models that allow evidence from the historical data to flexibly determine the speed at which a macro variable adjusts to a well-defined long run equilibrium.

This approach to macro-econometric modelling is well established in Australia. It began with the TARGET model, initially developed in The Treasury by the author of this report in 1982-83 and then further developed as the AMPS model at the Office of EPAC (Murphy, Bright, Brooker, Geeves and Taplin, 1986). This was followed by the Murphy model (Murphy, 1988a), which introduced model consistent expectations in financial markets (Murphy, 1988b). This model's well-defined long run properties were investigated in Murphy (1992). Fully-integrated industry detail was added in MM2 (Powell and Murphy, 1997), making it a dynamic CGE model. Next, the Independent macro model (Murphy and Prihardini, 2013) was developed from scratch, with a more modern treatment of monetary policy and household saving and streamlined industry detail. Most recently, semi-endogenous growth was added (Independent Economics, 2015).

Taplin, one of the authors of the AMPS model, led a team at the Treasury that developed the TRYM model (Australian Treasury, 1996). TRYM falls within the same general class of model, but has its own distinctive features. Later AUS-M (Downes, Hanslow and Tulip, 2014) was developed by adding industry detail and other modifications to TRYM.

The Treasury requires a macro-econometric model that is customised to its forecasting requirements. Besides the usual broad macro-economic forecasts, The Treasury requires a large number of forecasts of economic parameters to support Budget estimates. One reason for instigating the project to redesign TRYM was a concern that TRYM was not sufficiently customised to The Treasury's specific forecasting needs.

Against this background, The Treasury has made the understandable decision to develop a new economy-wide model, customised to its forecasting requirements. Section 4.2 discusses the potential general shape of this new model, placing most weight on the primary aim of meeting The Treasury's forecasting requirements. However, the proposed general design also meets the secondary aim of providing a tool for macroeconomic policy advice.

Macro-econometric models can be used for macro policy analysis using two different approaches. The first approach is scenario analysis, while the second approach is optimal control. Both approaches are utilised with MM2 in Murphy (1997) and with the Independent macro model in Murphy and Prihardini (2013).

Under scenario analysis, the model's responses to changes in monetary and fiscal policy are investigated. The model may also be subject to a range of non-policy shocks that policy makers have to contend with; these typically include demand shocks, supply shocks and external shocks. The results of the policy and non-policy scenarios are then compared to draw broad conclusions how changes in monetary and fiscal policy might be used to help negate the destabilising impacts of the non-policy shocks.

Optimal control takes this a step further: the design of monetary and fiscal policy responses to the non-policy shocks is optimised. This typically involves first placing relative weights on the importance of controlling unemployment and inflation. The non-policy shocks are then applied to the model and an optimal control algorithm is used to obtain the optimal responses for monetary and fiscal policy to each shock.

An interesting variation of this is to use optimal control to derive the optimal current stance for monetary and fiscal policy and the associated forward plan (Murphy and Prihardini, 2013). However, as Pagan (1997) notes, this "open loop" use of optimal control is subject to the qualification of potential time inconsistency. The policy plan may be revised over time, even if there are no new non-policy shocks, reducing the credibility of that plan. However, open loop optimal control remains popular.

Perhaps the highest profile use of open loop optimal control at present is by the US Federal Reserve. Recent examples are Brayton, Laubach and Reifschneider (2014) and Reifschneider (2016). Both papers use the Fed's macro-econometric model, known as the FRB/US model (Brayton and Tinsley, 1996). This falls into the same general class of macro-econometric models discussed above.

Brayton et al. (2014) use optimal control to provide a model-based perspective on the optimal current stance for US monetary policy. Naturally, this use of optimal control by the Fed attracts considerable public attention (Boesler, 2013). Reifschneider (2016) uses optimal control to derive the optimal response of monetary policy to a hypothetical recession.

As Pagan (1997) notes, optimal control is also a useful form of model validation. If the optimal policy outcomes do not appear to be reasonable, this may indicate problems with one or more linkages in the fiscal or monetary policy transmission mechanisms.

Interestingly, the US Fed chooses to use its FRB/US macro-econometric model over its DSGE model for its optimal control analysis of the stance of monetary policy. This may be because forecasting performance is important for this type of policy analysis. In any case, it suggests that The Treasury can be reasonably comfortable using its new macro-econometric model (in the style of MM2, TRYM, FRB/US etc) to undertake macro policy analysis.

Carbon pricing

Carbon price modelling was led by the Macroeconomic Modelling Division (MMD) (whose functions have since been included within MMPD) for "Strong growth low pollution: modelling a carbon price" (Australian Government, 2011). This followed a similar modelling approach to "Australia's Low Pollution Future - The Economics of Climate Change Mitigation" (Australian Government, 2008).

The impacts of alternative scenarios for global emissions reductions on the global economy were estimated using the GTEM model developed by ABARES. In Australia, emissions were assumed to be reduced via a carbon price, in line with government policy at that time. The impacts on the Australian economy were estimated using the MMRF model developed by the Centre of Policy Studies. This CGE modelling was enhanced using specialised models of energy-generating sectors.

The flow-on effects to the cost of living for different types of households were estimated using The Treasury's PRISMOD models, which are discussed further in the section dealing with Revenue Group.

While this climate price modelling was based on outside models (apart from the in-house PRISMOD), The Treasury then developed its own Computable General Equilibrium (CGE) model for climate change analysis, the Treasury CGE model or TCGE. Constructing TCGE involved linking together the two CGE models used previously, MMRF (now known as VURM) and GTEM (MMPD, 2016). One aim of this exercise was to build The Treasury's CGE modelling capability. However, The Treasury is no longer using TCGE, citing a concern that this class of CGE models has an outmoded treatment of household saving and business investment that does not fully incorporate intertemporal optimisation (MMPD, 2016). At the same time, the Treasury does not appear to be working on any replacement for this carbon price modelling capability.

4.2 Roadmap

This section sets out the recommended roadmap for macroeconomic modelling at The Treasury.

Macroeconomic model

In developing a modelling roadmap for macro modelling at The Treasury, this review has assessed the Macroeconomic Group's existing macro modelling capability (section 4.1), against macro modelling at fiscal authorities in other advanced economies (section 2.1). Based on that assessment, this Review considers that The Treasury should develop a new economy-wide model to embed in its forecasting process. This model should be customised to The Treasury's forecasting needs. This review recommendation echoes the recommendations of the 2012 and 2015 Treasury forecasting reviews.

Macro-econometric models place considerable weight on both macroeconomic theory and the evidence from historical data. This places them in the middle of the spectrum of macroeconomic models, between the more data-based VAR models at one end and the more theory-based DSGE models at the other end. Perhaps because of this balance, macro-econometric models play a more major role at fiscal authorities than either VAR or DSGE models, as seen in section 2.1.

At the same time, VAR models and DSGE models can play useful supporting roles. For forecasting, VAR models can provide a useful cross-check on the short-term forecasts from a macro-econometric model, as seen in section 2.1. DSGE models are likely to be less useful for this purpose: Langcake and Robinson (2013) find that, for Australia, forecasts from a VAR model outperform forecasts from a DSGE model. On the other hand, DSGE models can provide valuable economic depth in thinking about macroeconomic policy and the economic cycle. As discussed in section 2.1, they are particularly popular at central banks.

Accordingly, this Review recommends that The Treasury's new economy-wide forecasting model be a macro-econometric model. As explained in section 2.1, this means a model that combines strong short-term empirics with well-defined long-term economic properties. This combination of short-term and long-term properties is necessary if the model is to generate well-founded forecasts over the wide range of forecasting horizons required for The Treasury's work, which vary from two years to 41 years. This combination of properties has the secondary benefit that such a model is also likely to be suited to macro policy analysis. More specifically, forecasting with a new macro-econometric model, rather than with the 3-phase approach, can be expected to bring the six benefits that were identified in section 4.1.

Figure 4.2 gives a general idea of the economics of producing a forecast using a macro-econometric model. It can be compared to Figure 4.1, which represented the existing 3-phase forecasting approach. This comparison begins with long-run outcomes.

The long-run economic outcomes under each approach are shown at the bottom of Figures 4.1 and 4.2. Under the 3-phase approach, the economy reaches a long run equilibrium in which unemployment is at a sustainable rate (NAIRU) and inflation is at the midpoint of the Reserve Bank's target range. This is also the case with a macro-econometric model. However, the macro-econometric model goes further.

In the long-run equilibrium of a macro-econometric model, businesses maximise profits subject to a production function in which both labour and capital appear as inputs. This means that production depends not only on the level of employment but also the size of the capital stock. Further, businesses choose the capital to labour ratio that minimises costs. Finally, capital stocks have adjusted such that capital receives a required rate of return. None of this is built in to the long-run equilibrium of the 3-phase approach.

The long-run equilibrium of a macro-econometric model also satisfies the intertemporal budget constraints faced by government and households. For government, this means that the budget balance and public debt stabilise relative to GDP. For households, it means that net saving and net worth also stabilise relative to GDP. In contrast, under the 3-phase approach there are no feedback mechanisms to achieve sustainability, leaving public and private net worth to follow explosive or implosive paths relative to GDP.

The dynamic paths to these long run outcomes are also different between the two approaches.

In a macro-econometric model, stock-flow identities will keep track of the flow of investment into capital stocks, of budget deficits into government debt and of private net saving to private net worth. These stocks will have feedback effects in the model. None of this occurs in the 3-phase approach.

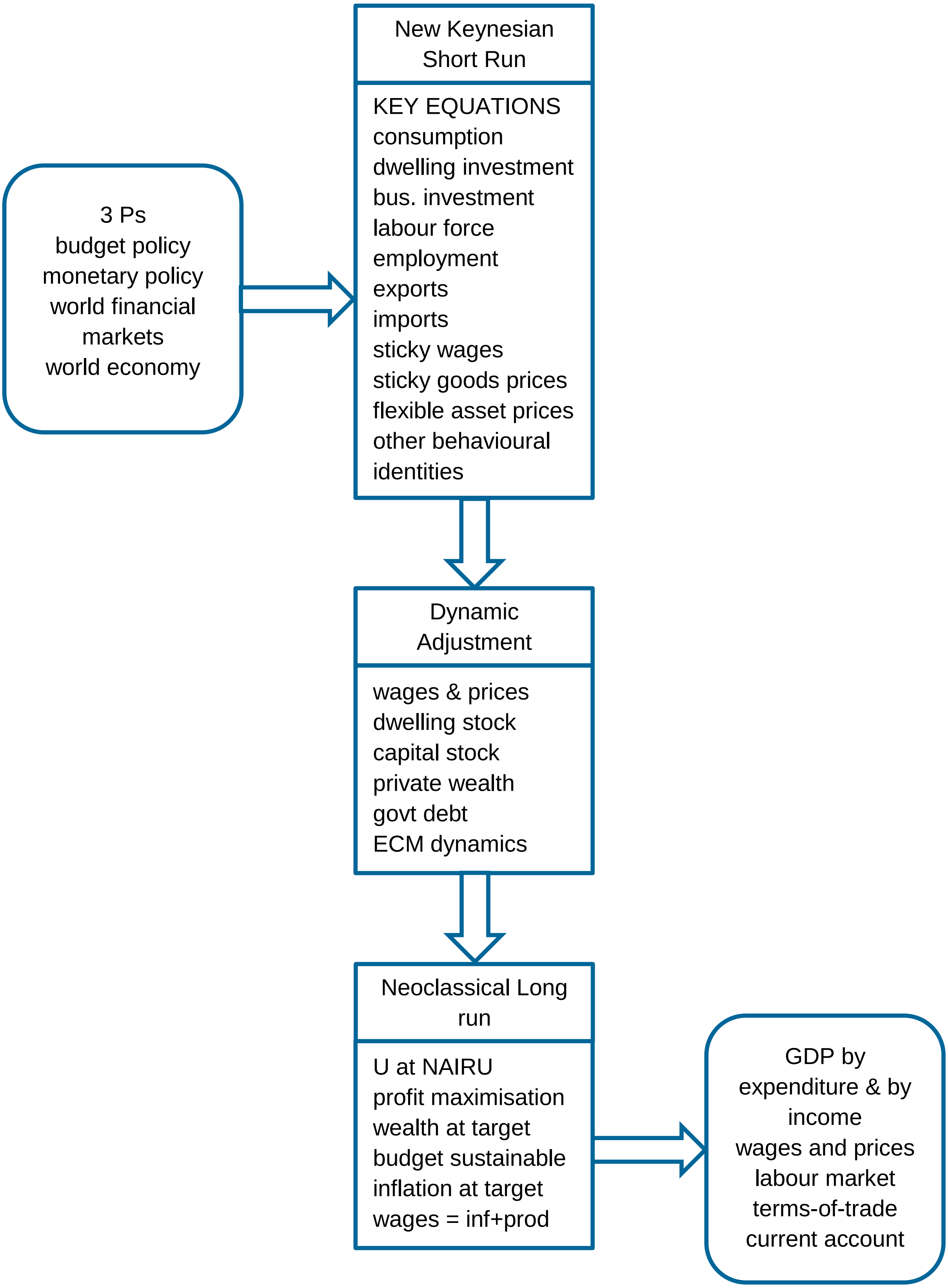
In a macro-econometric model, the dynamic adjustment of each variable towards its equilibrium value is based on parameters obtained from econometric analysis of historical data. Typically, the dynamic structures used are error-correction models, giving the flexibility needed to capture historical patterns of adjustment. Interactions between variables act to the complexity of the adjustment process. Ultimately, the model converges to its long-run equilibrium path, provided stability conditions are met. The adjustment process is smooth rather than separated into phases.

The 3-phase approach, as the name suggests, artificially segments the forecast into three separate phases, as shown in Figure 4.1.

In the first phase or "forecasting phase", which extends over the first two years, the individual regression equations are used. These equations use error-correction models for dynamics and so during this phase there is some similarity with the dynamics of a macro-econometric model. The main differences are that under the 3-phase approach the equations are not formally linked together and there are no feedback effects from the accumulation of productive and financial assets.

In the second phase or "adjustment phase", dynamic adjustment is driven by a mechanical (rather than data-based) assumption that the unemployment rate converges linearly to the NAIRU over a 5-year period. This phase extends from years three to seven. The implicit assumption that the evolution of stocks of productive and financial assets has no impact on the economic outlook over this medium-term horizon is highly questionable.

Figure 4.2
New Macroeconomic Model



While a macro-econometric model offers a higher level of consistency with both economic theory and data than does the 3-phase approach, there are also important common aspects. This can be seen by comparing Figure 4.2 with 4.1.

The individual regression equations used as the sector models of the "forecasting phase" in Figure 4.1 resemble the key equations of the macro-econometric model in Figure 4.2. Similarly, much of the modelling of the 3Ps that plays the central role in the "potential growth phase" in Figure 4.1, carries over to the neoclassical long run in Figure 4.2, particularly for population and participation. Similarly, the NAIRU is a key concept in both approaches. Finally, many of the accounting identities of the NAFF will also be needed in the macro-econometric model.

These common aspects suggest, as similarly proposed by Pagan and Wilcox (2015) in the context of modelling at the Reserve Bank, that the existing 3-phase forecasting approach should be used as the natural starting point for the new macro-econometric model. This approach has two important advantages. First, it ensures that the macro-econometric model improves on the existing 3-phase approach – the benefits of the work in developing the 3-phase approach are not lost. Second, the model development process takes Treasury forecasters on a journey that starts with the approach that they already know, making it easier for them to understand the new model.

