The Independent Extended CGE Model

A.1 Introduction

The Independent Extended CGE Model is Independent Economics' Computable General Equilibrium (CGE) model of the Australian economy, as recently extended. Some notable features which set the Independent CGE model apart from other models of the Australian economy are as follows.

- Following model development work in 2014, the model has now been extended to distinguish 288 industries, compared to 114 industries for comparable models that rely on the standard ABS input-output tables. This finer level of detail in the extended model is obtained by using the ABS product details tables to disaggregate industry demand information and broad assumptions to disaggregate industry supply information.

- The model is designed to represent a normalised version of 2013/14 Australian economy, using the latest information available. It takes as its starting point the 2009/10 ABS Input-Output (IO) tables, which are the latest available. These are uprated in a simulation of the model that allows for general growth in prices, productivity and labour supply from 2009/10 to 2013/14, includes a long-run assumption for the terms-of-trade, and adjusts investment rates, the trade balance and the government budget position to sustainable levels.

- The model incorporates refined modelling of production in each industry. This includes nine types of produced capital, three fixed factors to capture economic rents, and eight occupations for labour. The model allows for different degrees of substitutability between these factors.

- The model provides a valid measure of changes in consumer welfare based on the equivalent variation, so that policy changes can be correctly evaluated in terms of the public interest.

- The model includes the option to use the tax-adjusted Capital Asset Pricing Model to optimally allocate wealth across asset classes. This captures the economic distortions from applying personal income tax at non-uniform effective rates across asset classes.

- The model includes refined modelling of consumer demand based on a 2-tier approach. In the top tier households allocate their spending across 19 broad categories of consumption, and in the second tier they choose their pattern of consumption within each of these categories. This 2-tier structure takes into account that there may be more scope for households to switch spending within broad categories than between broad categories.

- The model has a highly detailed treatment of business taxation, with a focus on important features of the current Australian system as well as tax designs that have been proposed around the world. It takes into account factors such as: the different tax treatments of debt and equity financing; the complex system of depreciation allowances and tax concessions; franking credits; and the potential for international profit shifting.

A.2 General features

The Independent Extended CGE Model makes a number of general assumptions that are consistent with its long-term time horizon. Many of these features are shared with other long-run CGE models.

Long-term model

The Independent Extended CGE Model is a long-term model, meaning that results refer to the ongoing effects on the economy after it has fully adjusted to economic shocks. In keeping with this, all markets are assumed to have reached equilibrium. This includes key markets such as the labour market, where the real wage for each type of labour adjusts so that demand from industries is equal to supply from households. In addition, the behaviour of households and government is consistent with the inter-temporal budget constraints that they face. This involves levels of household saving and foreign capital inflow that are consistent with stocks of assets and liabilities growing at the same rate as GDP.

The long-term time horizon is fitting because economic policies should be judged against their lasting effects on the economy, not just their effects in the first one or two years.

Optimising behaviour

Industries and households in the Independent CGE Model optimise, while still remaining within the constraints of production technology and budgets.

- Profit maximisation: the representative business in each industry chooses how to produce (with a mix of primary factors and intermediate inputs) and how much to produce to maximise its profit subject to the prices of its inputs and outputs.

- Utility maximisation: A representative household chooses its consumption levels of each consumer good and service and leisure, and allocates its wealth between assets in a way that maximises its well-being (or utility), subject to budget and wealth constraints.

Budget and wealth constraints

In a sustainable equilibrium, governments and households must meet their budget constraints. For simplicity, we assume that the government budget is balanced in the long run. Given its expenditure requirement, the government chooses its level of taxation consistent with achieving this outcome. In the private sector, a sustainable outcome is one in which household saving is sufficient to generate growth in household assets in line with growth in real GDP. The household sector has an initial endowment of a bundle of assets that determines its wealth, which it then re-allocates between assets by maximising its expected utility in line with the Capital Asset Pricing Model (CAPM).

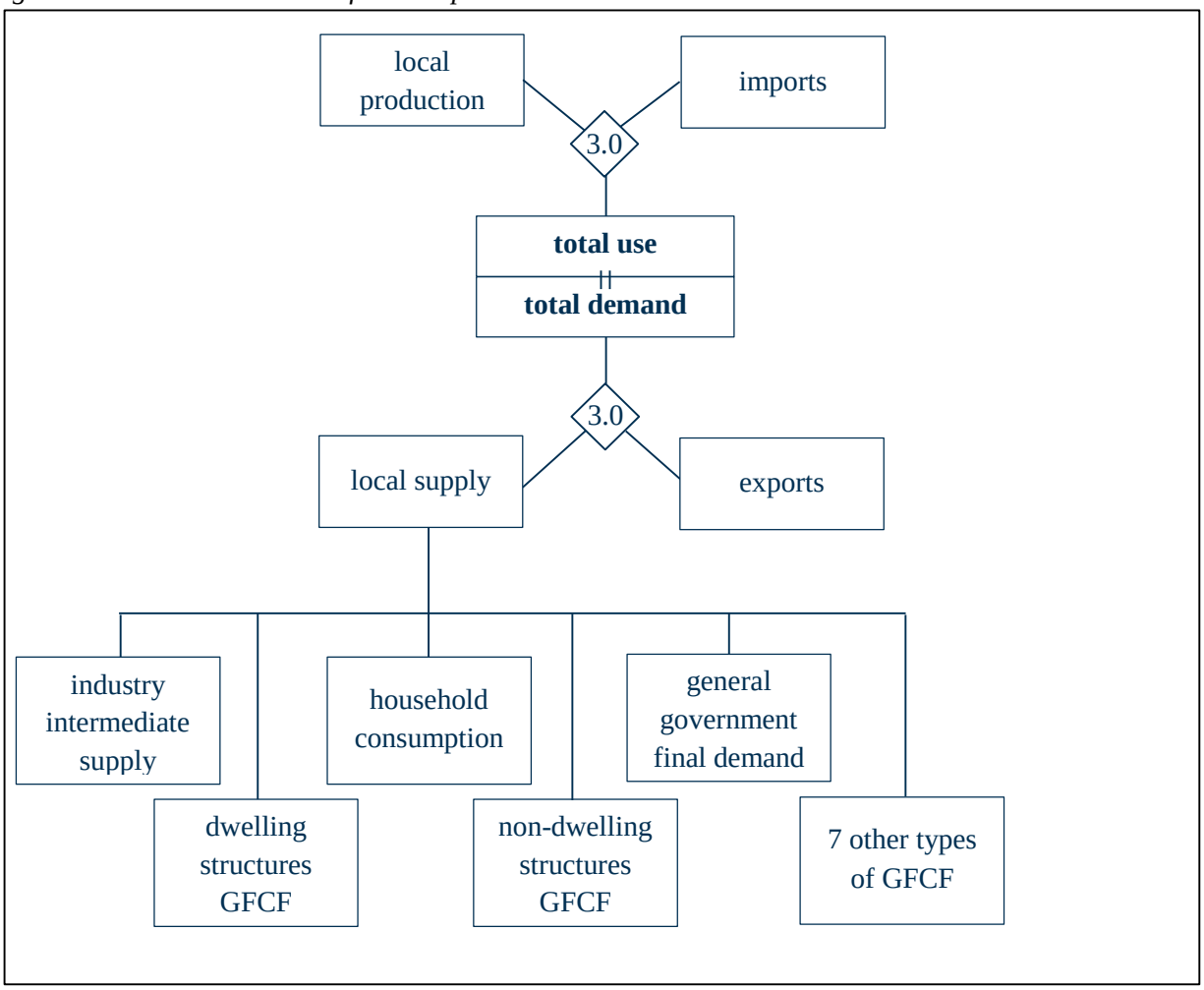
A.3 Decision makers

This section discusses the interactions between the different decision makers, or 'economic agents' in the Independent CGE model – industries, households, government and the foreign sector.

A.3.1 Trade and demand

The overall structure of each industry in the Independent Extended CGE Model is summarised in Diagram 3.1.

Diagram 3.1 Trade and demand for each product



Note: GFCF is Gross Fixed Capital Formation, or investment.

As shown in Diagram 3.1, total supply in the Independent CGE Model is made up of locally produced and imported varieties of each good. Local production competes with imports, and the elasticity of substitution has been set at 3.0 in most industries.

In each industry, the representative firm chooses the amount to supply to the export market and the amount to supply to the domestic market. It does this using a constant elasticity of transformation (CET) function, with an elasticity of 3.0.

Total supply equals total demand in long-run equilibrium. In the model, local production and imports supply the 13 different categories of demand that are shown in Diagram 3.1.

