CENTRE of POLICY STUDIES and the IMPACT PROJECT

Eleventh Floor, Menzies Building
Monash University, Wellington Road
CLAYTON Vic 3800 AUSTRALIA

Telephone: (03) 9905 2398, (03) 9905 5112 — from overseas: 61 3 9905 2398 or 61 3 9905 5112

Fax: (03) 9905 2426 — 61 3 9905 2426

e-mail: impact@buseco.monash.edu.au

Internet home page: http//www.monash.edu.au/policy/

MMRF: Monash Multi-Regional Forecasting Model: A Dynamic Multi-Regional Model of the Australian Economy

by

PHILIP ADAMS,
JANINE DIXON,
JAMES GIESECKE
AND
MARK HORRIDGE

Centre of Policy Studies
Monash University

General Paper No. G-223 December 2010

ISSN 1 031 9034

ISBN 978 1 921654 30 5

The Centre of Policy Studies (COPS) is a research centre at Monash University devoted to economy-wide modelling of economic policy issues.

MMRF: Monash Multi-Regional Forecasting Model

A Dynamic Multi-Regional Model of the Australian Economy

Philip Adams, Janine Dixon, James Giesecke and Mark Horridge

December 2010

MMRF is a dynamic CGE model of Australia's six State and two Territory economies. MMRF is used extensively in contract research. Several features of MMRF make it an ideal tool for policy analysis, including: dynamics, a highly disaggregated regional and sectoral database, a national labour market, and detailed modelling of government financial statistics.

JEL classification: C68, D58, R13

Key Words: CGE modelling, dynamics, regional economics

Table of Contents

Figures

1. Introduction

The Monash Multi-Regional Forecasting (MMRF) model is a multi-regional Computable General Equilibrium (CGE) model of Australia's eight regional economies — the six States and two Territories. Each region is modelled as an economy in its own right, with region-specific prices, region-specific consumers, region-specific industries, and so on. There are four types of agent: industries, households, governments and foreigners. In each region, there are 58 industries and 63 commodities recognised in the standard database, although the database may be disaggregated to many more industry/commodity pairs if required. The industries can produce a variety of commodities, and each creates a single type of capital. Capital is sector and region specific. In each region, there is a single household and a regional government. There is also a Federal government. Finally, there are foreigners, whose behaviour is summarised by demand curves for regional international exports and supply curves for regional international imports.

MMRF can be configured to run in one of two modes:

1. comparative static mode; or
2. recursive-dynamic (year-to-year) mode.

In comparative-static mode, MMRF indicates the effects of the specified policy change over a short-run or long-run time span, depending on the closure chosen.

In recursive-dynamic mode, MMRF produces sequences of annual solutions connected by dynamic relationships such as physical capital accumulation. Policy analysis with MMRF involves the comparison of two alternative sequences of solutions, one generated without the policy change, the other with the policy change in place. The first sequence, called the basecase projection serves as a control path from which deviations are measured in assessing the effects of the policy shock.

MMRF is a flexible model. It can be easily modified to meet suit particular tasks. As a result, there exist many versions of the model and database. In this document, the core version[1] of the model (incorporating input-output data from 2005-06) is described in detail, along with brief descriptions of some of the MMRF add-ins. In Chapter 2, we provide an overview of the MMRF model. Chapter 3 contains an overview of the method used to solve the model, and a discussion of closure options. The formal description of MMRF is given in Chapter 4. This description is organised around the TABLO file that implements the model in GEMPACK.[2] Aspects of model closure are discussed in Chapter 5.

[1] A similar version of the MMRF model, partly funded by the Productivity Commission, was designed to quantify the economy-wide and regional effects of the National Reform Agenda. One of the key features of this version of the model was a new database, reflecting the year 2001-02, which is based on the first post-GST national input-output table. Another key feature is a refined set of government fiscal accounts, with the same structure as the ABS *Government Financial Statistics*.

[2] GEMPACK is a flexible system for solving large economic models (see Harrison and Pearson, 1996). It automates the process of translating the model specification into a model solution program. As part of this automation, the GEMPACK user creates a text file listing the equations of the model in a language that resembles ordinary algebra. This text file is called the TABLO file.

2. Overview of the MMRF model

MMRF represents an extension of the Monash Multi-Regional (MMR) model, a comparative static CGE model of the six State and two Territory economies.[3] To this, many of the dynamic relationships from the MONASH model were added to enable the effects of policy to be traced through time.[4] MMRF includes MMR as a special case. As such, MMRF retains all of the strengths of its predecessor, including a highly disaggregated regional database. A range of further developments were then added to enhance the model's capacity for environmental, transport and Government fiscal analysis.

MMRF consists of a general equilibrium core, and a number of optional add-ins that may be used to enhance the model's capability for analysis of issues, particularly in relation to electricity, fuel usage and carbon emissions accounting.

2.1 *General equilibrium core*

2.1.1 The nature of markets

MMRF determines regional supplies and demands of commodities through optimising behaviour of agents in competitive markets. Optimising behaviour also determines industry demands for labour and capital. Labour supply at the national level is determined by demographic factors, while national capital supply responds to rates of return. Labour and capital can cross regional borders so that each region's stock of productive resources reflects regional employment opportunities and relative rates of return.

The assumption of competitive markets implies equality between the basic price and marginal cost in each regional sector. Demand is assumed to equal supply in all markets other than the labour market (where excess supply conditions can hold). The government intervenes in markets by imposing ad valorem sales taxes on commodities. This places wedges between the prices paid by purchasers and prices received by producers — the basic price of the good or service. The model recognises margin commodities (e.g., retail trade and road transport freight) which are required for each market transaction (the movement of a commodity from the producer to the purchaser). The costs of the margins are included in purchasers' prices but not in basic prices of goods and services.

2.1.2 Demands for inputs to be used in the production of commodities

MMRF recognises two broad categories of inputs: intermediate inputs and primary factors. Firms in each regional sector are assumed to choose the mix of inputs which minimises the costs of production for their level of output. They are constrained in their choice of inputs by a three-level nested production technology. At the first level, intermediate-input bundles, primary-factor bundles and other costs are used in fixed proportions to output. These bundles are formed at the second level. Intermediate-input bundles are combinations of international imported goods and domestic goods. The primary-factor bundle is a combination of labour, capital and land. At the third level, inputs of domestic goods are formed as combinations of goods from each of the eight regions, and

---

[3] An initial progress report on the development of MMR is given in Meagher and Parmenter (1993).

[4] MONASH is a dynamic CGE model of the Australian economy built and maintained at the Centre of Policy Studies, Monash University. It is described in Dixon and Rimmer (2002).

the input of labour is formed as a combination of inputs of labour from the nine different occupational categories.

2.1.3 Household demands

In each region, the household buys bundles of goods to maximise a utility function subject to a household expenditure constraint. The bundles are combinations of imported and domestic goods, with domestic goods being combinations of goods from each region. A Keynesian consumption function is usually used to determine aggregate household expenditure as a function of household disposable income.

2.1.4 Demands for inputs to capital creation and the determination of investment

Capital creators for each regional sector combine inputs to form units of capital. In choosing these inputs, they cost minimise subject to technologies similar to that used for current production; the only difference being that they do not use primary factors. The use of primary factors in capital creation is implicitly recognised in the commodities used in capital creation.

2.1.5 Governments' demands for commodities

Commodities are demanded from each region by regional governments and by the Federal government. In MMRF, there are several ways of handling these demands, including:

1. endogenously, by a rule such as moving government expenditures with household consumption expenditure or with domestic absorption;
2. endogenously, as an instrument which varies to accommodate an exogenously determined target such as a required level of government deficit; or
3. exogenously.

2.1.6 Foreign demand (international exports)

MMRF adopts the ORANI specification of foreign demand.[5] Each export-oriented sector in each state faces its own downward-sloping foreign demand curve. Thus, a shock that improves the price competitiveness of an export sector will result in increased export volume, but at a lower world price. By assuming that the foreign demand schedules are specific to product and region of production, the model allows for differential movements in world prices across domestic regions.

2.1.7 Regional labour markets

Equations relate regional population and population of working age, and regional population of working age and regional labour supply. Regional unemployment rates are defined in terms of regional demands and supplies of labour.

There are three main possible treatments in MMRF for regional labour markets:

1. regional labour supply and unemployment rates are exogenous and regional wage differentials are endogenous;

---

[5] ORANI is a large-scale multi-sectoral model of the Australian economy (see Dixon, *et al*., 1982). It is the predecessor of MONASH.

2. regional wage differentials and unemployment rates are exogenous and regional labour supply is endogenous (and the regional labour supply may adjust via interstate migration or changes in regional participation rates); or
3. regional labour supply and wage differentials are exogenous and regional unemployment rates are endogenous.

2.1.8 Physical capital accumulation

Investment undertaken in year t is assumed to become operational at the start of year t+1. Under this assumption, capital in industry i in state/territory q accumulates according to:

$$K_{i,q}(t+1) = (1 - DEP_{i,q}) \times K_{i,q}(t) + Y_{i,q}(t) \qquad (2.1)$$

where:

$K_{i,q}(t)$ is the quantity of capital available in industry i located in q at the start of year t;

$Y_{i,q}(t)$ is the quantity of new capital created for industry i in region q during year t; and

$DEP_{i,q}$ is the rate of depreciation in industry i in region q, treated as a fixed parameter.

Given a starting point value for capital in t=0, and with a mechanism for explaining investment through time, equation (2.1) can be used to trace out the time paths of industry capital stocks.

Investment in industry i in state/territory s in year t is explained via a mechanism of the form

$$\frac{K_{i,q}(t+1)}{K_{i,q}(t)} - 1 = F_{i,q}\left[EROR_{i,q}(t)\right] \qquad (2.2)$$

where

$EROR_{i,q}(t)$ is the expected rate of return on investment in industry i in region q in year t; and

$F^{t}_{i,q}[\ ]$ is an increasing function of the expected rate of return with a finite slope.

In MMRF, it is assumed that investors take account only of current rentals and asset prices when forming current expectations about rates of return (static expectations). Unlike the Monash model, investors in MMRF do not equate the expected rate of return with the present value in year t of investing $1 in industry i in region r, taking account of both the rental earnings and depreciated asset value of this investment in year t+1 as calculated in the model (rational expectations).

2.1.9 Lagged adjustment process in the labour market

MMRF contains one lagged adjustment processes relating to the operation of the labour market in year-to-year policy simulations.

In comparative static analysis, one of the following two assumptions is made about the national real wage rate and national employment:

1. the national real wage rate adjusts so that any policy shock has no effect on aggregate employment; or

2. the national real wage rate is unaffected by the shock and employment adjusts.

For year-to-year policy simulations, it is assumed that the deviation in the national real wage rate increases through time in proportion to the deviation in national employment from its base case-forecast level. The coefficient of adjustment is chosen so that the employment effects of a shock are largely eliminated after about ten years. This is consistent with macroeconomic modelling in which the NAIRU is exogenous.

2.1.10 Government fiscal accounts

MMRF is based on a post-goods and services tax (GST) database for the reference year 2001-02 and contains a more detailed treatment of government finances than do earlier versions of the model.

The government finance module is based, wherever possible, on the structure adopted for the ABS *Government Financial Statistics* (GFS, Cat. no. 5512.0). The module has three broad components:

1. all of the main items of income for each jurisdiction, including income taxes, taxes on goods and services and taxes on factor inputs;
2. all of the main items of expenditure for each jurisdiction, including gross operating expenses, personal benefit payments and grant expenses (which are both an item of expenditure for the federal government and items of income for each of the regional governments); and
3. drawing together the changes in government revenue and government expenditure to report the net operating balance and the net lending or borrowing balance for each jurisdiction.

To facilitate the modelling of the GFS module, indirect taxes — taxes on commodity sales and taxes on the use of primary factors (e.g., payroll tax) in the CGE-core section of the model — are now distinguished according to the jurisdiction levying the tax: state sales tax, federal sales tax and the GST. The federal and state sales taxes are modelled as *ad valorem* rates of tax levied on the basic price of the underlying flow. The GST is modelled as applying to the price inclusive of freight and other margins such as wholesale trade. Similarly, indirect taxes on the use of primary factors are also distinguished according to jurisdiction. For example, state payroll tax is identified separately from payroll taxes levied by the federal government (fringe benefit tax and the superannuation guarantee charge).

2.1.11 Transport capabilities

The primary MMRF database recognises six single product industries producing transport services. The four transport modes are road, rail, water and air. The road and rail industries provide both passenger services and freight transport. Passenger services are sold directly to categories of final demand. Freight services are sold indirectly as margins on flows of goods and services and non-margin usage in production.

Combining freight and passenger services into one product restricts the model's ability to analyse many transport issues, especially those that impinge on passenger transport differently from freight transport. Accordingly, in this add-in, each of the four transport industries has been disaggregated into two industries, one producing passenger services and one producing freight services. Each has a distinct production technology and sales pattern.

An MMRF add-in allows for substitution between road and rail freight (inter-modal substitution). Specifically, for a flow from region s to region q, substitution is allowed between road freight and rail freight provided by region q. The substitution is based on relative prices. If in region q, the price of road freight increases relative to the price of rail freight, then there will be substitution away from road freight towards rail freight in all margin uses of the two in region q.

The usage of road and rail freight margin will depend on:

1. the quantity of goods being transported from the point of production to some user (which varies according to the good and the user); and
2. the relative prices of road and rail freight.

2.2 *MMRF Add-ins*

The changes made to MMRF to enhance its capabilities, particularly for environmental analysis, can be run optionally in addition to the core model. These changes are not included in the documentation of the main model in Chapter 4, but are discussed in Chapter 7 (MMRF Extensions). These include:

1. an energy and gas emission accounting module, which accounts explicitly for each industry and region recognised in the model;
2. equations that allow for inter-fuel substitution in electricity generation by region, including the national electricity market;
3. mechanisms that allow for the endogenous take-up of abatement measures in response to greenhouse policy measures;

2.2.1 Emissions accounting

MMRF tracks emissions of greenhouse gases at a detailed level. It breaks down emissions according to:

1. emitting agent (industries and residential);
2. emitting state or territory; and
3. emitting activity.

2.2.2 Inter-fuel substitution

Fuel-burning emissions are modelled as being directly proportional to fuel usage. No allowance is made for any invention, which might, say, allow coal-fired electricity producers to release less CO_2 per tonne of coal burned. On the other hand, MMRF does allow for input-saving technical progress. For example, the coal electricity industry may reduce the amount of coal that it burns per kilowatt-hour of output. This sort of technical progress is imposed exogenously.

Other, indirect, forms of substitution offer the main scope within MMRF for emission reduction. Inter-fuel substitution in electricity generated is handled using the "technology bundle" approach (see Hinchy and Hanslow, 1996). In MMRF, six power-generating industries are distinguished in each region based on the type of fuel used.[6] There is also a separate end-use supplier (*Electricity Supply*). The electricity generated in each region flows directly to the local end-use supplier, which then distributes electricity to local and, in the case of states participating in the NEM, inter-state users. The end-use supplier can substitute between the five technologies in response to changes in their production costs. For example, the electricity supply industry in NSW might reduce the amount of power sourced from coal-using generators and increase the amount sourced from gas-fired plants. Such substitution is price-induced. Suppliers in NEM states may also substitute between suppliers in other NEM states.

The NEM covers electricity supply in the NEM-regions: NSW, VIC, QLD, SA, TAS and the ACT. Final demand for electricity in each NEM region continues to be determined within the CGE-core of the model in the same manner as demand for all other goods and services. All of the electricity used in any NEM-region is purchased from the electricity supply industry in that region. Each NEM-supplier sources its electricity from the NEM. The NEM does not have a regional dimension: in effect it is a single industry that sells a single product (electricity) to each NEM-supplier. The NEM sources its electricity from generation industries in each NEM region. Thus, the electricity sold by the NEM to the electricity supplier in QLD may be sourced from hydro generation in TAS. NEM demand for electricity generation is price-sensitive. Thus if the price of hydro generation from TAS rises relative to the price of gas generation from NSW, then NEM demand for generation will shift towards NSW gas generation and away from TAS hydro generation.

The explicit modelling of the NEM enables substitution between NEM regions and between different fuel types. It also allows explicitly for inter-state trade in electricity, without having to trace explicitly the bilateral flows. Note that WA and NT are not part of the NEM and electricity supply and generation in these regions continues to be determined on a state-of-location basis.

2.2.3 Endogenous take-up of abatement measures in response to greenhouse policy

In MMRF, non-combustion (or activity-related) emissions are generally modelled as directly proportional to the output of the related industries. However, in simulating the effects of a carbon tax or some other price-related penalty on gas emissions, allowance can be made for abatement of non-combustion emissions. The amount of abatement is directly related to the price of carbon. The constants of proportionality are derived from point estimates, from various sources, of the extent of abatement that might arise at a particular price level. It should be emphasised, however, that these estimates are quite speculative, but are only really important in the case of agriculture, which makes a large contribution to activity-related emissions.

[6] Coal, Gas, Oil, Nuclear, Hydroelectric, and Other.

3. Computational Method, Interpretation of Solutions and Closures

3.1 *Overview of computational method*

Many of the equations in MMRF are non-linear, which presents computational difficulties. However, following Johansen (1960), the model is solved by representing it as a system of linear equations relating changes in the model's variables. Results are deviations from an initial solution of the underlying non-linear model.

The system of linear equations is solved using GEMPACK. GEMPACK is a suite of general-purpose programs for implementing and solving large economic models. The linear version of MMRF is specified in the TABLO syntax, which is similar to ordinary algebra. GEMPACK solves the system by converting it to an Initial Value problem and then using one of the standard methods such as Euler. GEMPACK uses multi-step processes to generate accurate solutions of the underlying, non-linear, equations, as well as to compute linear approximations to those solutions. For details of the algorithms available in GEMPACK, see Harrison and Pearson (1996). For introductions to the Johansen/Euler solution method, see Dixon and Rimmer (2002, Section 11) and Horridge *et al.* (1993).

Writing down the equation system of the model in a linear (change) form has advantages from computational and economic standpoints. Linear systems are easy for computers to solve. This allows for the specification of detailed models, consisting of many thousands of equations, without incurring computational constraints. Further, the size of the system can be reduced by using model equations to substitute out those variables that may be of secondary importance for any given experiment. In a linear system, it is easy to rearrange the equations to obtain explicit formulae for those variables; hence the process of substitution is straightforward.

Compared to their levels counterparts, the economic intuition of the change versions of many of the model's equations is relatively transparent. In addition, when interpreting the results of the linear system, simple share-weighted relationships between variables can be exploited to perform back-of the-envelope calculations designed to reveal the key cause-effect relationships responsible for the results of a particular experiment.

3.1.1 Nature of dynamic solution

Algebraically, dynamic models like MMRF take the form

$$F(X(t)) = 0 \qquad (2.3)$$

where X(t) is a vector of length *n* referring to variables for year t, and F() is an *m*-length vector of differentiable functions of n variables. In simulations with (2.3), given an initial solution for the *n* variables that satisfies (2.3), GEMPACK computes the movements in *m* variables (the endogenous variables) away from their values in the initial solution caused by movements in the remaining *n* – *m* variables (the exogenous variables). In year-to-year simulations, the movements in the exogenous variables are from one year to the next. If the initial solution is for year t then our first computation creates a solution for year t+1. This solution can in turn become an initial solution for a computation that creates a solution for year t+2. In such a sequence of annual computations, links between one year and the next are recognised by ensuring, for example, that the quantities of opening capital stocks in the year t computation are the quantities of closing stocks in the year t-1 computation.

3.1.2 Deriving the linear form of the underlying non-linear equations

In deriving the linear equations from the non-linear equations, we use the three basic rules of logarithmic differentiation:

the product rule: $X = \beta YZ \Rightarrow$ $x = y + z$, where β is a constant,

the power rule: $X = \beta Y^{\alpha} \Rightarrow$ $x = \alpha y$, where α and β are constants, and

the sum rule: $X = Y + Z \Rightarrow$ $Xx = Yy + Zz$.[7]

In the equations above, x, y and z represent the *percentage* change deviations in the levels values X, Y and Z, respectively. The levels values (X, Y and Z) are solutions to the model's underlying levels equations.

Inaccuracy, or linearization error, is inherent in the linear equations, particularly for the product rule and the power rule. These errors can be reduced by the use of multi-step procedures, and further by extrapolation.

Using the product-rule equation as an example, suppose the initial solution is given by $\beta = 2$, $X_0 = 100$, $Y_0 = 10$ and $Z_0 = 5$ (where the 0 subscript indicates the initial value), and we wish to perturb Y and Z by 3 per cent and 2 percent respectively, and solve for X.