Figure 4.2 represents a basic macro-econometric model. Enhancements are possible in several areas. In considering these potential enhancements, there are two important considerations. First, given that it has been a long time since The Treasury developed the TRYM model and the key personnel involved have moved on, it is important that the initial version of The Treasury's new macro-econometric model avoids unnecessary complexities. Second, The Treasury's primary aim is to use the new model for forecasting, with policy analysis a secondary aim. The potential enhancements are now considered taking those two important considerations into account.

1. **budget economic parameters**: Macroeconomic Group needs to provide forecasts for a large number of economic parameters used in preparing projections of the Budget. These Budget economic parameters, which are listed at Appendix A, go well beyond the level of detail found in a basic macro-econometric model. It is important that the Budget economic parameters are fully covered and are consistent with each other. At the same time, as noted above, it is also important that the initial version of The Treasury's new model avoids unnecessary complexities.

   To strike the right balance, it is recommended that the budget economic parameters be sorted into two groups. Parameters in the first group would be determined within the new macro-econometric models, while the remaining parameters would be covered by satellite models. Initially, the majority of the budget parameters would be in the second group. As the model evolves through different versions, it is likely that some budget economic parameters may be gradually transferred from the second group to the first group, although some may remain in the second group.

2. **model-consistent expectations**: It is readily apparent that prices in foreign exchange, bond and stock markets are highly flexible and that agents in these markets respond in a forward-looking way to new information. Credible simulations of alternative economic scenarios should reflect this with upfront adjustments in exchange rates, bond rates and stock prices. In practice, these immediate adjustments in asset prices are usually achieved by assuming model-consistent or rational expectations in financial markets (e.g. Independent Economics (2015)). While this

assumption should only be viewed as an approximation to reality, it remains popular in economy-wide models because of the lack of competitive alternatives.

On the other hand, assuming model consistent expectations in financial markets complicates forecasting. In the absence of adjustments, asset prices will "jump" (up or down) at the start of the forecast, whereas government authorities generally wish to avoid second guessing financial markets in this way. These initial jumps in asset prices can be ironed out through adjustments, and such adjustments can be semi-automated. Nevertheless, adjustments to smooth the transition of asset prices from the historical period to the forecast period are an added complication when forecasting.

In assessing this issue, the two considerations mentioned earlier are important. Thus, taking into account that The Treasury's primary aim for the new model is forecasting and the need to avoid unnecessary complications, The Treasury could consider initially developing a model without model consistent expectations in financial markets. This initial model could use reduced form style equations for asset prices. Once The Treasury is comfortable with using its new model for forecasting and is ready to move on to scenario analysis, The Treasury could consider introducing model consistent expectations in financial markets.

3. **industry detail**: Macro-econometric models traditionally do not distinguish different industries, but some level of industry detail is becoming increasingly common. MM2 (Powell and Murphy, 1997) distinguished 12 industries and later 18 industries, but this partly reflected a desire to use the model for industry forecasting and scenario analysis. For The Treasury's macro purposes, industry detail should only be included to the extent that it contributes to more accurate macro forecasting or scenario analysis. Industry detail may be useful for macro analysis for two reasons.

   First, some of the non-model information that informs The Treasury's forecasts is industry based. As noted previously, The Treasury's non-model information includes insights of sectoral experts, partial data, forecasting cross-checks, an understanding of international and financial markets, insights of experienced senior staff and outside liaison. Examples where this information is industry based include ABARES forecasts of rural prices and volumes, Industry Department forecasts of mining prices and volumes, business liaison with companies in manufacturing and other industries, and the ABS industry-by-industry survey of actual and expected new capital expenditure. It is more straightforward to take this industry-based information into account in a model-based forecast if the model is also industry based.

   Second, it is difficult to robustly forecast some components of GDP by expenditure without an understanding of underlying industry developments. A close watch on developments in the Australian mining industry was key to preparing forecasts of investment and trade during the world commodity price boom.

   With the aim of macro analysis in mind, the Independent macro model (Independent Economics, 2015) distinguishes six industries and the RBA DSGE distinguishes three industries (Rees et al. 2016). Of these two models, the Independent macro model is closer in its aims to the new Treasury model so perhaps it provides the more useful point of reference. It distinguishes the following industries: (i) agriculture; (ii) mining; (iii) manufacturing; (iv) government services; (v) housing services; and (vi) other services.

In the Independent macro model, industries are distinguished where this assists from a macro perspective through more accurate modelling of GDP by expenditure, in real or nominal terms. Agriculture and mining are modelled, with their dependence on fixed factors of production, to allow more muted and realistic supply responses to world commodity price fluctuations. Manufacturing is distinguished because of the domination of imports by manufactures. Government services are separated because they are labour intensive and closely linked to government consumption expenditure. Housing services are distinguished to allow more complete modelling of the housing market to support modelling of housing investment.

Accordingly, it is recommended that these sectors be considered as the starting point in The Treasury preparing a blueprint for the initial version of the new model. Following further consideration of its forecasting needs, The Treasury may decide to include more or fewer sectors.

4. **semi-endogenous growth**: In traditional economy-wide models growth in productivity of labour (and capital) is assumed to be exogenous, as in the Solow-Swan balanced growth model. However, Romer (1990) upended this assumption with the concept of endogenous growth generated by research and development activity and then Jones (1995) proposed a less far-reaching change with his model of semi-endogenous growth. Modelling of semi-endogenous growth is making its way into DSGE and macro-econometric models. It is built in to the Quest III model of the European Commission (Varga and Veld, 2011) and a similar approach is followed in the Independent macro model of Australia (Independent Economics, 2015).

   In particular, the Independent macro model aims to capture the contributions of research and development activity, higher levels of educational attainment, skilled migration and government investment in infrastructure to productivity growth. With some of productivity growth explained by these four productivity drivers, less of productivity growth is left unexplained and exogenous.

   Because these endogenous growth elements evolve slowly, there are unlikely to be important for forecasting over a short to medium term horizon. However, they are likely to be important in projecting to long-term horizons, as in the case of the IGR. They are also likely to be important for meaningfully modelling the effects of changes in government policy towards the four productivity drivers.

   Given the need for simplicity and the focus on forecasting in the initial version of the new model, The Treasury may wish not to include semi-endogenous growth. However, incorporating semi-endogenous growth could be considered as the model evolves, particularly if the model is used to provide economic parameters for the IGR or to analyse the drivers of productivity growth.

5. **intertemporally-optimising households**: The assumption of intertemporarily optimising households is a distinguishing feature of DSGE, OLG and many CGE models. This assumption is appealing at a theoretical level. However, in its pure form, it is rejected by the data, as emphasised by Blanchard (2016). It implies that planned consumption paths swivel when post-tax rates of return on saving change generating high predicted volatility in consumption, whereas in reality consumption follows a smoother path. To better explain the data, the theory is typically softened. This is done by assuming that: (a) a proportion of consumers do not intertemporally optimise but rather base their consumption on current income; or (b) consumption levels are subject to habit persistence; or (c) the elasticity of intertemporal substitution is low so that

consumption paths swivel by relatively small amounts when post-tax rates of return on saving change.

Given the need for simplicity and the focus on short to medium-term forecasting in the initial version of the new model, The Treasury may wish to not assume that households intertemporally optimise. One alternative approach that combines desirable short-term and long-term properties is to assume that consumption is influenced by current income but at the same time households have a long-term wealth target based on their labour income (e.g. Independent Economics, 2015).

Carbon pricing

As noted in section 4.1, MMPD (2016) has successfully undertaken carbon price modelling in the past, but no longer invests significantly in this modelling system, citing a concern that the system has an outmoded treatment of household saving and business investment. At this time, The Treasury does not appear to be working on a replacement system.

Notwithstanding MMPD's reservations about the carbon pricing modelling system used previously, that work was generally regarded as credible. Carbon price modelling is challenging and will always have its limitations.

Some ongoing investment might be made in the carbon price modelling system to help maintain it. This would involve feasible model maintenance, keeping abreast of modelling in this area, and having a plan ready to improve the system if the system needs to be put back into service.

For any future development work, perhaps the most important way in which the existing system could be improved is to allow for forward-looking behaviour in investment. This would take into account that investment behaviour is influenced not only by the current carbon price but also by expected future carbon prices. The modelling would then take into account that a credible, announced plan for higher future carbon prices is likely to reduce emissions sooner than if the plan is not formulated and announced in advance. GTEM and VURM do not currently capture this.

In addition, the assumption of economy-wide perfect competition might be relaxed to take into account the presence of imperfect competition in some sectors. This would allow for more realistic pass through of changes in carbon prices to consumer prices via oligopoly mark-up pricing in some sectors.

4.3 Summary of main recommendations

Macroeconomic Group – Recommendation 1 (macro forecasting model) – higher priority

Prior to this review, The Treasury decided it would develop a new economy-wide forecasting model. This review recommends that the new model be a macro-econometric model, combining strong short-term empirics with well-defined long-run properties. This is necessary so that the model can be used over the greatly varying time horizons (from two to 41 years) required in The Treasury's forecasting/projections work. The new model should use the existing 3-phase forecasting approach as its starting point so the value of the research used to develop it is preserved and to make it easier for Treasury forecasters to learn the new model.

Macroeconomic Group – Recommendation 2 (macro forecasting judgement) – higher priority

Judgemental adjustments should be applied to the forecasts from the macro-econometric model, especially in the first year or two of the forecast period, to allow for information not already taken into account in the model. This information may include forecasts from other models, insights from sectoral experts, partial data, expectations surveys, the views of experienced senior Treasury staff and intelligence from business liaison. However, this information should be critically assessed. This approach is consistent with research that shows that judgemental adjustments of model-based forecasts tend to improve their accuracy but are overdone.

Macroeconomic Group – Recommendation 3 (macro forecasting cross-check) – lower priority

The Treasury should consider adopting or developing a Vector Autoregression (VAR) model to use as a cross-check on the key short-term forecasts. This cross-check can be applied both in assessing The Treasury's forecasting track record, as well as in each forecasting round.

Macroeconomic Group – Recommendation 4 (primary analysis of macro policy) – medium priority

The Treasury should consider using the new macro-econometric model as its primary model for macroeconomic policy analysis. Such models have significant government budget detail, strong short-term empirics and recognise that consumer spending depends partly on current income, while allowing for the long term constraints on the economy. All of these features are needed so that realistic short and long term policy responses are generated.

Macroeconomic Group – Recommendation 5 (alternative analysis of macro policy) – lower priority

The Treasury should consider adding more fiscal structure to its version of the Reserve Bank's DSGE model so that it can use it as an alternative tool for macroeconomic policy analysis.

5 Revenue Group

This section continues the group-by-group review of The Treasury's economic modelling capability. Having reviewed Macroeconomic Group in section 4, this section reviews Revenue Group, and this is followed in section 6 by the review of Fiscal Group.

The Revenue Group provides advice on tax policy proposals. This advice may include estimates of impacts on the economy, an assessment of equity implications and budget costings. In addition, Revenue Group provides revenue forecasts that feed into the Budget forecasts prepared by Fiscal Group. Economic modelling can be used as a tool in providing each of these four types of advice. The use of economic modelling in providing such advice at fiscal authorities in other advanced economies was discussed in section 2.2 (which should be read before this section). That serves as an international benchmark in reviewing the Revenue Group's modelling capabilities here.

This review of Revenue Group starts in section 5.1 with a stocktake of its existing modelling capability against the international benchmark. This is followed in section 5.2 by proposals for approaching that international benchmark. The main recommendations for further developing the modelling capability of Revenue Group are in section 5.3.

Before moving on to the stocktake, it is worth re-iterating that in some cases in The Treasury, a model is housed in one Group but used in another group. For example, the economy-wide impacts of tax policy are modelled by MMPD in Macroeconomic Group for Revenue Group, while retirement incomes policy is modelled by TAD in Revenue Group for Fiscal Group. As noted in section 4, this review considers a model when reviewing the Group that uses the results, rather than when reviewing the Group that houses the model. Thus, the MMPD modelling of the economy-wide effects of tax policy are discussed in the section, while the TAD modelling of retirement incomes policy is discussed in section 6.

5.1 Modelling Capability Stocktake

In providing advice on tax policy proposals, Revenue Group may include estimates of impacts on the economy, an assessment of equity implications and budget costings. As explained in section 2.2, at fiscal authorities in advanced economies three main types of models are used to estimate such economic and equity impacts of tax proposals. Economic impacts are estimated using input-output (IO) models or computable general equilibrium (CGE) models. This modelling of economic impacts may be linked to a microsimulation model of individual households to assess equity impacts.

The Treasury broadly follows this international practice. For economic impacts it has an IO model known as PRISMOD.IO and it uses IE CGE as its CGE model. For microsimulation of equity effects it uses PRISMOD.DIST and CAPITA. The PRISMOD models only come into play for indirect tax changes.

As another way of estimating economic impacts of tax policy proposals, MMPD in Macroeconomic Group is developing a Treasury version of the Overlapping Generations (OLG) model of Kudrna, Tran and Woodland (2015) or KTW OLG. As discussed in section 2.3, fiscal authorities in advanced economies use OLG models in areas that are covered by Fiscal Group and, to a lesser extent, Revenue Group. Thus, the potential uses of KTW OLG (Treasury) are reviewed both here and in section 6.

This sub-section is organised as follows. The Treasury's use of models to estimate the economic impacts of tax proposals is reviewed first. The current use of a CGE model is discussed first, followed by the planned use of an OLG model. Next, The Treasury's use of microsimulation models to estimate equity effects is reviewed. Finally, other uses of modelling in Revenue Group are discussed.

Economic effects of tax policy with CGE models

The Treasury's use of CGE models to estimate the economic effects of tax proposals is reviewed here. Before doing so, it is useful to summarise the findings in section 2.2 concerning the use of CGE models for this purpose at fiscal authorities in advanced economies.

CGE models are based on optimal economic choices, subject to preferences, technologies and budget constraints. They study the impact of permanent policies like the tax system and so the focus is on long-run outcomes. Medium-term dynamics associated with adjustments in capital stocks and wealth are optionally included. Fiscal authorities in the US, UK and Canada have all used CGE models to simulate the economic effects of tax reform proposals.

The latest example of The Treasury using CGE modelling to simulate the economy-wide impacts of tax policy is provided by the recent Tax Review. As part of that review, the Treasury version of the Independent Economics Computable General Equilibrium (IE CGE) model was used in two studies. One study modelled the economic efficiency of five major taxes (Cao, Hosking, Kouparitsas, Mullaly, Rimmer, Shi, Stark and Wende, 2015). The other study modelled the economic impacts of the proposed cut in the company tax rate from 30 to 25 per cent (Kouparitsas, Prihardini and Beames, 2016). It is useful to put these studies in historical context of CGE tax modelling at The Treasury.

The author of this Review has led three CGE model-based studies to estimate the efficiency of various parts of the Australian tax system. Like the overseas studies reviewed in section 2.2, these Australian studies have focussed mainly on estimating the relative inefficiency of different taxes as measured by their marginal excess burdens (MEBs). These three Australian studies, which used the MM900, IE CGE and CGETAX models, are now discussed in turn.