A.3.2 Industry production

Local production in each of the 288 industries in the Independent CGE Model is modelled in a sophisticated way that identifies a large set of inputs used by industries. It distinguishes 9 types of capital and 9 types of labour according to occupation. It also identifies land and two industry-specific fixed factors, one of which is fixed in supply in Australia (location-specific) and the other which is fixed in supply globally (or firm-specific). These primary factors are combined with intermediate inputs purchased from other industries. The structure of the production decisions is shown in Diagram 3.2.

Each industry can change the mix of inputs that it uses as relative prices change. Some types of primary factors are more substitutable with other factors, and other types of primary factors are less substitutable. To reflect this, the nesting structure of production decisions in the Independent CGE Model is set up in a way that provides for a high degree of flexibility.

Diagram 3.2 below shows an overview of the production technology used by firms in each industry in the Independent CGE model. Further details for non-structure capital, labour and structure services are provided in Diagrams 3.3, 3.4 and 3.5 respectively.

Diagram 3.2 Production in each industry

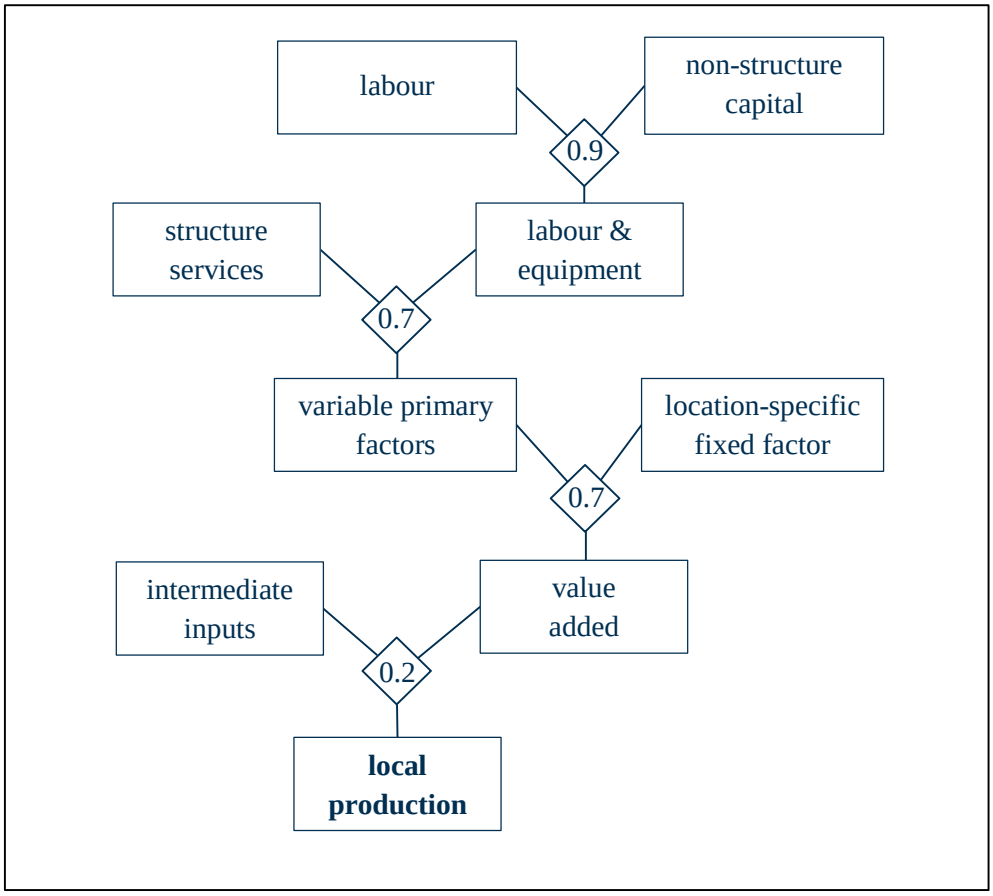
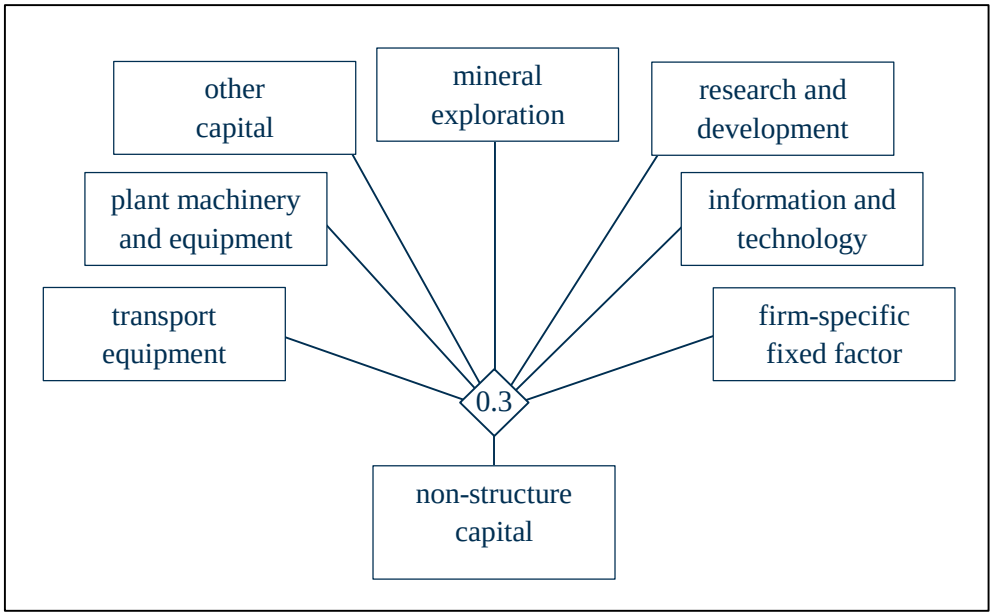


Diagram 3.3 Non-structure capital in each industry



As shown in Diagram 3.4, the modelling of industry demand for each occupation employs a 2-tier structure covering eight occupations. However, the same elasticity of substitution of 1.5 is used at both tiers. This makes it equivalent to arranging the occupations on a single tier with the one elasticity of substitution of 1.5. However, the 2-tier approach allows for greater flexibility in the future.

Diagram 3.4: Industry demand for labour

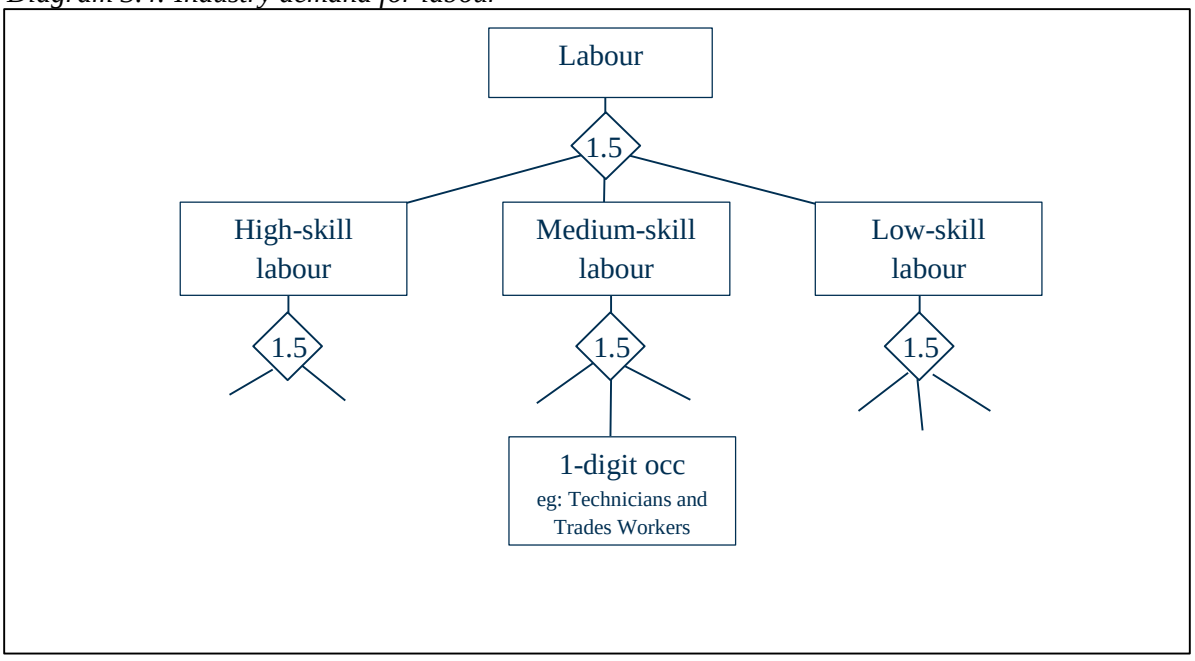
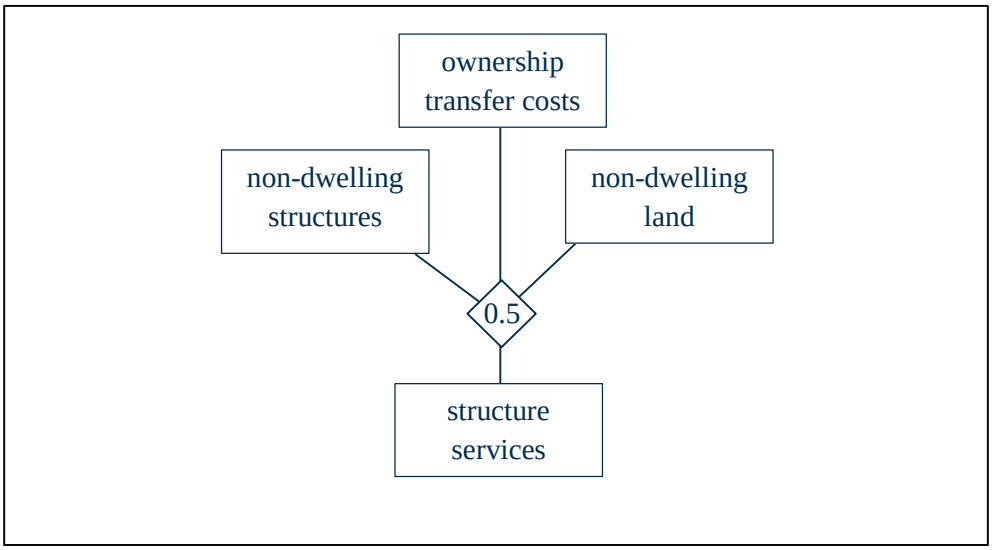