In the linear representation, y = 3 and z = 2. Therefore

$$x = y + z$$

$$= 3 + 2$$

$$=5.$$

We interpret this to mean that X has increased by 5 per cent, i.e. from $X_0 = 100$ to $X_1 = 105$ (where the 1 subscript indicates the perturbed value).

The exact, non-linear solution for X_1 is calculated as:

$$X_1 = \beta Y_1 Z_1$$

$$= 2 * (10 * (103\%)) * 5 * ((102\%))$$

$$= 105.06$$

Comparing the levels solution to the percentage change solution shows there is a linearisation error of 0.06 (i.e., 0.06 = 105.06 - 105). We can reduce this linearisation error by the application of a multistep procedure which exploits a positive relationship between the size of the perturbation from

[7] Another common representation of the sum rule is $x = S_Y y + S_Z z$ where $S_Y = Y/X$ and $S_Z = Z/X$. In this case the S coefficients are interpreted as shares.

the initial solution and the size of the linearisation error. The principle of the Euler version of the multistep solution method can be illustrated using our above example. Instead of increasing the values of Y and Z by 3 per cent and 2 per cent, let us break the perturbation into two steps of half the desired amount. Thus (with notation $x_{1,2}$ indicating the solution for x for step 1 of 2),

$x_{1,2} = y_{1,2} + z_{1,2}$

$= 1.5 + 1$

$= 2.5$

The new solutions to the levels equations are

$X_{1,2} = X_0 * (100 + x_{1,2})\%$

$= 100 * (102.5\%)$

$= 102.5$

$Y_{1,2} = Y_0 * (100 + y_{1,2})\%$

$= 10 * (101.5\%)$

$= 10.15$

$Z_{1,2} = Z_0 * (100 + z_{1,2})\%$

$= 5 * (101\%)$

$= 5.05$

Now apply the remainder of our desired perturbation to Y and Z. The values for $y_{2,2}$ and $z_{2,2}$ are:

$y_{2,2} = 100 * (103/101.5 – 1) = 1.4778$

and

$z_{2,2} = 100 * (102/101 – 1) = 0.9901$

Therefore

$x_{2,2} = 1.4778+0.9901$

$= 2.4679$

The final solution for X is

$X_{2,2} = X_{1,2} * (100 + x_{2,2})\%$

$= 102.5 * (102.4679\%)$

$= 105.0296$

Recalling that the true solution is X_1 = 105.06, the two step procedure produces a solution that is clearly more accurate than the one step procedure. The reader may have noticed that the size of the linearization error in the two step procedure is approximately half of that in the one step procedure. In general, by doubling the number of steps, the linearization error may be halved. This is the basis of the *extrapolation* procedure, which can further reduce linearization error without adding to the computational load.

To extrapolate a solution for X, we must calculate two linear approximations with differing numbers of steps. In our example, $X_{1,1}$ = 105 (the one step solution), and $X_{2,2}$ = 105.0296. By doubling the number of steps, the change in the solution is

$X_{2,2} - X_{1,1}$ = 105.0296 – 105 = 0.0296.

The extrapolation rule states that the linearization error is halved when the number of steps is doubled. Thus the linearization error on the one step solution must be 2 * 0.0296, so the extrapolated solution is:

$$X = X_{1,1} + 2 * (X_{2,2} - X_{1,1})$$

$$= 105 + 2 * 0.0296$$

$$= 105.0593$$

The linearization error is now 0.0007, which represents a significant improvement over the one and two step procedures which yield errors of 0.06 and 0.0304 respectively.

Further improvements are gained by increasing the number of steps, for example by calculating 4-step and 2-step solutions and doing a similar extrapolation. However, the increase in steps comes at a computational cost, e.g. a 4-step 2-step extrapolation requires solving the model 6 times, which takes approximately 6 times the computational effort of a Johansen (single step) solution.

3.2 *Closures of MMRF*

A choice of the n-m variables to be made exogenous is called a closure. In MMRF, there are three basic classes of closure:

- comparative-static closures;
- forecasting closures; and
- policy or deviation closures.[8]

Comparative static closures are used in single computation comparative static analyses. Forecasting and policy closures are used in year-to-year simulations. A brief overview is provided here, and closures are discussed in detail in Chapter 5.

3.2.1 Comparative-static closures

In a comparative-static closure, we include in the exogenous set all variables that can be regarded as naturally exogenous in a CGE model. These may be observable variables such as tax

[8] Dixon and Rimmer (2002) discuss two additional closures for the MONASH model — historical and decomposition closures — that are used in single-computation analyses of historical periods.

rates or unobservable variables such as technology and preference variables. We also include in the exogenous set all variables that are naturally endogenous in a dynamic model, but which are naturally exogenous in a static model. These will typically include investment by industry and one of the capital stock or rate of return for each industry.

3.2.2 Forecasting and policy closures

Forecasting and policy closures utilise the dynamic features of the model. Thus, for both classes of closure, we include in the endogenous set all variables that are naturally endogenous in a dynamic model, but naturally exogenous in a static model.

In forecasting with MMRF we often want to take on board forecasts and information available from outside sources. Typical examples include macro forecasts made by specialist private or public-sector groups and information about future changes in tax and benefit rates announced by the government. To accommodate this information, numerous naturally endogenous variables are typically exogenised. These might include:

- the volumes of agricultural exports; and
- most macro variables.

To allow such naturally endogenous variables to be exogenous, an equal number of naturally exogenous variables must be made endogenous. For example, to accommodate forecasts for the volumes of agricultural exports we would make endogenous variables that locate the positions of foreign demand curves. To accommodate forecasts for macro variables, we would endogenise various macro coefficients such as the average propensity to consume.

In forecasting closures, tastes and technology are exogenous. In MMRF, the taste and technology terms are typically set to national-level historical values drawn from the MONASH model.[9] Policy variables are also generally exogenous in forecasting closures.

In policy closures naturally endogenous variables, such as the volumes of agricultural exports and macro variables are endogenous. They respond to the policy change under consideration. Correspondingly, naturally exogenous variables, such as the positions of foreign demand curves and macro coefficients, are exogenous in policy closures. They are set at the values revealed in the forecasts.

In a policy simulation, most, but not all, of the exogenous variables have the values they had in the associated forecast solution. The exceptions are the exogenous variables that are shocked. The policy simulation, therefore, generates deviations from the corresponding forecast simulation in response to the exogenously imposed change.

---

[9] An historical simulation with MMRF is reported in Giesecke and Madden (2006).

4. MMRF represented in the TABLO Language

4.1 *Introduction*

In this chapter, we present a formal description of the linear form of MMRF. Our description is organised around excerpts from the TABLO file[10], which implements the model in GEMPACK. The TABLO language in which the file is written is essentially conventional algebra, with names for variables and coefficients chosen to be suggestive of their economic interpretations.

We base our description on the TABLO file for a number of reasons. First, familiarity with the TABLO code allows the reader ready access to the programs used to conduct simulations with the model and to convert the results to readable form. Both the input and the output of these programs employ the TABLO notation. Second, familiarity with the TABLO code is essential for users who may wish to change the model. Finally, by documenting the TABLO form of the model, we ensure that our description is complete and accurate.

In the remainder of this introduction, we provide a summary of the TABLO syntax. The remainder of this chapter is devoted to the exposition of the MMRF equation system. The derivation and interpretation of every equation that appears in the MMRF TABLO code is described, under the following section headings:[11]

4.2 The CGE core

4.3 Government financial accounts

4.4 Household accounts

4.5 Regional labour markets and demography (comparative statics)

4.6 Foreign Accounts and Gross National Product

4.7 Decompositions and Reporting Variables

4.8 Year-to-year equations

4.9 Regional disaggregation

4.10 Miscellaneous additions to MMRF

4.1.1 TABLO syntax and conventions observed in the TABLO representation

Each equation in the TABLO model description is linear in the changes (percentage or absolute) of the model's variables. For example, the industry labour demand equations appear as:

---

[10] This description of the model is based on MMRF_V1.0 by Philip Adams, November 26, 2009. A zipped archive of the model is available from the authors. A proliferation of model extensions exists.

[11] Other components of the TABLO code, such as variable and coefficient declarations and formulae, are not included in this description. Readers wishing to learn more about these features are referred to the GEMPACK documentation (available with the GEMPACK software).

```
Equation E_x1lab_o # Industry demands for effective labour #
(all,i,IND)(all,q,REGDST)
x1lab_o(i,q) = x1prim(i,q) + a1lab_o(i,q) + nata1lab_io -
   SIGMA1FAC(i,q)*[p1lab_o(i,q) + a1lab_o(i,q) + nata1lab_io - p1prim(i,q)] +
    [V1CAP(i,q)/[tiny+V1LAB_O(i,q)+V1CAP(i,q)]]*
        (twistlk(i,q) + twistlk_i(q) + nattwistlk_i);
```

The first element is the identifier for the equations, which must be unique. In the MMRF code, all equation identifiers are of the form *E_<variable>,* where <variable> is the variable that is explained by the equation in the long-run comparative static closure of the model. The identifier is followed by descriptive text between the # symbols. This is optional. The description appears in certain GEMPACK generated report files. The expression (all,i,IND)(all,q,REGDST) signifies that the equations are defined over all elements of the set IND (the set of industries) and REGDST (the set of domestic regions of use).

Within the equation, we generally distinguish between change variables and coefficients by using lower-case script for variables and upper-case script for coefficients. Note, however, that the GEMPACK solution software ignores case. Thus in the excerpt above, the variables are x1lab_o(i,q), x1prim(i,q), a1lab_o(i,q), nata1lab_oi, p1lab_o(i,q), p1prim(i,q), twistlk(i,q), twistlk_i(q) and nattwistlk_i. The coefficients are: SIGMA1FAC, which is the fixed elasticity of substitution between labour and other primary factors; and V1CAP(i,q) and V1LAB_O(i,q), which are the costs of capital and labour for industry i in region q. A semi-colon signals the end of the TABLO statement.

Typically, set names appear in upper-case characters in the TABLO code. Some of the main sets defined for MMRF are given in Tables

Table 4.1. The size and elements of each set vary according to the application for which the model is used. In this documented version of the model there are 63 commodities[12] identified, produced by 58 industries[13] in 8 regions (corresponding to Australia's States and Territories). When used for more extensive analysis, these sets may be expanded to over 100 commodities and industries, whereas when used for analysis specific to a single region, the region set may be reduced to just 2 regions (the region of interest and "Rest of Australia").

[12] See Table 4.3

[13] See Table 4.3

4.2 *The CGE core*

Figure 4.1 is a schematic representation of the core's input-output database. It reveals the basic structure of the core. The columns identify the following agents:

1. domestic producers divided into I industries in R regions;
2. investors divided into I industries in R regions;
3. a single representative household for each of the R regions;
4. an aggregate foreign purchaser of exports for each of the R regions;
5. an other demand category corresponding to R regional governments;
6. an other demand category corresponding to Federal government demands in the R regions;
7. inventory accumulation for each of the R regions; and
8. a single national electricity market (discussed in Chapter 7).

The rows show the structure of the purchases made by each of the agents identified in the columns. Each of the c commodity types identified in the model can be obtained within the region, from other regions or imported from overseas. The source-specific commodities are used by industries as inputs to current production and capital formation, are consumed by households and governments, are exported, accumulate as inventories, and a subset are used in the national electricity market. Only domestically produced goods appear in the export column.

There are m domestically produced goods that are used as margin services, which are required to transfer commodities from their source to their user. Various types of commodity tax are payable on the purchases.

As well as intermediate inputs, current production requires inputs of three categories of primary factor: labour (divided into o occupations), fixed capital and agricultural land. The other costs category covers various miscellaneous industry expenses.

The electricity supply industry in some regions also uses inputs from the national electricity market.

Each cell in the input-output table contains the name of the corresponding matrix of the values (in some base year) of flows of commodities, indirect taxes or primary factors to a group of users. For example, V2MAR is a 5-dimensional array showing the cost of the m margins services on the flows of c goods, both domestically and imported (s), to i investors in r regions.

The theoretical structure of the CGE core includes: demand equations required for our eight users; equations determining commodity and factor prices; market clearing equations; definitions of commodity tax rates. In common with ORANI, the equations of MMRF's CGE core can be grouped according to the following classification:

- producers' demands for produced inputs and primary factors;
- demands for inputs to capital creation;
- household demands;

- export demands;
- government demands;
- demands for margins;
- zero pure profits in production and distribution;
- indirect taxes;
- market-clearing conditions for commodities and primary factors; and
- regional and national macroeconomic variables and price indices.

		ABSORPTION MATRIX								
		1	2	3	4	5	6	7	8	
		Producers	Investors	Households	Exports	Regional Govt.	Federal Govt.	Stocks	NEM	Total
	Size	I × R	I × R	R	R	R	R	R	1	
Basic Flows	C × S	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS	V7BAS	V8BAS	Sales (part[*])
NEM	1	V1NEM								
Margins	C × S × M	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	V6MAR			Sales (part[**])
Taxes: Regional	C × S	V1TAXS	V2TAXS	V3TAXS	V4TAXS					
Taxes: Federal	C × S	V1TAXF	V2TAXF	V3TAXF	V4TAXF					
Taxes: GST	C × S	V1GST	V2GST	V3GST	V4GST					
Labour	O	V1LAB								
Capital	1	V1CAP								
Land	1	V1LND								
Other Costs	1	V1OCT								
Total		Costs								

C = Number of commodities

I = Number of industries

O = Number of occupation types

M = Number of commodities used as margins

R = Number of regions

S = Number of sources = R+1: Domestic regions plus foreign imports

[*] Total for domestically produced non-margin commodities equals total production (Sales in MAKE matrix)

[**] Total for domestically produced margin commodities for both basic and margin use equals total production (Sales in MAKE matrix)

	MAKE MATRIX	
Size	I × R	Total
C × R	MAKE	Sales
Total	Costs	

Figure 4.1: The CGE core input-output database

The following conventions are used (as far as possible) in naming variables of the CGE core. Names consist of a prefix, a main user number and a source dimension. The prefixes are:

a ⇔ technological change, change in preferences;

f ⇔ shift variable;

nat ⇔ a national aggregate of the corresponding regional variable;

p ⇔ price;

x ⇔ quantity demanded.

The main user numbers are:

1 ⇔ industries, current production;

2 ⇔ industries, capital creation;

3 ⇔ households;

4 ⇔ foreign exports;

5 ⇔ regional governments;

6 ⇔ Federal government;

7 ⇔ inventories;

8 ⇔ National Electricity Market (NEM);

0 ⇔ General – without a specific user.

The source dimensions are:

a ⇔ all sources, i.e., 8 regional sources and 1 foreign;

r ⇔ regional sources only;

t ⇔ two sources, i.e., a domestic composite source and foreign;

c ⇔ domestic composite source only;

o ⇔ domestic-foreign composite source only.

The following are examples of the above notational conventions:

p1a ⇔ price (p) of a commodity averaged over all sources (a) for use by firms in production (1);

x2c ⇔ demand (x) for the domestic composite commodity (c) for use in capital creation (2).

Ordinary change variables, as opposed to percentage change variables, are indicated by the prefix d_. Thus d_x2c is the ordinary ($m) change equivalent of the percentage-change variable x2c.

Variable names may also include an (optional) suffix description, such as:

cap ⇔ capital;

imp ⇔ imports;

lab ⇔ labour;

lnd ⇔ agricultural land;

marg ⇔ margins;

oct ⇔ other cost tickets.

4.2.1 Production: An overview of demand and prices for inputs to the production process

MMRF recognises two broad categories of inputs: intermediate inputs and primary factors. Industries in each region are assumed to choose the mix of inputs which minimises the costs of production for their level of output. They are constrained in their choice of inputs by a production technology of several branches (or nests), each with a number of levels as illustrated in Figure 4.2. At the first level, the intermediate-input bundle, the primary-factor bundle and other costs are used in fixed proportions to output. These bundles are formed at the second level. Intermediate input bundles are constant-elasticity-of-substitution (CES) combinations of international imported goods and domestic goods. The primary-factor bundle is a CES combination of land, labour and capital.

At the third level, inputs of domestic goods are formed as CES combinations of goods from each of the eight regions, and the input of labour is formed as a CES combination of inputs of labour from eight different occupational categories.

We now proceed to describe the derivation of the input demand functions working upwards from the bottom of the tree in Figure 4.2. We begin with the intermediate-input branch on the left hand side of Figure 4.2.

4.2.2 Demands and prices for domestic and imported intermediate inputs (TABLO excerpt 2.5.1.1)

At the bottom of the nest (Level 3 in Figure 4.2), industry i in region q chooses intermediate input type c from domestic region s (X1A(c,s,i,q)) to minimise the cost

$$\sum_{s \in regsrc} P1A(c,s,i,q) \times X1A(c,s,i,q) \qquad c \in COM \quad i \in IND \quad q \in REGDST \qquad (4.1)$$

of a composite domestic bundle

$$X1C(c,i,q) = \underset{s \in regsrc}{CES}\left\{X1A(c,s,i,q)\right\} \qquad c \in COM \quad i \in IND \quad q \in REGDST \qquad (4.2)$$

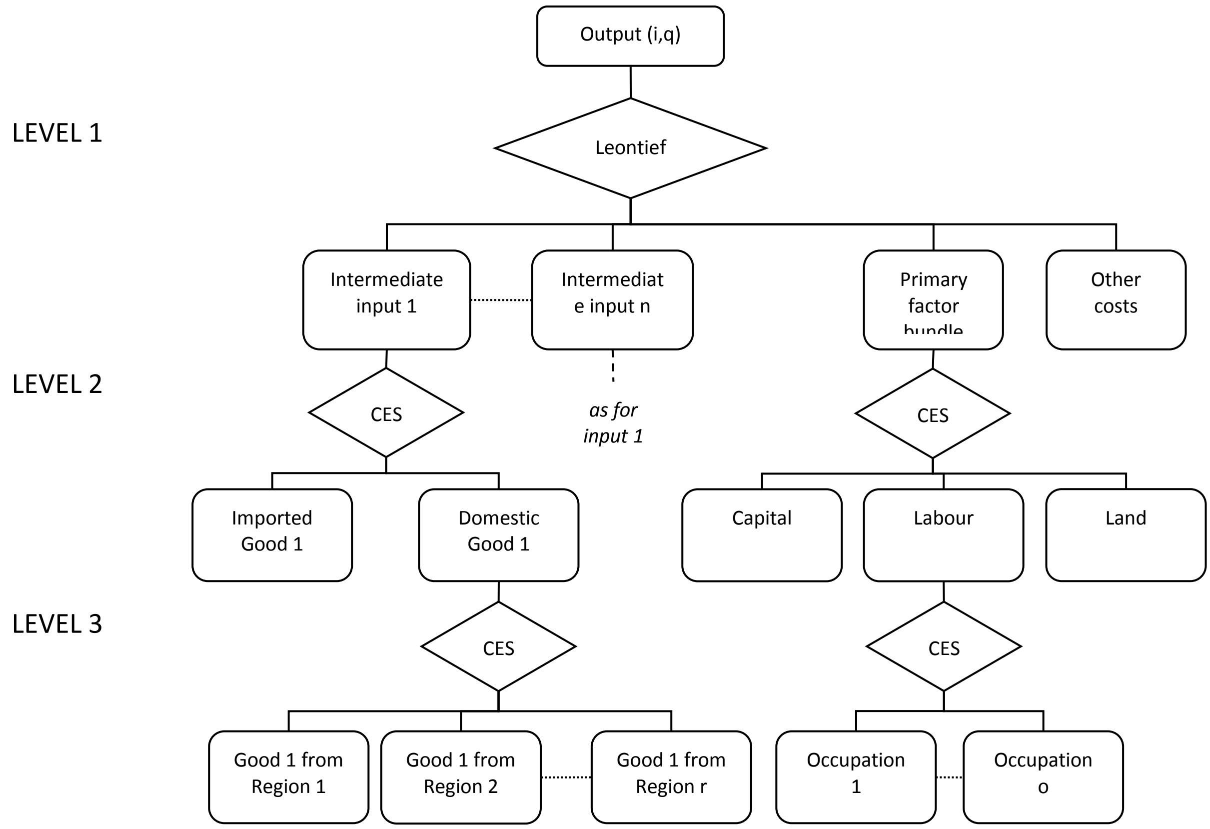

Figure 4.2: Production technology for industry i in region q

where the composite domestic bundle (X1C(c,i,q)) is exogenous at this level of the nest. The notation CES{} represents a CES function defined over the set of variables enclosed in the curly brackets. The subscript indicates that the CES aggregation is over all elements *s* of the set of regional sources (REGSRC), where REGSRC is a subset of ALLSRC. The CES specification means that inputs of the same commodity type produced in different regions are not perfect substitutes for one another. This is an application of the so-called Armington (1969, 1970) specification typically imposed on the use of domestically produced commodities and foreign-imported commodities in national CGE models such as ORANI.