MM900 modelling (KPMG Econtech, 2010) of inefficiencies in the Australian tax system was commissioned by The Treasury for the Australia's Future Tax System Review ("Henry Tax Review"). That modelling focussed on work and investment disincentives as well as on the inefficiencies from narrowly-based taxes. The resulting estimates of MEBs were included in the Henry Tax Review report (AFTSR, 2009). The Treasury contributed important ideas on the disincentive effects of particular taxes.

IE CGE modelling (Australian Government, 2012b) of company tax reform was commissioned by The Treasury for the Business Tax Working Group (BTWG). Like the MM900 modelling, the IE CGE modelling allowed for work and investment disincentive effects. In addition, it incorporated a much more detailed treatment of the company tax system and also allowed for profit shifting by MNCs. This led to improved estimates of the MEB for company tax. However, the IE CGE model dealt with taxes other than company tax in far less detail than the earlier MM900 modelling.

Treasury contributed important ideas to the development of IE CGE and has continued to use this model under licence. As part of the recent Tax Review process, The Treasury further developed the IE CGE model, beyond the earlier detailed modelling of company tax, to cover GST and land tax. It also utilised the existing treatments in the model of personal income tax (as it applies to labour income) and stamp duty on conveyances. Then, using this Treasury version of IE CGE, Cao et al. (2015) reported MEB estimates for five taxes: company income tax; personal income tax; GST; stamp duty on conveyances; and land tax. The IE CGE (Treasury) modelling involved is represented simply in Figure 5.1.

Separate to that Treasury model development work, IE further developed its own version of the IE CGE model. This work aimed to provide relatively detailed treatments of all of the major taxes, comparable to the existing detailed treatment of company tax. Inefficiencies from the narrowly-based taxes were added, which involved more than doubling the number of industries from 116 to 278. The advantages of this disaggregation included making it possible to distinguish the different tax rates applying to different forms of fuel, alcohol, insurance and gambling.

Then, in November 2015, The Treasury commissioned IE to undertake modelling to support the Tax Review process, leading to further model development work. This included adding saving disincentive effects for the first time. This was done using intertemporal optimisation by a representative infinitely-lived household, as in the Ramsey model. It also included allowing for superannuation tax concessions. The resulting version of the IE CGE model was renamed CGETAX. As part of its relatively comprehensive modelling of disincentive effects from taxes, it covered work, saving and investment disincentive effects, profit shifting and the inefficiencies from narrowly-based taxes.

The Treasury also commissioned Independent Economics to use CGETAX to undertake two simulation studies for the Tax Review. These studies were similar in scope to the two studies undertaken by The Treasury that were referred to at the outset of this sub-section. Versions of these two Independent Economics studies have subsequently appeared as ANU Working Papers. Murphy (2016a) models the economic impacts of the proposed cut in the company tax rate from 30 to 25 per cent and Murphy (2016b) models the MEBs of a large range of Commonwealth, state and local government taxes.

Table 5.1 summarises the main features on the versions of the IE CGE model, including the original version, the Treasury version and CGETAX. This table can be used to identify the advantages of using CGETAX to model economic inefficiencies from taxes compared to using the Treasury version of the IE CGE model for the same purpose. For a more detailed comparison, the interested reader can compare the CGETAX modelling in Murphy (2016b) with the Treasury IE CGE modelling in Cao et al. (2015).

Company Income Tax

Both models provide quite comprehensive and similar treatments of company tax. This treatment is based on the modelling developed jointly by Independent Economics and The Treasury for the BTWG (Australian Government, 2012b). Investment and work disincentive effects, profit shifting, tax allowances for depreciation, investment allowances, interest deductibility and foreign tax credits for Australian company tax are all taken into account. CGETAX has the advantage that it more fully takes into account the level of foreign ownership of Australian companies. It does this by separately modelling foreign investment in Australia and Australian investment abroad, whereas IE CGE nets the later from the former in modelling net foreign investment in Australia.

Figure 5.1
IE CGE (Treasury) Model of Long-run Effects of Taxes on the Economy

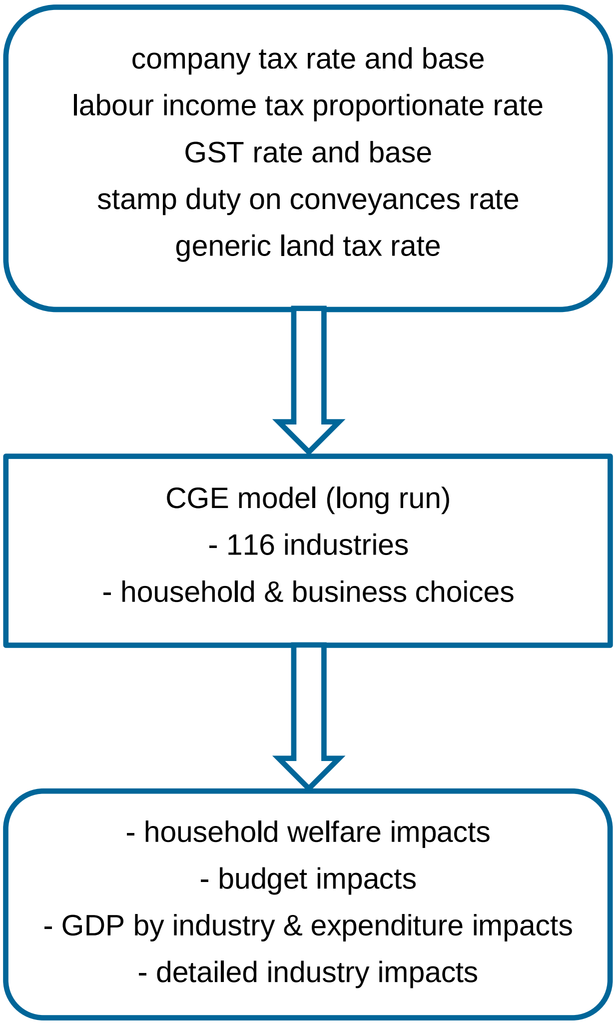


Table 5.1: Development of Model: detail, taxes, behavioural responses and calibration

Feature	*Original IE CGE Model*	*Treasury version of IE CGE Model*	*CGETAX*
Detail			
Industries	116	116	278
Types of labour	1	1	2 x 8
Types of capital	9	9	9
Location rents (land and minerals)	yes	yes	yes
Oligopoly rents	no	no	yes
Taxes			
personal income tax	average rate, franking credits	average rate, franking credits	marginal and average rates, franking credits
superannuation income tax	NA	NA	contributions, earnings, franking credits
Payroll tax	NA	NA	threshold and rate
Company income tax	historic cost depreciation, investment allowances, foreign tax credits, interest deductibility, profit shifting, net foreign investment	historic cost depreciation, investment allowances, foreign tax credits, interest deductibility, profit shifting, net foreign investment	historic cost depreciation, investment allowances, foreign tax credits, interest deductibility, profit shifting with avoidance costs, foreign investment in both directions
Externality taxes	NA	NA	beer, spirits, wine, fuel, tobacco, gambling
GST	NA	taxable/exempt/ zero-rated	taxable/exempt/ zero-rated
Property taxes	conveyancing duty	generic land tax, conveyancing duty	land tax, municipal rates, residential conveyancing duty, commercial conveyancing duty
Other specific taxes	NA	NA	import duty, insurance taxes, mining royalties, PRRT
Behavioural responses / elasticities			
present-future consumption (EIS)	NA (0)	NA (0)	0.25
labour supply (compensated)	0.4	0.4	0.4
within consumption	0.6	0.6	0.6 broad, 0.6-2.4 detailed
labour-capital	0.9 equipment, 0.5-0.7 structures	0.9 equipment, 0.5-0.7 structures	0.9 equipment, 0.5-0.7 structures
between occupations	NA	NA	3
between taxed & untaxed labour	NA	NA	3
company tax base: semi-elasticity	-0.5	-0.5	-0.73
Calibration			
I-O Table	2007/08	2007/08	2012/13
Baseline Year (after uprating)	2012/13	2013/14	2015/16

Note: PRRT is the petroleum resource rent tax

Personal Income Tax and Superannuation Taxes

The disincentive effects of taxes on personal income, including personal income tax and superannuation tax, are covered more precisely in CGETAX than in IE CGE. This is true both for taxation of labour income and asset income. For taxation of labour income, both models take into account the work disincentive effect. However, only CGETAX takes into account the greater inefficiencies that arise from the progressive nature of personal tax. It does this by distinguishing marginal and average tax rates, whereas IE CGE treats personal tax as a proportional tax.For taxation of asset income, CGETAX not only takes into account the saving disincentive effect. CGETAX also more fully recognises the tax concessions for asset income. Both models take into account the tax concession provided by franking credits. However, only CGETAX takes into account the tax concessions provided on (imputed and actual) asset income from housing. Similarly, only CGETAX takes into account the tax concessions on asset income from superannuation savings.

GST

Turning to GST, both models take into account that a tax on consumption, by reducing the purchasing power of the wage, has a work disincentive effect. Both models also take into account that a consumption tax with partial coverage distorts consumption patterns away from taxable consumption items and towards tax-free consumption items. However, only CGETAX allows for differences in the degree of substitutability between different consumer goods and services. As part of this, it takes into account that the tax-free status of unserved fresh food is particularly distorting, because consumption of unserved fresh food is likely to be a relatively close substitute for processed food and served food.

Municipal Rates and Land Tax

Both models take into account that land is a fixed factor of production, so a hypothetical broad-based tax on land would not distort land supply. Further, to the extent that land is foreign owned, such a hypothetical tax raises national income by requiring foreign land owners to pay tax in Australia. The Treasury version of IE CGE models abstracts by assuming that both state government land taxes and municipal rates take this hypothetical, broad-based form. However, CGETAX takes into account that state government land tax is applied to rented housing but not to owner-occupied housing and that municipal rates apply to both.

Stamp Duty on Conveyances

Both models take into account that stamp duty on conveyances can be viewed as a tax on investment in ownership transfer costs. For policy purposes, there is an important distinction between stamp duty on residential and commercial conveyancing, and this distinction is made in CGETAX (Murphy, 2016b). In Cao et al. (2015) this distinction is not made, but it is understood it may have been introduced more recently in The Treasury version of IE CGE.

Seven Other Categories of Taxes

While the tax coverage of the Treasury version of IE CGE is limited to the five major taxes just discussed, CGETAX also models seven other major categories of taxes as follows.

The first of these other categories is payroll tax. It is modelled allowing for a distorting effect from the small business exemption. The importance of this distortion varies by industry based on the employment size distribution of firms in each industry.

The remaining six categories of tax are all highly specific in nature. As such, their robust modelling is dependent on the fine level of industry disaggregation built into CGETAX. These six categories of tax are modelled as follows:

- excise (and customs-equivalent) duty and wine equalisation tax are modelled, as they apply to seven categories of alcoholic beverages, and allowing for a negative externality from alcohol consumption;
- excise duty on cigarettes is modelled allowing for a negative externality from cigarette consumption;
- gambling taxes on four categories of gambling are modelled, allowing for negative externalities;
- import duty is modelled by industry, allowing for its distorting effect on import demand;
- insurance tax is modelled, allowing for the unevenness in its application to four categories of insurance; and
- mining royalties and taxes are modelled, with royalties treated as a production tax and the PRRT as a resource rent tax.

CGETAX has also been updated for the 2012-13 ABS input-output tables, which were released in 2015. IE CGE continues to be based on the 2007-08 tables. Therefore CGETAX uses a structure for the economy that is more up to date by five years.

Finally, IE CGE assumes perfect competition in every industry. However, CGETAX allows for imperfect competition via mark-up pricing in selected blocks of industries. These industry blocks include financial services, insurance and superannuation services, telecommunications services and beverages and tobacco.

In summary, CGETAX includes detailed modelling of tax-based work, saving and investment disincentive effects, as well as the disincentives from narrowly-based taxes. This allows the effects of the design of the tax system on economic efficiency to be assessed more comprehensively than with the previous models. Further, CGETAX has a more up-to-date database and allows for imperfect competition. These developments make CGETAX the leading model for assessing the efficiency of the Australian tax system.

Based on this comparison, and the more detailed comparison that can be made by comparing Cao et al. (2015) with Murphy (2016b), The Treasury may wish to upgrade from its version of the IE CGE model to CGETAX[20].

This is not to suggest that CGETAX is perfect. There are some ways it could be further developed to enhance its usefulness for tax policy and other public economics analysis. For example, CGETAX could take on two features of the HMRC CGE model of the UK.

[20] The IE CGE and CGETAX models were developed by Independent Economics. To address the potential conflict of interest in this recommendation, the upgrade from IE CGE to CGETAX is being offered for free.

- Annual dynamics could be introduced in the form of capital stock adjustment and household wealth accumulation, so that an annual time path can be traced towards the long run equilibrium outcome.
- The representative household could be replaced with 50 types of households, distinguished by 10 income levels and five household compositions. This would allow for differences in behavioural responses between different types of households. It would also provide a basic analysis of equity effects.

In addition, there could be some aggregation of industries where this did not limit the usefulness of the model for public economics applications and while retaining the full industry detail found in the standard input-output tables. This may reduce the number of industries from around 278 to around 150.

Economic effects of tax policy with OLG models

While The Treasury already has access to a CGE model (IE CGE or CGETAX) to estimate the economic impacts of tax policy proposals, MMPD (2016) has proposed that The Treasury use an Overlapping Generations (OLG) model for the same purpose. The Treasury is working on replicating the OLG model of Kudrna, Tran and Woodland (2015), or KTW OLG, and proposes to then further develop it for Treasury's purposes.

OLG models are a type of CGE model that models each successive generation over the periods of life. Introducing multiple generations is a modelling complication that can be justified for policies affecting the allocation of resources across different generations. Hence, as explained in section 2.3, OLG models are used at fiscal authorities to study the effects of retirement incomes policies, government debt policies and demographic change. This emphasis is also seen in the journal publications in which KTW OLG has been used by the model's authors. Those publications cover applications of the model to age pension policy, superannuation policy and the effects of demographic change on the government budget.

Those applications fall within the responsibilities of the Fiscal Group. Thus, the main discussion of KTW OLG (Treasury) is in the review of Fiscal Group in section 6, where the KTW OLG journal publications are fully referenced.

While OLG models can be used to analyse tax proposals, simpler CGE models are preferred when modelling tax policies that have less effect on intergenerational equity. In these Ramsey CGE models, the choice between present and future consumption is made by a representative household (or households) that notionally has (have) an infinite lifetime. Fiscal authorities in advanced economies, including the US, UK and Canada, rely mainly on Ramsey CGE models for modelling the economic effects of tax policy proposals, as documented in section 2.2. CGETAX is a Ramsey CGE model.

Overly complex models take a long time to construct, are difficult to understand and costly to maintain. This makes it important not to include unnecessary detail in a model for the purpose at hand because this leaves less scope for including the details that are important. Tax policy analysis of the richness available from CGETAX requires a lot of fiscal detail and associated behavioural responses, as well as considerable industry detail. Including many generations of households by using an OLG model would significantly limit the amount of fiscal and industry detail that would be prudent to include. In short, for many tax policy applications, fiscal and industry detail, as in CGETAX, is more useful than the multi-generation detail of an OLG model.

Of course if life cycle considerations are important for a tax proposal, there is a case for modelling the proposal using an OLG model. One example would be modelling a hypothetical estate/inheritance tax and there are other examples.