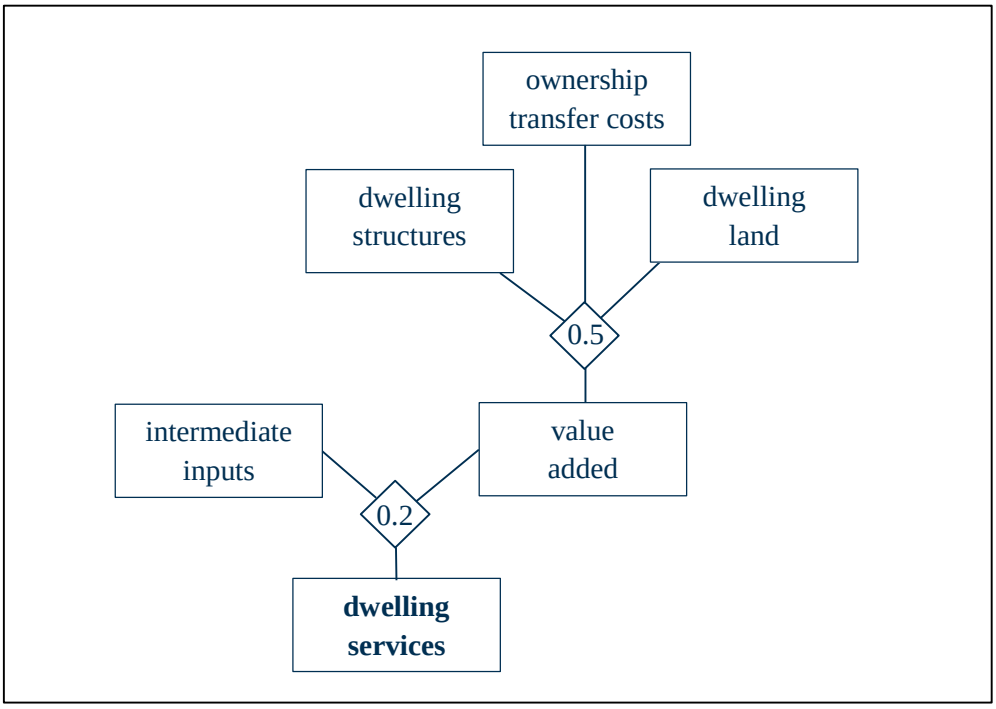
Diagram 3.5 shows that the structure services are produced using non-dwelling structures (which includes commercial buildings and engineering structures such as roads and bridges), non-dwelling land and ownership transfer costs. The need for non-dwelling structures and non-dwelling land to produce structure services is relatively obvious. Ownership transfer costs are incurred as businesses change premises as their needs changes in terms of location or building size or type.

Diagram 3.5 Structure Services in each industry (except Dwellings Services)



Dwelling services are produced in a broadly comparable way to structure services. The primary factors involved are dwelling structures, dwelling land and ownership transfer costs. This production technology for dwellings services is shown in Diagram 3.6 below. In the Independent Extended CGE model, there are two industries that produce dwelling services, namely, the owner-occupied sector and the rented sector. This is a useful distinction, partly because of differences in tax regimes.

Diagram 3.6 Production of Dwelling Services



A.3.3 Households

The model separates household decision making into two stages. In the first stage, households allocate their wealth across asset classes. In the second stage, households make choices between work and leisure and between different consumer goods and services. These two stages are now discussed in turn.

In the first stage, the model provides two options for allocating wealth across four broad asset classes: housing, domestic business capital, direct equity investment abroad and portfolio equity investment abroad. The first and simpler option is to use a fixed allocation.

The second option is to model an optimal asset allocation using the tax-adjusted using the Capital Asset Pricing Model (CAPM). This allows the model to capture the economic distortions from applying personal income tax at non-uniform effective rates across asset classes.

The version of the CAPM used here was adjusted for taxes by Brennan (1970), framed in an open economy setting by Bond et al. (2007) and used to model the impacts of changes to taxation of foreign dividends by Desai et al. (2011a).

In the CAPM, none of the four assets are assumed to be "riskless". Households have an initial endowment of each asset that determines the value of their wealth, W. They then allocate this wealth across the four asset classes, W(i), to maximise expected utility, V, which is given by the following.

$$V = W + \Sigma(1\text{-}t(i)).r(i).W(i) + \Sigma a(i).W(i) - \gamma.\sigma^2(W)/(2.W)$$

In the above, the expected pre-tax return from an asset is represented by r(i), the tax rate applied to that return is t(i), a(i) refers to the "amenity" of an asset, which may be positive or negative. The extent of risk aversion is captured in the parameter, γ, and the variance of the return associated with uncertain capital gains is $\sigma^2(W)$ and which depends on the chosen portfolio,. The optimal asset allocation depends on:

- the expected after-tax returns for each asset;
- the variances of returns for each asset;
- the covariances of returns between assets; and
- the amenity of each asset.

After-tax returns are modelled as follows. For the three equity-related asset classes, personal income tax on the component of profits paid out as dividends is taken into account. Dividend payout ratios are assumed to be 2/3 for local-sourced income and 1/2 for foreign-sourced income, based on historical data presented in Shaw Stockbroking (2013). Effective personal income tax rates on dividends are calculated using the formula:

$$(tp\text{-}tc)/(1\text{-}tc)$$

where "tp" is the rate of personal income tax applied to dividends and "tc" is the rate of tax credit. For dividends paid from local-sourced income the rate of tax credit is 30%, reflecting franking credits, while it is zero for dividends paid from foreign-sourced income. The remaining asset class, housing, is assumed to be free of personal income tax. This is on the basis that owner-occupied housing is free of personal income tax, while for investor housing, debt-related and other deductions mean that the net impact on personal income payment is slightly negative.

The variances and covariances of asset returns are derived from the pre-GFC estimates in the Australian empirical study of Peat et al. (2012). Importantly, as seen in Table 3.1, the returns from the three business capital-based asset classes are strongly positively correlated, suggesting these assets are substitutable, but these returns are largely uncorrelated with the returns from housing.

Table 3.1 Correlation matrix of investment returns

	domestic business capital	housing	direct equity abroad	portfolio equity abroad
domestic business capital	1.00			
housing	-0.13	1.00		
direct equity abroad	0.64	0.06	1.00	
portfolio equity abroad	0.64	0.06	0.70	1.00

Source: Peat et al. (2012) and Independent Economics calculations.