By solving the above problem, we generate the industries' demand equations for domestically produced intermediate inputs to production.[14] The percentage-change forms of these demand equations are given by equation *E_x1a* at the end of this section. On the RHS of *E_x1a*, the first IF statement refers to inputs from the domestic sources.

Within the first IF statement on the RHS of *E_x1a*, the first term is the percentage change in the demand for the domestic composite (x1c(c,i,q)). In the absence of changes in prices and technology, it is assumed that the use of input c from all domestic sources expands proportionately with industry (i,q)'s overall usage of domestic c. The second term in the first IF statement allows for price substitution. The percentage-change form of the price term is an elasticity of substitution,

[14] For details on the solution of input demands given a CES production function, and the linearistion of the resulting levels equation, see Dixon, Bowles and Kendrick (1980), and Horridge, Parmenter and Pearson (1993).

SIGMA1C(c), multiplied by the percentage change in a price ratio representing the price from the regional source relative to the cost of the regional composite, i.e., an average price of the commodity across all regional sources. Lowering of a source-specific price, relative to the average, induces substitution in favour of that source. The second term on the LHS of *E_x1a* allows for technological change. If a1a(c,s,i,q) is set to –1, then we are allowing for a 1 per cent input-(c,s) saving technical change by industry (i,q).

The percentage change in the average price of the domestic composite commodity c, p1c(c,i,q), is given by equation *E_p1c*. In *E_p1c*, the coefficient V1PURT(c,"domestic",i,q) is the total purchasers value of commodity c from all domestic sources used by industry i in region q, and V1PURA(c,s,i,q) is the cost of commodity c from domestic source s used by industry i in region q. Hence, p1c(c,i,q) is a cost-weighted Divisia index of individual prices from the regional sources. Note that in cases where V1PURT(c,s,i,q) equals zero, *E_p1c* would leave the corresponding p1c undefined. To avoid this problem, the function ID01(V1PURT(c,s,i,q)) returns the value of 1 when V1PURT(c,s,i,q) = 0.

At the next level of the production nest (Level 2, Figure 4.2), firms decide on their demands for the domestic-composite commodities and the foreign imported commodities following a pattern similar to the previous nest. Here, the firm chooses a cost-minimising mix of the domestic-composite commodity and the foreign imported commodity

$$\mathrm{P1A}(c,\text{"imp"},i,q)\times \mathrm{X1A}(c,\text{"imp"},i,q)+\mathrm{P1C}(c,i,q)\times \mathrm{X1C}(c,i,q) \qquad c\in COM \quad i\in IND \quad q\in REGDST \qquad (4.3)$$

where the subscript 'imp' refers to the foreign import, subject to the production function

$$\mathrm{X1O}(c,i,q)=\mathrm{CES}\left\{\frac{\mathrm{X1A}(c,\text{"imp"},i,q)}{\mathrm{A1A}(c,\text{"imp"},i,q)},\frac{\mathrm{X1C}(c,i,q)}{\mathrm{A1A}(c,\circ,i,q)}\right\} \qquad c\in COM \quad i\in IND \quad q\in REGDST \qquad (4.4)$$

where $\mathrm{A1A}(c,\circ,i,q)$ is a composite of the domestic $\mathrm{A1A}(c,s,i,q)$ terms.

As with the problem of choosing the domestic-composite, the Armington assumption is imposed on the domestic-composite and the foreign import by the CES specification in (4.4).

The solution to the problem specified by (4.3) and (4.4) yields the input demand functions for the domestic-composite and the foreign import; represented in their percentage-change form by equations *E_x1c* and *E_x1a* (second IF statement). These equations show, respectively, that the demands for the domestic-composite commodity (X1C(c,i,q)) and for the foreign import (X1A(c,"imp",i,q)) are proportional to demand for the domestic-composite/foreign-import aggregate (X1O(c,i,q)) and to a price term. The X1O(c,i,q) are exogenous to the producer's problem at this level of the nest. Common with the previous nest, the percentage-change form of the price term is an elasticity of substitution, SIGMA1O(c) multiplied by a price ratio representing the percentage change in the price of the domestic-composite (p1c(c,i,q) in equation *E_x1c*) or of the foreign import (p1a(c,"imp",i,q) in equation *E_x1a*) relative to the price of the domestic-composite/foreign-import aggregate (p1o(c,i,q) in equations *E_x1c* and *E_x1a*).

On the RHS of *E_x1a* and *E_x1c* are terms involving the variables twistsrc(c,q), twistsrc_c(q), and nattwistsrc_c. These variables allow for cost-neutral twists in import/domestic preferences for commodity c used by industries in region q.

To see how the cost-neutral aspect works, assume zero values for the "a" terms and no changes in prices in *E_x1a* and *E_xlc*. Also, assume x1o(c,i,q) = 0 and tiny = 0.0000001[15]. Under these assumptions

$$\mathrm{x1c(c,i,q)} = -\frac{\mathrm{V1PURT(c,"imp",i,q)}}{\mathrm{V1PURO(c,i,q)} + 0.0000001} \times \left(\mathrm{twistsrc}(\mathrm{c,q}) + \mathrm{twistsrc\_c}(\mathrm{q}) + \mathrm{nattwistsrc\_c}\right)$$

and

$$\mathrm{x1a(c,"imp",i,q)} = \frac{\mathrm{V1PURT(c,"dom",i,q)}}{\mathrm{V1PURO(c,i,q)} + 0.0000001} \times \left(\mathrm{twistsrc}(\mathrm{c,q}) + \mathrm{twistsrc\_c}(\mathrm{q}) + \mathrm{nattwistsrc\_c}\right)$$

Taking account of the fact that

$$\frac{\mathrm{V1PURT(c,"domestic",i,q)}}{\mathrm{V1PURO(c,i,q)}} + \frac{\mathrm{V1PURT(c,"imp",i,q)}}{\mathrm{V1PURO(c,i,q)}} = 1,$$

we see that

$$\mathrm{x1c(i,j,q)} - \mathrm{x1a(i,"imp",j,q)} = -\left(\mathrm{twistsrc}(\mathrm{c,q}) + \mathrm{twistsrc\_c}(\mathrm{q}) + \mathrm{nattwistsrc\_c}\right) \qquad (4.5)$$

Hence, in the absence of changes in prices and "a" terms, if twistsrc(c,q) were set at -10, then all industries in region q would increase their ratio of domestic to imported inputs of commodity c by 10 per cent. In other words, there is a 10 per cent twist by all industries in favour of the use of domestic good c relative to imported good c. Similarly, if twistsrc_c(q) were set at -10, then all industries in region q would increase their ratio of domestic to imported inputs of all commodities by 10 per cent. If nattwistsrc_c was set at -10, then all industries in all regions would increase their ratio of domestic to imported inputs of all commodities by 10 per cent.

We have now arrived at the Level 1 input-demand nest of Figure 4.2. Total intermediate inputs, the primary-factor composite and 'other costs' are combined using a Leontief production function, MIN(), given by

$$\mathrm{X1TOT(i,q)} = \frac{1}{\mathrm{A1(i,q)}} \times$$
$$\mathrm{MIN}\left\{\begin{array}{l} \dfrac{\mathrm{X1O}(\mathrm{c,i,q})}{\mathrm{A1O}(\mathrm{c,i,q}) \times \mathrm{ACOM}(\mathrm{c,q}) \times \mathrm{AGREEN}(\mathrm{c,i,q}) \times \mathrm{ACOMIND}(\mathrm{c,i,q}) \times \mathrm{ELECSUB}(\mathrm{c,i,q})}, \\ \dfrac{\mathrm{X1PRIM(i,q)}}{\mathrm{A1PRIM(i,q)} \times \mathrm{A1PRIM\_I(q)} \times \mathrm{NATA1PRIM\_I}}, \dfrac{\mathrm{X1OCT(i,q)}}{\mathrm{A1OCT(i,q)}} \end{array}\right\}$$

[15] The purpose of the coefficient "TINY" is to avoid division by zero. In this example, if V1PURO(c,i,q) = 0 for any c,i,q-flow, the model is still able to solve for x1c(c,i,q) and x1a(c,s,i,q). It does not matter that a nonsensical result is found for x1c(c,i,q) and x1a(c,s,i,q) because these variables are percentage changes of a zero base. If V1PURO(c,i,q) > 0, the effect of adding "TINY" is negligible.

i∈IND q∈REGDST (4.6)

In the function above, X1TOT(i,q) is the output of industry i in region q and the A variables are Hicks-neutral technical change terms. X1O(c,i,q), X1PRIM(i,q) and X1OCT(i,q) are the demands by industry i in region q for intermediate input c, primary factors and other cost tickets respectively. The cost minimisation solution to this production function is for effective units (allowing for technical change) of each of these three composite inputs to be used in fixed proportion to output. For intermediate inputs, this is indicated in equation *E_x1o*.

```
! Subsection 2.5.1.1: Industry demand for goods and services, User 1
---------------------------------!
Equation E_x1a # Demand for c from s by industry i in q #
(all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
x1a(c,s,i,q) - a1a(c,s,i,q) =
IF{s ne "imp",
x1c(c,i,q) - SIGMA1C(c)*[p1a(c,s,i,q) + a1a(c,s,i,q) - p1c(c,i,q)]} +
IF{s eq "imp",
x1o(c,i,q) - SIGMA1O(c)*[p1a(c,"imp",i,q) + a1a(c,"imp",i,q) - p1o(c,i,q)] +
    (V1PURT(c,"domestic",i,q)/(tiny+V1PURO(c,i,q)))*
        (twistsrc(c,q) + twistsrc_c(q) + nattwistsrc_c + nattwistsrc(c))};

Equation E_p1o # Price of domestic/imp composite, User 1 #
(all,c,COM)(all,i,IND)(all,q,REGDST)
ID01(V1PURO(c,i,q))*p1o(c,i,q) =
    sum{s,ALLSRC, V1PURA(c,s,i,q)*(p1a(c,s,i,q) + a1a(c,s,i,q) )};

Equation E_p1c # Price of domestic composite, User 1 #
(all,c,COM)(all,i,IND)(all,q,REGDST)
ID01(V1PURT(c,"domestic",i,q))*p1c(c,i,q)  =
    sum{s,REGSRC, V1PURA(c,s,i,q)*(p1a(c,s,i,q) + a1a(c,s,i,q))};

Equation E_x1c # Demand for domestic composite, User 1 #
(all,c,COM)(all,i,IND)(all,q,REGDST)
x1c(c,i,q) =
    x1o(c,i,q) - SIGMA1O(c)*[p1c(c,i,q) - p1o(c,i,q)] -
    (V1PURT(c,"imp",i,q)/(tiny+V1PURO(c,i,q)))*
        (twistsrc(c,q) + twistsrc_c(q) + nattwistsrc_c + nattwistsrc(c));

Equation E_x1o # Demands for composite inputs, User 1 #
(all,c,COM)(all,i,IND)(all,q,REGDST)
x1o(c,i,q) = x1tot(i,q) +
    a1(i,q) + a1o(c,i,q) + acom(c,q) + natacom(c) + acomind(c,i,q);
```

4.2.3 Demand for primary factors and other cost tickets (TABLO excerpt 2.5.1.2)

4.2.3.1 Demand for labour by occupation

At the lowest-level nest in the primary-factor branch of the production tree in Figure 4.2, producers choose a composition of o occupation-specific labour inputs to minimise the costs of a given composite labour aggregate input. The demand equations for labour of the various occupation types are derived from the following optimisation problem for the industry i in region q.

Choose inputs of occupation-specific labour type o, X1LAB(i,q,o), to minimise total labour cost

$$\sum_{o \in occ} \mathrm{P1LAB}(i,q,o) \times \mathrm{X1LAB}(i,q,o) \qquad i \in \mathrm{IND} \quad q \in \mathrm{REGDST} \qquad (4.7)$$

subject to

$$\mathrm{X1LAB\_O}(i,q) = \underset{o \in occ}{\mathrm{CES}}\{\mathrm{X1LAB}(i,q,o)\} \qquad i \in \mathrm{IND} \quad q \in \mathrm{REGDST} \qquad (4.8)$$

Exogenous to this problem are the price paid by regional industry (i,q) for each occupation-specific labour type (P1LAB(i,q,o)) and the regional industries' demands for the effective labour input (X1LAB_O(i,q)).

The solution to this problem, in percentage-change form, is given by equations *E_x1lab* and *E_p1lab_o*. Equation *E_x1lab* indicates that the demand for labour type o is proportional to the demand for the effective composite labour demand and to a price term. The price term consists of an elasticity of substitution, SIGMA1LAB(i,q), multiplied by the percentage change in a price ratio representing the wage of occupation o (p1lab(i,q,o)) relative to the average wage for labour in industry i of region q (p1lab_o(i,q))). Changes in the relative wages of the occupations induce substitution in favour of relatively cheapening occupations. The percentage change in the average wage is given by equation *E_p1lab_o*. The coefficient V1LAB(i,q,o) is the wage bill for occupation o employed by industry i in region q. The coefficient V1LAB_O(i,q) is the total wage bill of industry i in region q. Thus, p1lab_o(i,q) is a Divisia index of the p1lab(i,q,o).

4.2.3.2 Demand for all primary factors

At the next level of the primary-factor branch of the production nest, we determine the composition of demand for primary factors. Their derivation follows the same CES pattern as the previous nests. Here, total primary factor cost for industry i in region q is given by

$$\mathrm{P1LAB\_O}(i,q) \times \mathrm{X1LAB\_O}(i,q) + \mathrm{P1CAP}(i,q) \times \mathrm{X1CAP}(i,q) + \mathrm{P1LND}(i,q) \times \mathrm{X1LND}(i,q)$$
$$i \in \mathrm{IND} \quad q \in \mathrm{REGDST} \qquad (4.9)$$

where P1CAP(i,q) and P1LND(i,q) are the unit costs of capital and agricultural land for industry i in region q, and X1LAB_O(i,q), X1CAP(i,q) and X1LND(i,q) are the demands for labour, capital and agricultural land for industry i in region q. Total cost is minimised subject to substitution possibilities given by the function

$$\text{X1PRIM}(i,q) = \text{CES}\left\{\frac{\text{X1LAB\_O}(i,q)}{\text{A1LAB\_O}(i,q) \times \text{NATA1LAB\_OI}}, \frac{\text{X1CAP}(i,q)}{\text{A1CAP}(i,q)}, \frac{\text{X1LND}(i,q)}{\text{A1LND}(i,q)}\right\}$$

$i \in$ IND $q \in$ REGDST (4.10)

where X1PRIM(i,q) is overall demand for primary factors by industry i in region q. The CES function above allows us to impose factor-specific technological change via the variables A1LAB_O(i,q), NATA1LAB_OI, A1CAP(i,q) and A1LND(i,q).

The solution to the problem, in percentage-change form is given by equations *E_x1lab_o*, *E_p1cap*, *E_p1lnd* and *E_p1prim*. From these equations, we see that for a given level of technical change, industries' factor demands are proportional to overall factor demand (X1PRIM(i,q)) and a relative price term. In percentage change form, the relative price term is an elasticity of substitution (SIGMA1FAC(i,q)) multiplied by the percentage change in a price ratio representing the unit cost of the factor relative to the overall effective cost of primary factor inputs in industry i in region q. Changes in the relative prices of the primary factors induce substitution in favour of relatively cheapening factors. The percentage change in the average effective cost (p1prim(i,q)), given by equation *E_p1prim*, is again a cost-weighted Divisia index of individual prices and technical changes.

Another group of twist terms, twistlk(i,q), twistlk_i(q), and nattwistlk_i, appears in equations *E_x1lab_o* and *E_p1cap*. A positive value for twistlk(i,q) causes a cost-neutral twist towards labour and away from capital in regional industry (i,q). A negative value for twistlk(i.q) causes a twist towards capital and away from labour. The coefficient attached to the twist terms in *E_x1lab_o* is the share of the cost of capital in the total cost of labour and capital for industry i in region q. The coefficient attached to the twist terms in *E_p1cap* is the negative of the share of the cost of labour in the total cost of capital and labour for industry (i,q).

Recalling the Leontief specification of the production function from above, each of the categories of inputs identified at the top level of the nest are demanded in direct proportion to X1TOT(i,q), as indicated in equations *E_x1prim* and *E_x1oct*.

Other cost tickets allow for costs not explicitly identified in MMRF such as working capital and the costs of holding inventories.

The final equation in this section (*E_p1octinc*) specifies the movements in the post-tax rental price of other cost tickets (*p1octinc(j,q)*). Equation *E_p1octinc* must be interpreted in conjunction with Equation *E_p1oct*: with the post-tax rental price of other cost tickets tied-down via equation *E_p1octinc*, equation *E_p1oct* ensures that owners of other cost tickets pass through to industry and taxes on other costs (see Section 4.2.18). The levels form of *E_p1octinc* is specified as

$$\text{P1OCTINC}(i,q) = \text{P3TOT}(q) \times \text{F1OCT}(i,q) \qquad i \in \text{IND} \;\; q \in \text{REGDST} \qquad (4.11)$$

where P3TOT(q) is the level of the consumer price index (CPI) in region q, and F1OCT(i,q) is a shift variable. If F1OCT(i,q) is constant, then the post-tax price of other costs tickets for industry i in region q moves with the CPI in q. Changes in F1OCT(i,q) cause changes in the post-tax price of other costs tickets relative to the CPI. *E_p1octinc* is the percentage change form of (4.11).

```
! Subsection 2.5.1.2: Industry demand for primary factors
--------------------------------!
! Labour !
Equation E_x1lab # Demand for labour by industry and occupation #
(all,i,IND)(all,q,REGDST)(all,o,OCC)
x1lab(i,q,o) = x1lab_o(i,q) - SIGMA1LAB(i,q)*[p1lab(i,q,o) - p1lab_o(i,q)];

Equation E_x1lab_o # Industry demands for effective labour #
(all,i,IND)(all,q,REGDST)
x1lab_o(i,q) = x1prim(i,q) + a1lab_o(i,q) + nata1lab_oi + nata1lab_o(i) -
    SIGMA1FAC(i,q)*
    [p1lab_o(i,q) + a1lab_o(i,q) + nata1lab_oi + nata1lab_o(i) - p1prim(i,q)] +
    [V1CAP(i,q)/[tiny+V1LAB_O(i,q)+V1CAP(i,q)]]*
        (twistlk(i,q) + twistlk_i(q) + nattwistlk_i);

! Capital !
Equation E_p1cap # Industry demands for capital #
(all,i,IND)(all,q,REGDST)
x1cap(i,q) = x1prim(i,q) + a1cap(i,q) -
    SIGMA1FAC(i,q)*[p1cap(i,q) + a1cap(i,q) - p1prim(i,q)] -
    [V1LAB_O(i,q)/[tiny+V1LAB_O(i,q)+V1CAP(i,q)]]*
        (twistlk(i,q) + twistlk_i(q) + nattwistlk_i);

! Agricultural land !
Equation E_p1lnd # Industry demands for land #
(all,i,IND)(all,q,REGDST)
x1lnd(i,q) = x1prim(i,q) + a1lnd(i,q) -
    SIGMA1FAC(i,q)*[p1lnd(i,q) + a1lnd(i,q) - p1prim(i,q)];

! Demand for and price of primary factor (labour, capital, land) composite !
Equation E_x1prim # Demand for the primary-factor composite #
(all,i,IND)(all,q,REGDST)
x1prim(i,q) =
  x1tot(i,q) + a1(i,q) + a1prim(i,q) + a1prim_i(q) + nata1prim_i + nata1prim(i);

Equation E_p1prim # Effective price term for factor demand equations #
(all,i,IND)(all,q,REGDST)
ID01(V1PRIM(i,q))*p1prim(i,q) =
    V1LAB_O(i,q)*[p1lab_o(i,q) + a1lab_o(i,q) + nata1lab_oi + nata1lab_o(i)] +
    V1CAP(i,q)*  [p1cap(i,q) + a1cap(i,q)] +
    V1LND(i,q)*  [p1lnd(i,q) + a1lnd(i,q)];

! Demand for other cost tickets !
Equation E_x1oct # Industry demands for other cost tickets #
(all,i,IND)(all,q,REGDST)
x1oct(i,q) = x1tot(i,q) + a1(i,q) + a1oct(i,q);

Equation E_p1octinc # Indexation of post-tax price of "Other Cost" tickets #
(all,i,IND)(all,q,REGDST)
p1octinc(i,q) = p3tot(q) + f1oct(i,q);
```

4.2.4 Demands for investment goods (TABLO excerpt 2.5.2)

Capital creators for each regional sector combine inputs to form units of capital. In choosing these inputs they minimise costs subject to technologies similar to that in Figure 4.3, which shows the nesting structure for the production of new units of fixed capital. Capital is produced with inputs of domestically produced and imported commodities. No primary factors are used directly as inputs to capital formation. However, primary factors are used in the production of the commodity inputs to investment.