As noted above, MMPD (2016) have indicated that they intend to replicate KTW OLG and then undertake further development work. KTW OLG is already a substantial model, partly because of its modelling of 80 generations of households, distinguished by single years of age from 21 to 100. While there would be scope to further develop it, there is a limit to the extent that it would be prudent to add further complexity. In view of that, here the tax modelling capability of the existing KTW OLG model is compared to the tax modelling capability of the existing CGETAX model.

KTW OLG distinguishes three categories of taxes: taxes on household income and superannuation; taxes on consumption; and taxes on corporate profit. Closer examination shows that CGETAX has a more comprehensive treatment of the potential distorting effects of each of these three taxes.

Like CGETAX, KTW OLG allows for the work disincentive effect from taxing labour income and consumption and the saving disincentive effect from taxing asset income. Also like CGETAX, KTW OLG allows for the progressive nature of personal income tax and the concessional tax treatment of superannuation. Indeed, there are distinct similarities in how these aspects are handled in the two models.

KTW OLG lacks further elaboration of these taxes. However, this is both reasonable and unsurprising given that model's focus on the effects of retirement incomes policies and demographic change.

In contrast, CGETAX contains considerable further elaboration of these taxes. This detail was explained above so it is only re-iterated briefly here. In modelling company tax, CGETAX allows for profit shifting, investment allowances, interest deductibility and foreign tax credits. In modelling personal tax, CGETAX allows for franking credits. In modelling GST, CGETAX takes into account that GST distorts the pattern of consumption by taxing some areas of consumption but not others. These aspects are not covered in KTW OLG.

Finally, KTW OLG does not distinguish any of the remaining nine categories of taxes that are represented in CGETAX: (i) land-related taxes; (ii) stamp duty on conveyances; (iii) payroll tax; (iv) alcohol taxes; (v) cigarette tax; (vi) gambling taxes; (vii) import duty; (viii) insurance taxes; and (ix) mining taxes.

So there are major advantages in using CGETAX to analyse the economy-wide effects of tax policy compared to the existing version of KTW OLG.

At the same time, KTW OLG has the advantage that it is dynamic, so a time path can be traced to its long run equilibrium outcomes. However, as suggested above, CGETAX could also be made dynamic, following the approach used in the HMRC CGE model.

Also, KTW OLG has the advantage of heterogeneous households, distinguished by age, and this could be extended to distinguishing households by income-earning capacity. However, CGETAX can also be extended to include heterogeneous households. This can be done in either or both of two ways.

- As suggested above, as in the HMRC CGE model, the representative household could be replaced with 50 types of households, distinguished by 10 income levels and five household compositions.

- CGETAX could be linked to The Treasury's household microsimulation models, PRISMOD.DIST and CAPITA. These microsimulation models support detailed equity analysis with multiple dimensions covering factors such as household composition, income and stage of life. This linking idea is discussed further below.

The KTW OLG model may have limited immediate potential to contribute to the work of Revenue Group. However, it has more potential to contribute to the work of Fiscal Group, as discussed in section 6.

Equity impacts of tax policy

The Treasury's use of household microsimulation models to estimate the equity effects of tax proposals is reviewed here. This is placed in context by first reiterating the findings in section 2.2 concerning the uses elsewhere of this type of modelling.

Household microsimulation models can play a useful role in modelling tax policy proposals. These microsimulation models are more useful when linked to an economy-wide model that provides estimates of economic changes that result from tax proposals. With IO-microsimulation linking, estimates of equity effects can be obtained for many tax proposals. With CGE-microsimulation modelling, broadly consistent estimates of real economic effects can be obtained as well. To provide a more complete perspective on equity effects, the CGE-microsimulation modelling should aim not only to provide estimates of effects on current real incomes, but also on lifetime real incomes.

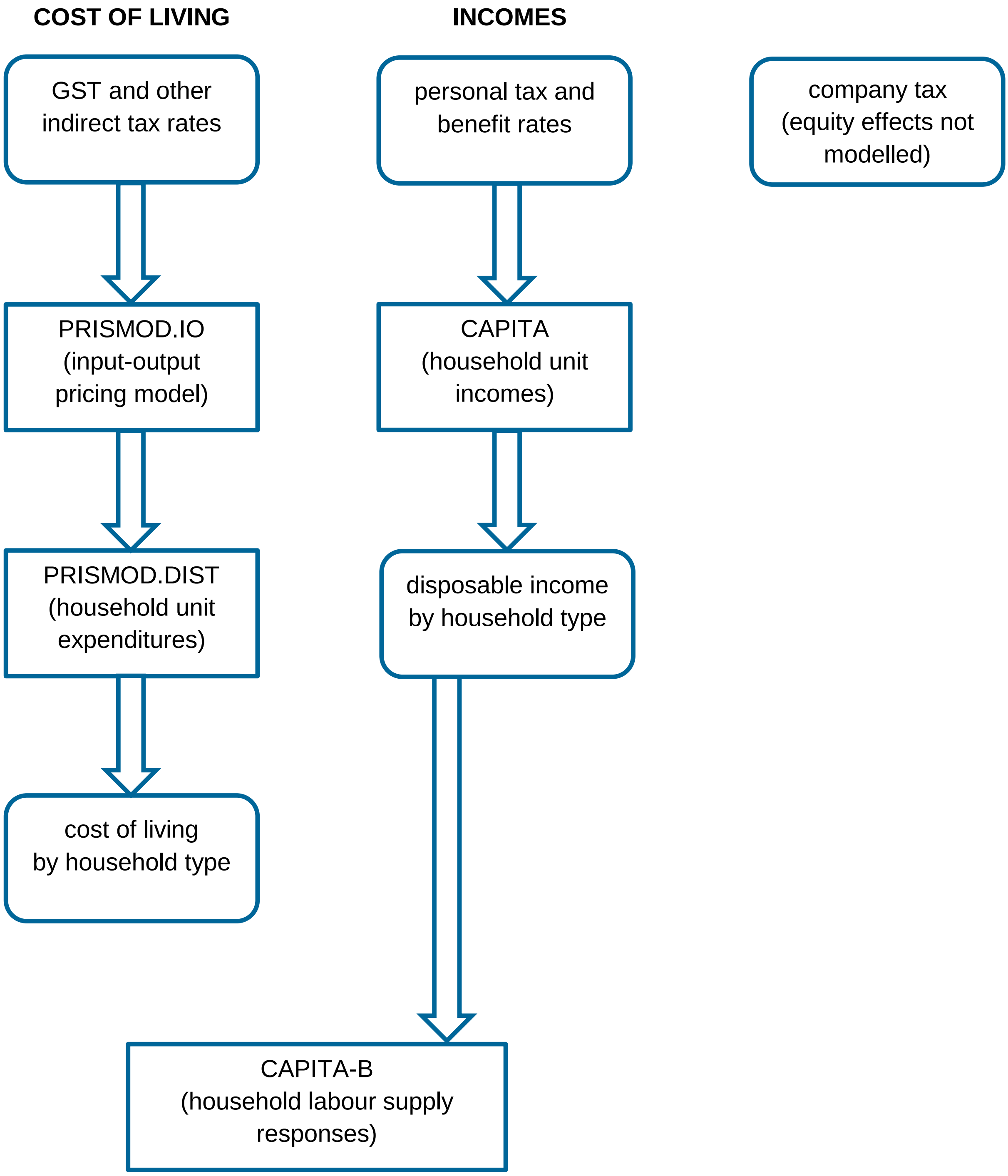
In reviewing The Treasury's household microsimulation models, the important issues to consider are their nature, their linking to economy-wide models, and examining equity from the perspectives of both current real incomes and lifetime real incomes. These issues are now considered in turn.

For estimating the equity impacts of tax policy options, TAD uses microsimulation models. In broad terms these models simulated how changes in tax rates affect the disposable incomes and cost of living of different types of households. These equity effects are also modelled for changes in benefit rates. The main tax not included in this equity analysis is company tax.

The equity analysis uses unit record data of incomes and expenditures from surveys of thousands of individual households. These microsimulation models are implemented in the SAS statistical package. Four steps are involved, as depicted in Figure 5.2.

- PRISMOD.IO models the direct and indirect effects of changes to GST and other indirect taxes on production costs and prices to consumers for 114 industries. It does this using an input-output pricing model based on the 2009-10 input-output tables.
- PRISMOD.DIST takes these impacts for consumer prices by industry and maps them to consumer prices for the expenditure categories used in ABS household surveys. In a microsimulation, it then applies these price impacts for expenditure categories to the patterns of expenditure for thousands of individual households, to arrive at a change in the cost of living for each household. Households are then categorised and aggregated by category (e.g. by household composition, household income and household stage of life) to estimate average cost of living impacts for different categories of households.

Figure 5.2
Microsimulation Modelling of Effects of Taxes and Benefits on Household Equity



- CAPITA is another microsimulation model, but deals with incomes rather than the cost-of-living. It simulates the effects of changes to personal tax and benefit rates on the disposable incomes of thousands of individual households. It does this using unit record data on incomes by source (wages and salaries, personal business income, interest income, superannuation benefits and other investment income) for each household. Similar to PRISMOD.DIST, households are then categorised and aggregated by category, to estimate average disposable income impacts for different categories of households.
- CAPITA-B models how changes in disposable incomes and after-tax wages from CAPITA may induce changes in labour supplies. CAPITA-B is maintained by the Department of Employment but is available to TAD. It replaces STINMOD-B, which is no longer maintained by The Treasury.

This modelling of equity impacts of changes in tax and benefit rates feeds into the policy advice provided by two divisions of The Treasury. The Individuals and Indirect Tax Division (IITD) provides advice on changes to indirect taxes and personal tax. The Social Policy Division (SPD) of Fiscal Group is responsible for policy advice on benefits.

This type of equity analysis is similar to approaches that are widely used elsewhere. Leading examples are the EUROMOD project (Sutherland and Figari, 2013) and a recent US Treasury study (Horowitz et al., 2017).

At the same time, there is room for improvement in the Treasury equity modelling to take into account academic critiques of this type of modelling.

- The final incidence of each tax and benefit appearing in the modelling system is based on the simple assumption that it is fully borne by households. This contrasts with economic modelling under which the sharing of the final incidence of a tax between the buyer and seller depends on the slopes of the buyers' demand curve and the sellers' supply curve. Further, because of the challenges of allocating the incidence of company tax without economic modelling, company tax is not represented in the equity modelling. It is acknowledged that using the concept of economic incidence makes the modelling more difficult to understand.
- This microsimulation modelling of the equity impacts of changes in tax policy is separate from, and therefore not fully consistent with, the CGE modelling of the economic impacts. The CGE modelling provides estimates of the incidence of all taxes, including company tax.
- The labour supply responses in CAPITA-B depend on the changes in after-tax nominal wages and incomes from CAPITA. However, in principle, labour supply responses should depend on real changes, not nominal changes. To address this, the cost of living impacts estimated in PRISMOD.DIST would need to be taken into account.
- As explained in section 2.2, household living standards depend not only on current incomes, but also lifetime incomes. The Treasury microsimulation models and similar models elsewhere focus on current incomes and current spending patterns. Thus, it is desirable, if feasible, that the existing microsimulation analysis of impacts on current real incomes is extended so that it also shows impacts on lifetime real incomes.

In section 5.2 the roadmap proposes ways of dealing with these four limitations.

Other revenue modelling

Besides the equity modelling depicted in Figure 5.2, TAD also undertakes a wide range of other revenue-related modelling. This other modelling is concerned with forecasting, costings and cameos (i.e. impacts on a representative household with a given set of characteristics).

For forecasting personal income tax, TAD uses a microsimulation model based on unit record information for a 16 per cent sample of individual taxpayers. Using unit record information makes it possible to account for the nuances of the personal income tax system, including its progressive nature, in a way that is not possible using grouped data. In forecasting each unit record, growth in income and deduction items is based on growth in forecasts for appropriate economic aggregates. Tax payable is calculated by applying the statutory rates for the forecast year.

Unit record data is de-identified by removing names and addresses. De-identified data has been used for decades without any security problems. Other revenue forecasting models, such as for company income tax, GST revenue and customs and excise, do not directly use unit record data.

In addition, there are models for costings of tax policy changes, including TAXmod, which is used for costings of personal income tax and superannuation tax changes. In principle, the budget impacts from a tax policy change can be divided into a direct impact from a change in a tax rate, and indirect effects arising from behavioural responses to the tax rate change. These behavioural responses can in turn be categorised into microeconomic and macroeconomic responses.

An example of allowing for a microeconomic behavioural response is when higher tobacco excise is estimated to induce lower tobacco consumption, thereby reducing the tobacco tax base. This reduction in the tax base partially offsets the revenue gain from the direct effect of the tax increase. This partial equilibrium analysis of a tax change is confined to a single market and a single budget item. It assumes national income is unaffected.

An example of a macroeconomic behavioural response is when a tax cut stimulates the demand for capital or supply of labour, leading to higher GDP and national income. This gain in national income is likely to lead to higher collections from a wide range of taxes partly offsetting the direct revenue loss from the tax cut. This general equilibrium analysis involves the entire economy and the entire budget and is known as dynamic scoring (Mankiw and Weinzierl, 2004).

The Treasury regularly estimates microeconomic behavioural responses. That is, when a tax change lends itself to a partial equilibrium analysis such as the tobacco excise example, a within-market behavioural response may be taken into account using a price elasticity assumption, in arriving at a final estimate of the budget impact.

It is relatively unusual for The Treasury to conduct dynamic scoring. This would require a general equilibrium analysis that takes into account the effects on the budget of any induced change in national income or other macroeconomic variables resulting from the tax change.

There are two reasons why it is important to take into account both types of indirect impacts on the budget from a tax change. First, there is a close relationship between the total size of the indirect impacts on the budget and the impact on consumer welfare. Favourable indirect effects are a sign of consumer gain. Tax policy changes should be focussed on consumer welfare so knowing the size of the indirect impacts is important in judging the desirability of the policy. Second, taking into account indirect impacts should also improve the accuracy of the costings where they can be reasonably estimated.

For those two reasons, this review recommends that dynamic scoring be undertaken where material and possible and the resulting estimates of indirect budget effects be separately identified. CGE models like CGETAX provide an appropriate way of estimating indirect impacts for some tax policy changes. Of course these model-based impacts refer to the long-run, and hence would need to be adjusted to provide a realistic time profile.

Dynamic scoring is now a requirement in the US, where material and practical. "To the greatest extent practicable, CBO and JCT shall incorporate the budgetary effects of changes in macroeconomic variables resulting from legislation that has a gross budgetary effect of 0.25 per cent of GDP in any year over the next ten years" (Hall, 2015)[21]. Such a rule of thumb could be useful for Treasury consideration of the macroeconomic effects of tax policy changes.

Finally, TAD also uses cameo models. This provide estimates of impacts on a representative household with a given set of attributes regarding its composition, income etc. Cameo models are not reviewed here as the main focus is economy-wide modelling.

5.2 Roadmap

As discussed in section 5.1, it is recommended that The Treasury upgrade from IE CGE to CGETAX for analysing the economy-wide impacts of tax policy options. This will increase the depth and breadth of the tax policy analysis.