The amenity of each asset is determined in calibrating the model to actual asset holdings at the end of the 2013-14 financial year. The risk aversion parameter was set equal to 10, giving the model's asset allocation similar sensitivity to tax changes to that seen in earlier similar studies by Desai et al. (2011b) and Devereux (2008).

Irrespective of whether asset allocation is based on the first option (fixed allocation) or the second option (CAPM), this asset allocation has a number of functions in the model. It determines the level of asset income, which feeds into the second stage of the household decision making process. It also determines personal income tax collections from asset income. Finally, under the CAPM option, it determines the amenity and riskiness of household portfolios, which both influence household welfare, as discussed below in section 3.4.

Turning to the second stage of the household decision making process, households in the Independent Extended CGE model, after saving at a sustainable rate, choose between leisure and consumption, and then divide their consumption between the 288 goods and services. They do so in a way that maximises their utility. This behaviour is illustrated in Diagram 3.7.

Household full income is the amount of income that households would earn if they maximised their time working and consumed no leisure. Full income is made up of full labour income net of tax, after-tax income from owning assets, and transfers from government.

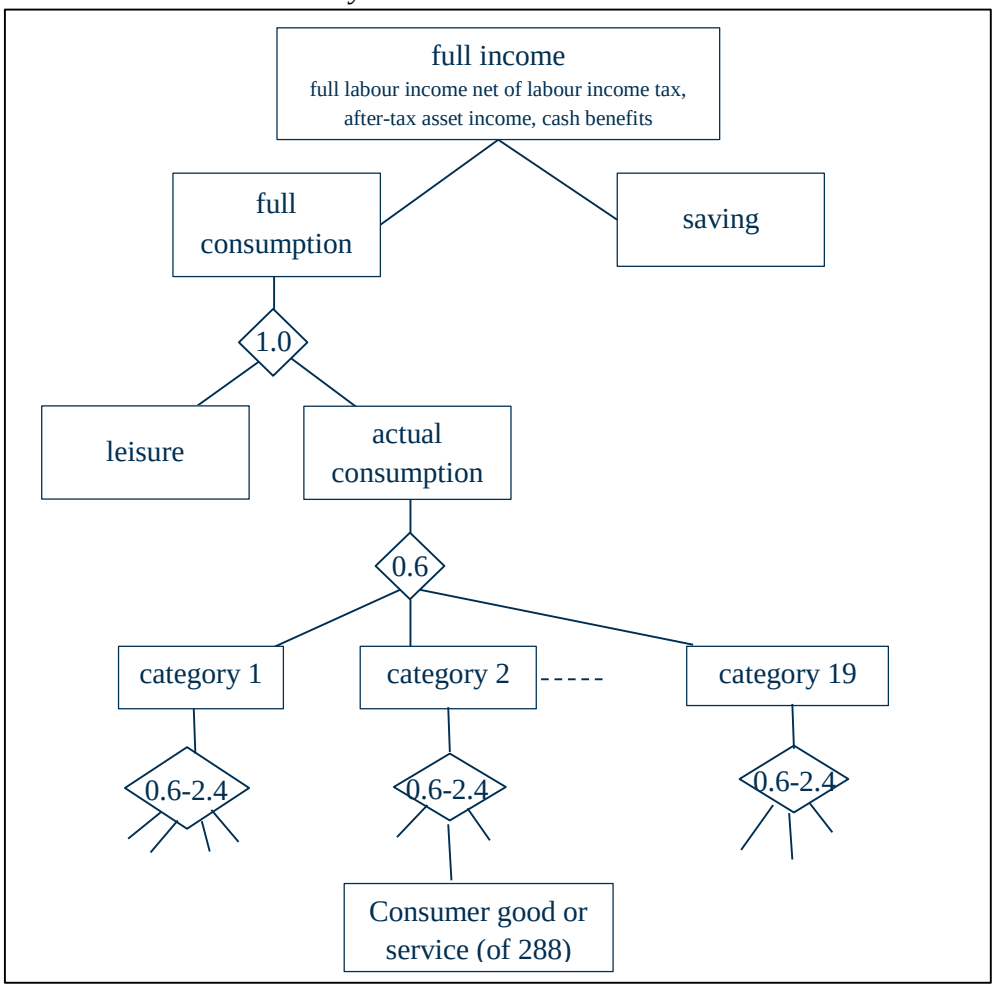
Household saving out of full income is set at a sustainable rate, namely the rate at which the assets owned by households grow in line with GDP. After saving at this rate, the remainder of full income is available for 'full consumption' – which includes the consumption of leisure and of goods and services.

As illustrated in Diagram 3.7, a 3-tier CES utility function is used in modelling the price-sensitive choices that households make concerning their labour supply and the level and pattern of their consumer demand. The first tier describes household choice between leisure and consumption, the second tier describes their choices between 19 broad categories of consumption, and the third tier their choices within each of these broad categories. These three tiers are now discussed in turn.

After meeting their savings target, in the first tier households decide how much of their time to spend in leisure, and how much to spend working. The cost of taking leisure is the amount that would have been earned if the time were instead spent working – which is the real after-tax wage.

Having made their saving and leisure decisions, households are left with a budget for actual consumption expenditure. This budget is allocated across the 288 goods and services distinguished in the model in the second and third tiers of decision making.

Diagram 3.7 Household choices and utility



In the second tier, households allocate their spending across 19 broad categories of consumption. Those broad categories are listed in Table 3.1.

Table 3.1 Broad Categories of Consumption

Food	Transport services
Alcoholic beverages	Communication
Cigarettes and tobacco	Goods for recreation and culture
Clothing and footwear	Recreational and cultural services
Housing services	Education services
Water and sewerage services	Catering
Electricity, gas and other fuel	Accommodation services
Furnishings and household equipment	Other goods and services
Health	Financial services
Vehicle purchase and operation	

In the final tier, households choose their pattern of consumption within each of the broad categories, which gives consumer demand for each of the model's 288 goods and services. There is likely to be more scope for households to vary consumption patterns within broad categories than between broad categories. This is taken into account by using a higher default elasticity of substitution of 1.2 in the final tier, compared to 0.6 in the preceding tier. With the final tier, the elasticity of substitution varies between the broad categories, reflecting differing degrees of substitutability.

A.3.4 Measuring household living standards

Measuring household welfare or living standards needs to take into account both stages of the household decision making process.

In the second stage, the assumed homothetic nature of household preferences means that the indirect utility function, V, takes the following simple form.

$$V = CF\$/PFC$$

In the above, CF refers to full consumption, including leisure and actual consumption. CF$ is total nominal expenditure on full consumption, while PFC is the associated constant utility price index.

Regarding the first stage, no further adjustment to the indirect function is required under the first option of fixed asset allocation. However, under the second option of CAPM allocation, expected utility depends on the three factors, as set out in section 3.3. This first factor was the expected value of asset income. However, its contribution to utility has already been taken into account in the second stage via the inclusion of asset income in full income, as seen in Diagram 3.7. This ensures that changes in asset income flow through dollar-for-dollar to utility via CF$.

Under CAPM asset allocation, as seen in section 3.3, expected utility also depends on two other factors, the variance of asset income and the amenity of each asset. This can be taken into account by extending the concept of nominal full consumption used in defining indirect utility as follows.

$$CFE\$ = CF\$ + \Sigma a(i).W(i) - \gamma.\sigma^2(W)/(2.W)$$

$$V = CFE\$/PFC$$

In the above, W refers to total wealth and W(i) to a component of wealth. The parameters represented by Greek letters are $\sigma^2(W)$, which is the variance in asset income and wealth associated with uncertainty in capital gains, and γ, which reflects the degree of risk aversion. Taking into account that the variance

in asset income depends on the variances and covariances of asset returns, σ(i,j), the expression for extended nominal full consumption becomes the following.

$$CFE\$ = CF\$ + \Sigma a(i).W(i) - \gamma.\ \Sigma\Sigma W(i).W(j).\sigma(i,j)/(2.W)$$

In practice, the covariances in asset returns are calculated using the data in Peat et al. (2012) on standard deviations and correlations of returns.

$$\sigma(i,j) = \rho(i,j,).\sigma(i).\sigma(j)$$

Having constructed an indirect utility function, welfare losses can now be measured. In comparing a policy scenario ("p") with a baseline scenario ("b"), the loss in consumer welfare from the policy scenario can be measured using either the compensating variation, CV, or the equivalent variation, EV.

$$CV = \{PFC(p)/PFC(b)\}.CFE\$(b) - CFE\$(p)$$

$$EV = CFE\$(b) - \{PFC(b)/PFC(p)\}.CFE\$(p)$$

In practice, the model calculates the EV. Formally, this is defined as the amount of income that households could forego under the baseline scenario while still enjoying the same level of utility as they would under the policy scenario.