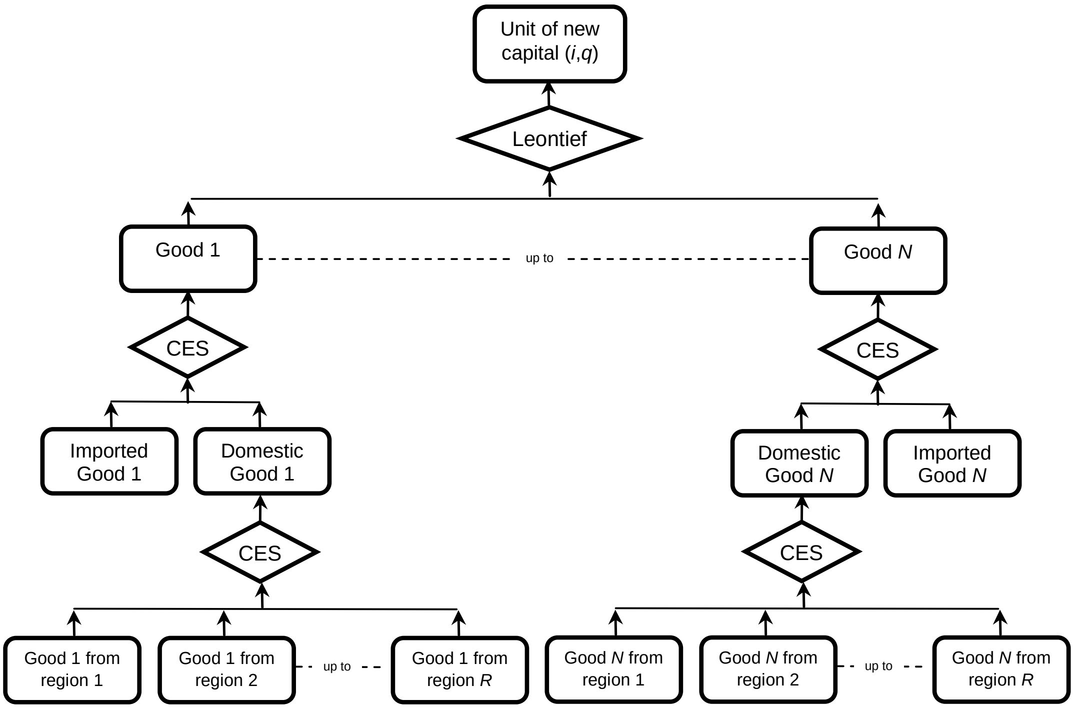

Figure 4.3: Structure of investment demand

The model's capital-input demand equations are derived from the solutions to the investor's three-part cost-minimisation problem. At the bottom level, the total cost to industry i of domestic-commodity composites of good c (X2C(c,i,q)) is minimised subject to the CES production function

$$X2C(c,i,q) = \underset{s \in regsrc}{CES}\{X2A(c,s,i,q)\} \qquad c \in COM \;\; i \in IND \;\; q \in REGDST \qquad (4.12)$$

where the X2A(c,s,i,q) are the demands of the i^{th} industry in the q^{th} region for the c^{th} commodity from the s^{th} domestic region for use in the creation of capital. Similarly, at the second level of the nest, the total cost of the domestic/foreign-import composite (X2O(c,i,q)) is minimised subject to the CES production function

$$X2O(c,i,q) = CES\{X2A(c,"imp",i,q), X2C(c,i,q)\} \qquad c \in COM \;\; i \in IND \;\; q \in REGDST \qquad (4.13)$$

where the X2A(c,"imp",i,q) are demands for the foreign imports.

The equations describing the demand for the source-specific inputs (*E_x2a*, *E_x2c*, *E_p2c* and *E_p2o*) are similar to the corresponding equations describing the demand for intermediate inputs to current production (i.e., *E_x1a*, *E_x1c*, *E_p1c* and *E_p1o*). The main difference is the lack of technological change terms in the investment equations at this level. However, the twistsrc terms do appear in the investment equations.

At the top level of the nest, the total cost of commodity composites is minimised subject to the Leontief function

$$\mathrm{X2TOT}(i,q) = \underset{c \in com}{\mathrm{MIN}}\left\{\frac{\mathrm{X2O}(c,i,q)}{\mathrm{A2}(q) \times \mathrm{ACOM}(c,q)}\right\} \qquad i \in \mathrm{IND} \quad q \in \mathrm{REGDST} \qquad (4.14)$$

where the total amount of investment in each industry (X2TOT(i,q)) is exogenous to the cost-minimisation problem, the A2(q) terms are technological-change variables in the use of inputs in capital creation, and the ACOM(c,q) terms are technological-change variables in all uses of commodity c in region q.

As a consequence of the Leontief specification of the production function for investment, demand for the composite commodity inputs at the top level of the nest are in direct proportion to X2TOT(i,q), as indicated in equations *E_x2o*. Note the similarity between this equation and *E_x1o*.

Determination of the number of units of capital to be formed for each regional industry (i.e., determination of X1TOT(i,q)) depends on the nature of the experiment being undertaken. For comparative-static experiments, a distinction is drawn between the short run and long run. In short-run experiments (where the year of interest is one or two years after the shock to the economy), capital stocks in regional industries are exogenously determined.

In long-run comparative-static experiments (where the year of interest is five or more years after the shock), it is assumed that the aggregate capital stock adjusts to preserve an exogenously determined economy-wide rate of return, and that the allocation of capital across regional industries adjusts to satisfy exogenously specified relationships between relative rates of return and relative capital growth. Industries' demands for investment goods are determined by exogenously specified investment/capital ratios.

In year-to-year dynamic experiments, regional industry demand for investment is determined via dynamic equations like (2.1) and (2.2). Details of the determination of investment and capital, when MMRF is run in dynamic mode, are provided in Section 4.8.1.

```
! Subsection 2.5.2:  Demands by industries for capital creation, User 2
---------------------------------!
Equation E_x2a # Demand for c from s for investment in region q, User 2 #
(all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
x2a(c,s,i,q) =
IF{s ne "imp",
    x2c(c,i,q) - SIGMA2C(c)*[p2a(c,s,i,q) - p2c(c,i,q)]} +
IF{s eq "imp",
    x2o(c,i,q) - SIGMA2O(c)*[p2a(c,"imp",i,q)- p2o(c,i,q)]+
    (V2PURT(c,"domestic",i,q)/(tiny + V2PURO(c,i,q)))*
```

```
        (twistsrc(c,q) + twistsrc_c(q) + nattwistsrc_c + nattwistsrc(c))};

Equation E_p2o # Price of domestic/imp composite, User 2 #
(all,c,COM)(all,i,IND)(all,q,REGDST)
ID01(V2PURO(c,i,q))*p2o(c,i,q) =
    sum{s,ALLSRC, V2PURA(c,s,i,q)*p2a(c,s,i,q)};

Equation E_p2c # Price of domestic composite, User 2 #
(all,c,COM)(all,i,IND)(all,q,REGDST)
ID01(V2PURT(c,"domestic",i,q))*p2c(c,i,q) =
    sum{s,REGSRC, V2PURA(c,s,i,q)*p2a(c,s,i,q)};

Equation E_x2c # Demand for domestic composite, User 2 #
(all,c,COM)(all,i,IND)(all,q,REGDST)
x2c(c,i,q) = x2o(c,i,q) - SIGMA2O(c)*[p2c(c,i,q) - p2o(c,i,q)] -
    [V2PURT(c,"imp",i,q)/(tiny + V2PURO(c,i,q))]*
        (twistsrc(c,q) + twistsrc_c(q) + nattwistsrc_c + nattwistsrc(c));

! The following equation links the change in investment demand for commodity c
  in region q to a weighted-average (industry weights) change in investment
  demand in region q !
Equation E_x2o # Demands for composite inputs, All User 2 #
(all,c,COM)(all,i,IND)(all,q,REGDST)
x2o(c,i,q) - a2(q) - acom(c,q) - natacom(c) = x2tot(i,q);
```

4.2.5 Household demands (TABLO excerpt 2.5.3)

Each regional household determines the optimal composition of its consumption bundle by choosing commodities to maximise a Stone-Geary utility function subject to a household budget constraint. A Keynesian consumption function determines aggregate regional household expenditure as a function of household disposable income.

Figure 4.4 reveals that the structure of household demand follows nearly the same nesting pattern as that of investment demand. The only difference is that commodity composites are aggregated by a Stone-Geary, rather than a Leontief, function leading to the linear expenditure system (LES).

The equations for the two lower nests (*E_x3a*, *E_p3o*, *E_p3c* and *E_x3c*) are similar to the corresponding equations for intermediate and investment demands.

The equations determining the commodity composition of household demand, which is determined by the Stone-Geary nest of the structure, differ from the CES pattern established in sections 4.2.2 and 4.2.3.[16] To analyse the Stone-Geary utility function, it is helpful to divide total economy-wide consumption of each commodity composite (X3O(c,q)) into two components: a subsistence (or minimum) part (X3SUB(c,q)) and a luxury (or supernumerary) part (X3LUX(c,q))

[16] For details on the derivation of demands in the LES, see Dixon, Bowles and Kendrick (1980) and Horridge *et al.* (1993).

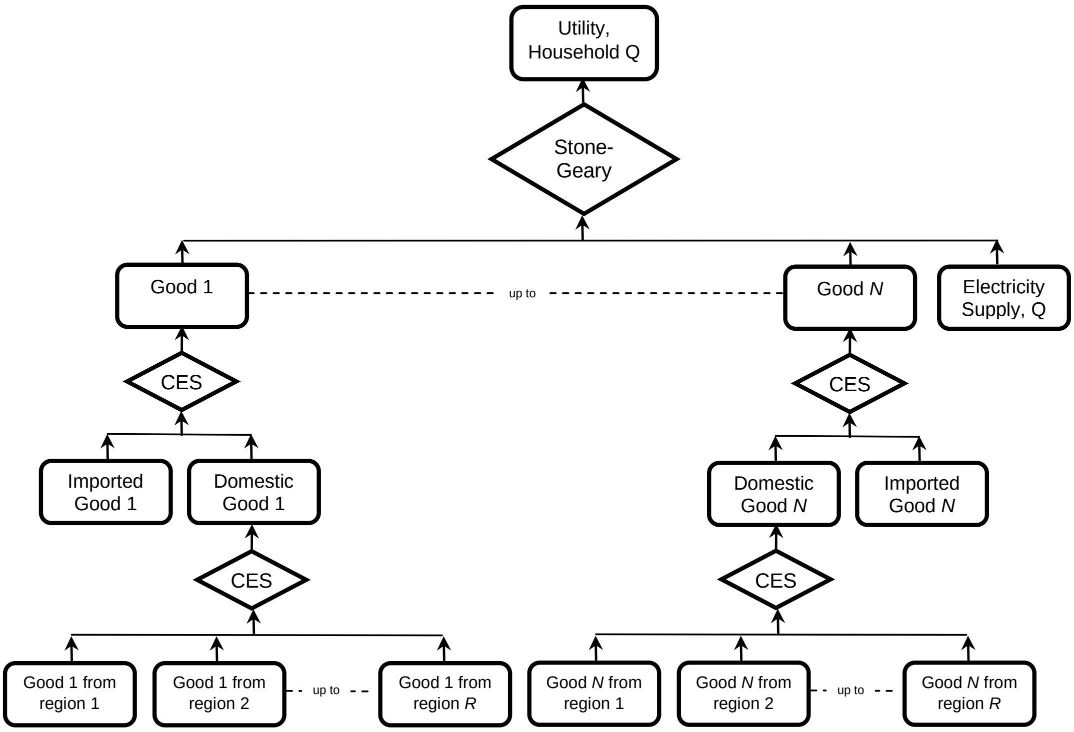

Figure 4.4: Structure of household demand

$$\mathrm{X3O(c,q) = X3SUB(c,q) + X3LUX(c,q)} \qquad \text{c}\in\text{COM q}\in\text{REGDST} \qquad (4.15)$$

A feature of the Stone-Geary function is that only the luxury components affect per-household utility (UTILITY), which has the Cobb-Douglas form

$$\mathrm{UTILITY(q)} = \frac{1}{\mathrm{QHOUS(q)}} \times \sum_{c\in com} \mathrm{X3LUX(c,q)}^{\mathrm{A3LUX(c,q)}} \qquad \text{q}\in\text{REGDST} \qquad (4.16)$$

where

$$\sum_{c\in com} \mathrm{A3LUX(c,q)} = 1 \qquad \text{q}\in\text{REGDST}.$$

Because the Cobb-Douglas form gives rise to exogenous budget shares for spending on luxuries

$$\mathrm{P3O(c,q) \times X3LUX(c,q) = A3LUX(c,q) \times W3LUX(q)} \qquad \text{c}\in\text{COM q}\in\text{REGDST}, \qquad (4.17)$$

A3LUX(i,q) may be interpreted as the marginal budget share of total spending on luxuries (W3LUX(q)). Rearranging (4.17), substituting into (4.15) and linearising gives equation *E_x3o*, where the subsistence component is proportional to the number of households and to a taste-change variable (a3sub(c,q)), but not dependent on any price terms, and B3LUX(c,q) is the share of supernumerary expenditure on commodity c in total expenditure on commodity c. Equation *E_utility* is the percentage-change form of (4.16); the utility function.

Equations *E_a3sub* and *E_a3lux* provide default settings for the taste-change variables (a3sub(i,q) and a3lux(i,q)), which allow for the average budget shares to be shocked, via the a3com(c,q), in a way that preserves the pattern of expenditure elasticities.

The equations just described determine the composition of regional household demands, but do not determine total regional consumption. As mentioned, total household consumption is determined by regional household disposable income. The determination of regional household disposable income and regional total household consumption is described in section 4.4.

```
! Subsection 2.5.3:  Household demands for commodities, User 3
---------------------------------!
! Household demand for subsistence and luxury consumption by commodities, and
  local and national Armington nests for commodity demand for household
  consumption. !
Equation E_x3o # Household demand for composite commodities #
(all,c,COM)(all,q,REGDST)
x3o(c,q) = (1 - B3LUX(c,q))*[qhous(q) + a3sub(c,q)] +
    B3LUX(c,q)*[w3lux(q) + a3lux(c,q) - p3o(c,q)];

Equation E_a3lux # Default setting for luxury taste shifter #
(all,c,COM)(all,q,REGDST)
a3lux(c,q) = a3sub(c,q) - sum{k,COM, DELTA(k,q)*a3sub(k,q)};

Equation E_a3sub # Default setting for subsistence taste shifter #
(all,c,COM)(all,q,REGDST)
a3sub(c,q) = a3tot(c,q) + nata3tot(c) -
    sum{k,COM, S3O(k,q)*(a3tot(k,q) + nata3tot(k))};

Equation E_utility # Change in utility disregarding taste change terms #
(all,q,REGDST)
utility(q) = w3lux(q) - qhous(q) - sum{c,COM, DELTA(c,q)*p3o(c,q)};

Equation E_x3a # Demand for goods by source, User 3 #
(all,c,COM)(all,s,ALLSRC)(all,q,REGDST)
x3a(c,s,q) =
IF{s ne "imp",
    x3c(c,q) - SIGMA3C(c)*[p3a(c,s,q) - p3c(c,q)]} +
IF{s eq "imp",
    x3o(c,q) - SIGMA3O(c)*[p3a(c,"imp",q) - p3o(c,q)] +
    (V3PURT(c,"domestic",q)/(tiny+V3PURO(c,q)))*
        (twistsrc(c,q) + twistsrc_c(q) + nattwistsrc_c + nattwistsrc(c))};

Equation E_p3o # Price of domestic/imp composite, User 3 #
(all,c,COM)(all,q,REGDST)
ID01(V3PURO(c,q))*p3o(c,q) = sum{s,ALLSRC, V3PURA(c,s,q)*p3a(c,s,q)};

Equation E_p3c # Price of domestic composite, User 3 #
(all,c,COM)(all,q,REGDST)
ID01(V3PURT(c,"domestic",q))*p3c(c,q) = sum{s,REGSRC, V3PURA(c,s,q)*p3a(c,s,q)};
```

```
Equation E_x3c # Demand for domestic composite, User 3 #
(all,c,COM)(all,q,REGDST)
x3c(c,q) = x3o(c,q) - SIGMA3O(c)*[p3c(c,q) - p3o(c,q)] -
    [V3PURT(c,"imp",q)/(tiny + V3PURO(c,q))]*
        (twistsrc(c,q) + twistsrc_c(q) + nattwistsrc_c + nattwistsrc(c));
```

4.2.6 Foreign export demands (TABLO excerpt 2.5.4)

To model export demands, commodities in MMRF are divided into four groups: traditional exports, which comprise the bulk of exports; non-traditional exports, which are mainly utilities and local services; tourism (travel and hospitality services); and special, which consists of Communications and Water Transport. For each category, the model allows a different treatment of export demand. The relevant export demand set for each commodity in the model is given in Table 4.2.

4.2.6.1 Traditional exports (E_x4rA)

Exports account for relatively large shares in total sales of traditional export commodities. They (i.e., commodities in the set TEXP) are modelled as facing downward-sloping foreign-export demand functions

$$X4R(c,s) = F4Q(c,s) \times NATF4Q\_C \times F4Q\_C(s) \times NATF4Q(c) \times \left(\frac{P4R(i,s)}{F4P(c,s) \times NATF4P\_C \times F4P\_C(s) \times NATF4P(c)} \right)^{SIGMAEXP(c)}$$

$$c \in TEXP \quad s \in REGSRC \qquad (4.18)$$

X4R(c,s) is the export volume of commodity c from region s. The coefficient SIGMAEXP(c) is the (constant) own-price elasticity of foreign-export demand. As SIGMAEXP(c) is negative, (4.18) says that traditional exports are a negative function of their foreign-currency prices on world markets (P4R(c,s)). The variables F4Q(c,s) and F4P(c,s) allow for horizontal (quantity) and vertical (price) shifts in the demand schedules. The variables NATF4Q_C and NATF4P_C allow for economy-wide horizontal and vertical shifts in the demand schedules. The variables F4Q_C(s) and F4P_C(s), and NATF4Q(c) and NATF4P(c) allow for source-specific and commodity-specific economy wide shifts in the demand schedules. *E_x4rA* is the percentage-change form of (4.18).

4.2.6.2 Non- traditional exports (E_x4r_ntrad, E_x4rB and E_p4r_ntrad)

E_x4r_ntrad specifies the export demand for the non-traditional export commodities (i.e., commodities in the set NTEXP). The set NTEXP consists of all commodities except those for which special modelling of export demands is provided and the commodities classified as traditional exports. In MMRF, the commodity composition of aggregate non-traditional exports is exogenised by treating non-traditional exports as a Leontief aggregate. Thus, as shown in *E_x4rB*, with the shift variable fntrad(c,s) set to zero, the export demand for non-traditional export commodity c from source-region s moves by the common non-traditional export percentage, x4r_ntrad(s). The common percentage change is explained by equation *E_x4r_ntrad*. This equation relates movements in demand for non-traditional exports from region s to movements in the average foreign currency price of those exports via a constant-elasticity demand curve, similar to those for traditional exports. The elasticity of substitution is given by the coefficient SIGMAEXPNTR, which is set to -4. Under this treatment, non-traditional exports respond as a group to changes in the group's international competitiveness.

We use the shift variables in equations *E_x4r_ntrad* to simulate various types of vertical and horizontal shifts in the export demand schedule for non-traditional exports from region s. For example, if f4q_ntrad(s) has a non-zero value, then we impose a horizontal shift on the group's export demand curve.

To simulate changes in the commodity composition of non-traditional exports, we can use non-zero settings for the shift variables in *E_x4rB*. For example, to cause the export volume of non-traditional component "Construction" in region s to change by a given percentage amount, we can make x4r("Construction",s) exogenous by freeing up fntrad("Construction",s). In this case, the model would endogenously determine the value for fntrad("Construction",s) which would reconcile the exogenously imposed setting of x4r("Construction",s) with the simulated value for x4r_ntrad(s).