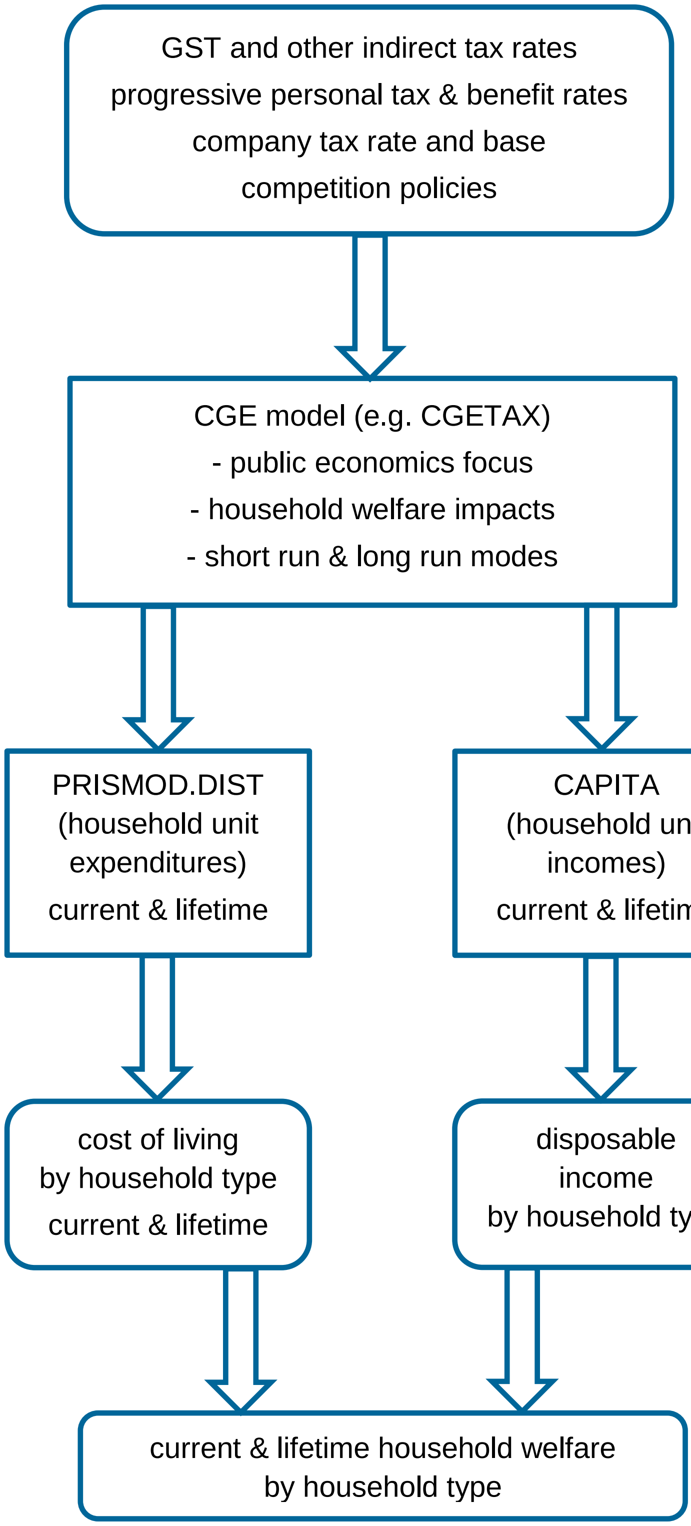
As discussed in section 5.1, the simple assumptions about tax incidence in the existing equity modelling is a concern for two reasons. First, it is not fully consistent with economic principles and second, it is inconsistent with the efficiency modelling, which is based on those same economic principles.

To resolve this problem, it is recommended that the modelling of the economy-wide and equity impacts of tax policy should be linked rather than separate, to achieve greater consistency. The microsimulation modelling of impacts on individual households in PRISMOD.DIST and CAPITA would then be driven by the economy-wide impacts generated by the CGE model, and PRISMOD.IO would no longer be needed. This recommended approach is depicted in Figure 5.3. Essentially it integrates the CGE modelling from Figure 5.1 with the equity modelling from Figure 5.2.

Under this approach, the CGE model would provide the impacts of tax changes on prices to consumers by industry, which are currently provided by PRISMOD.IO. However, this information would be more detailed, as CGETAX has 278 industries compared to 114 industries in PRISMOD. This would support a more accurate mapping of consumer prices by industry to consumer prices by expenditure category.

[21] I would like to thank Robert Ewing and Susie Kluth of the Tax Analysis Division in The Treasury for drawing my attention to this reference.

Figure 5.3
Tax and other micro reform policies: effects on economy and household equity



Apart from this greater accuracy, the results will be broadly consistent with the current approach because both PRISMOD and CGETAX assume that prices are determined from unit cost. Similarly, both rely on input-output tables to capture the linkages between industries. The similarity in the PRISMOD and CGE model estimates for consumer price impacts by industry is confirmed from a comparison of their respective estimates for the introduction of the New Tax System in 2000.

Under this approach, the CGE model would also provide estimates of the impacts of tax changes on income by type. However, it would provide more robust estimates than the current approach based on simple incidence assumptions.

For example, CGETAX captures that the incidence of economic rent taxes (e.g. PRRT, a hypothetical efficient land tax, a hypothetical tax on oligopoly rents) falls on the owner of the rents. Similarly, it recognises that under perfect international capital mobility, a tax on the normal return to capital will, in the long run, be fully passed on to labour and rent owners. Finally, it takes into account that taxes on labour are likely to be largely borne by labour, but partly borne by owners of economic rents. In contrast, the existing modelling approach makes polar assumptions, and does not capture any effects on households from changes to company income tax.

Further, it is recommended that the labour supply responses in CAPITA-B depend on changes in after-tax wages and incomes measured in real terms rather than nominal terms, for consistency with economic principles. This adjustment from nominal to real terms can be made by utilising the cost of living impacts estimated in PRISMOD.DIST, as indicated in Figure 5.3.

As a final point on equity modelling, as discussed in section 5.1, it is recommended that CAPITA is upgraded to extend its simulation of the impacts of changes in taxes and benefits on incomes of individual households. The existing CAPITA simulates impacts on individual household current incomes, but this might be extended to also include lifetime incomes. This is indicated in the CAPITA box in Figure 5.3. This does not mean choosing between impacts on current and lifetime incomes in assessing equity impacts. Rather, as indicated in section 2.3, this review agrees with Levell, Roantree and Shaw (2016) when they suggest that "we view the two approaches as complementing one another". Credit market imperfections mean that impacts on lifetime incomes don't tell the full story.

Based on a discussion with TAD, it is understood that the modelling of impacts on lifetime incomes of individual households could potentially be developed using MARIA as a base. MARIA is TAD's microsimulation model of retirement incomes of individual households. Reporting on impacts on lifetime incomes would be a major enhancement to The Treasury's modelling of equity impacts.

The nature of the economy-wide information needed to drive microsimulation of impacts on incomes of individual households differs between current income and lifetime income. For lifetime income, the long-run economic impacts already provided by CGETAX would be a broadly reasonable driver. They are based on full adjustment of capital stocks to long run equilibrium. However, impacts on current incomes of individual households would need to be driven by short-run impacts on the economy.

To provide short-run economic impacts, CGETAX would need to be simulated in a short-run mode. In particular, capital stocks and wealth would be taken as given. This short run mode for CGETAX would need to be designed and developed. Short run and long run modes have been developed previously for comparable CGE models focussed on tax analysis, such as the MM600 model. Figure 5.3 indicates that CGETAX would need to be run under both short run and long run modes.

Alternatively, a dynamic CGE model could be used, for example a dynamic version of CGETAX, and used to generate year-by-year results to feed into the existing microsimulation models. However, this would generate year-by-year results for current incomes, not lifetime incomes.

A final issue in linking an economy-wide model with microsimulation models of individual households is whether it is worthwhile to introduce some heterogeneity in households in the economy-wide (CGE) model. This could add to the economic richness of the information fed into the microsimulation models.

CGETAX already distinguishes labour by eight occupations. This could readily be used to take into account variability in percentage impacts on wages across occupations in the microsimulations of individual households. This would be an improvement on the existing approach used by The Treasury and depicted in Figure 5.2 under which percentage impacts on wages are homogeneous. Other heterogeneity in households could potentially be added to CGETAX, and used in linking to the equity modelling. For example, earlier it was suggested that 50 types of households could be distinguished in CGETAX, following the approach used in the HMRC CGE model.

The final issue discussed in section 5.1 was the use of dynamic scoring to allow for the effects on the budget of any macroeconomic responses to a tax policy proposal. Following the US lead, The Treasury could consider using dynamic scoring of tax proposals in cases where this is practical and the tax proposal is material in the sense that it has a gross budgetary effect of 0.25 per cent of GDP or more in any year over the next 10 years. The indirect budget effects estimated from dynamic scoring would be separately identified. This will make costings of substantial policy changes more accurate and assessments of the merits of policy options better informed.

5.3 Summary of main recommendations

Revenue Group – Recommendation 1 (Economic impacts of tax policy model) – higher priority

For its CGE model analysis of the economy-wide impacts of tax policy, The Treasury should upgrade from using the IE CGE model to using the CGETAX model[22]*. This will increase the depth of the analysis for the five categories of tax that are covered by IE CGE. It will also increase the number of categories of tax that are covered from five to twelve.*

Revenue Group – Recommendation 2 (Equity impacts of tax policy model) – higher priority

The Treasury should consider upgrading CAPITA to extend its reporting of the impacts of changes in taxes and benefits on incomes. The existing CAPITA reports impacts on current incomes, but this could be extended to include both current incomes and lifetime incomes. This would give a more complete picture of the equity impacts of changes in taxes and benefits.

[22] The IE CGE and CGETAX models were developed by Independent Economics. To address the potential conflict of interest in this recommendation, the upgrade from IE CGE to CGETAX is being offered for free.

Revenue Group – Recommendation 3 (Consistent modelling of impacts) – medium priority

The Treasury should consider linking the modelling of the economy-wide and equity impacts of tax policy to achieve greater consistency. The microsimulation modelling of impacts on individual households in PRISMOD.DIST and CAPITA would then be driven by a CGE model, and PRISMOD.IO would no longer be needed. The CGE model would be run in two modes, a short-run mode for generating impacts on current incomes and a long-run mode for generating impacts on lifetime incomes.

Revenue Group – Recommendation 4 (Tax Costings with dynamic scoring) – medium priority

The Treasury should consider whether, in estimating the budget impact from a tax policy change, it takes into account potential economy-wide effects. Such dynamic scoring is required in the US for costings with a gross budgetary effect of 0.25 per cent of GDP or more in any year over the next 10 years. When taken into account, economy-wide effects on the costings should be separately identified. The size of such effects is important in judging the desirability of a policy and taking them into account should also improve the accuracy of costings.

6 Fiscal Group

This section completes the group-by-group review of The Treasury's economic modelling capability. Having reviewed Macroeconomic Group in section 4 and Revenue Group in section 5, this section reviews Fiscal Group.

An important responsibility of fiscal authorities in advanced economies is preparing projections of government budgets over short-term, medium-term and long-term horizons. Long-term fiscal projections highlight the future pressure on the budget from population ageing and the influence of retirement incomes policies on that pressure. At The Treasury, advice on these matters is provided by the Fiscal Group. The use of economic modelling in providing such advice at fiscal authorities in other advanced economies was discussed in section 2.3 (which should be read before this section). That serves as an international benchmark in reviewing the Fiscal Group's modelling capabilities here.

The main modelling activities in Fiscal Group are undertaken by Social Policy Division (SPD) and Budget Policy Division (BPD). SPD projects health, education and transfer payments. These expenditure projections feed into the model of the overall Budget position that is operated by BPD and is known as FAPmod. Revenue projections for FAPmod are provided by Revenue Group. The projections of the Budget balance from FAPmod feed into a model that tracks Commonwealth government debt. That model is also operated by BPD and is known as DEBTmod.

Hence, several divisions in The Treasury are involved in putting together Budget projections. For simplicity, this review focusses on the overall modelling approach rather than on the activities on a division-by-division basis.

Elsewhere in Fiscal Group, Retirement Income Policy Division (RIPD) provides advice on retirement incomes policy. It draws on modelling of retirement incomes that is undertaken by TAD in the Revenue Group. The main retirement incomes model is now known as MARIA, which is under development.

The Commonwealth-State Relations Division (CSRD) provides advice on payments to the states and territories. These payments include general revenue assistance through the distribution of GST revenue, and special purpose payments. GST revenue is distributed between the states and territories on a per capita basis, but is then adjusted to achieve Horizontal Fiscal Equalisation (HFE) based on HFE modelling by the Commonwealth Grants Commission. CSRD also provides policy advice on these payments to the states. It undertakes the monthly calculation of general revenue assistance payments to each state and territory. It uses modelling to forecast future GST distributions for the Budget and to estimate hypothetical GST distributions under alternative HFE policies.

This review of Fiscal Group starts in section 6.1 with a stocktake of its existing modelling capability against the international benchmark established in section 2.3. This is followed in section 6.2 by proposals for approaching that international benchmark. The main recommendations for further developing the modelling capability of Fiscal Group are in section 6.3.

As noted previously, this review considers a model when reviewing the Group that uses the results, rather than when reviewing the Group that houses the model. Thus, the modelling of retirement incomes policy is considered here because policy advice in that area is provided by RIPD in Fiscal Group; the modelling is actually undertaken by TAD in Revenue Group.

6.1 Modelling Capability Stocktake

As discussed in section 2.3, in advanced economies fiscal authorities typically use budget models to prepare fiscal projections over various time horizons, using their economic projections as inputs. The Treasury also follows this practice, and its use of budget models in preparing projections is reviewed here.

Less commonly, fiscal authorities in advanced economies use overlapping generation (OLG) models to analyse the intergenerational issues associated with long-term fiscal projections. The Treasury does not currently do this. However, as foreshadowed in section 5, MMPD in Macroeconomic Group is developing a Treasury version of the OLG model of Kudrna, Tran and Woodland (2015) or KTW OLG. The potential uses of KTW OLG (Treasury) in Fiscal Group are also reviewed here.

The Treasury's use of budget models is reviewed first. This is followed by the review of the potential uses of KTW OLG (Treasury).

Budget Projections

The Treasury's use of budget models in preparing fiscal projections of various time horizons is reviewed here. Before doing so, it is useful to summarise the findings in section 2.3 concerning the use of budget models for this purpose at fiscal authorities in advanced economies.

For the most part, budget projection models assume the continuation of existing Government fiscal policy. The budget projections are influenced by projected growth in tax bases and spending bases (populations of benefit recipients and more intensive users of health, education and other government services).

In preparing their forecasts, fiscal authorities typically follow a sequential approach. The economic forecasts are prepared first, and then those economic forecasts are used as an input in preparing the fiscal forecasts. Even over long time horizons, this sequential approach is favoured over preparing both the economic and fiscal forecasts using a single integrated model of the economy and the budget.

Fiscal authorities in advanced economies typically prepare long-term fiscal projections. Motivated by the budget pressures from population ageing, the main aim in preparing such projections is to develop fiscal sustainability gap indicators. These indicators show how much taxes should be increased or expenditures reduced to fulfil the government intertemporal budget constraint.

The time horizon of long-term fiscal projections varies between countries. It is 15 years in New Zealand, 30 years in the US, 40 years in Canada and 50 years in the UK. The long-term projections on the expenditure side of the budget are invariably based on the assumption of unchanged policy. However, only in the US are long-term projections on the revenue side made under the same assumption. In the UK, Canada and New Zealand, fiscal drag is switched off after five to seven years, resulting in revenue projections that are approximately stable relative to GDP from then on.