For ease of interpretation, the model reverses the sign of the EV so that it measures welfare gains as positive and welfare losses as negative.

One application of the EV is in determining the excess burden of taxes, which is a measure of the welfare loss per dollar of tax revenue raised. Excess burdens can be calculated for each tax and compared across taxes to assist policy makers in designing a tax system which minimises the adverse impact of raising revenue on household welfare.

A.3.5 Government

On the expenditure side of the government budget, it is assumed that real government final demand for the 288 goods and services is determined exogenously by government spending policies. Because government expenditures are exogenous in real terms, if prices change, then nominal government expenditures change accordingly. Cash benefits paid to households are modelled as lump sum transfers.

On the revenue side of the government budget, the model distinguishes indirect taxes on production and components of final demand, as well as direct taxes such as company income tax, personal income tax, and mining taxes. To ensure that the government budget position is sustainable, the model user designates a swing tax policy that adjusts automatically to keep the budget in balance in long run equilibrium. In the Independent CGE Model, either the tax rate on labour income or cash benefits or GST can be used for this purpose.

A.3.6 Foreign sector

The modelling of Australia's relationship with the foreign sector recognises Australia's position as a small, open economy. This is the case for both trade and capital flows.

Australia is a price taker for imports, meaning that changes in the Australian economy do not influence the foreign-currency price of imports. Likewise, Australia is also close to being a price taker for exports, with a standard value for the export price elasticity of demand of -12. For some industries, where Australia has some market power or product differentiation (e.g. tourism services) a lower value of -6 is used.

Under the small country assumption, Australia can access the world market for funds, so long as the post-corporate tax rate of return that is achieved matches the given rate required on the world capital market. That is, the after-tax required rate of return on capital is determined overseas and is not influenced by changes in the domestic economy.

Australian wealth is allocated across four asset classes using a CAPM, as outlined in section 3.3. With levels of Australian-owned assets determined in this way, any change in the capital stock is funded by a change in foreign-owned capital.

Foreign ownership of the capital stock must also be in a sustainable long-run equilibrium. The annual inflow of investment funds, recorded on the capital account in the balance of payments, is an amount that ensures that the foreign-owned capital stock grows at a sustainable rate – the long-run rate of GDP growth. The payments to service this borrowing, an outflow on the current account, reflects the required after-tax return on the foreign-owned assets.

Together, the inflow on the capital account and the outflow on the current account imply a certain trade balance if external balance is to be achieved. Exchange rate adjustments ensure that this balance is achieved.

A.4 Industry detail

The original Independent CGE model, which was developed in 2012, followed comparable models in basing its industry detail on the standard ABS input-output tables. Those tables distinguish around 110 industries, the precise number depending on the year of the tables.

The Independent Extended CGE model was developed in 2014. Among its enhancements to the original model, it now extends its detail to distinguish 288 industries. The 288 industries are listed in Table 4.1. The two main aspects of this development work were to devise a method for disaggregating the original 114 industries and to choose the specific disaggregation.

To split the original industries, a disaggregation is needed for both the demand and supply sides.

On the demand side, a disaggregation is available from the ABS product details tables. The 2009/10 edition of these tables provide the demand side information for as many as 1,231 products. These were aggregated to obtain the demand side information for the 288 industries used in the extended model.

On the supply side, there is no disaggregation available from the ABS. In disaggregating from 114 to 288 industries, on the supply side inevitably an initial, simplifying assumption was made that the cost structure of each sub-industry was the same as for its parent industry. This assumption will be refined over time. In particular, in undertaking model applications that may be sensitive to this assumption, the sub-industries that are important for the application will be identified and investigated and, where appropriate, adjustments will be made to the allocation of costs between sub-industries.

In principle, using the 2009/10 product details tables allows a model developer to distinguish anything between 114 and 1,231 industries. Choosing 288 industries involved a trade-off between model richness and model maintenance costs. The trade-off was resolved by distinguishing industries that are more likely to be useful in model applications.

A complication in using the product details tables is that there are a significant number of entries that are suppressed by the ABS to protect the confidentiality of individual businesses. However, the information that is provided, together with reasonable assumptions, were used to obtain estimates for these entries that are considered to be reasonable. This was a time-intensive process.

Table 4.1 List of Industries in the Independent Extended CGE model

0101A	Sheep Farming
0101B	Beef Cattle Farming
0101C	Grain Growing
0101D	Dairy Cattle Farming
0102A	Poultry Farming
0102B	Other Livestock Farming
0103A	Nursery and Floriculture Production
0103B	Mushroom Growing
0103C	Vegetable Growing (Under Cover): levied
0103D	Vegetable Growing (Under Cover): tomatoes
0103E	Vegetable Growing (Outdoors): levied
0103F	Vegetable Growing (Outdoors): potatoes
0103G	Vegetable Growing (Outdoors): tomatoes, onions
0103H	Fruit and Tree Nut Growing
0103I	Other Crop Growing
0201Z	Aquaculture
0301Z	Forestry and Logging
0401Z	Fishing, hunting and trapping

0501A	Forestry Support Services
0501B	Agriculture and Fishing Support Services
0601Z	Coal mining
0701A	Crude oil (incl. condensate)
0701B	Gas Extraction
0801Z	Iron Ore Mining
0802A	Gold Ore Mining
0802B	Other Metal Ore Mining
0901A	Construction Material Mining
0901B	Other Non-Metallic Mineral Mining and Quarrying
1001A	Exploration
1001B	Other Mining Support Services
1101A	Meat Processing
1101B	Poultry Processing
1101C	Bacon and Ham
1101D	Other Smallgoods
1102Z	Processed Seafood Manufacturing
1103A	Milk
1103B	Cheese
1103C	Ice cream and other dairy products
1104A	Jams
1104B	Other Fruit Processing
1104C	Vegetables, frozen
1104D	Vegetables, prepared or preserved
1104E	Tomato pulp, puree and paste
1104F	Other processed vegetables
1105Z	Oils and Fats Manufacturing
1106A	Grain Mill Product Manufacturing
1106B	Cereal, Pasta and Baking Mix Manufacturing
1107A	Bread Manufacturing
1107B	Other Bakery Product Manufacturing
1108A	Sugar Manufacturing
1108B	Confectionery Manufacturing
1109A	Potato, Corn and Other Crisp Manufacturing
1109B	Prepared Animal and Bird Feed Manufacturing
1109C	Coffee and tea, including substitutes
1109D	Other Food Product Manufacturing n.e.c.
1201Z	Soft Drinks, Cordials and Syrup Manufacturing
1202A	Beer: packaged
1202B	Beer: draught
1205A	Spirits: full-strength
1205B	Spirits: RTDs
1205C	Wine: premium
1205D	Wine: cask
1205E	Cider
1205F	Cigarette and Tobacco Product Manufacturing
1301Z	Textile Manufacturing
1302Z	Tanned Leather, Dressed Fur and Leather Product Manufacturing
1303A	Textile Floor Covering Manufacturing
1303B	Rope, Cordage and Twine Manufacturing
1303C	Cut and Sewn Textile Product Manufacturing
1303D	Textile Finishing and Other Textile Product Manufacturing
1304Z	Knitted Product Manufacturing
1305Z	Clothing Manufacturing
1306Z	Footwear Manufacturing
1401Z	Sawmill Product Manufacturing
1402Z	Other Wood Product Manufacturing
1501Z	Pulp, Paper and Paperboard Manufacturing
1502A	Paper Stationery Manufacturing
1502B	Sanitary Paper Product Manufacturing