Movements in the average foreign-currency price of non-traditional exports from region s (p4r_ntrad(s)) are determined via equation *E_p4r_ntrad*. The coefficient V4NTRAD(s) is the aggregate purchasers' value of non-traditional exports from region s.

4.2.6.3 Tourism exports (E_x4r_tour, E_x4rC, E_p4r_tour and E_natx4r_tour)

These equations specify demands by foreign visitors in region s for tourism services, i.e., for commodities in the set TOUR. The foreign elasticity of demand for tourism services is set at –5.

The equations for tourism exports are similar to the equations for non-traditional exports. We adopt a similar "bundle" approach to explaining exports of tourism services. Foreigners are viewed as buying a bundle of tourism services. The price of the tourism bundle is a Divisia index of the prices of all tourism exports.

The bundle-specification for tourism exports, which is also adopted in MONASH, is theoretically attractive. It is reasonable to think of foreign tourists as buying service bundles consisting of a fixed combination of commodities (say, an air ticket, a certain number of nights' accommodation, and food), with the number of bundles purchased being sensitive to the cost of a "bundle", but with little scope for substitution within the bundle. In other words, it is reasonable to think of the export demands for tourism commodities being tightly linked, not to movements in their individual price, but to movements in their overall average price.

4.2.6.4 Exports of communications services (E_x4rD)

This equation explains exports of communication services, the only element in the set COMMUNIC. Following the treatment in MONASH, exports of communications services from source s are driven by the volume of foreign imports of communications services into s (X0IMP(c,s), for c$\in$ COMMUNIC). This is based on the observation that communication exports consist mainly of charges by Australian telephone companies for distributing incoming phone calls, and of charges by Australian post for delivering foreign mail within Australia. Accordingly, on the assumption that outgoing communications generate incoming communications, the volume of communications imports drives the volume of communications exports.

The variable fcommunic(c,s) for c∈ COMMUNIC allows for shifts in the ratio of communication exports to imports in region s.

4.2.6.5 Exports of water transport services (E_x4r_trad and E_x4rE)

When activated, *E_x4rE* deals with exports of commodities in the set WATTRANS. This equation is not activated unless the database is appropriately disaggregated. This set contains a single element, water transport freight services. Following the treatment in MONASH, exports of water transport freight in region s are assumed to move in line with the aggregate volume of traditional exports as found in equation *E_x4r_trad*. The rationale is that the main use of water transport services outside Australia is for the shipment of bulk traditional exports, especially, iron ore, coal, wool and grain. The variable fwattrans(c,s) for c∈ WATTRANS allows for shifts in the ratio of water transport exports to the volume of traditional exports.

```
! Subsection 2.5.4: Demands for exports
---------------------------------!
!  There are four category of exports: traditional, non-traditional, tourism
   and special (Communications, Water transport, Other transport). For each
   category, the model allows a different treatment of export demands. !

Equation E_x4rA # Export demand functions - traditional exports #
(all,c,TEXP)(all,s,REGSRC)
x4r(c,s) - f4q(c,s) - natf4q_c - f4q_c(s) - natf4q(c)  =
[0 + IF[V4BAS(c,s) NE 0, SIGMAEXP(c)]]*
        [p4r(c,s) - f4p(c,s) - natf4p_c - f4p_c(s) - natf4p(c)];

Equation E_x4r_ntrad # Export demand functions, non-traditional aggregate #
(all,s,REGSRC)
x4r_ntrad(s) - f4q_ntrad(s) - natf4q_c - f4q_c(s) - natf4q_ntrad =
    SIGMAEXPNTR*[p4r_ntrad(s) - f4p_ntrad(s) - natf4p_c - f4p_c(s)];

Equation E_x4rB # Individual exports linked to non-traditional aggregate #
(all,c,NTEXP)(all,s,REGSRC)
x4r(c,s) =
[0 + IF[V4BAS(c,s) NE 0, 1]]*x4r_ntrad(s) + fntrad(c,s);

Equation E_p4r_ntrad # Foreign-currency price of non-traditional aggregate #
(all,s,REGSRC)
ID01(V4NTRAD(s))*p4r_ntrad(s) = sum{c,NTEXP, V4PURR(c,s)*p4r(c,s)};

Equation E_natx4r_ntrad # Quantity of non-traditional exports, national #
sum{s,REGSRC, V4NTRAD(s)}*natx4r_ntrad =
    sum{s,REGSRC, sum{c,NTEXP, V4PURR(c,s)*x4r(c,s)}};

Equation E_x4r_tour # Export demand functions, tourism aggregate #
```

```
(all,s,REGSRC)
x4r_tour(s) - f4q_tour(s) - natf4q_c - f4q_c(s)  - natf4q_tour =
    SIGMAEXPNTR*[p4r_tour(s) - f4p_tour(s) - natf4p_c - f4p_c(s)];

Equation E_x4rC # Individual exports linked to tourism aggregate #
(all,c,TOUR)(all,s,REGSRC)
x4r(c,s) =
[0 + IF[V4BAS(c,s) NE 0, 1]]*x4r_tour(s) + ftour(c,s);

Equation E_p4r_tour # Foreign-currency price of tourism exports #
(all,s,REGSRC)
ID01(sum{cc,TOUR, V4PURR(cc,s)})*p4r_tour(s) = sum{c,TOUR,V4PURR(c,s)*p4r(c,s)};

Equation E_natx4r_tour # Quantity of tourism exports, national #
sum{c,TOUR, sum{s,REGSRC, V4PURR(c,s)}}*natx4r_tour =
    sum{c,TOUR, sum{s,REGSRC, V4PURR(c,s)*x4r(c,s)}};

Equation E_x4rD # Communication exports move with communication imports #
(all,c,COMMUNIC)(all,s,REGSRC)
x4r(c,s) = x0imp(c,s) + fcommunic(c,s);

Equation E_x4r_trad # Volume of traditional exports from region s #
(all,s,REGSRC)
x4r_trad(s) = sum{c,TEXP, V4PURR(c,s)/sum{cc,TEXP, V4PURR(cc,s)}*x4r(c,s)};

Equation E_x4rE # Exports of water transport move with traditional exports #
(all,c,WATTRANS)(all,s,REGSRC)
x4r(c,s) = x4r_trad(s) + fwattrans(c,s) ;
```

4.2.7 Government consumption demands (TABLO excerpt 2.5.5)

Equations *E_x5a* and *E_x6a* determine State/territory government and Federal government demands (respectively) for commodities for current consumption.[17]

In *E_x5a*, State/territory government consumption is constrained to preserve a constant ratio with State private consumption expenditure (X3TOT(q)). The shift variables f5a(c,s,q), f5tot(q) and natf5tot allow for shifts in the ratio of X5A(c,s,q) to X3TOT(q). To impose a non-uniform change in the ratio, we can use non-zero settings for the 'f5a' variables. To impose a uniform change in any region, we can use non-zero settings for the 'f5tot' variables, and to impose a uniform change across all regions, we can use a non-zero setting for natf5tot.

Likewise, Federal government consumption expenditure may be constrained, using an appropriate closure, to preserve a constant ratio with national private consumption expenditure

[17] This corresponds to general government consumption in the ABS Input-Output tables.

(NATX3TOT(q)), with changes in the ratio made possible by non-zero settings for the f6a, f6tot and natf6tot variables.

```
! Subsection 2.5.5: Demands for commodities for government consumption
---------------------------------!
Equation E_x5a # Regional government consumption #
(all,c,COM)(all,s,ALLSRC)(all,q,REGDST)
x5a(c,s,q) = x3tot(q) + f5a(c,s,q) + f5tot(q) + natf5tot;

Equation E_x6a # Federal government consumption #
(all,c,COM)(all,s,ALLSRC)(all,q,REGDST)
x6a(c,s,q) = natx3tot + f6a(c,s,q) + f6tot(q) + natf6tot;
```

4.2.8 Inventory accumulation (TABLO excerpt 2.5.6)

Inventories of commodity c in region s are assumed to accumulate in proportion to output of commodity c in region s. In equation *E_d_x7r*, the ordinary change in inventories, d_x7r(c,s) is used instead of the percentage change, because the volume of inventories may be zero or negative. The shift term d_fx7r(c,s) allows for a change in the ratio of inventories to output.

Equation *E_d_w7r* gives the value of the change in inventories by including the price terms. Margins and taxes are assumed not to apply to inventories, so they are valued at basic prices.

```
! Subsection 2.5.6: Inventory accumulation
---------------------------------!
Equation E_d_x7r # Stocks follow domestic output #
(all,c,COM)(all,s,REGSRC)
100*ID01(LEVP7R(c,s))*d_x7r(c,s) = V7BAS(c,s)*x0com_i(c,s) + d_fx7r(c,s);

Equation E_d_w7r # Value of change in inventory accumulation #
(all,c,COM)(all,s,REGSRC)
d_w7r(c,s) = 0.01*V7BAS(c,s)*p0a(c,s) + LEVP7R(c,s)*d_x7r(c,s);
```

4.2.9 Demands for margin services (TABLO excerpt 2.5.7)

Commodities in the set MARGCOM can be used as margins. Typical elements of MARGCOM are wholesale and retail trade, road freight, rail freight, water freight and air freight. These commodities, in addition to being consumed directly by the users (e.g., consumption of transport when taking holidays or commuting to work), are also consumed to facilitate trade (e.g., the use of transport to ship commodities from point of production to point of consumption). The latter type of demand for transport is a so-called demand for margins.

Equations *E_x1marg*, *E_x2marg*, *E_x3marg, E_x4marg, E_x5marg* and *E_x6marg* give the demands by users 1 to 6 for margins. As indicated in Figure 4.1, we assume that there are no margins on inventory accumulation. Equations *E_x1marg* to *E_x6marg* indicate that the demands are proportional to the commodity flows with which the margins are associated. For example, the demand for margin type r = 'wholesale trade' on the flow of commodity c from source s to industry i in region q for use in current production (X1MARG(c,s,i,q,r)) moves with the underlying demand (X1A(c,s,i,q)). In each equation, there is a technological variable specific to users (a1marg(q,r), etc.), and non-user-specific terms acom(r,q) and natacom(r) representing technological change in the use of margin service r per unit of demand in region q.

The final variable in each equation, modalsub1(c,s,q,r) etc, captures substitution between road and rail freight transport. The derivation of this variable is given in section 4.10.4.

```
! Subsection 2.5.7: Margin usage of commodities
---------------------------------!
Equation E_x1marg # Margins on sales to producers #
(all,c,COM)(all,i,IND)(all,q,REGDST)(all,s,ALLSRC)(all,r,MARGCOM)
x1marg(c,s,i,q,r) - a1marg(q,r) - acom(r,q) - natacom(r)  =
    x1a(c,s,i,q) + modalsub1(c,s,i,q,r);

Equation E_x2marg # Margins on sales to capital creators #
(all,c,COM)(all,q,REGDST)(all,s,ALLSRC)(all,i,IND)(all,r,MARGCOM)
x2marg(c,s,i,q,r) - a2marg(q,r) - acom(r,q) - natacom(r) =
    x2a(c,s,i,q) + modalsub2(c,s,i,q,r);

Equation E_x3marg # Margins on sales to household consumption #
(all,c,COM)(all,s,ALLSRC)(all,q,REGDST)(all,r,MARGCOM)
x3marg(c,s,q,r) - a3marg(q,r) - acom(r,q) - natacom(r) =
    x3a(c,s,q) + modalsub3(c,s,q,r);

Equation E_x4marg # Margins on exports: factory gate to port #
(all,c,COM)(all,r,MARGCOM)(all,s,REGSRC)
x4marg(c,s,r) - a4marg(s,r) - acom(r,s) - natacom(r) =
    x4r(c,s) + modalsub4(c,s,r);

Equation E_x5marg # Margins on sales to regional government consumption #
(all,c,COM)(all,s,ALLSRC)(all,q,REGDST)(all,r,MARGCOM)
x5marg(c,s,q,r) - a5marg(q,r) - acom(r,q) - natacom(r) =
    x5a(c,s,q) + modalsub5(c,s,q,r);

Equation E_x6marg # Margins on sales to federal government consumption #
(all,c,COM)(all,s,ALLSRC)(all,q,REGDST)(all,r,MARGCOM)
x6marg(c,s,q,r) - a6marg(q,r) - acom(r,q) - natacom(r) =
    x6a(c,s,q) + modalsub6(c,s,q,r);
```

4.2.10 Zero pure profits and Basic prices (TABLO excerpt 2.5.8)

As is typical of ORANI-style models, the price system underlying MMRF is based on two assumptions: (i) that there are no pure profits in the production or distribution of commodities, and (ii) that the price received by the producer is uniform across all customers.

Also in the tradition of ORANI, there are two types of price equations: (i) zero pure profits in current production, capital creation and importing and (ii) zero pure profits in the distribution of commodities to users. The zero pure profits condition in current production, capital creation and importing is imposed by setting unit prices received by producers of commodities (i.e., the commodities' basic values) equal to unit costs. Zero pure profits in the distribution of commodities is imposed by setting the prices paid by users equal to the commodities' basic value plus commodity taxes and the cost of margins.

4.2.10.1 Basic prices in current production (E_p1tot and E_a)

Equations *E_p1tot* and *E_a* impose the zero pure profits condition in current production. Given the constant returns to scale which characterise the model's production technology, equation *E_p1tot* defines the percentage change in the price received per unit of output by industry i of region q (p1tot(i,q)) as a cost-weighted average of the percentage changes in effective input prices. The percentage changes in the effective input prices represent: (i) the percentage change in the cost per unit of input and (ii) the percentage change in the use of the input per unit of output (i.e., the percentage change in the technology variable). These cost-share-weighted averages define percentage changes in average costs. In section 4.2.17 on market clearing equations, commodity prices are set to be equal to average costs, which imposes the competitive zero pure profits condition.

In equation *E_a*, a(i,q) is defined as an aggregation of all the different types of technological change that affect the costs of industry i in region q. All input-augmenting technological change a1(i,q) appears as a negative on the LHS because its weighting coefficient is total costs. The various different types of input-specific technological change appear on the RHS of the equation with weights reflecting their influence on industry i's unit costs.

The mathematical derivation of the zero pure profits condition in current production is similar (although slightly more complex) to the derivation of the zero pure profits condition in capital creation, which is given below.

4.2.10.2 Basic prices in capital creation (E_p2tot)

Equation *E_p2tot* imposes zero pure profits in capital creation. *E_p2tot* determines the percentage change in the price of new units of capital (p2tot(i,q)) as the percentage change in the effective average cost of producing the unit. Total investment by industry i in region q is given by

$$
\begin{aligned}
& \mathrm{X2TOT}(i,q) \times \mathrm{P2TOT}(i,q) \\
& = \mathrm{V2TOT}(i,q) \\
& = \sum_{c \in COM} \sum_{s \in ALLSRC} \mathrm{V2PURA}(c,s,i,q) \qquad i \in IND \quad q \in REGDST \qquad (4.19), \\
& = \sum_{c \in COM} \sum_{s \in ALLSRC} \mathrm{X2A}(c,s,i,q) \times \mathrm{P2A}(c,s,i,q)
\end{aligned}
$$

or in percentage change form

$$\begin{aligned}&\text{V2TOT}(i,q)\times(\text{x2tot}(i,q)+\text{p2tot}(i,q))\\&=\sum_{c\in COM}\sum_{s\in ALLSRC}\text{V2PURA}(c,s,i,q)\times(\text{x2a}(c,s,i,q)+\text{p2a}(c,s,i,q))\end{aligned}\qquad i\in IND\quad q\in REGDST \quad (4.20).$$

Recalling from Section 4.1.2 that

$$\begin{aligned}&\sum_{s\in ALLSRC}\text{V2PURA}(c,s,i,q)\times\text{x2a}(c,s,i,q)\\&=\sum_{s\in DOMSRC}\text{V2PURA}(c,s,i,q)\times\text{x2a}(c,s,i,q)+\text{V2PURA}(c,\text{"imp"},i,q)\times\text{x2a}(c,\text{"imp"},i,q)\\&=\sum_{s\in DOMSRC}\text{V2PURA}(c,s,i,q)\times\begin{pmatrix}\text{x2o}(c,s,i,q)-\text{SIGMA2O}(c)\times(\text{p2c}(c,i,q)-\text{p2o}(c,i,q))\\-\text{SIGMA2C}(c)\times(\text{p2a}(c,s,i,q)-\text{p2c}(c,i,q))\end{pmatrix}\\&+\text{V2PURA}(c,\text{"imp"},i,q)\times(\text{x2o}(c,i,q)-\text{SIGMA2C}\times(\text{p2a}(c,\text{"imp"},i,q)-\text{p2o}(c,i,q)))\\&=\sum_{s\in ALLSRC}\text{V2PURA}(c,s,i,q)\times(\text{x2o}(c,s,i,q))\\&=\sum_{s\in ALLSRC}\text{V2PURA}(c,s,i,q)\times(\text{x2tot}(i,q)+\text{a2}(q)+\text{acom}(c,q)+\text{natacom}(c)),\end{aligned}$$

the x2tot(i,q) terms may be cancelled to leave

$$\text{V2TOT}(i,q)\times(\text{p2tot}(i,q))=\sum_{c\in COM}\sum_{s\in ALLSRC}\text{V2PURA}(c,s,i,q)\times(\text{p2a}(c,s,i,q)+\text{a2}(q)+\text{acom}(c,q)+\text{natacom}(c))$$

$$i\in IND\quad q\in REGDST \qquad 4.21).$$

4.2.10.3 Basic prices in importing (E_p0aB)

Zero pure profits in imports of foreign-produced commodities is imposed by equation *E_p0aB*. The price received by the importer for the c^{th} commodity (p0a(c,"imp")) is given as the product of the foreign c.i.f. (cost, insurance, freight) price of the import (NATP0CIF(c)), the exchange rate (PHI) and one plus the rate of tariff (the so-called power of the tariff: POWTAR(c)).[18]

```
! Subsection 2.5.8: Basic prices
---------------------------------!
Equation E_p1tot # Zero pure profits in current production #
(all,i,IND)(all,q,REGDST)
ID01(COSTS(i,q))*{p1tot(i,q) - a(i,q)} =
   sum{c,COM, sum{s,ALLSRC, V1PURA(c,s,i,q)*p1a(c,s,i,q)}} +
                  sum{o,OCC, V1LAB(i,q,o)* p1lab(i,q,o)} +
                             V1CAP(i,q)*p1cap(i,q) +
                             V1LND(i,q)*p1lnd(i,q) +
                             V1OCT(i,q)*p1oct(i,q);

Equation E_a # Technical change by industry-current production #
(all,i,IND)(all,q,REGDST)
```

[18] If the tariff rate is 20 percent, the power of tariff is 1.20. If the tariff rate is increased from 20 percent to 25 percent, the percentage change in the power of the tariff is 4.2, i.e., 100×(1.25-1.20)/1.20 = 4.2.

```
ID01(COSTS(i,q))*[a(i,q) - a1(i,q)] =
sum{c,COM,sum{s,ALLSRC, V1PURA(c,s,i,q)*a1a(c,s,i,q)}} +
             sum{c,COM, V1PURO(c,i,q)*
(a1o(c,i,q) + acom(c,q) + natacom(c) + acomind(c,i,q))} +
     V1PRIM(i,q)*(a1prim(i,q) + a1prim_i(q) + nata1prim_i + nata1prim(i)) +
                    V1LAB_O(i,q)*(a1lab_o(i,q) + nata1lab_oi + nata1lab_o(i)) +
                    V1CAP(i,q)*a1cap(i,q) +
                    V1LND(i,q)*a1lnd(i,q) +
                    V1OCT(i,q)*a1oct(i,q);

Equation E_p2tot # Zero pure profits in capital creation #
(all,i,IND)(all,q,REGDST)
ID01(V2TOT(i,q))*p2tot(i,q) =
    sum{c,COM, sum{s,ALLSRC,
           V2PURA(c,s,i,q)* [p2a(c,s,i,q) + a2(q) + acom(c,q) + natacom(c)]}};

Equation E_p0aB # Zero pure profits in importing #
(all,c,COM)
p0a(c,"imp") = natp0cif(c) + phi + powtar(c);
```

4.2.11 Zero pure profits and Purchasers' prices and Indirect Tax Rates (TABLO excerpt 2.5.9)

4.2.11.1 Purchasers' prices (E_p1a to E_p6a)

The remaining zero-pure-profits equations relate purchasers' prices to basic prices, the cost of margins and commodity taxes. Eight classes of users are recognised in MMRF (see Figure 4.1). Zero pure profits in the distribution of commodities to non-inventory users are imposed by the equations *E_p1a*, *E_p2a*, *E_p3a*, *E_p4r*, *E_p5a,* and *E_p6a*.