Turning to Australia, under the Charter of Budget Honesty Act 1998 (Office of Parliamentary Council, 2014), there are three streams in the reporting of the budget outlook.

The first stream is the annual budget cycle. The budget outlook is reported both in the annual Budget itself and in the mid-year economic and fiscal outlook (MYEFO) report. Both reports are required to contain the following four-year-ahead fiscal projection (Office of Parliamentary Council, 2014), commonly referred to as the Forward Estimates.

> *Commonwealth budget sector and Commonwealth general government sector fiscal estimates for the budget year and the following 3 financial years.*

In practice, the four-year Budget outlook of the Forward Estimates is extended for a further seven years. This 11-year outlook, or medium-term budget outlook, provides the Government with a fuller picture of the fiscal outlook and how it changes with new policy decisions.

The second stream is the pre-election economic and fiscal outlook (PEFO) report. PEFO is triggered by a general election and is similar in scope to MYEFO. PEFO differs from the other two streams in that Secretaries of the Treasury and the Department of Finance, rather than their Ministers, take responsibility for it.

The third stream is the intergenerational report (IGR), which is released "at least once every 5 years" (Office of Parliamentary Council, 2014). The long-term budget outlook in the IGR extends out 41 years, and the most recent IGR (Australian Government, 2015a) was released in 2015. The prescribed contents of an IGR are as follows (Office of Parliamentary Council, 2014).

> *An intergenerational report is to assess the long term sustainability of current Government policies over the 40 years following the release of the report, including by taking account of the financial implications of demographic change.*

In summary, The Treasury produces Budget outlooks that extend out 4, 11 and 41 years.

On the expenditure side of the Budget, much of the work for the Forward Estimates years is undertaken in the Department of Finance and the spending Departments, placing it outside of the scope of this review. Hence, on the expenditure side, this review focusses on how The Treasury extends the Forward Estimates to the medium-term (11-year ahead) and the long-term (41-year ahead).

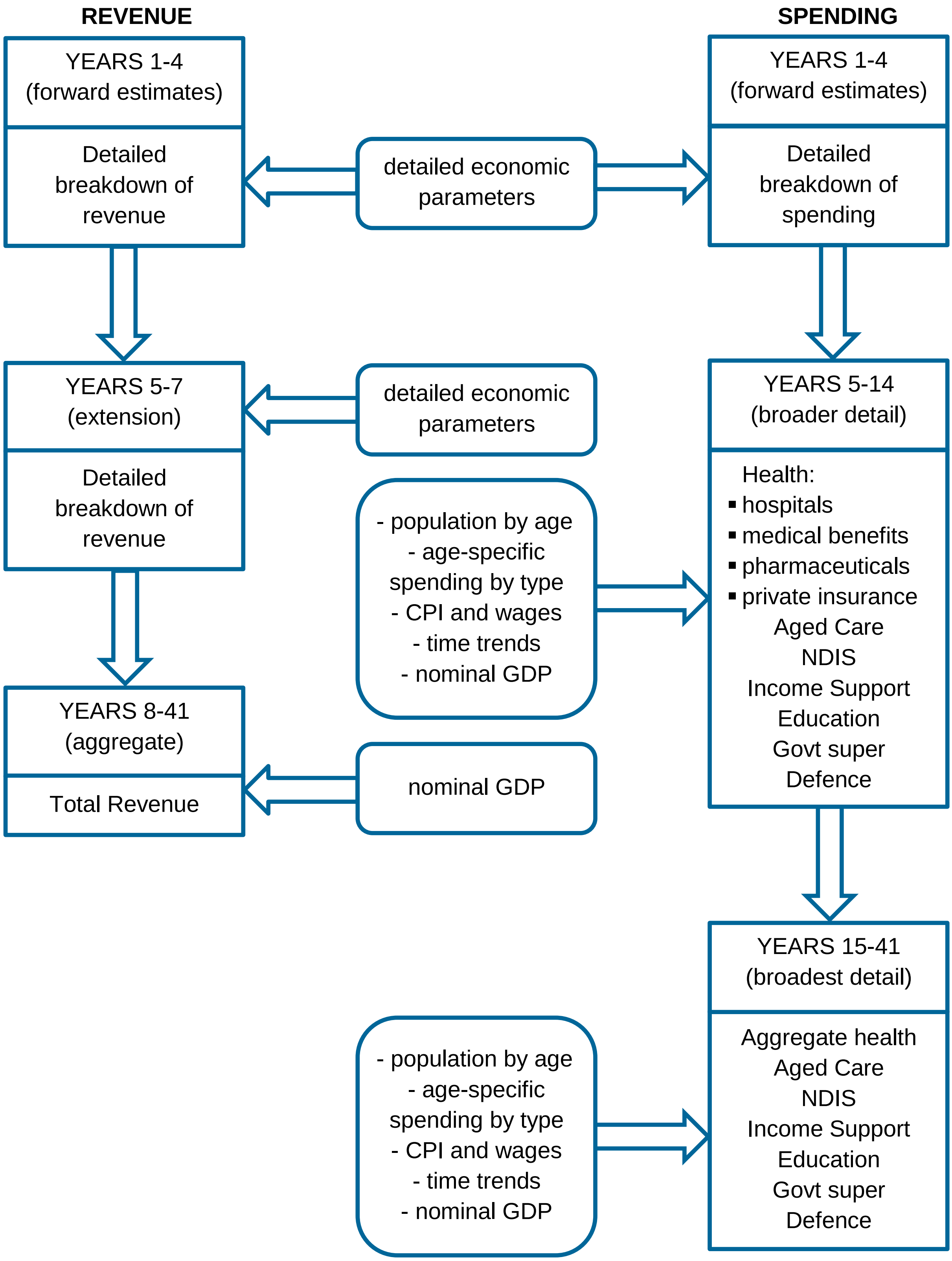
The Budget outlook modelling approach is depicted in a highly stylised form in Figure 6.1. For a more detailed explanation, see Appendix C of the IGR (Australian Government, 2015a).

The Forward Estimates, which appear semi-annually in the Budget and MYEFO, cover the first four years of the revenue and expenditure projections, as shown in Figure 6.1. These Forward Estimates are based on detailed modelling, which depends on many government policy settings and an extensive range of economic parameters.

This modelling for the Forward Estimates is undertaken in The Treasury, Finance and spending departments. See Appendix A for a listing of the budget economic parameters that are generated by Macroeconomic Group and used in preparing the Forward Estimates.

Treasury modelling extends the Budget outlook from the 4-year period used in the Forward Estimates to 41 years. For expenditures, this is necessarily done in a simplified way because the exercise is undertaken within The Treasury. This differs from the Forward Estimates of expenditures, which closely involve Finance and the spending departments. The approach taken by The Treasury in extending the budget projections beyond the Forward Estimates period is now considered, taking the revenue and expenditure projections in turn.

Figure 6.1
Budget Outlook Modelling



Revenue

Because The Treasury (working with the ATO) prepares the revenue projections over the Forward Estimates, it is able to maintain a similar approach when extending the revenue projections further out. This approach is followed in year five to around year seven. Detailed economic parameters and tax policy settings are used in generating the revenue projections over this period. At around year seven, this approach faces two issues.

First, the application of a progressive income structure to rising nominal incomes per head means that personal income tax revenues steadily rise as a share of GDP. By around year seven the total tax-to-GDP ratio has reached an historical norm and is continuing to rise, potentially indefinitely. An indefinite continuation of bracket creep (also known as fiscal drag) would conflict with the historical experience that governments cut personal income tax on an irregular basis to avoid such an eventuality.

As noted previously, this problem is avoided in the long-term fiscal projections of the UK, Canada and New Zealand by switching off fiscal drag after five to seven years. This stabilises the ratio of personal income tax revenue to personal income.

Only in the US is fiscal drag allowed to continue to the end of the projection period, which is for 30 years. However, in the US fiscal drag is a milder force than in Australia, because personal income tax brackets are indexed to inflation, so there is only real fiscal drag, not nominal fiscal drag. Further, the projection period in Australia is longer, at 40 years. The combination of the greater strength of fiscal drag and longer projection period in Australia means that the US approach, if used in Australia, would not produce plausible long-term revenue projections.

In Australia, the problem of fiscal drag in long-term revenue projections is addressed differently from elsewhere. Once total taxation revenue reaches an historical benchmark as a share of GDP, it is held fixed at that benchmark for the remainder of the projection. In the 2015 IGR, that point is reached after seven years. What distinguishes this approach from the approaches used elsewhere is the switch in Australia from a bottom up projection of tax revenue, to a top-line projection.

In practical terms, this Australian difference in approach has little impact on the projection outcome. While the UK, Canada and New Zealand maintain a bottom up approach to the end of their projection periods, in practice total revenue stays fairly stable as a share of GDP once bracket creep is switched off. This suggests that if Australia were to follow their lead and switch off bracket creep instead of switching to a top-line revenue projection, the Australian revenue projection would still be very similar. Nevertheless, this seems a worthwhile change to make, given the artificial nature of the top-line approach, and the greater flexibility of the bottom-up approach.

It is somewhat surprising that switching off bracket creep is sufficient to stabilise the projected ratio of tax revenue to GDP in UK, Canada and New Zealand. Closer examination shows that this reflects the simple nature of the long-term economic projections. Beyond a certain time horizon, all components of GDP are explicitly or implicitly assumed to grow at the same rate, leading all tax bases to grow at the same rate as GDP. Thus, switching off bracket creep becomes sufficient to broadly stabilise the ratio of total tax revenue to GDP, even using a bottom up approach.

In Australia, the long-term economic projections follow a similar, simple pattern. As seen earlier in Figure 4.1, by year eight the economic projections are entering their third and final phase. In this potential growth phase, GDP is growing quite smoothly, and its composition is fixed. Thus, all the nominal economic parameters that drive revenue projections are likely to be growing at a similar rate to nominal GDP.

This raises the issue of whether this common international practice in fiscal projections of assuming balanced growth in the economy after 5 to 8 years is reasonable. A consideration of the economics of population ageing suggests that it may not be for two reasons.

First, the share of private investment in GDP is likely to decline with declining population growth. This can be seen by considering the hypothetical extreme case in which the population and productivity are constant and abstracting from depreciation of capital. In that extreme case no investment is required to maintain the economy. In real world conditions, investment will be needed to cover depreciation, but the general point remains that investment can be expected to be lower as a share of GDP when population growth is lower.

Second, population ageing is likely to affect the private saving rate. Over the life cycle, saving rates rise as retirement approaches, but then fall sharply once the retirement phase is entered. This suggests that the effects of population ageing on the aggregate private saving rate may be complex. However, ultimately the proportion of the population of retirement age will reach much higher levels, suggesting an eventual fall in the aggregate private saving rate.

Allowing for these effects of demographic change on private investment and saving may have a significant effect on revenue projections. For example, a declining saving rate is likely to mean that revenue from consumption-oriented taxes is likely to rise faster than GDP and other sources of revenue.

Despite this, in the long-term fiscal projections of the advanced economies considered – US, UK, Canada, New Zealand and Australia – there does not seem to be any allowance for the possibility that population ageing will result in tax bases growing at different rates. This reflects the simple nature of the underlying long-term economic projections, which appear to invariably assume stable household saving rates, so that consumption expenditure grows in line with income. In reality, population ageing might be expected to have substantial effects on household saving.

This suggests that, for more robust long-term fiscal projections, it may be useful to investigate the potential longer term effects of demographic change on relative growth in each of the major tax bases. Some initial research to investigate these potential effects would be a logical first step. If demographic effects on long-term relative growth in tax bases were found to be important, they could be built into the new macro-econometric model, which could in turn be used to provide the economic parameters for the IGR. Most macro-econometric models will automatically take into account that the investment share of GDP is likely to decline as population growth declines, but substantial development work will usually be needed to take into account the effects of demographic change on private saving.

As discussed in section 2.3, Leal et al. (2007, p. 27) make a similar observation about using a macro-econometric or general equilibrium model to generate the economic parameters for a long-term fiscal projection. This has the advantage of taking into account "the implications of population ageing on consumption, investment and savings decisions" (Leal et al., 2007, p. 27).

At the same time, it is acknowledged that this approach is uncommon. As mentioned in section 2.3, Leal et al. (2007) attribute this uncommonness to economy-wide models being difficult to build and understand, the modelling assumptions being open to debate, and the policy conclusions from them being difficult to communicate to the public.

Expenditure

As shown in Figure 6.1, the expenditure projections beyond the Forward Estimates, like the revenue projections, involve two phases, but with different timing. In the decade from years 5 to 14, expenditures are projected using around a dozen categories (most of which are shown in Figure 6.1), the categories being far broader than those used in the Forward Estimates. For years 15 and beyond, the categories used are even broader, with health expenditure aggregated to a single category.

Health, aged care and education spending are projected using a similar method, which takes into account that demand for these government services is age related. This involves using historical data to estimate real spending per head by type of spending by age – this captures demographic effects. Education spending is higher for younger age groups and health and aged care spending is higher for older age groups. Next, the historical data is used to estimate trends in these real age-specific levels of per capita spending for each type of spending – this captures non-demographic effects. Examples of non-demographic effects include advances in medical science leading to changes in health expenditures.

The aggregation of health to a single category for year 15 and beyond appears to be motivated by a desire for greater policy realism. From years 5 to 14, existing government policy leads to steady falls in both the Commonwealth's share of hospital funding and the average rate of private health insurance rebate. The aggregated approach taken from years 15 onwards implicitly assumes that this share and this rate finally stabilise.

This overall approach provides generally plausible projections and appears to have a high level of acceptance. However, three weaknesses can be identified.

- There is a lack of policy detail compared to that available in preparing projections over the Forward Estimates period. This means there is broad-brush element in applying government policy in the medium-term estimates.
- There are no behavioural responses routinely applied to different spending scenarios. A shift in government spending from, say, funding of government provision of education or health services to funding of private provision of competing services is likely to cause a shift in consumer demand in favour of the private services, but this is not taken into account.
- The non-demographic trends are somewhat arbitrary and can have odd implications over long horizons. While linear and exponential trends are currently used, consideration should be given to using logistic trends and s-curves in cases where the variables in question are bounded.

The KTW OLG model

As indicated previously, The Treasury intends to replicate and then further develop the KTW OLG model for its own uses. The potential role of KTW OLG (Treasury) in Fiscal Group is reviewed here. Before doing so, it is useful to summarise the findings in section 2.3 concerning the use of OLG models in fiscal authorities in advanced economies.

OLG models are a type of CGE model that models each successive generation over the periods of life. Introducing multiple generations is a modelling complication that can be justified for policies affecting the allocation of resources across different generations. Hence, as explained in section 2.3, OLG models are used at fiscal authorities to study intergenerational issues such as the effects of retirement incomes policies, government debt policies and demographic change. Further, because OLG models focus on life cycles rather than economic cycles, they are ill-suited to forecasting. However, they can be used for scenario analysis.

These considerations are reflected in research at the US CBO. In a working paper, Nishiyama (2013) simulates four scenarios involving intergenerational issues such as the effects of population ageing, alternative public debt levels and changes to government old age benefits. It appears that OLG models are predominately used in such research reports rather than for forecasting or for major reports.

A similar emphasis on intergenerational issues is seen in the journal publications in which KTW OLG has been used by the model's authors. Those publications cover age pension policy, superannuation policy and the effects of demographic change on the government budget.