1502C	Other Converted Paper Product Manufacturing
1601A	Printing and Printing Support Services
1601B	Reproduction of Recorded Media
1701A	Automotive petrol; gasoline refining or blending; motor spirit (incl aviation spirit)
1701B	Kerosene (incl kerosene type jet fuel)
1701C	Petrodiesel
1701D	Other Petroleum Refining and Petroleum Fuel Manufacturing
1701E	Other Petroleum and Coal Product Manufacturing
1801Z	Human Pharmaceutical and Medicinal Product Manufacturing
1802Z	Veterinary Pharmaceutical and Medicinal Product Manufacturing
1803A	Basic Chemical Manufacturing
1803B	Basic Polymer Manufacturing
1803C	Fertiliser and Pesticide Manufacturing
1803D	Other Basic Chemical Product Manufacturing
1804A	Soap and Toothpaste Manufacturing
1804B	Other Cleaning Compound Manufacturing
1804C	Cosmetic and Toiletry Preparation Manufacturing
1901A	Tyre Manufacturing
1901B	Other Polymer Product Manufacturing
1902Z	Natural Rubber Product Manufacturing
2001Z	Glass and Glass Product Manufacturing
2002Z	Ceramic Product Manufacturing
2003Z	Cement, Lime and Ready-Mixed Concrete Manufacturing
2004Z	Plaster and Concrete Product Manufacturing
2005Z	Other Non-Metallic Mineral Product Manufacturing
2101A	Basic Ferrous Metal Manufacturing
2101B	Basic Ferrous Metal Product Manufacturing
2102A	Alumina Production
2102B	Aluminium Smelting
2102C	Copper, Silver, Lead and Zinc Smelting and Refining
2102D	Gold - primary and secondary (excl from purchased scrap)
2102E	Other Basic Non-Ferrous Metal Manufacturing
2102F	Basic Non-Ferrous Metal Product Manufacturing
2201Z	Forged Iron and Steel Product Manufacturing
2202Z	Structural Metal Product Manufacturing
2203A	Metal Container Manufacturing
2203B	Sheet Metal Product Manufacturing (except Metal Structural and Container Products)
2204Z	Other Fabricated Metal Product manufacturing
2301A	Motor Vehicle Manufacturing
2301B	Motor Vehicle Body and Trailer Manufacturing
2301C	Automotive Electrical Component Manufacturing
2301D	Other Motor Vehicle Parts Manufacturing
2301E	Other Transport Equipment Manufacturing n.e.c.
2302A	Shipbuilding and Repair Services
2302B	Boatbuilding and Repair Services
2303Z	Railway Rolling Stock Manufacturing and Repair Services
2304Z	Aircraft Manufacturing and Repair Services
2401A	Photographic, Optical and Ophthalmic Equipment Manufacturing
2401B	Medical and Surgical Equipment Manufacturing
2401C	Other Professional and Scientific Equipment Manufacturing
2401D	Computer and Electronic Office Equipment Manufacturing
2401E	Communication Equipment Manufacturing
2401F	Other Electronic Equipment Manufacturing
2403Z	Electrical Equipment Manufacturing
2404Z	Domestic Appliance Manufacturing
2405A	Pump, Compressor, Heating and Ventilation Equipment Manufacturing
2405B	Specialised Machinery and Equipment Manufacturing
2405C	Other Machinery and Equipment Manufacturing
2501Z	Furniture Manufacturing
2502A	Jewellery and Silverware Manufacturing

2502B	Toy Manufacturing
2502C	Sporting Product Manufacturing
2502D	Other Manufacturing n.e.c.
2601A	Fossil Fuel Electricity Generation
2601B	Hydro-Electricity Generation
2601C	Other Electricity Generation
2605A	Other electricity service income
2605M	Margin - Electricity transmission, distribution and on selling (2620-2640)
2701A	Other gas service income
2701M	Margin - gas distribution
2801Z	Water Supply, Sewerage and Drainage Services
2901Z	Waste Collection, Treatment and Disposal Services
3001Z	Residential Building Construction
3002Z	Non-Residential Building Construction
3101A	Road and Bridge Construction
3101B	Other Heavy and Civil Engineering Construction
3201Z	Construction Services
3301A	Non-margin - wholesaling services
3301B	Commission-Based Wholesaling
3301M	Margin - wholesaling services
3901A	Non-margin - retailing services
3901B	Retail commission on sales
3901M	Margin - retailing services
4401Z	Accommodation
4501A	Meal preparation and presentation
4501B	Beverage serving
4501C	Takeaway food
4501D	Catering services
4501E	Net losses from gambling - Clubs, pubs, taverns and bars (Hospitality)
4501M	Margin - food and beverage services (4511-4530)
4601A	Non-margin - Road Freight Transport
4601B	Road Passenger Transport
4601M	Margin - Road Freight Transport
4701A	Non-margin - Rail Freight Transport
4701B	Rail Passenger Transport
4701M	Margin - Rail Freight Transport
4801A	Non-margin - Water Freight Transport
4801B	Water Passenger Transport
4801M	Margin - Water Freight Transport
4901A	Non-margin - Air and Space Freight Transport
4901B	Air and Space Passenger Transport
4901M	Margin - Air and Space Freight Transport
4801C	Scenic and Sightseeing Transport
4801D	Non-margin - Pipeline and Other Transport
4801N	Margin - Pipeline and Other Transport
5101Z	Postal and Courier Pick-up and Delivery Service
5201A	Water Transport Support Services
5201B	Airport Operations and Other Air Transport Support Services
5201C	Other Transport Support Services
5201D	Warehousing and Storage Services
5201M	Margin - Water Transport Support Services
5401A	Newspaper and Magazine publishing
5401B	Book publishing
5401C	Other Publishing
5401D	Software Publishing
5501A	Motion Picture and Video Activities
5501B	Sound Recording and Music Publishing
5601A	Radio Broadcasting
5601B	Television Broadcasting
5701A	Internet Publishing and Broadcasting

5701B	Internet Service Providers and Web Search Portals
5701C	Data Processing, Web Hosting and Electronic Information Storage Services
5801A	Wired Telecommunications Network Operation
5801B	Other Telecommunications Network Operation
5801C	Other Telecommunications Services
6001A	Libraries and Archives
6001B	Other Information Services
6201A	Banks, building societies, credit unions
6201B	Other Depository Financial Intermediation
6201C	Non-Depository Financing
6201D	Financial Asset Investing
6301A	Life Insurance
6301B	Health Insurance
6301C	General Insurance
6301D	Superannuation Funds
6301M	Marine insurance provision (Margin)
6401A	Financial Asset Broking Services
6401B	Other Auxiliary Finance and Investment Services
6401C	Auxiliary Insurance Services
6601A	Goods and Equipment Rental and Hiring
6601B	Non-Financial Intangible Assets (Except Copyrights) Leasing
6701A	Residential Property Operators: owner-occupied
6701B	Residential Property Operators: rented
6702A	Non-Residential Property Operators
6702B	Real Estate Services
6901A	Scientific Research Services
6901B	Architectural Services
6901C	Surveying and Mapping Services
6901D	Engineering Design and Engineering Consulting Services
6901E	Other Specialised Design Services
6901F	Scientific Testing and Analysis Services
6901G	Legal Services
6901H	Accounting Services
6901I	Advertising Services
6901J	Market Research and Statistical Services
6901K	Corporate Head Office Management Services
6901L	Management Advice and Related Consulting Services
6901O	Veterinary Services
6901P	Professional Photographic Services
6901Q	Other Professional, Scientific and Technical Services n.e.c.
7001Z	Computer Systems Design and Related Services
7210A	Employment Placement and Recruitment Services
7210B	Labour Supply Services
7210C	Travel Agency and Tour Arrangement Services
7210D	Other Administrative Services
7310A	Building Cleaning, Pest Control and Gardening Services
7310B	Packaging Services
7501Z	Public Administration and Regulatory Services
7601Z	Defence
7701Z	Public Order and Safety
8010A	Preschool Education
8010B	Primary Education
8010C	Secondary Education
8010D	Special School Education
8110A	Technical and Vocational Education and Training
8110B	Higher Education
8210A	Adult, Community and Other Education
8210B	Educational Support Services
8401A	Hospitals
8401B	Medical Services

8401C	Pathology and Diagnostic Imaging Services
8401D	Dental Services
8401E	Optometry and optical dispensing
8401F	Other Allied Health Services
8401G	Other Health Care Services
8601A	Aged Care Residential Services
8601B	Other Residential Care Services
8601C	Child Care Services
8601D	Other Social Assistance Services
8901A	Museum Operation
8901B	Parks and Gardens Operations
8901C	Creative and Performing Arts Activities
9101A	Sports and Physical Recreation Activities
9101B	Horse and Dog Racing Activities
9101C	Amusement and Other Recreation Activities
9201A	Casino Operation
9201B	Lottery Operation
9201C	Other Gambling Activities
9401Z	Automotive Repair and Maintenance
9402A	Machinery and Equipment Repair and Maintenance
9402B	Other Repair and Maintenance
9501A	Personal Care Services
9501B	Funeral, Crematorium and Cemetery Services
9501C	Laundry and Dry-Cleaning Services
9501D	Photographic Film Processing
9501E	Parking Services
9501F	Other Personal Services n.e.c.
9501G	Private Households Employing Staff and Undifferentiated Goods- and Service-Producing Activities of Households for Own Use
9502A	Religious Services
9502B	Civic, Professional and Other Interest Group Services

A.5 Regional module

The Independent Extended CGE model is designed as a national model. This is because many economic issues are national in scope and the most important data source for CGE models – the input-output tables – are only available at the national level. However, economic impacts sometimes vary markedly across regions and to take that into account it is useful to be able to disaggregate national outputs to the regional level.