The tax variables appearing on the RHS of each equation are change variables. Specifically, they are percentage-point changes in rates of *ad valorem* sales taxes. For example, d_t3S(c,s,q) is the percentage point change in the *ad valorem* rate of state tax imposed in region q on sales to consumption of commodity c from source s.

On current production, investment, household consumption and exports, three types of tax are imposed: Federal taxes, States taxes and the GST. For Federal (V1TAXF etc) and State (V1TAXS etc) taxes, the base is the basic value of the flow, i.e. V1BAS, etc. However, for the GST, the base is the value of the basic flow plus margins and Federal and State taxes. Using households as an example, the purchaser's value in region q of commodity c from source s is

$$\begin{aligned}&\mathrm{V3PURA}(c,s,q)=\mathrm{V3BAS}(c,s,q)+\mathrm{V3TAXF}(c,s,q)+\mathrm{V3TAXS}(c,s,q)\\&+\mathrm{V3GST}(c,s,q)+\sum_{m\in \mathrm{MARGCOM}}\mathrm{V3MAR}(c,s,q,m)\end{aligned} \qquad (4.22)$$

The definition of the federal tax rate is

$$T3F(c,s,q)=\frac{V3TAXF(c,s,q)}{V3BAS(c,s,q)}\times 100 \quad (4.23)$$

The definition of the state tax rate is

$$T3S(c,s,q)=\frac{V3TAXS(c,s,q)}{V3BAS(c,s,q)}\times 100 \quad (4.24)$$

The definition of the GST rate uses a different base, and is

$$T3GST(c,s,q)=\frac{V3GST(c,s,q)}{V3GSTBASE(c,s,q)}\times 100 \quad (4.25)$$

where

$$\begin{aligned}&V3GSTBASE(c,s,q)=V3BAS(c,s,q)+V3TAXF(c,s,q)\\&+V3TAXS(c,s,q)+\sum_{m\in MARGCOM}V3MAR(c,s,q,m)\end{aligned} \quad (4.26)$$

The percentage change form of 4.22 is therefore

$$\begin{aligned}&V3PURA(c,s,q)\times\left[p3a(c,s,q)+x3a(c,s,q)\right]\\&=\left(1+\frac{T3GST(c,s,q)}{100}\right)\times\left\{\begin{array}{l}\left[V3BAS(c,s,q)+V3TAXF(c,s,q)+V3TAXS(c,s,q)\right]\\ \times\left(p0a(c,s)+x3a(c,s,q)\right)\\ +V3BAS(c,s,q)\times\left[d\_T3F(c,s,q)+d\_T3S(c,s,q)\right]\\ +\sum_{m\in MARGCOM}V3MAR(c,s,q,m)\times\left[p0(m,q)+x3marg(c,s,q,m)\right]\end{array}\right\}\\&+V3GSTBASE(c,s,q)\times d\_T3GST(c,s,q)\end{aligned}$$

(4.27)

Note the use of ordinary change variables for the tax rates.

Recalling from section 4.1.6, the definition of margin use is

$$x3marg(c,s,q,m)=x3a(c,s,q)+a3marg(q,m)+acom(m,q)+mod\,alsub3(c,s,q,m) \quad (4.28)$$

substitute 4.1.25 into 4.1.24 and cancel the x3a(c,s,q) terms to arrive at the definition of the household purchaser's price in region q for commodity c from source s:

$$
\begin{aligned}
&\text{V3PURA}(c,s,q)\times \text{p3a}(c,s,q) \\
&=\left(1+\frac{\text{T3GST}(c,s,q)}{100}\right)\times\left\{
\begin{array}{l}
\left[\text{V3BAS}(c,s,q)+\text{V3TAXF}(c,s,q)+\text{V3TAXS}(c,s,q)\right]\times \text{p0a}(c,s) \\
+\text{V3BAS}(c,s,q)\times\left[\text{d\_T3F}(c,s,q)+\text{d\_T3S}(c,s,q)\right] \\
+\sum_{m\in \text{MARGCOM}} \text{V3MAR}(c,s,q,m)\times\left[\begin{array}{l}\text{p0}(m,q)+\text{a3marg}(q,m) \\ +\text{acom}(m,q)+\text{modalsub3}(c,s,q,m)\end{array}\right]
\end{array}\right\} \\
&+\text{V3GSTBASE}(c,s,q)\times \text{d\_T3GST}(c,s,q)
\end{aligned}
\tag{4.29}
$$

Note that

$$
\sum_{m\in \text{MARGCOM}} \text{V3MAR}(c,s,q,m)\times\left(\text{modalsub3}(c,s,q,m)\right)=0
$$

therefore equation 4.29 is equivalent to E_p3a in the TABLO code.

4.2.11.2 Indirect tax rates (E_d_t1F to E_d_t4gst)

This block of equations contains the default rules for setting federal and state sales-tax rates for producers (*E_d_t1F* and *E_d_t1S*), investors (*E_d_t2F* and *E_d_t2S*), households (*E_d_t3F* and *E_d_t3S*), and exports (*E_d_t4F*)[19], and GST rates (*E_d_t1GST* to *E_d_t4GST*). Non-GST sales taxes are treated as *ad valorem* on the price received by the producer, while GST taxes are treated as *ad valorem* on the price received by the producer plus any mark-up due to margins (freight, etc) applying to the underlying flow. The sales-tax variables (d_t1F(c,s,i,q), etc) are ordinary changes in the percentage tax rates, i.e., the percentage-point changes in the tax rates. Thus, a value of d_t1F(c,s,i,q) of 20 means that the percentage tax rate on commodity c from source s used as an input to current production in industry i in region q increased from, say, 24 to 44 per cent.

```
! Subsection 2.5.9: Purchasers' prices of commodities and indirect tax rates
---------------------------------!

Equation E_p1a # Purchasers prices - User 1 #
(all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
ID01(V1PURA(c,s,i,q))*p1a(c,s,i,q) = (1 + T1GST(c,s,i,q)/100)*{
    [V1BAS(c,s,i,q) + V1TAXF(c,s,i,q) + V1TAXS(c,s,i,q)]*p0a(c,s) +
     V1BAS(c,s,i,q)*[d_t1F(c,s,i,q) + d_t1S(c,s,i,q)] +
sum{r,MARGCOM, V1MAR(c,s,i,q,r)*[p0a(r,q)+a1marg(q,r)+acom(r,q)+natacom(r)]} } +
    V1GSTBASE(c,s,i,q)*d_t1GST(c,s,i,q);

Equation E_p2a # Purchasers prices - User 2 #
(all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
ID01(V2PURA(c,s,i,q))*p2a(c,s,i,q) = (1 + T2GST(c,s,i,q)/100)*{
    [V2BAS(c,s,i,q) + V2TAXF(c,s,i,q) + V2TAXS(c,s,i,q)]*p0a(c,s) +
     V2BAS(c,s,i,q)*[d_t2F(c,s,i,q) + d_t2S(c,s,i,q)] +
sum{r,MARGCOM,V2MAR(c,s,i,q,r)*[p0a(r,q)+a2marg(q,r)+acom(r,q)+natacom(r)]} } +
    V2GSTBASE(c,s,i,q)*d_t2GST(c,s,i,q);
```

[19] Note that there are no state sales taxes on exports in MMRF, and no taxes on governments.

```
Equation E_p3a # Purchasers prices - User 3 #
(all,c,COM)(all,q,REGDST)(all,s,ALLSRC)
ID01(V3PURA(c,s,q))*p3a(c,s,q) = (1 + T3GST(c,s,q)/100)*{
    [V3BAS(c,s,q) + V3TAXF(c,s,q) + V3TAXS(c,s,q)]*p0a(c,s) +
     V3BAS(c,s,q)*[d_t3F(c,s,q) + d_t3S(c,s,q)] +
sum{r,MARGCOM,V3MAR(c,s,q,r)*[p0a(r,q)+a3marg(q,r)+acom(r,q)+natacom(r)]} } +
    V3GSTBASE(c,s,q)*d_t3GST(c,s,q);

Equation E_p4r # Purchasers prices - User 4 #
(all,c,COM)(all,s,REGSRC)
ID01(V4PURR(c,s))*(p4r(c,s) + phi) = (1 + T4GST(c,s)/100)*{
    [V4BAS(c,s)+V4TAXF(c,s)]*p0a(c,s) +
    V4BAS(c,s)*d_t4f(c,s) +
sum{r,MARGCOM,V4MAR(c,s,r)*[p0a(r,s)+a4marg(s,r)+acom(r,s)+natacom(r)]} } +
    V4GSTBASE(c,s)*d_t4GST(c,s);

Equation E_p5a # Purchasers prices - User 5 #
(all,c,COM)(all,s,ALLSRC)(all,q,REGDST)
ID01(V5PURA(c,s,q))*p5a(c,s,q) =
    V5BAS(c,s,q)*p0a(c,s) +
sum{r,MARGCOM,V5MAR(c,s,q,r)*[p0a(r,q)+a5marg(q,r)+acom(r,q)+natacom(r)]};

Equation E_p6a # Purchasers prices - User 6 #
(all,c,COM)(all,s,ALLSRC) (all,q,REGDST)
ID01(V6PURA(c,s,q))*p6a(c,s,q) =
    V6BAS(c,s,q)*p0a(c,s) +
sum{r,MARGCOM,V6MAR(c,s,q,r)*[p0a(r,q)+a6marg(q,r)+acom(r,q)+natacom(r)]};

! Indirect tax rates !
Equation E_d_t1F # Federal tax rate (not GST) on sales to User 1 #
(all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
d_t1F(c,s,i,q) = {0 + IF(V1TAXF(c,s,i,q) gt 0,1)}*
    [d_tF+d_t1F_csiq+d_t1F_si(c,q)+d_t1F_siq(c)+d_tFs(s)+d_tFq(q)+d_tFc(c)];

Equation E_d_t1S # State tax rate on sales to User 1 #
(all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
d_t1S(c,s,i,q) = {0 + IF(V1TAXS(c,s,i,q) gt 0,1)}*
    [d_t1S_si(c,q)+d_t1S_siq(c)+d_tSs(s)+d_tSq(q)+d_tSc(c)+d_tScq(c,q)];

Equation E_d_t2F # Federal tax rate (not GST) on sales to User 2 #
(all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
d_t2F(c,s,i,q) =  {0 + IF(V2TAXF(c,s,i,q) gt 0,1)}*
    [d_tF+d_t2F_csiq+d_t2F_si(c,q)+d_t2F_siq(c)+d_tFs(s)+d_tFq(q)+d_tFc(c)];

Equation E_d_t2S # State tax rate on sales to User 2 #
(all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
d_t2S(c,s,i,q) =  {0 + IF(V2TAXS(c,s,i,q) gt 0,1)}*
    [d_t2S_si(c,q)+d_t2S_siq(c)+d_tSs(s)+d_tSq(q)+d_tSc(c)+d_tScq(c,q)];

Equation E_d_t3F # Federal tax rate (not GST)on sales to User 3 #
(all,c,COM)(all,s,AllSrc)(all,q,REGDST)
```

```
d_t3F(c,s,q) =  {0 + IF(V3TAXF(c,s,q) gt 0,1)}*
    [d_tF+d_t3F_csq+d_t3F_s(c,q)+d_t3F_sq(c)+d_tFs(s)+d_tFq(q)+d_tFc(c)];

Equation E_d_t3S # State tax rate on sales to User 3 #
(all,c,COM)(all,s,AllSrc)(all,q,REGDST)
d_t3S(c,s,q) =  {0 + IF(V3TAXS(c,s,q) gt 0,1)}*
    [d_t3S_s(c,q)+d_t3S_sq(c)+d_tSs(s)+d_tSq(q)+d_tSc(c)+d_tScq(c,q)];

Equation E_d_t4f # Federal tax rate (not GST) on sales to User 4 #
(all,c,COM)(all,s,REGSRC)
d_t4f(c,s) = {0 + IF(V4TAXF(c,s) gt 0,1)}*
    [d_tF+d_tFs(s)+d_tFc(c)+d_t4f_cs+d_t4f_s(c)+d_tFs(s)+d_tFc(c)];

Equation E_d_t1GST
(all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
d_t1GST(c,s,i,q) =
    {0 + IF(V1GST(c,s,i,q) gt 0,1)}*[d_tGST + d_tGSTq(q) + d_t0(q)];

Equation E_d_t2GST
(all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
d_t2GST(c,s,i,q) =
    {0 + IF(V2GST(c,s,i,q) gt 0,1)}*[d_tGST + d_tGSTq(q) + d_t0(q)];

Equation E_d_t3GST
(all,c,COM)(all,s,ALLSRC)(all,q,REGDST)
d_t3GST(c,s,q) =
    {0 + IF(V3GST(c,s,q) gt 0,1)}*[d_tGST + d_tGSTq(q) + d_t0(q)];

Equation E_d_t4GST
(all,c,COM)(all,s,REGSRC)
d_t4GST(c,s) =
    {0 + IF(V4GST(c,s) gt 0,1)}*[d_tGST + d_tGSTq(s) + d_t0(s)];
```

4.2.12 Indirect tax revenues (TABLO excerpt 2.5.10)

In this large block of equations, the percentage changes in regional aggregate revenue raised from indirect commodity taxes is computed. Equation *E_wtaxf_c* gives aggregate revenue from federal sales taxes by region, and *E_wnattaxf* gives the national aggregate. Equation *E_wtaxs_c* gives aggregate state sales taxes by region, and *E_wtaxs* gives aggregate state sales taxes by commodity and region. The equations in the remainder of the section give aggregate federal and state taxes by user, region, and commodity, as well as GST revenue by user, region and commodity. The final equation in this group, *E_natwgst*, gives aggregate national GST revenue.

The bases for the federal and state non-GST sales taxes are the regional basic values of the corresponding commodity flows. Hence, for any component of sales tax, we can express revenue (say VTAX), in levels, as the product of the base (BAS) and the tax rate (T), i.e.,

$$\mathrm{VTAX} = \mathrm{BAS} \times \frac{\mathrm{T}}{100}.$$

Hence

$$\Delta VTAX = \Delta BAS \times \frac{T}{100} + BAS \times \frac{\Delta T}{100} \qquad (4.30)$$

The basic value of the commodity is the product of the producer's price (P0) and output (XA)

$$BAS = P0 \times XA \qquad (4.31)$$

Using (4.30) and (4.31), we can derive the tax revenue equations as follows

$$VTAX \times wtax = VTAX \times (xa + p0) + BAS \times d\_T \qquad (4.32)$$

where

$$wtax = 100 \times \frac{\Delta VTAX}{VTAX},$$

$$p0 = 100 \times \left(\frac{\Delta P0}{P0}\right),$$

$$xa = 100 \times \left(\frac{\Delta XA}{XA}\right).$$

and

$$d\_T = \Delta T.$$

The base for the GST is the basic value plus federal and state non-GST sales taxes plus margins. Using households as an example, and recalling the definitions (4.25) and (4.26), GST revenue from households in region q, V3GST_CS(q), is

$$V3GST\_CS(q) = \sum_{c \in COM} \sum_{s \in ALLSRC} \frac{T3GST(c,s,q)}{100} \times V3GSTBASE(c,s,q) \qquad (4.33)$$

Thus,

$$\Delta V3GST\_CS(q) = \sum_{c \in COM} \sum_{s \in ALLSRC} \begin{pmatrix} \frac{\Delta T3GST(c,s,q)}{100} \times V3GSTBASE(c,s,q) \\ + \frac{T3GST(c,s,q)}{100} \times \Delta V3GSTBASE(c,s,q) \end{pmatrix} \qquad (4.34)$$

or

$$V3GST\_CS(q) \times w3gst\_cs(q) = \sum_{c \in COM} \sum_{s \in ALLSRC} \begin{pmatrix} \Delta T3GST(c,s,q) \times V3GSTBASE(c,s,q) \\ +T3GST(c,s,q) \times \begin{pmatrix} \Delta V3BAS(c,s,q) + \Delta V3TAXF(c,s,q) \\ +\Delta V3TAXS(c,s,q) + \sum_{m \in MARGCOM} \Delta V3MAR(c,s,q,m) \end{pmatrix} \end{pmatrix} \qquad (4.35)$$