- Age pension policy is analysed in Tran and Woodland (2014), Kudrna (2016), Kudrna and Woodland (2011a) and Kudrna and Woodland (2011b).
- Superannuation policy is modelled in Kudrna and Woodland (2013).
- The effects of demographic change on the government budget is simulated in Kudrna, Tran and Woodland (2015).

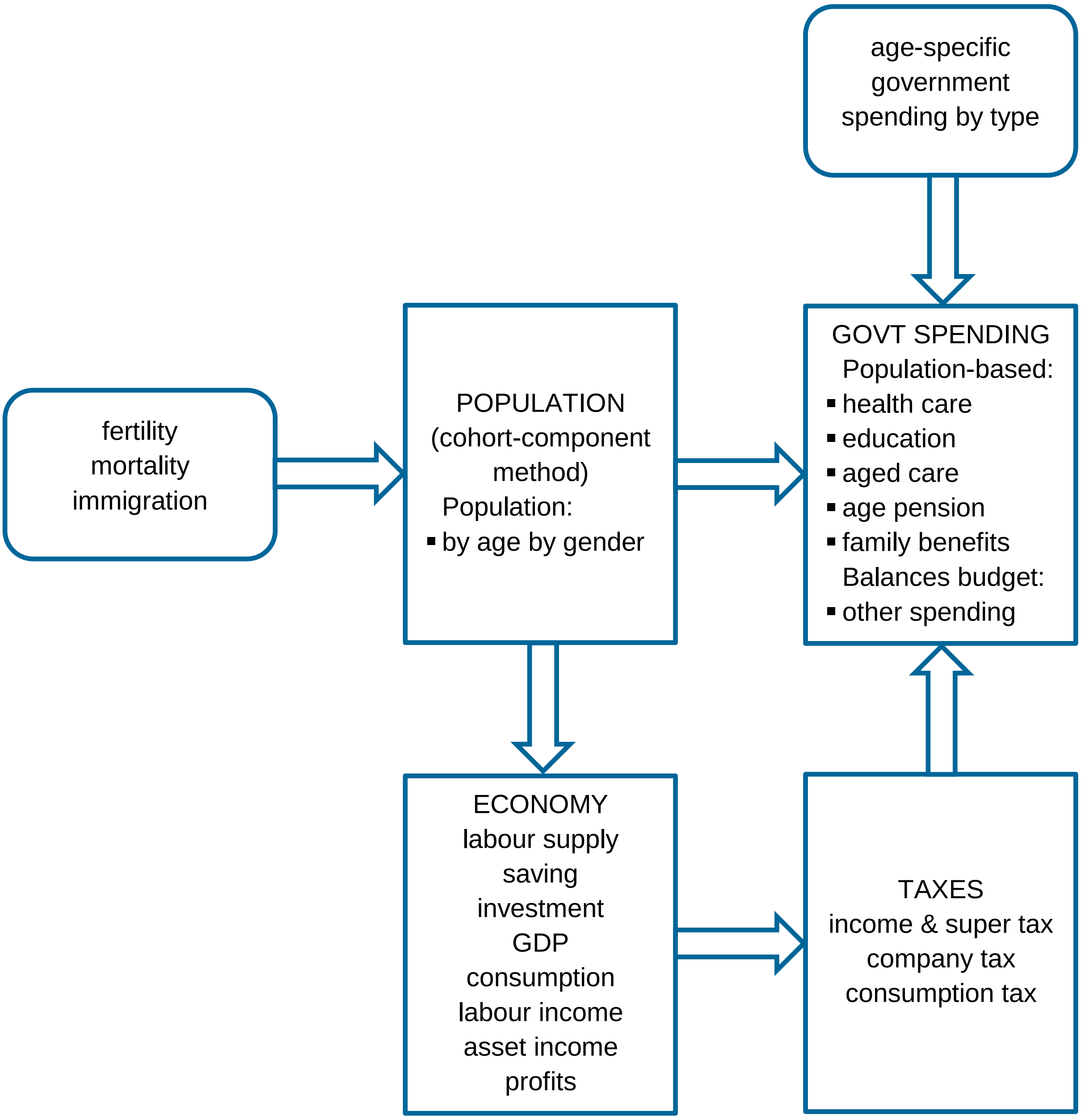
There is also a similar focus on intergenerational issues in the collection of eight applications of the KTW OLG model (Kudrna and Woodland, 2010) that was commissioned by The Treasury for the AFTS ("Henry") Review.

To consider how KTW OLG (Treasury) might be used with the IGR, it is useful to start by comparing the budget model used in the IGR, as represented in Figure 6.1, with the general structure of the existing KTW OLG model, as represented in Figure 6.2. This comparison shows the following.

- The IGR uses a more disaggregated treatment of government spending than KTW OLG.
- The IGR allows for both demographic and non-demographic effects on government spending, while KTW OLG only allows for the former.
- The IGR allows for productivity growth whereas in its default mode KTW OLG does not, although it can be introduced as a variation.
- the IGR distinguishes many categories of taxes (although switches to a top-line tax projection after seven or so years) whereas the KTW OLG only distinguishes three categories of taxes.

In short, the budget model in the IGR contains more of the detail needed to support a robust baseline fiscal projection than does KTW OLG. Like most OLG models, KTW OLG does not contain the shorter-term dynamics needed for forecasting. Rather, its dynamics is focussed on adjustment of capital stocks and assets. Further, because it is a deterministic model with model consistent expectations, some variables will "jump", up or down, at the start of the projection period, including consumer spending and investment, and that is a problem in forecasting.

Figure 6.2
The KTW Overlapping Generations (OLG) model



In short, it is very doubtful if KTW OLG could be developed to provide a baseline scenario for the IGR that is more acceptable to Treasury than the existing baseline scenario generated by The Treasury's budget modelling. However, OLG models are mainly intended for scenario or sensitivity analysis, which is also the use emphasised by MMPD (2016).

The existing IGR includes sensitivity analysis of the fiscal projections to some of the assumptions (Australian Government, 2015a, Appendix B). However, this is confined to varying some of the demographic and economic assumptions. KTW OLG (Treasury) may contribute by providing sensitivity analysis to varying some of the policy assumptions. This may be more meaningful than using the budget model for the same purpose because OLG models allow for a range of behavioural responses to policy changes.

In particular, in KTW OLG changes in the policy environment can induce behavioural responses in saving rates, investment rates and labour supply. A useful focus for The Treasury's development work on KTW OLG (Treasury) may be to review and strengthen the model's capability to provide credible policy sensitivity analysis for the fiscal projections in the IGR. This would involve working closely with the IGR experts in Fiscal Group and the MARIA experts in Revenue Group.

Retirement Incomes

TAD previously used RIMGROUP for long-term modelling of retirement incomes for the Retirement Incomes Policy Division (RIPD) of Fiscal Group. RIMGROUP was used for assessing the adequacy of retirement incomes and for Budget projections of age-related pension outlays and superannuation income tax revenue in the long term. However, RIMGROUP has been retired[23] from use.

RIMGROUP is now being replaced by the Model of Australian Retirement Income and Assets (MARIA). Like RIMGROUP before it, MARIA models the long term effects of age pension and superannuation policy on retirement incomes. It improves on RIMGROUP by using administrative unit record data in place of data on groups of individuals. The ATO provides unit record data on superannuation contributions while DSS provides unit record data on age-related pension payments. Because MARIA is still under development, it is not reviewed further here.

KTW OLG (Treasury) might play a supporting role to MARIA, in the same way that it might for the IGR generally. MARIA, because of its fine level of detail – both the use of unit record data and considerable detail on pension and superannuation policies – is very likely to provide a more credible baseline projection of retirement incomes than KTW OLG (Treasury). However, KTW OLG (Treasury) may provide useful policy sensitivity analysis for that baseline, which takes into account behavioural responses to policy change.

The existing policy levers in KTW OLG provide an indication of the potential scope for policy sensitivity analysis in support of MARIA and the IGR more generally. For the age pension there is a maximum pension rate, an income threshold, and a taper rate, but no modelling of the assets test or distinction between singles and couples. For superannuation there is a mandatory contributions rate with no voluntary contributions, a contributions tax rate and a single earnings tax rate, with benefits assumed to be taken as lump sums. For taxation there is a GST rate and a corporate tax rate. Compared

[23] no pun intended

to other Treasury modelling this setup is broad brush, but perhaps it could be further developed as part of the Treasury development work on KTW OLG.

6.2 Roadmap

In most respects the Australian IGR is developed in a similar way to other countries. Exceptions are that it is issued in the name of the government rather than the department and it provides only a top-line revenue projection for the long term. This review proposes that consideration be given to the IGR being issued in the name of The Treasury, with revenue projections developed on a bottom up basis. This would involve following the practice of the UK, Canada and New Zealand of switching off bracket creep at a suitable point in the projection period.

As noted in section 6.1, like similar exercises in other countries, the IGR currently analyses the long term effects of demographic change on relative growth in spending bases but not tax bases. This review proposes that The Treasury should consider investigating the potential longer term effects of demographic change and other factors on relative growth in the major tax bases.

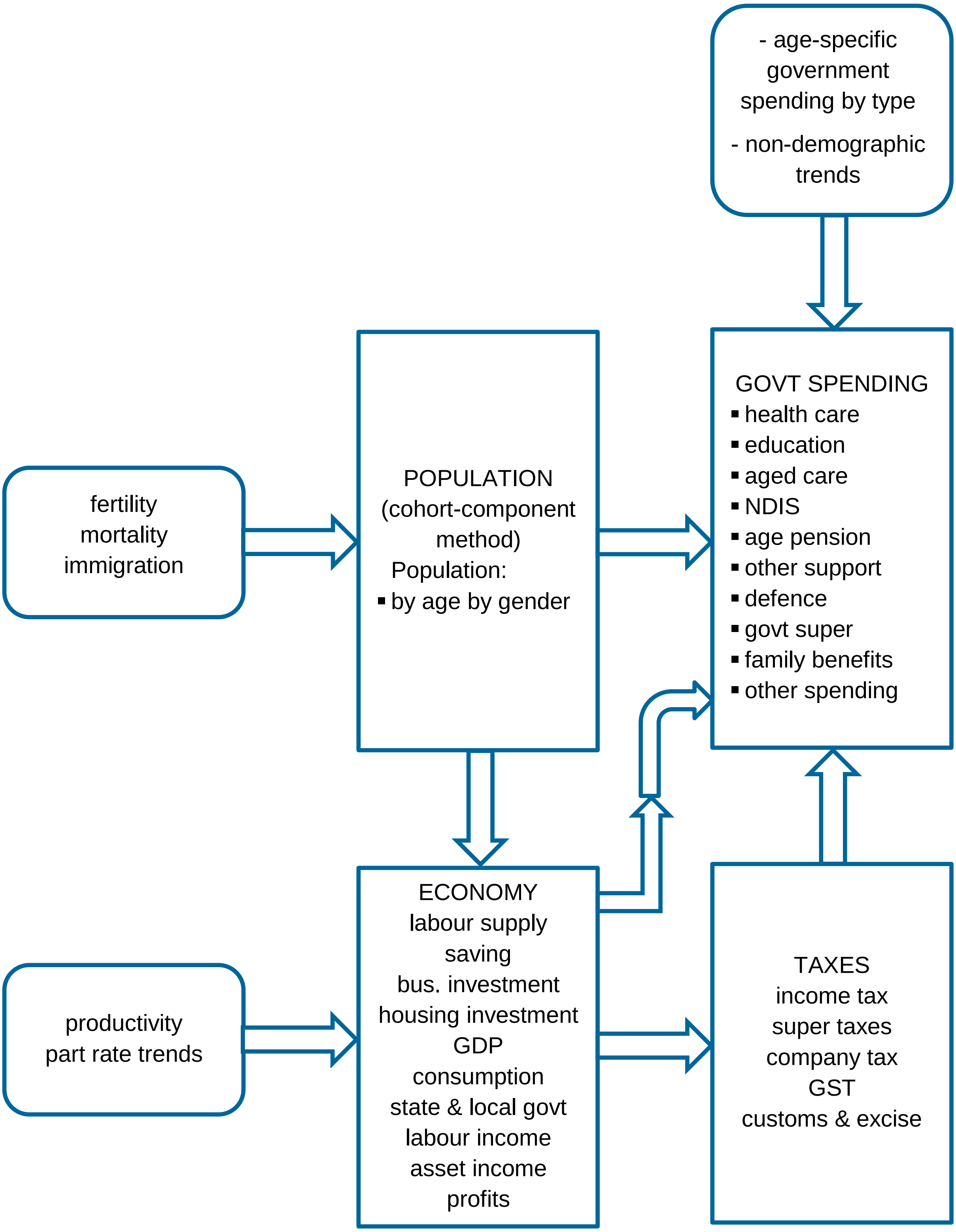
In particular, demographic change is likely to affect rates of private saving and investment, which in turn affects government revenue, including from personal income tax and GST. The effects of demographic change on private saving and investment could be incorporated in the new macro-econometric model, which in turn could be used to provide the economic parameters for the IGR. Figure 6.3 depicts the IGR modelling framework after it is upgraded in this way. The role of the "economy" box would be filled by the macro-econometric model.

The Forward Estimates draw on elaborate modelling of government expenditures conducted by Finance and spending departments. However, expenditure projections from year five onwards rely on more broad-brush modelling conducted by The Treasury. Consideration could be given to upgrading the expenditure models used by SPD. The aims would be to include greater richness of policy levers and to factor in behavioural responses to health and education spending programs.

The Treasury is aiming to replicate the Kudrna et al. (2015) Overlapping Generations (OLG) model with a view to further developing it. The Treasury could consider investigating the potential use of the KTW OLG (Treasury) model in producing policy sensitivity analysis for the IGR that allows for behavioural responses to changes in retirement incomes policy.

Finally, it can be noted that the New Zealand Government has been developing a policy of social investment. The idea is that early investment in intervention with at risk groups to help place then in jobs and improve education and health levels can help avoid long-term dependence on government assistance. Thus, the taxpayer may receive a high rate of return on such early social investments. Estimating rates of return for options for social investments is a potential future area of modelling.

Figure 6.3
Extending the Budget outlook modelling to including private saving and investment



6.3 Summary of main recommendations

Fiscal Group – Recommendation 1 (IGR framework) – higher priority

In most respects the Australian IGR is developed in a similar way to other countries, except that it is issued in the name of the government rather than the department and it provides only a top-line revenue projection for the long term. This review proposes that consideration be given to the IGR being issued in the name of The Treasury, with revenue projections developed on a bottom up basis.

Fiscal Group – Recommendation 2 (IGR and long-term revenue projections) – medium priority

Like similar exercises in other countries, the IGR currently analyses the long term effects of demographic change on relative growth in spending bases but not tax bases. The Treasury should consider investigating the potential longer term effects of demographic change and other factors on relative growth in the major tax bases.

Fiscal Group – Recommendation 3 (IGR and long-term expenditure projections) – lower priority

The Forward Estimates draw on elaborate modelling of government expenditures conducted by Finance and spending departments. However, expenditure projections from year five onwards rely on more broad-brush modelling conducted by The Treasury. The Treasury could consider further developing the medium-term expenditure estimates to increase the policy detail. In the medium-term and long-term projections it could also potentially incorporate behavioural responses to changes in the spread of government expenditure between the government and private sectors in both health and education.