A regional module was added in 2015. It uses a top down approach to extend the model outputs from the national level to the regional level. This involved selecting regions, designing the top down methodology and sourcing regional data.

In selecting regions, it is important that each region is defined broadly enough to be considered as a distinct regional economy. This is so it can be assumed, in broad terms, that people live and work within the same region. Taking that into account, the ABS recommends the Statistical Area Level 4 (SA4) as the most detailed level that is suitable for regional economic modelling. The Independent Extended CGE model distinguishes 50 regions in Australia, consisting of the six greater state capital regions, and the 44 SA4s that make up the rest of Australia. The six greater capital cities are not divided down into the SA4 level. This is because the confined geographic areas of the capital cities combined with urban transport networks mean that people in state capital cities often live and work in different SA4s within the same city.

The top down methodology used in the regional module is derived rigorously starting from economic assumptions about regional economies. For a rigorous top down approach to be applied, regional economies are assumed to differ in a limited number of ways. In particular, it is assumed that each region has access to the same production technologies, consumers have the same tastes, labour is perfectly mobile between regions, and consumers in each region own assets from a national pool rather than a regional pool. As will be demonstrated below, these assumptions, taken together, mean that prices and wages can be expected to be same in each region. This in turn means that consumer spending patterns and input mixes in each industry are the same in each region.

As is common in regional modelling, a distinction is made between industries that produce tradeables and industries that produce non-tradeables. A tradeable industry is assumed to be a price taker for its output, which it sells on national and/or international markets. A non-tradeable industry is assumed to sell its output in the market of its own region, with no competition from imports from other regions or countries.

Where regional economies are assumed to differ is in the resources available to each tradeable industry. In particular, each tradeable industry has its own fixed factor of production, which is distributed exogenously between regions. A region's share of production for a tradeable industry is then determined by its share of that industry's fixed factor. Production in each tradeable industry in turn stimulates its own pattern of local demand across non-tradeable industries, including demand generated by household and government consumption, investment and exports.

The high degree of sameness between regions under this approach provides the conditions for top down modelling, where regional outcomes can be derived starting from national outcomes. Indeed, given national outcomes, regional outcomes can be generated using the simple technique of input-output analysis. This can be seen by considering each regional economy under the above assumptions.

Perfect mobility of labour means that utility of a household will be equalised across regions at some level, V. This is expressed below in terms of the indirect utility function, V(.), which takes the same form in each region because of the assumption that tastes are the same. The price of tradeables is determined at the national level and so is the same in each region.

$V = V(P_t, P_{nr}, M_r/N_r)$ for all r

P_t and P_{nr} are the vectors of prices for traded and non-traded goods in region r, M_r is income in region r, and N_r is employment in region r.

Income in region r is made up of labour income, plus the region share of national income from productive assets, includes variable capital K and fixed capital F. Assuming a national capital market, rates of return will not vary between regions for any particular asset.

$$M_r = W_r.N_r + (N_r / N).\sum_r (rk_n.PK_{nr}.K_{nr} + rk_t.PK_{tr}K_{tr} + rf_t.PF_{tr}.F_{tr})$$

Dividing by employment to obtain income per employed person and substituting this into the indirect utility function gives equation (1).

$$V = V(P_t, P_{nr}, W_r + (1/N).\sum_r (rk_n.PK_{nr}.K_{nr} + rk_t.PK_{tr}K_{tr} + rf_t.PF_{tr}.F_{tr})) \text{ for all r} \quad (1)$$

Under constant returns to scale, profit maximisation leads to a zero pure profits condition for each non-tradeable industry. These zero pure profit conditions take the same form in each region, under the assumption that the available technology is the same in each region. They are expressed after eliminating the price for capital goods used by the non-tradeables industries, PK_{nr}.

$P_{nr} = g(P_t, P_{nr}, W_r, rk_n)$ (2)

Because the price of tradeables and the required rate of return on capital are determined at the national level, equation (2) is a set of n equations, which are the same for each region, and involve the (n+1) unknowns of P_{nr} and W_r. This means that the prices for non-tradeables will be the same in each region if wages are also the same. However, the perfect labour mobility assumption of equation (1) provides a further equation, which is also the same in each region and involves the same set of endogenous variables. Effectively it requires the real wage to be the same in each region. Thus, each region will have the same wage and the same prices for all non-traded goods.

With relative prices the same in each region, Hicks composite commodity theorem applies. In this case it is regions, rather than commodities, which may be aggregated for analysis. In this case the theorem is not been used to aggregate from regions to the national level but rather to do the reverse – to disaggregate from the national level to regions.

For tradeable industries, the key assumption is that each such industry has a fixed factor that is distributed exogenously between regions. With prices the same in each region, each region will combine other inputs in the same proportions with the fixed factor. This means that each region's share of national production of a given tradeable will equal its given share of the fixed factor for that tradeable.

This makes it straightforward to apply the top down methodology to estimate production of tradeables in each region. The first step is to simulate the national model, to obtain national production of each

tradeable. Each region's historical share of activity for each tradeable industry is then used to estimate production of tradeables, x_T, in any given region.

To determine the production of non-tradeables, the key observation is that relative prices and the associated optimal consumption and input mixes have already been determined at the national level. Under the assumptions made above, the same mixes are also optimal at the regional level. This means that the technique of input-output analysis can be adapted to solve for the production of non-tradeables.

It is important that the various coefficient matrices are re-calculated for each simulation of the national model. This is because relative prices and associated optimal mixes are likely to vary between simulations of the national model.

To obtain the solution for production of non-tradeables in a region, the regional model is written in the following form, which is similar to the form of an input-output model.

$$x = A.x + D.i + e - m + n \quad (3)$$

$$f = L.x \quad (4)$$

In the above, x is the vector of industry production, A is the usual matrix of input-output coefficients determining intermediate use, D is the matrix of domestic demands, i is a column vector of ones, e is foreign exports, m is foreign imports and n is inter-regional net exports. Note that in solving the regional module A is fixed, because any sensitivity of intermediate demands to relative prices has already been taken into account in constructing A from the outputs of the national model. The same principle applies for factor demands so L is also fixed when solving the regional module.

Equation (4) determines a region's demand for primary factors, f, by aggregating over the demand from all industries. This involves applying the matrix of primary factor demand intensities, L, to the industry production vector, x. The matrix L, like the matrix A, is constructed from the outputs of the national model.

Under the assumptions made earlier, the following relationships will hold in the regional model.

$$e = \hat{\theta} \cdot x \quad (5)$$

$$m = \hat{\alpha} \cdot x \quad (6)$$

$$D.i = D_n . \hat{f}_n^{-1} . f \quad (7)$$

Exports and imports are determined from production using the national-level propensities that appear in the diagonal matrices of $\hat{\theta}$ and $\hat{\alpha}$.

A region's share of each column of the national matrix of domestic demands, Dn, is determined by its share of use of the associated primary factor. For example, under the assumptions made above, its share of the consumption vector will be determined by its share of national employment. Further, its share of each category of investment will be determined by its share of use of the corresponding category of capital.

$\hat{f}_n$ is a diagonal matrix showing the total use of each primary factor at the national level. The ordering of the rows of fn and f is based on the ordering of primary factors in driving each column of final demands. If the same primary factor drives more than one category of final demand (employment drives both household consumption and government consumption) it appears more than once and if it does not drive any categories of final demand (as is the case for fixed factors) it does not appear at all.