which is equivalent to MMRF equation *E_w3gst_cs*, where

$$w3gst\_cs(q) = \frac{\Delta V3GST\_CS(q)}{V3GST\_CS(q)} \times 100 \qquad (4.36)$$

```
! Subsection 2.5.10: Indirect tax revenues
-----------------------------------!
Equation E_wtaxf_c # Total federal sale tax (not GST) on 1, 2, 3, 4 #
(all,q,REGDST)
ID01(VTAXF_C(q))*wtaxf_c(q) =
    V1TAXF_CSI(q)*w1taxf_csi(q) + V2TAXF_CSI(q)*w2taxf_csi(q) +
    V3TAXF_CS(q)*w3taxf_cs(q) + V4TAXF_C(q)*w4taxf_c(q);

Equation E_wnattaxf # Total national federal sale tax (not GST) on 1, 2, 3, 4 #
ID01(sum{q,REGDST, VTAXF_C(q)})*wnattaxf =
    sum{q,REGDST, VTAXF_C(q)*wtaxf_c(q)};

Equation E_wtaxs_c # Total state sale tax on 1, 2, and 3 #
(all,q,REGDST)
ID01(VTAXS_C(q))*wtaxs_c(q) =
    V1TAXS_CSI(q)*w1taxs_csi(q) + V2TAXS_CSI(q)*w2taxs_csi(q) +
    V3TAXS_CS(q)*w3taxs_cs(q);

Equation E_wtaxs # Total state sale tax on 1, 2, and 3 by commodity and region #
(all,c,COM)(all,q,REGDST)
ID01(VTAXS(c,q))*wtaxs(c,q) =
    V1TAXS_SI(c,q)*w1taxs_si(c,q) + V2TAXS_SI(c,q)*w2taxs_si(c,q) +
    V3TAXS_S(c,q)*w3taxs_s(c,q);

Equation E_w1taxf_csi
# Federal revenue from commodity taxes (not GST) on current production #
(all,q,REGDST)
ID01(V1TAXF_CSI(q))*w1taxf_csi(q) = sum{c,COM, sum{s,ALLSRC, sum{i,IND,
   V1TAXF(c,s,i,q)*{p0a(c,s) + x1a(c,s,i,q)} + V1BAS(c,s,i,q)*d_t1F(c,s,i,q)}}};

Equation E_w1taxs_csi
# State revenue from commodity taxes on current production #
(all,q,REGDST)
ID01(V1TAXS_CSI(q))*w1taxs_csi(q) = sum{c,COM, sum{s,ALLSRC, sum{i,IND,
   V1TAXS(c,s,i,q)*{p0a(c,s) + x1a(c,s,i,q)} + V1BAS(c,s,i,q)*d_t1S(c,s,i,q)}}};

Equation E_w1gst_csi
# GST on current production #
(all,q,REGDST)
ID01(V1GST_CSI(q))*w1gst_csi(q) = sum{c,COM, sum{s,ALLSRC, sum{i,IND, [
    V1GSTBASE(c,s,i,q)*d_t1GST(c,s,i,q) + T1GST(c,s,i,q)*{
```

```
    d_w1bas(c,s,i,q) + d_w1taxf(c,s,i,q) + d_w1taxs(c,s,i,q) +
    sum{r,MARGCOM, d_w1mar(c,s,i,q,r)} }  ]}}};

Equation E_w1taxf_si
# Federal revenue from commodity taxes (not GST) on current production #
(all,c,COM)(all,q,REGDST)
ID01(V1TAXF_SI(c,q))*w1taxf_si(c,q) = sum{s,ALLSRC, sum{i,IND,
    V1TAXF(c,s,i,q)*{p0a(c,s) + x1a(c,s,i,q)} + V1BAS(c,s,i,q)*d_t1F(c,s,i,q)}};

Equation E_w1taxs_si
# State revenue from commodity taxes on current production #
(all,c,COM)(all,q,REGDST)
ID01(V1TAXS_SI(c,q))*w1taxs_si(c,q) = sum{s,ALLSRC, sum{i,IND,
    V1TAXS(c,s,i,q)*{p0a(c,s) + x1a(c,s,i,q)} + V1BAS(c,s,i,q)*d_t1S(c,s,i,q)}};

Equation E_w1taxf_siq
# Federal revenue from commodity taxes (not GST) on current production #
(all,c,COM)
ID01(sum{q,REGDST,V1TAXF_SI(c,q)})*w1taxf_siq(c) =
sum{s,ALLSRC, sum{i,IND, sum{q,REGDST,
   V1TAXF(c,s,i,q)*{p0a(c,s) + x1a(c,s,i,q)} + V1BAS(c,s,i,q)*d_t1F(c,s,i,q)}}};

Equation E_w1taxs_siq
# State revenue from commodity taxes on current production #
(all,c,COM)
ID01(sum{q,REGDST, V1TAXS_SI(c,q)})*w1taxs_siq(c) =
    sum{s,ALLSRC, sum{i,IND, sum{q,REGDST,
   V1TAXS(c,s,i,q)*{p0a(c,s) + x1a(c,s,i,q)} + V1BAS(c,s,i,q)*d_t1S(c,s,i,q)}}};

Equation E_w2taxf_csi
# Federal revenue from commodity taxes (not GST) on to investment #
(all,q,REGDST)
ID01(V2TAXF_CSI(q))*w2taxf_csi(q) = sum{c,COM, sum{s,ALLSRC, sum{i,IND,
   V2TAXF(c,s,i,q)*{p0a(c,s) + x2a(c,s,i,q)} + V2BAS(c,s,i,q)*d_t2F(c,s,i,q)}}};

Equation E_w2taxs_csi
# State revenue from commodity taxes on investment #
(all,q,REGDST)
ID01(V2TAXS_CSI(q))*w2taxs_csi(q) = sum{c,COM, sum{s,ALLSRC, sum{i,IND,
   V2TAXS(c,s,i,q)*{p0a(c,s) + x2a(c,s,i,q)} + V2BAS(c,s,i,q)*d_t2S(c,s,i,q)}}};

Equation E_w2gst_csi
# GST on investment #
(all,q,REGDST)
ID01(V2GST_CSI(q))*w2gst_csi(q) = sum{c,COM, sum{s,ALLSRC, sum{i,IND, [
```

```
    V2GSTBASE(c,s,i,q)*d_t2GST(c,s,i,q) + T2GST(c,s,i,q)*{
    d_w2bas(c,s,i,q) + d_w2taxf(c,s,i,q) + d_w2taxs(c,s,i,q) +
    sum{r,MARGCOM, d_w2mar(c,s,i,q,r)} }  ]}}};

Equation E_w2taxf_si
# Federal revenue from commodity taxes (not GST) on investment #
(all,c,COM)(all,q,REGDST)
ID01(V2TAXF_SI(c,q))*w2taxf_si(c,q) = sum{s,ALLSRC, sum{i,IND,
    V2TAXF(c,s,i,q)*{p0a(c,s) + x2a(c,s,i,q)} + V2BAS(c,s,i,q)*d_t2F(c,s,i,q)}};

Equation E_w2taxs_si
# State revenue from commodity taxes on investment #
(all,c,COM)(all,q,REGDST)
ID01(V2TAXS_SI(c,q))*w2taxs_si(c,q) = sum{s,ALLSRC, sum{i,IND,
    V2TAXS(c,s,i,q)*{p0a(c,s) + x2a(c,s,i,q)} + V2BAS(c,s,i,q)*d_t2S(c,s,i,q)}};

Equation E_w2taxf_siq
# Federal revenue from commodity taxes (not investment) on investment #
(all,c,COM)
ID01(sum{q,REGDST, V2TAXF_SI(c,q)})*w2taxf_siq(c) =
    sum{s,ALLSRC, sum{i,IND, sum{q,REGDST,
   V2TAXF(c,s,i,q)*{p0a(c,s) + x2a(c,s,i,q)} + V2BAS(c,s,i,q)*d_t2F(c,s,i,q)}}};

Equation E_w2taxs_siq
# State revenue from commodity taxes on investment #
(all,c,COM)
ID01(sum{q,REGDST, V2TAXS_SI(c,q)})*w2taxs_siq(c) =
    sum{s,ALLSRC, sum{i,IND, sum{q,REGDST,
   V2TAXS(c,s,i,q)*{p0a(c,s) + x2a(c,s,i,q)} + V2BAS(c,s,i,q)*d_t2S(c,s,i,q)}}};

Equation E_w3taxf_cs
# Federal revenue from commodity taxes (not GST) on household consumption #
(all,q,REGDST)
ID01(V3TAXF_CS(q))*w3taxf_cs(q) = sum{c,COM, sum{s,ALLSRC,
    V3TAXF(c,s,q)*{p0a(c,s) + x3a(c,s,q)} + V3BAS(c,s,q)*d_t3F(c,s,q)}};

Equation E_w3taxs_cs
# State revenue from commodity taxes on sales to household consumption #
(all,q,REGDST)
ID01(V3TAXS_CS(q))*w3taxs_cs(q) = sum{c,COM, sum{s,ALLSRC,
    V3TAXS(c,s,q)*{p0a(c,s) + x3a(c,s,q)} + V3BAS(c,s,q)*d_t3S(c,s,q)}};

Equation E_w3gst_cs
# GST on consumption #
(all,q,REGDST)
```

```
ID01(V3GST_CS(q))*w3gst_cs(q) = sum{c,COM, sum{s,ALLSRC, [
    V3GSTBASE(c,s,q)*d_t3GST(c,s,q) + T3GST(c,s,q)*{
    d_w3bas(c,s,q) + d_w3taxf(c,s,q) + d_w3taxs(c,s,q) +
    sum{r,MARGCOM, d_w3mar(c,s,q,r)} }  ]}};

Equation E_w3taxf_s
# Federal (not GST) revenue from commodity taxes on household consumption #
(all,c,COM)(all,q,REGDST)
ID01(sum{s,ALLSRC, V3TAXF(c,s,q)})*w3taxf_s(c,q) = sum{s,ALLSRC,
    V3TAXF(c,s,q)*{p0a(c,s) + x3a(c,s,q)} + V3BAS(c,s,q)*d_t3F(c,s,q)};

Equation E_w3taxs_s
# State revenue from commodity taxes on household consumption #
(all,c,COM)(all,q,REGDST)
ID01(sum{s,ALLSRC, V3TAXS(c,s,q)})*w3taxs_s(c,q) = sum{s,ALLSRC,
    V3TAXS(c,s,q)*{p0a(c,s) + x3a(c,s,q)} + V3BAS(c,s,q)*d_t3S(c,s,q)};

Equation E_w3taxf_sq
# Federal revenue from commodity taxes (not GST) on household consumption #
(all,c,COM)
ID01(sum{q,REGDST, V3TAXF_S(c,q)})*w3taxf_sq(c) = sum{s,ALLSRC, sum{q,REGDST,
    V3TAXF(c,s,q)*{p0a(c,s) + x3a(c,s,q)} + V3BAS(c,s,q)*d_t3F(c,s,q)}};

Equation E_w3taxs_sq
# State revenue from commodity taxes on household consumption #
(all,c,COM)
ID01(sum{q,REGDST, V3TAXS_S(c,q)})*w3taxs_sq(c) = sum{s,ALLSRC, sum{q,REGDST,
    V3TAXS(c,s,q)*{p0a(c,s) + x3a(c,s,q)} + V3BAS(c,s,q)*d_t3S(c,s,q)}};

Equation E_w4taxf_c
# Aggregate revenue from commodity taxes (not GST) on exports #
(all,s,REGSRC)
ID01(V4TAXF_C(s))*w4taxf_c(s) =
    sum{c,COM, V4TAXF(c,s)*{p0a(c,s) + x4r(c,s)} + V4BAS(c,s)*d_t4f(c,s)};

Equation E_w4gst_c
# GST on exports #
(all,s,REGSRC)
ID01(V4GST_C(s))*w4gst_c(s) = sum{c,COM, [
    V4GSTBASE(c,s)*d_t4GST(c,s) + T4GST(c,s)*{
    d_w4bas(c,s) + d_w4taxf(c,s) + sum{r,MARGCOM, d_w4mar(c,s,r)} }  ]};

Equation E_natwgst # Total GST tax collection #
ID01(sum{q,REGDST, V1GST_CSI(q) + V2GST_CSI(q) + V3GST_CS(q) + V4GST_C(q)})*
    natwgst =
```

```
sum{q,REGDST, V1GST_CSI(q)*w1gst_CSI(q) + V2GST_CSI(q)*w2gst_csi(q) +
V3GST_CS(q)*w3gst_cs(q) + V4GST_C(q)*w4gst_c(q)};
```

4.2.13 Market-clearing equations for commodities (TABLO excerpt 2.5.11)

4.2.13.1 Market clearing for commodities (E_x0com_iA to E_x0imp)

Equations *E_x0com_iA*, *E_x0com_iB* and *E_x0imp* impose the condition that demand equals supply for domestically produced margin and non-margin commodities and for imported commodities.

The output of regional industries producing margin commodities must equal the direct demands by the model's eight users and their demands for the commodity as a margin. Note that the specification of equation *E_x0com_iA* imposes the assumption that margins are produced in the destination region, with the exception that margins on exports are produced in the source region. We write the market-clearing equations in terms of basic values. On the LHS of *E_x0com_iA*, the coefficient SALES(r,s) is the basic value of the output of domestic margin good r produced in region s. On the RHS, the coefficients are the basic values of the eight users' demands plus the basic values of margin demands by producers, investors, households and foreigners.

In equation *E_x0com_iB*, changes in the outputs of the non-margin regional industries are set equal to the changes in direct demands of the model's eight users. The equation is similar to *E_x0com_iA*, except that it excludes the margin demands.

Equation *E_x0imp* imposes the supply/demand balance for imported commodities. Import supplies are equal to the demands of the users excluding foreigners, i.e., all exports involve some domestic value added.

4.2.13.2 Commodity supply and other market clearing related equations (E_x1tot to E_p0aA)

MMRF incorporates multiproduct industries, which are industries producing more than one commodity. The MAKE matrix, MAKE(c,i,q), details the production of all commodities by all industries in all regions. Most industries produce a single commodity (for example, the Iron Ore industry produces Iron Ore), but there are two industries which produce multiple commodities. The Grain industry produces two commodities: Grain and Bio fuels; and the Refinery industry produces five commodities: Gasoline, Diesel, LPG, Aviation fuel and Other fuel. There are no commodities which are produced by more than one industry. However, the model equations are designed in a general format allowing for this possibility.

Equation *E_x1tot* relates movements in the average price received by industry i in region q to movements in the prices of products produced by industry i. On the RHS, the coefficient MAKE_C(i,q) is the output of all commodities by industry i in region q. There is a one to one relationship between many industries and commodities in MMRF. For these industries and commodities, MAKE_C(i,q) is equal to MAKE(c,i,q) for commodity c where it corresponds to industry i.

Equation *E_x0com* explains the commodity composition of the multiproduct industries. It specifies that the percentage change in the supply of commodity c by multiproduct industry i is made up of two parts. The first is x1tot(i,q), the percentage change in the overall level of output of industry i. The second is a price-transformation term. This compares the percentage change in the price received by industry i for product c with the weighted average of the percentage changes in the prices of all industry i's products. The derivation of equation *E_x0com* is detailed in Section 11 of Dixon *et al.* (1982). As there are no multiproduct industries in the current version of the model, the commodity composition of multiproduct industries is a theoretical consideration only.

Equation *E_p0aA* explains the percentage change in overall output of commodity c in region q in terms of the industry-specific outputs of commodity c in region q.

```
! Subsection 2.5.11: Supply equals demand for domestic & imported commodities
--------------------------------!
Equation E_x0com_iA  # Demand equals supply for margin commodities #
(all,r,MARGCOM)(all,s,REGSRC)
ID01(SALES(r,s))*x0com_i(r,s) =
sum{q,REGDST, sum{i,IND,
    V1BAS(r,s,i,q)*x1a(r,s,i,q) + V2BAS(r,s,i,q)*x2a(r,s,i,q) } +
V3BAS(r,s,q)*x3a(r,s,q) + V5BAS(r,s,q)*x5a(r,s,q) + V6BAS(r,s,q)*x6a(r,s,q) } +
    V4BAS(r,s)*x4r(r,s) + 100*LEVP7R(r,s)*d_x7r(r,s) +
sum{c,COM, sum{ss,ALLSRC, sum{i,IND,
V1MAR(c,ss,i,s,r)*x1marg(c,ss,i,s,r) + V2MAR(c,ss,i,s,r)*x2marg(c,ss,i,s,r) } +
    V3MAR(c,ss,s,r)*x3marg(c,ss,s,r) + V5MAR(c,ss,s,r)*x5marg(c,ss,s,r) +
    V6MAR(c,ss,s,r) *x6marg(c,ss,s,r) } + V4MAR(c,s,r) *x4marg(c,s,r) };
 ! In the above, we assume that margins are produced in the
      destination region, except that MAR4 is produced
      in the source region !

Equation E_x0com_iB # Demand equals supply for non margin commodities #
(all,r,NONMARGCOM)(all,s,REGSRC)
ID01(SALES(r,s))*x0com_i(r,s) =
sum{q,REGDST, sum{i,IND,
    V1BAS(r,s,i,q)*x1a(r,s,i,q) + V2BAS(r,s,i,q)*x2a(r,s,i,q) } +
V3BAS(r,s,q)*x3a(r,s,q) + V5BAS(r,s,q)*x5a(r,s,q) + V6BAS(r,s,q)*x6a(r,s,q) } +
    V4BAS(r,s)*x4r(r,s) + 100*LEVP7R(r,s)*d_x7r(r,s);

Equation E_x0imp #  Import volumes of commodities by region #
(all,c,COM)(all,q,REGDST)
ID01(V0IMP(c,q))*x0imp(c,q) =
    sum{i,IND,
V1BAS(c,"imp",i,q)*x1a(c,"imp",i,q) + V2BAS(c,"imp",i,q)*x2a(c,"imp",i,q) } +
    V3BAS(c,"imp",q)*x3a(c,"imp",q) + V5BAS(c,"imp",q)*x5a(c,"imp",q) +
    V6BAS(c,"imp",q)*x6a(c,"imp",q);

Equation E_x1tot # Average price received by industries #
(all,i,IND)(all,q,REGDST)
ID01(MAKE_C(i,q))*p1tot(i,q) = sum{c,COM, MAKE(c,i,q)*p0a(c,q)};
```

```
Equation E_x0com # Supplies of commodities by industries #
(all,c,COM)(all,i,IND)(all,q,REGDST)
x0com(c,i,q) = x1tot(i,q) + SIGMA1OUT(i)*[p0a(c,q) - p1tot(i,q)];

Equation E_p0A # Total output of domestic commodities #
(all,c,COM)(all,q,REGDST)
ID01(MAKE_I(c,q))*x0com_i(c,q) = sum{i,IND, MAKE(c,i,q)*x0com(c,i,q)};
```

4.2.14 Regional incomes and expenditures (TABLO excerpt 2.5.12)

In this section, we outline the derivation of the income and expenditure components of regional gross product. It is a basic condition of the model's validity that Gross State Product (GSP) in each region is the same whether derived from its income components or its expenditure components. We begin with the nominal income components.

4.2.14.1 Income-side aggregates of regional gross product (E_w1cap_i to E_w1octinc)

The income-side components of regional gross product include regional totals of factor payments, other costs and the total yield from commodity taxes. Nominal regional factor payments are given in equations *E_w1cap_i*, *E_w1lab_io* and *E_w1lnd_i* for payments to capital, labour and agricultural land, respectively. The regional nominal payments to other costs are given in equation *E_w1oct_i*.

The derivation of the factor payments and other cost regional aggregates are straightforward. Equation *E_w1cap_i*, for example is derived as follows. The total value of payments to capital in region q (V1CAP_I(q)) is the sum of the payments to capital by all i industries in region q (V1CAP(i,q)), where the industry payments are a product of the unit rental value of capital (P1CAP(i,q)) and the number of units of capital employed (X1CAP(i,q))

$$\mathrm{V1CAP\_I(q)} = \sum_{\mathrm{i \in IND}} \mathrm{P1CAP(i,q)} \times \mathrm{X1CAP(i,q)} \qquad \mathrm{q} \in \mathrm{REGDST} \qquad (4.37).$$

Equation (4.37) can be written in percentage changes as

$$\mathrm{V1CAP\_I(q)} \times \mathrm{w1cap\_i(q)} = \sum_{\mathrm{i \in IND}} \mathrm{V1CAP(i,q)} \times (\mathrm{p1cap(i,q)} + \mathrm{x1cap(j,q)}) \qquad \mathrm{q} \in \mathrm{REGDST} \qquad (4.38),$$

giving equation E_w1cap_i, where the variable w1cap_i(q) is the percentage change in rentals to capital in region q and has the definition

$$\mathrm{w1cap\_i(q)} = 100 \times \frac{\Delta \mathrm{V1CAP\_I(q)}}{\mathrm{V1CAP\_I(q)}} \qquad \mathrm{q} \in \mathrm{REGDST} \qquad (4.39)$$

The regional income equations are given by *E_w1capinc_i*, *E_w1labinc_io*, *E_w1lndinc_i* and *E_w1octinc_i*. The difference between payments to factors and income from factors is the taxes paid on the factors of production, which are a wedge between the price paid by the producer and the price received by the owner of the factor. Using capital as an example, the total value of income from capital in region q is V1CAPINC(q), where income is a product of the unit price received (P1CAPINC(i,q)) and the number of units of capital employed

$$\text{V1CAPINC\_I}(q) = \sum_{i \in IND} \text{P1CAPINC}(i,q) \times \text{X1CAP}(i,q) \qquad q \in REGDST \qquad (4.40)$$

In percentage change form, this is

$$\text{V1CAPINC\_I}(q) \times \text{w1capinc\_i}(q) = \sum_{i \in IND} \text{V1CAPINC}(i,q) \times (\text{p1capinc}(i,q) + \text{x1cap}(j,q))$$

$$q \in REGDST \qquad (4.41)$$

where

$$\text{w1capinc\_i}(q) = 100 \times \frac{\Delta \text{V1CAPINC\_I}(q)}{\text{V1CAPINC\_I}(q)} \qquad q \in REGDST \qquad (4.42)$$

giving MMRF equation *E_w1capinc_i.*

Note, that the relationships between p1capinc(i,q) and p1cap(i,q), pwage(i,q,o) and p1lab(i,q,o), p1lndinc(i,q) and p1lnd(i,q), and p1octinc(i,q) and p1oct(i,q) are discussed in Sections 4.2.17 and 4.2.18.

4.2.14.2 Tariff revenue (E_w0tar_c)

Equation *E_w0tar_c* determines tariff revenue on imports absorbed in region q (w0tar_c(q)). Equation *E_w0tar_c* is similar in form to equations such as *E_w1taxs_csi* discussed in Section 4.1.11. However, the tax-rate term in equation *E_w0tar_c*, powtar(c), refers to the percentage change in the power of the tariff rather than the percentage-point change in the tax rate (as is the tax-rate term in the commodity-tax equations of section 4.2.11.2). The basic value of imports is equal to the c.i.f. foreign currency value multiplied by the nominal exchange rate and the power of the tariff,

$$\text{V0IMP}(c,q) = \text{V0CIF}(c,q) \times \text{PHI} \times \text{POWTAR}(c) \qquad c \in COM,\ q \in REGDST \qquad (4.43)$$

Tariff revenue from commodity c absorbed in region q, V0TAR(c,q) is given by

$$\text{V0TAR}(c,q) = \text{V0CIF}(c,q) \times \text{PHI} \times (\text{POWTAR}(c) - 1) \qquad c \in COM,\ q \in REGDST \qquad (4.44)$$

Hence

$$\begin{aligned} \Delta\text{V0TAR}(c,q) &= \Delta\text{V0CIF}(c,q) \times \text{PHI} \times (\text{POWTAR}(c) - 1) \\ &+ \text{V0CIF}(c,q) \times \Delta\text{PHI} \times (\text{POWTAR}(c) - 1) + \text{V0CIF}(c,q) \times \text{PHI} \times \Delta\text{POWTAR}(c) \end{aligned}$$

$$c \in COM,\ q \in REGDST \qquad (4.45)$$

or

$$\begin{aligned} \text{V0TAR}(c,q) \times \text{w0tar}(c,q) &= \text{V0TAR}(c,q) \times \\ &(\text{x0imp}(c,q) + \text{natp0cif}(c) + \text{phi}) + \text{V0IMP}(c,q) \times \text{powtar}(c) \end{aligned}$$

$$c \in COM,\ q \in REGDST \qquad (4.46)$$

where

$$\mathrm{w0tar}(\mathrm{c},\mathrm{q}) = \frac{\Delta \mathrm{V0TAR}(\mathrm{c},\mathrm{q})}{\mathrm{V0TAR}(\mathrm{c},\mathrm{q})} \times 100 \qquad \mathrm{c} \in \mathrm{COM},\ \mathrm{q} \in \mathrm{REGDST} \qquad (4.47)$$

Equation 4.47 aggregated over all commodities gives MMRF equation *E_w0tar_c*. Note that the c.i.f. price of imports has no regional dimension as imports are assumed to have the same c.i.f. price in all regions.