Fiscal Group – Recommendation 4 (IGR and policy sensitivity) – medium priority

The Treasury is aiming to replicate the Kudrna et al. (2015) Overlapping Generations (OLG) model with a view to further developing it. The Treasury should consider investigating the potential use of the KTW OLG (Treasury) model in producing policy sensitivity analysis for the IGR that allows for behavioural responses to changes in retirement incomes policy.

7 Management

This review now discusses the management issues in implementing its recommendations. The aim of management is to ensure that the modelling activities are fully aligned with The Treasury's advisory responsibilities and are executed efficiently. Topics discussed include the arrangement of modelling activities within The Treasury's organisational structure, the development of modelling skills, and the approach to new modelling projects.

7.1 Organisation

It is a challenge for any government economic agency to keep its modelling activities fully integrated with the agency's functions. This issue was considered extensively when the Department of Finance Canada (DFC) conducted a review of its modelling activities (DFC, 2012). Modelling is centralised at the DFC in the Economic Studies and Policy Analysis Division (ESPAD). The review found that integration of ESPAD in the department had improved considerably over the last five years, but there was scope for further improvement.

> *ESPAD's roles and responsibilities were found to have changed over the last five years. It is now better integrated into the Department, and this has led to some changes in its activities and outputs. More time is being spent on the development and maintenance of complex economic models that are necessary for quick answers to current policy questions, and outputs are increasingly communicated through vehicles that are easy to use for policy makers, such as presentations and short nontechnical notes. There has been a commensurate decline in time spent producing research on economic issues intended for a more general audience and an associated decline in working paper publications and in ESPAD's active participation in economic conferences.*
>
> *The evaluation found that better departmental integration of ESPAD has benefited the Department by making ESPAD's work more responsive to its needs. It also found that a balance in the conduct of policy relevant research is beneficial over the long term. Continued work on current policy questions allows ESPAD to stay connected to current departmental issues, which in turn can help inform longer term research projects that are more policy relevant. At the same time, maintaining in depth research on general economic policy issues and building modeling and analytic capacity remains important; otherwise, management runs the risk of depleting the analytical and research capacity that ESPAD has built over the last 20 years.*
>
> *ESPAD's integration within the Department could be reinforced further with a more integrated research agenda based on departmental needs and priorities. Input into ESPAD's annual research plan from departmental senior management and other departmental branches was found to be limited.*

There are three organisational messages for any economic agency with a centralised economic modelling capability from this evaluation of ESPAD.

- Model development work should be partly shaped by department-wide inputs about current needs and priorities.

- Model development work should also focus on developing a general modelling capability, consistent with an agency's general role.
- Modelling teams need to produce outputs that are suitable for use by policy makers as well as other outputs that can be used for peer review of their modelling work.

If the experience of the ESPAD is any guide, it seems that a centralised approach to modelling can give rise to challenges in integrating modelling activities with an agency's advisory functions. On the other hand, the potential advantages of centralisation is that there may by synergies and economies in gathering modelling expertise in one area.

The Reserve Bank of Australia (RBA) has recently adopted a decentralised approach. The Economic Research Department (ER) has developed a DSGE model (Rees et al., 2016) that it uses as a tool in providing advice on monetary policy. The Economic Analysis Department (ED) is now developing a macro-econometric forecasting model that it will use as a tool in generating its forecasts. In their recent review of forecasting at the RBA, Pagan and Wilcox (2015) judged that it was important to locate the forecasting model in ED to promote engagement between the forecasters and the model, including its development process.

For its macroeconomic models, it is understood that The Treasury is proposing to follow the same co-location approach as the RBA. Thus, as a macro policy model, RBA DSGE (Treasury) is being developed in MMPD, which has responsibility for macro policy advice. Similarly, as a forecasting model, the new macro-econometric model is being located in MECD, which has responsibility for the macroeconomic forecasts.

The historical experience of The Treasury with forecasting models also suggests that co-location is the better option. From the early 1970s to the early 1980s, the forecasting model was located in the forecasting section, and it successfully formed the backbone of the forecasting process. However, in the early 1980s forecasting and modelling were divided into separate sections. At the time this was seen as a way of fostering modelling. However, gradually the forecasting model played a reduced role in the forecasting process, first being relegated to a consistency check, and then being retired in 2010. This may indicate that separation of the forecasting model from the forecasting function led to integration issues.

With its other modelling activities, The Treasury follows an approach that is neither centralised nor decentralised. Rather, perhaps due to historical circumstances, there are cross-overs between the Group that houses a particular model and the Group with the associated advisory function.

The Revenue Group provides tax policy advice. While the modelling of the equity impacts of tax policy with microsimulation models also takes place in Revenue Group, the modelling of the economic effects takes place in Macro Group using IE CGE (Treasury). This review has recommended that the economic impacts and equity impacts models be linked to achieve greater consistency in the analysis of tax policy. This would virtually necessitate co-location in the same Group, with Revenue Group being the most obvious choice.

The Fiscal Group provides advice on retirement incomes policy. The associated microsimulation model, MARIA, is housed in Revenue Group, while the associated policy scenario model, KTW OLG (Treasury) is being developed in Macroeconomic Group. This arrangement involving three separate

Groups is likely to make integration challenging. Given the similar subject matter of the two models, there is a case for locating them in the same Group.

One solution to these cross-over issues which is consistent with the considerations canvassed above would be for Revenue Group to obtain a CGE modelling capability. This would equip it to house IE CGE (or a similar model) and KTW OLG (Treasury).

RBA DSGE (Treasury), while technically a CGE model, has the nature of a macroeconomic model and so logically would remain in Macroeconomic Group. There should be some synergies between work on RBA DSGE (Treasury) and work on the new macro-econometric model e.g. similarities in databases and behavioural equations.

All of these organisational suggestions are being made from outside of The Treasury. Management would need to also weigh up a range of internal considerations and make their own better-informed judgements.

7.2 Modelling Skills

Successful economy-wide modelling requires a range of specialist skills:

1) modelling system concepts and software;
2) mathematical economics;
3) econometrics;
4) an understanding of relevant data;
5) macroeconomic or microeconomic theory, depending on the nature of the model;
6) an appreciation of the uses of the model, typically a specific area of forecasting or policy analysis; and
7) the ability to communicate modelling results to non-modelling audiences.

Often an individual has some, but not all, of these skills. For example, a more technically minded individual may possess skills (1)-(4), which are necessary for constructing and operating a model. An individual more interested in economics may possess skills (5)-(7), which are necessary for ensuring that a model is useful. A successful modelling team will bring the full range of required skills together.

Good modellers are mobile in the workforce[24]. The Treasury faces competition for modellers from within government (e.g. Australian Taxation Office, the Department of Social Security, the Australian Institute of Health and Welfare and the Productivity Commission) as well as from the private sector (e.g. Deloitte Access Economics and the CIE). It therefore needs to be able to attract and retain good modellers. This is likely to require a combination of career-developing and financial incentives.

For career development, initiatives in the following areas would assist: (i) clear career paths for modellers; (ii) training in models and model software; (iii) coaching; (iv) rotation between modelling areas within The Treasury; (v) modelling secondments outside of The Treasury e.g. to the organisations mentioned above; (vi) briefer non-modelling secondments to broaden skills; (vii) study courses at ANU;

[24] I would like to thank the Tax Analysis Division of The Treasury for input into the following discussion, while taking full personal responsibility for the content.

(viii) collaborate with modelling academics; (ix) allow time for self-development e.g. reading recent journal articles related to modelling responsibilities or learning new modelling software; and (x) identify modelling mentors.

Regarding financial incentives, specialist modelling positions could be created and filled placing more weight on modelling skills rather than broader skills. This would better reflect the value to The Treasury of the work performed by better modellers. By rewarding specialist skills in this way, pressure on divisions to oversimplify the nature of their work so that it can be performed by the people available to do it will be eased, adding to the quality and/or efficiency of The Treasury's work.

High-performing specialist modellers generally reach a point where they need to move to a generalist position to achieve further promotion. However, their value to The Treasury may be reduced when they make such a move. This problem could be addressed by paying specialist bonuses to keep people in positions where they add most value.

7.3 New Modelling Projects

The Treasury has committed to developing a new macro-econometric model, and a team will be needed to devise a detailed blueprint and implement it. The exact required size of the team will depend on the skills and experience of team members and the details of the design. However, a broad estimate of required size can be made.

The RBA has assembled a team of five modellers to develop its new macro-econometric model. However, it seems likely the RBA has chosen a large team to progress the project quickly.

ESPAD at the Department of Finance Canada (DFC) "has stated that the development of a model from scratch requires two FTEs for one year" (DFC, 2012). The ESPAD is highly experienced in model development, having successfully developed a portfolio of several models. Similarly, Independent Economics has successfully developed a variety of large-scale economy-wide models for different countries (Australia, New Zealand, Singapore, Malaysia, Hong Hong and the UAE), and developing a typical model has required two FTEs for between six months and a year.

Because the Macroeconomic Group appears to lack recent experience in developing new models, it would be prudent for Macroeconomic Group to both assemble a larger team and to obtain external expert assistance. Given some substantial external assistance, it is likely that The Treasury will need to assemble a team of three or four FTE macro-econometric modellers. Building new models requires close collaboration so a team size of five should be considered a maximum.

In management deciding about a new model, there are six important questions to be answered clearly and early to ensure effective integration between the modelling and The Treasury's advisory functions and efficient progression of the modelling.

1. Who are the stakeholders?
2. What is the purpose of the model?
3. Where is the design?
4. How many FTE and for how long?
5. Have the stakeholders approved the project and joined the steering committee?
6. Where else can I see a project like this functioning successfully?

Besides the new macro-econometric model, The Treasury is also at the early stages of two other modelling projects, the development of a Treasury version of the RBA DSGE model and a Treasury version of the KTW OLG model. This review considers that it is very important that the six questions set out above are asked and satisfactorily answered for all three projects early in their development. As noted above, this is necessary to ensure that the modelling is well aligned with the Treasury's advisory responsibilities and is executed efficiently.

Subject to that, the view of this review concerning these three new modelling projects is that they all have some merit. However, as detailed in this review and indicated in the relevant recommendations, for meeting the needs of The Treasury as a fiscal authority, the macro-econometric modelling project is of the highest importance, followed by the OLG project and then the DSGE project. This ordering would be different for a monetary authority or an academic institution.

The Treasury is already invested in models that provide analysis of the economy-wide and equity impacts of tax reform that is nuanced and competitive with that undertaken at other fiscal authorities. Further investment in those models in the way proposed in the four recommendations for Revenue Group offers a surer and more cost effective way of further developing The Treasury's capability in this area than embarking on alternative modelling approaches.

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Appendix A: Budget Economic Parameters

This Appendix contains the list of economic parameters that The Treasury needs to forecast/project to support Budget projections. The Budget economic parameters are referenced in section 3 of the report.

- Nominal GDP (orig)
- Non-farm GDP deflator (orig)
- Gross domestic product (cvm, orig)
- Gross domestic product (cp, sa)
- Gross domestic product (cp, orig)
- Non-farm gross domestic product (cvm, orig)
- Non-farm gross domestic product (cp, orig)
- Gross domestic product at factor cost (cp, sa)
- Gross domestic product at factor cost (cp, orig)
- Total compensation of employees (cp, orig)
- Total gross operating surplus inc. GMI (cp, orig)
  - Non-financial (cp, orig)
  - Financial (cp, orig)
  - GMI (cp, orig)
- Consumer price index (Headline)
- Average weekly ordinary time earnings (survey basis, sa)
- Male average weekly earnings (survey basis, orig)
- Average weekly earnings (national accounts basis, orig)
- Average weekly earnings (survey basis, orig)
- Average weekly ordinary time earnings (survey basis, orig)
- Wage and salary employment (orig)
- Non-farm employers and self-employed (orig)
- Employment (orig)
- Wages, salaries and supplements (orig)
- Consumption that is subject to GST (cp, orig)
- Consumption (cp, sa)
- Private dwelling investment (cp, orig)
- Ownership transfer costs (cp, orig)
- Exchange rate (AUD/USD)
- Oil price ($US per barrel, Malaysian Tapis)
- Oil price ($US per barrel, West Texas Intermediate)
- Private consumption - alcohol (cp, orig)
- Private consumption - alcohol (cvm, orig)
- Private consumption - cigarettes (cvm, orig)
- Private consumption - fuel and lubricants (cvm, orig)
- Private consumption - motor vehicles (cvm, orig)
- Motor vehicle price indicator
- Motor vehicle sales
- Commodity prices (AUD)
  - Iron ore
  - Metallurgical coal
  - Thermal coal
  - LNG
- Commodity volumes (Mt)
  - Iron ore
  - Metallurgical coal
  - Thermal coal
  - LNG
- Commodity prices (USD)
  - Iron ore
  - Metallurgical coal
  - Thermal coal
  - LNG
- Other business income
  - GOS
  - Interest payments
  - Total
- Property income
  - Realised rental income
  - Dividend receipts
  - Interest and non dwelling rent
  - Total
- Primary producer realised income
  - GOS
  - Net rent, interest payments
  - Total
- Endogenous goods imports (cp)
  - Non-industrial transport equipment
  - Textile, clothing & footwear
  - Other endogenous goods
- Endogenous goods (less capital)
- House prices (ABS Established House Price Index)
- Employment - Full-time share (sa)
- Employment - Part-time share (sa)
- Other personal travel services, debits (cp, orig)
- Other personal travel services, credits (cp, orig)

- Cars and station wagons (orig)
- Commercial vehicles (orig)
- Cars and station wagons - incl. SUVs (orig)
- Commercial vehicles - excl. SUVs (orig)

Non-financial corporate income indicator

- GOS – Total
- GOS – Private
- GOS – Public
- Stock valuation adjustment
- Net interest receipts
- Interest receipts
- Interest payments
- Total

Financial corporate income indicator

- GOS
- Interest receipts
- Interest payments
- Total

Corporate GOS

Total corporate income indicator

Mining GOS

Plant and equipment investment (new) (cp, sa)

Business investment (new) (cp, sa)

Mining GFCF (cp, orig)

- Mining non-dwelling construction
- Mining machinery and equipment
- Mining IPP - research and development
- Mining IPP – exploration
- Mining IPP - computer software
- Total IPP
- Mining total GFCF

TWI exchange rate

USD exchange rate and other exchange rates

Domestic final demand (cp, sa)

Statistical discrepancy - E-side (cp, orig)

Statistical discrepancy - E-side (cvm, orig)

Statistical discrepancy - I-side (cp, orig)

Average weekly earnings (survey basis, orig)

Male average weekly earnings (survey basis, orig)

Headline consumer price index

Non-farm GDP deflator (sa)

Implicit price deflators

Private consumption

Commonwealth consumption

Commonwealth investment

State and local consumption

State and local investment

Total public consumption

Dwelling investment

Other buildings and structures investment

Machinery and equipment investment

Domestic machinery and equipment investment

Business investment

Gross domestic product deflator

Gross domestic product (cp, sa)

Gross domestic product (cvm, sa)

Gross national income (cp, sa)

Oil price ($US per barrel, Malaysian Tapis)

Oil price ($US per barrel, West Texas Intermediate)

CPI rents

Wage price index

Unemployment benefit recipients

Total UBRs ('000) (excl. policy measures)

Policy - End of Parenting Payment Grandfathering

DEEWR other policy measures

Total UBRs ('000) (incl. policy measures)