Using equations (4), (5), (6) and (7) in equation (3) and re-arranging gives the following.

$$Q.x = n \tag{8}$$

where:

$$Q = I - A - D_n.\hat{f}_n^{-1}.L - \hat{\theta} + \hat{\alpha}$$

Without loss of generality, the industries can be ordered so that the tradeable industries appear first, followed by the non-tradeable industries. The matrices in equation (8) can then be partitioned as follows.

$$Q = \begin{bmatrix} Q_{TT} & Q_{TN} \\ Q_{NT} & Q_{NN} \end{bmatrix}$$

$$x = \begin{bmatrix} x_T \\ x_N \end{bmatrix}$$

$$n = \begin{bmatrix} n_T \\ 0 \end{bmatrix}$$

Equation (8) can now be divided into separate sets of equations for tradeables and non-tradeables.

$$Q_{TT}.x_T + Q_{TN}.x_N = n_T \tag{9}$$

$$Q_{NT}.x_T + Q_{NN}.x_N = 0 \tag{10}$$

Using equation (10), the solution for production non-tradeables is given be equation (11).

$$x_N = -Q_{NN}^{-1} \cdot Q_{NT}.x_T \tag{11}$$

Net inter-regional exports of tradeables can then be determined recursively from equation (9), which can be written more simply as equation (12), where Q_T represents the rows of Q for tradeable industries.

$$n_T = Q_T.x \tag{12}$$

It is computationally straightforward to use equations (11) and (12) to solve the system. Having obtained x_T in the simple manner described earlier, solving the system for each region only requires the matrix Q, which is constructed entirely from outputs of the national model. Q is transformed according to equations (10) and (11), stored, and used repeatedly to solve for each region. Thus, only one matrix

inversion is required using national data, and no further matrix inversions or manipulations are required in solving for all of the regions.

Once x has been determined, regional-level results for other variables are readily generated as required using equations (4), (5), (6) and (7).

As is clear from equation (11), under this approach, any expansion or contraction in a tradeable industry in a region will flow through to demand for non-tradeables, generating a regional multiplier effect. Major examples of such non-tradeable industries in the regional module include retail trade, health services, school education and food and beverage services.

An advantage of the top down modelling approach is that, by assuming that regional economies differ in only limited ways, less region-specific data is needed. This is just as well because the key data needed for CGE modelling at the national level, input-output tables, are not available at the regional level. The top-down approach only requires data on each region's share of each tradeable industry.

These regional shares were calculated primarily from employment data collected in the 2011 ABS Census. This data shows, for each SA4 region, the breakdown of employment across 86 2-digit industries. One of these 2-digit industries is agriculture. Activity in each SA4 region in agriculture was broken down further to 13 sub-industries using the 2012-13 ABS data on the value of individual agricultural commodities produced in each SA4 region (ABS Cat No. 7503.0).

After matching industries in this regional database to industries in the national model, the final outcome was a regional module with 89 industries. This is fewer than the 288 industries in the national model. The regional module provides results only for quantities. However, prices are not required, because they are the same as at the national level.

A.6 Baseline scenario and validation

The model uses a variety of recent data, but the main source is the detailed Input-Output (IO) tables from the ABS, giving the model a detailed picture of the Australian economy. The latest available tables are used, specifically the 2009/10 IO tables released in late 2013. This also means that the model uses the contemporary ABS industry classification, ANZSIC 2006. The model is calibrated so that it exactly reproduces this 2009/10 data.

The next step is to simulate a baseline scenario for use as a point of reference. This involves two aspects, uprating the economy from 2009/10 to 2013/14 and normalising the economy to a sustainable position. That is, the baseline scenario provides a normalised, or sustainable, version of the 2013/14 economy.

Uprating the economy from 2009/10 to 2013/14 involves simulating the model after adjusting the model's inputs for the effects of economic developments from 2009/10 to 2013/14. This includes allowing for growth in wages, import prices, productivity and employment from 2009/10 to 2013/14.

Normalising the economy involves taking into account the differences between the structure of the economy in 2009/10, compared to an economy in a long-run sustainable equilibrium. This involves normalising the trade balance, the government budget balance, rates of business investment, and the level of the terms-of-trade.

The model has been tested to ensure that it observes a number of widely-accepted balance and neutrality properties for CGE models.

- GDP by expenditure always equals GDP by income. This is true for both nominal and real GDP in all simulations, which is a useful check on the consistency of the model's coding.
- Walras' Law states that if all but one market is in equilibrium, then the last market must also be in equilibrium. In the Independent Extended CGE Model, equilibrium is not imposed in one of the 8 labour markets, but is nevertheless always achieved in that market in model simulations as a consequence of Walras' Law.
- The Independent CGE Model observes price neutrality. When the average nominal wage or numeraire is increased by two per cent, all prices in the model increase by exactly two per cent, and all real variables are unaffected, in accordance with the expected price neutrality property.
- The Independent CGE Model also observes real neutrality. This means that when all of the exogenous real variables are two per cent higher, all of the endogenous real variables are also two per cent higher. The exogenous real variables in the Independent CGE Model are: full labour supply; real general government final demand by industry; the supplies of industry-specific fixed factors; the supplies of land; the initial holdings of the four real assets owned by the household sector; and the size of the world economy.

A.7 Business tax

Analysis of the business tax system is important. High or poorly designed business taxes have the potential to cause major economic distortions because of the open economy assumption that the after-tax required rate of return on capital is determined overseas. This assumption implies that an increase in taxation of foreign investment into Australia may need to be offset by higher pre-tax returns on capital to maintain the after-tax returns received by foreign investors. Higher pre-tax returns are achieved by reducing investment and capital, which leads to lower labour productivity.

In light of this, the model has a highly detailed treatment of business taxation, with a focus on important features of the current Australian system as well as tax designs that have been proposed around the world. This takes into account factors such as: the different tax treatments of debt and equity financing; the complex system of depreciation allowances and tax concessions; franking credits; and the potential for international profit shifting.

Treatment of debt and equity financing

Four alternative business income tax systems that have been proposed around the world are provided for in the Independent CGE model. These systems differ in the deductions available for the costs of debt and equity financing, and are modelled as follows.

- Standard corporate income tax (CIT), such as the current Australian system, allows deductions for the interest costs of debt financing, but no deduction with respect to equity financing costs.
- Comprehensive business income tax (CBIT), allows no deductions for financing costs, giving the widest possible tax base.
- Allowance for corporate equity tax (ACE), gives deductions for the interest costs of debt financing, along with an imputed cost for equity financing.
- Allowance for corporate capital tax (ACC), allows a single deduction for an imputed cost for the full capital base, so both equity and debt financing costs are covered by the one deduction.

Both ACE and ACC aim to provide deductions that cover all capital financing costs. With the full cost of capital deductible, the tax base is intended to only include economic rents. In principle, this means that a business tax system based on ACE or ACC would be more efficient than the existing CIT system.

In modelling deductions for the cost of debt financing (under the CIT and ACE), the debt-to-equity ratio of each industry has been estimated using ATO Taxation Statistics data. This allows the model to take into account that the current company income tax system provides higher tax deductions for industries which tend to have higher debt-to-equity ratios.

Depreciation allowances and tax concessions

Company income tax in Australia allows for a number of depreciation allowances and tax concessions, which differ by asset type. The model takes into account the following aspects of the system of depreciation allowances.

- The tax system allows for depreciation at historic cost which is less generous than economic depreciation which would be calculated at replacement cost.
- Tax and economic depreciation rates differ for each of the nine types of produced assets in the model. Where tax depreciation rates are more concessional for some types of capital than for others, the choice of the mix of capital may be distorted.
- Immediate expensing is allowed for investment in some assets, sometimes with a loading. This includes certain R&D expenditure, which can be immediately expensed, with loadings that differ by industry.

Franking credits

Some corporate tax revenue is refunded when franking credits are used, reducing the overall contribution to the budget from company tax. However, some franking credits are "lost" because companies may choose to retain profits rather than distribute them as franked dividends, or because the franking credits accrue to overseas investors who are not able to use them. The use of franking credits is explicitly modelled as part of the CAPM that was discussed in section 3.4. In the CAPM, the availability of franking credits creates a tax bias in favour of Australian wealth being allocated to Australian-based capital.

Choice of firm location

Multinational firms can generate rents through access to intangible assets such as brand names, patents and market power. Company income tax can have an important effect on the locational choice of multinational firms and their rents, which is taken into account in the model. It assumes that multinational firms have access to a firm-specific fixed factor that represents their intangible assets. They allocate the factor between countries to maximise their profit.

The response of firm-specific capital to an increase in the Australian company tax rate is not dissimilar to the response of variable capital. In both cases, capital is likely to be withdrawn, until pre-tax returns rise sufficiently to restore after-tax returns to the levels available in other jurisdictions.

Profit shifting

The model takes into account that multinational companies may seek to reduce their business tax liability by shifting profits from Australia to countries with lower rates of business tax. Profit shifting may occur through transfer pricing, the method of internal charging for company know-how and the way debt is allocated between countries.

Following de Mooij and Devereux (2011), profit shifting, which is assumed to involve costs, is modelled as a shifting of part of the company tax base from Australia to tax havens. The extent of profit shifting depends on the extent of the gap between the Australian company tax rate and the tax haven

tax rate. The model takes into account the overall effect that this behaviour has on both revenue collections and the user cost of capital.

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