4.2.14.3 Other aggregates: employment, capital, land, other costs and output (E_x1lab_io to E_x1tot_i)

The equations in this section define movements in miscellaneous supply-side aggregates. *E_x1lab_io* explains movements in aggregate employment, *E_x1cap_i* explains movements in the aggregate stock of capital, *E_x1lnd_i* explains movements in aggregate land use, *E_x1oct_i* explains movements in aggregate other cost tickets, and *E_x1tot_i* explains movements in aggregate output (an add-up of the 'x1tot' variables).

4.2.14.4 Expenditure-side aggregates of regional gross product (E_w3tot to E_x0cif_c)

For each region, MMRF contains equations determining aggregate expenditure by households, investors, regional government, the Federal government and the interregional and foreign trade balances. For each expenditure component (with the exception of the foreign trade flows), we define a quantity index and a price index and a nominal value of the aggregate. For exports and imports, we define an aggregate price index and quantity index only.

As with the income-side components, each expenditure-side component is a definition. As with all definitions within the model, the defined variable and its associated equation could be deleted without affecting the rest of the model. The exception is regional household consumption expenditure (see equations *E_w3lux*, *E_x3tot* and *E_p3tot*). It may seem that the variable w3tot(q) is determined by the equation *E_w3lux*. This is not the case. Nominal household consumption is determined either by a macro-style consumption function or, say, by a constraint on the regional trade balance. Equation *E_w3lux* plays the role of a budget constraint on household expenditure.

4.2.14.5 Inter-regional trade flows (E_xsflo to E_wsexp_c)

The derivation of the quantity and price aggregates for the interregional trade flows involves an intermediate step represented by equations *E_xsflo, E_xsflo_c* and *E_psflo_c*. These equations determine inter- and intra- regional nominal trade flows in basic values.[20] To determine the interregional trade flows, say for interregional exports in *E_xsexp_c*, the intraregional trade flow (the second term on the RHS of *E_xsexp_c*) is deducted from the total of inter- and intra- regional trade flows (the first term on the RHS of *E_xsexp_c*).

4.2.14.6 Nominal and Real GSP at market prices and factor cost (E_w0gspexp to E_x0gspfc)

This section contains equations for real GSP at market prices from the expenditure side (*E_x0gspexp*) and the income side (*E_x0gspinc*), and at factor cost (*E_x0gspfc*). The equations for nominal GSP from the expenditure side, income side, and factor cost are *E_w0gspexp*, *E_w0gspinc*, and *E_w0gspfc*, respectively.

[20] The determination in basic values reflects the convention in MMRF that all margins and commodity taxes are paid in the region which absorbs the commodity.

On the expenditure side, the usual definition of national GDP is the sum of household consumption, investment, regional and federal government expenditure, foreign exports, and inventory accumulation, less foreign imports. In equation *E_x0gspexp*, which defines GSP at the regional level, we also include inter-regional exports less inter-regional imports, and sales into the NEM (national electricity market) less purchases from the NEM.

On the income side, GDP is defined as payments to the factors of production – labour, capital and land – plus other cost tickets, total indirect taxes and tariffs, the real value of technological improvements in production, investment, and the use of margins. The first four terms on the RHS of *E_x0gspinc* cover the factors of production, and the lengthy fifth term accounts for all federal and state sales taxes, tariffs and GST revenue. The sixth term accounts for technological improvements in the production process, and the seventh term accounts for technological improvements in the creation of capital. The final term accounts for technological improvements in margin use, which are weighted by the basic value of margins and the component of GST attributed to margin use.

The definition of GDP at factor cost is the payments to the factors of production, plus the cost savings from technological improvements. This is equivalent to the income definition of GDP less indirect taxes.

```
! Subsection 2.5.12: Components of regional GSP, real and nominal
--------------------------------!
Equation E_w1cap_i # Aggregate payments to capital #
(all,q,REGDST)
V1CAP_I(q)*w1cap_i(q) = sum{i,IND,V1CAP(i,q)*(p1cap(i,q) + x1cap(i,q))};

Equation E_w1capinc_i # Capital income by region (V1CAP-V1CAPTAX) #
(all,q,REGDST)
V1CAPINC_I(q)*w1capinc_i(q) =
    sum{i,IND, V1CAPINC(i,q)*(p1capinc(i,q) + x1cap(i,q))};

Equation E_w1lab_io # Aggregate payments to labour #
(all,q,REGDST)
V1LAB_io(q)*w1lab_io(q) =
    sum{i,IND, sum{o,OCC, V1LAB(i,q,o)*(p1lab(i,q,o) + x1lab(i,q,o))}};

Equation E_w1labinc_i # Labour income by region (V1LAB-V1LABTAX) #
(all,q,REGDST)
sum{o,OCC, V1LABINC_I(q,o)}*w1labinc_i(q) =
    sum{o,OCC, sum{i,IND, V1LABINC(i,q,o)*(pwage(i,q,o) + x1lab(i,q,o))}};

Equation E_natw1labinc_i # Labour income (V1LAB-V1LABTAX) #
sum{o,OCC, sum{q,REGDST, V1LABINC_I(q,o)}}*natw1labinc_i =
    sum{o,OCC, sum{q,REGDST, sum{i,IND,
        V1LABINC(i,q,o)*(pwage(i,q,o) + x1lab(i,q,o))}}};

Equation E_w1lnd_i # Aggregate payments to land #
(all,q,REGDST)
```

```
V1LND_I(q)*w1lnd_i(q) = sum{i,IND,V1LND(i,q)*(p1lnd(i,q) + x1lnd(i,q))};

Equation E_w1lndinc_i # Land income by region (V1LND-V1LNDTAX) #
(all,q,REGDST)
V1LNDINC_I(q)*w1lndinc_i(q) =
    sum{i,IND, V1LNDINC(i,q)*(p1lndinc(i,q) + x1lnd(i,q))};

Equation E_w1oct_i # Aggregate other cost ticket payments #
(all,q,REGDST)
V1OCT_I(q)*w1oct_i(q) = sum{i,IND,V1OCT(i,q)*(p1oct(i,q)+x1oct(i,q))};

Equation E_w1octinc_i # Other cost income by region (V1OCT-V1OCTTAX) #
(all,q,REGDST)
V1OCTINC_I(q)*w1octinc_i(q) =
    sum{i,IND, V1OCTINC(i,q)*(p1octinc(i,q) + x1oct(i,q))};

Equation E_w0tar_c # Aggregate tariff revenue #
(all,q,REGDST)
ID01(V0TAR_C(q))*w0tar_c(q) =
    sum{c,COM,V0TAR(c,q)*(natp0cif(c) + phi + x0imp(c,q)) +
             V0IMP(c,q)*powtar(c)};

Equation E_x1lab_io # Aggregate employment- wage bill weights #
(all,q,REGDST)
V1LAB_io(q)*x1lab_io(q) = sum{i,IND, V1LAB_O(i,q)*x1lab_o(i,q)};

Equation E_x1cap_i # Aggregate usage of capital,rental weights #
(all,q,REGDST)
V1CAP_I(q)*x1cap_i(q) = sum{i,IND, V1CAP(i,q)*x1cap(i,q)};

Equation E_x1lnd_i # Aggregate stock of land, land-rent weights #
(all,q,REGDST)
V1LND_I(q)*x1lnd_i(q) = sum{i,IND, V1LND(i,q)*x1lnd(i,q)};

Equation E_x1oct_i # Aggregate quantity of other cost tickets #
(all,q,REGDST)
V1OCT_I(q)*x1oct_i(q) = sum{i,IND, V1OCT(i,q)*x1oct(i,q)};

Equation E_x1tot_i # Aggregate output: value-added weights #
(all,q,REGDST)
V1PRIM_I(q)*x1tot_i(q) = sum{i,IND, V1PRIM(i,q)*x1tot(i,q)};

Equation E_luxexp # Household budget constraint #
(all,q,REGDST)
V3TOT(q)* w3tot(q) =
    sum{c,COM, sum{s,ALLSRC, V3PURA(c,s,q)*(x3a(c,s,q) + p3a(c,s,q))}};

Equation E_x3tot # Real household consumption #
(all,q,REGDST)
x3tot(q) = w3tot(q) - p3tot(q);
```

```
Equation E_x2tot_i # Real investment #
(all,q,REGDST)
V2TOT_I(q)*x2tot_i(q) = sum{i,IND, V2TOT(i,q)*x2tot(i,q)};

Equation E_w2tot_i # Total nominal investment #
(all,q,REGDST)
w2tot_i(q) = x2tot_i(q) + p2tot_i(q);

Equation E_w5tot # Aggregate nominal value of regional government consumption #
(all,q,REGDST)
w5tot(q) = x5tot(q) + p5tot(q);

Equation E_x5tot # Aggregate real regional government consumption #
(all,q,REGDST)
V5TOT(q)*x5tot(q) = sum{c,COM, sum{s,ALLSRC,V5PURA(c,s,q)*x5a(c,s,q)}};

Equation E_w6tot # Nominal federal government consumption #
(all,q,REGDST)
w6tot(q) = x6tot(q) + p6tot(q);

Equation E_x6tot # Real federal government consumption #
(all,q,REGDST)
V6TOT(q)*x6tot(q) = sum{c,COM, sum{s,ALLSRC, V6PURA(c,s,q)*x6a(c,s,q)}};

Equation E_x56tot # Aggregate real government consumption in region q #
(all,q,REGDST)
[V5TOT(q) + V6TOT(q)]*x56tot(q) = [V5TOT(q)*x5tot(q) + V6TOT(q)*x6tot(q)];

Equation E_d_w7tot # Change in mominal inventory accumulation #
(all,q,REGDST)
d_w7tot(q) = sum{c,COM, d_w7r(c,q)};

Equation E_d_x7tot # Change in real inventory accumulation #
(all,q,REGDST)
LEVP7R_C(q)*d_x7tot(q) = sum{c,COM, LEVP7R(c,q)*d_x7r(c,q)};

Equation E_x0gne # Real final local absorption (equivalent to real GNE) #
(all,q,REGDST)
[V3TOT(q) + V2TOT_I(q) + V5TOT(q) + V6TOT(q) + V7TOT(q)]*x0gne(q) =
    V3TOT(q)*x3tot(q) + V2TOT_I(q)*x2tot_i(q) + V5TOT(q)*x5tot(q) +
    V6TOT(q)*x6tot(q) + 100*LEVP7R_C(q)*d_x7tot(q);

Equation E_x4tot # Export volume index #
(all,q,REGDST)
sum{c,COM, V4PURR(c,q)}*x4tot(q) = sum{c,COM, V4PURR(c,q)*x4r(c,q)};

Equation E_natx0cif # Import volumes, cif-weights #
(all,c,COM)
ID01(NATV0CIF(c))*natx0cif(c) = sum{q,REGDST, V0CIF(c,q)*x0imp(c,q)};

Equation E_natx4r # Export volumes #
```

```
(all,c,COM)
ID01(NATV4R(c))*natx4r(c) = sum{q,REGSRC, V4PURR(c,q)*x4r(c,q)};

Equation E_x0cif_c # Import volume index #
(all,q,REGDST)
sum{c,COM, V0CIF(c,q)}*x0cif_c(q) = sum{c,COM, V0CIF(c,q)*x0imp(c,q)};

Equation E_xsflo # Volumes of inter-regional trade (inc diagonal term) #
(all,c,COM)(All,s,REGSRC)(all,q,REGDST)
ID01(VSFLO(c,s,q))*xsflo(c,s,q) =
sum{i,IND, V1BAS(c,s,i,q)*x1a(c,s,i,q) + V2BAS(c,s,i,q)*x2a(c,s,i,q)} +
    V3BAS(c,s,q)*x3a(c,s,q) + V5BAS(c,s,q)*x5a(c,s,q) + V6BAS(c,s,q)*x6a(c,s,q);

Equation E_xsflo_c # Inter-regional trade flows (inc diagonal term) #
(all,s,REGSRC)(all,q,REGDST)
ID01(VSFLO_C(s,q))*(psflo_c(s,q) + xsflo_c(s,q)) =
sum{c,COM, sum{i,IND,
    V1BAS(c,s,i,q)*(p0a(c,s) + x1a(c,s,i,q)) +
    V2BAS(c,s,i,q)*(p0a(c,s) + x2a(c,s,i,q)) } +
    V3BAS(c,s,q)*(p0a(c,s) + x3a(c,s,q)) + V5BAS(c,s,q)*(p0a(c,s) + x5a(c,s,q))+
    V6BAS(c,s,q)*(p0a(c,s) + x6a(c,s,q)) };

Equation E_psflo_c # Price index - inter-regional trade flows #
(all,s,REGSRC)(all,q,REGDST)
ID01(VSFLO_C(s,q))*psflo_c(s,q) =
sum{c,COM, sum{i,IND,
    V1BAS(c,s,i,q)*p0a(c,s) + V2BAS(c,s,i,q)*p0a(c,s) } +
    V3BAS(c,s,q)*p0a(c,s) + V5BAS(c,s,q)*p0a(c,s) + V6BAS(c,s,q)*p0a(c,s) };

Equation E_psexp_c # Price index - inter-regional exports #
(all,s,REGSRC)
ID01(VSEXP_C(s))*psexp_c(s) =
    sum{q,REGDST, VSFLO_C(s,q)*psflo_c(s,q)} - VSFLO_C(s,s)*psflo_c(s,s);

Equation E_psimp_c # Price index - inter-regional imports #
(all,q,REGDST)
ID01(VSIMP_C(q))*psimp_c(q) =
    sum{s,REGSRC, VSFLO_C(s,q)*psflo_c(s,q)} - VSFLO_C(q,q)*psflo_c(q,q);

Equation E_xsexp_c # Inter-regional exports #
(all,s,REGSRC)
ID01(VSEXP_C(s))*(psexp_c(s) + xsexp_c(s)) =
sum{q,REGDST, VSFLO_C(s,q)*(psflo_c(s,q) + xsflo_c(s,q))} -
    VSFLO_C(s,s)*(psflo_c(s,s) + xsflo_c(s,s));

Equation E_xsimp_c # Inter-regional imports #
(all,q,REGDST)
ID01(VSIMP_C(q))*(psimp_c(q) + xsimp_c(q)) =
sum{s,REGSRC, VSFLO_C(s,q)*(psflo_c(s,q) + xsflo_c(s,q))} -
    VSFLO_C(q,q)*(psflo_c(q,q) + xsflo_c(q,q));
```

```
Equation E_wsimp_c # Inter-regional imports, value #
(all,q,REGDST)
ID01(VSIMP_C(q))*wsimp_c(q) =
sum{s,REGSRC, VSFLO_C(s,q)*(psflo_c(s,q) + xsflo_c(s,q))} -
    VSFLO_C(q,q)*(psflo_c(q,q) + xsflo_c(q,q));

Equation E_wsexp_c # Inter-regional exports, value #
(all,s,REGSRC)
ID01(VSEXP_C(s))*wsexp_c(s) =
sum{q,REGDST, VSFLO_C(s,q)*(psflo_c(s,q) + xsflo_c(s,q))} -
    VSFLO_C(s,s)*(psflo_c(s,s) + xsflo_c(s,s));

Equation E_w0gspexp # Value of GSP from the expenditure side #
(all,q,REGDST)
w0gspexp(q) = p0gspexp(q) + x0gspexp(q);

Equation E_w0gspfc # Value of GSP at factor cost #
(all,q,REGDST)
w0gspfc(q) = p0gspfc(q) + x0gspfc(q);

Equation E_w0gspinc # Value of GSP from the income side #
(all,q,REGDST)
w0gspinc(q) = p0gspinc(q) + x0gspinc(q);

Equation E_a0mar # Average change in margin specific tech change #
(all,q,REGDST)
V0MAR(q)*a0mar(q) =
[sum{c,COM,
    sum{r,MARGCOM,
        sum{s,ALLSRC,
            sum{i,IND,
V1MAR(c,s,i,q,r)*(a1marg(q,r) + acom(r,q) + natacom(r)) +
    V2MAR(c,s,i,q,r)*(a2marg(q,r) + acom(r,q) + natacom(r))} +
        [V3MAR(c,s,q,r)  *(a3marg(q,r) + acom(r,q) + natacom(r)) +
            V5MAR(c,s,q,r)  *(a5marg(q,r) + acom(r,q) + natacom(r)) +
                V6MAR(c,s,q,r)  *(a6marg(q,r) + acom(r,q) + natacom(r))]} +
                  [V4MAR(c,q,r)   *(a4marg(q,r) + acom(r,q) + natacom(r))]}}];

Equation E_x0gspexp # Real GSP from the expenditure side #
(all,q,REGDST)
V0GSPEXP(q)*x0gspexp(q) =
    V3TOT(q)*x3tot(q) + V2TOT_I(q)*x2tot_i(q) + V5TOT(q)*x5tot(q) +
    V6TOT(q)*x6tot(q) + 100*LEVP7R_C(q)*d_x7tot(q) +
    VSEXP_C(q)*xsexp_c(q) - VSIMP_C(q)*xsimp_c(q) +
    V4TOT(q)*x4tot(q) - V0CIF_C(q)*x0cif_c(q) ;

Equation E_x0gspinc # Real GSP from the income side #
(all,q,REGDST)
V0GSPINC(q)*x0gspinc(q) =
    V1LND_I(q)*x1lnd_i(q)   + V1CAP_I(q)*x1cap_i(q) +
    V1LAB_io(q)*x1lab_io(q) + V1OCT_I(q)*x1oct_i(q) +
```

```
sum{c,COM, sum{s,AllSRC, sum{i,IND,
    (V1TAXF(c,s,i,q) + V1TAXS(c,s,i,q))*x1a(c,s,i,q) +
    T1GST(c,s,i,q)/100 * {
        V1BAS(c,s,i,q)*x1a(c,s,i,q) +
        (V1TAXF(c,s,i,q) + V1TAXS(c,s,i,q))*x1a(c,s,i,q) +
        sum{r,MARGCOM, V1MAR(c,s,i,q,r)*x1marg(c,s,i,q,r)}} +
    (V2TAXF(c,s,i,q) + V2TAXS(c,s,i,q))*x2a(c,s,i,q) +
    T2GST(c,s,i,q)/100 * {
        V2BAS(c,s,i,q)*x2a(c,s,i,q) +
        (V2TAXF(c,s,i,q) + V2TAXS(c,s,i,q))*x2a(c,s,i,q) +
        sum{r,MARGCOM, V2MAR(c,s,i,q,r)*x2marg(c,s,i,q,r)}} } +
    (V3TAXF(c,s,q) + V3TAXS(c,s,q))*x3a(c,s,q) +
    T3GST(c,s,q)/100 * {
        V3BAS(c,s,q)*x3a(c,s,q) +
        (V3TAXF(c,s,q) + V3TAXS(c,s,q))*x3a(c,s,q) +
        sum{r,MARGCOM, V3MAR(c,s,q,r)*x3marg(c,s,q,r)}} } +
    V4TAXF(c,q)*x4r(c,q) + V0TAR(c,q)*x0imp(c,q) +
    T4GST(c,q)/100 * {
        V4BAS(c,q)*x4r(c,q) +
        V4TAXF(c,q)*x4r(c,q) +
        sum{r,MARGCOM, V4MAR(c,q,r)*x4marg(c,q,r)}} } -
sum{k,IND, COSTS(k,q)*a(k,q)} -
sum{c,COM, sum{i,IND, V2PURO(c,i,q)*(a2(q) + acom(c,q) + natacom(c))}} -
 [sum{c,COM,
    sum{r,MARGCOM,
        sum{s,ALLSRC,
            sum{i,IND,
(1+T1GST(c,s,i,q)/100)*V1MAR(c,s,i,q,r)*(a1marg(q,r) + acom(r,q) + natacom(r)) +
(1+T2GST(c,s,i,q)/100)*V2MAR(c,s,i,q,r)*(a2marg(q,r) + acom(r,q) + natacom(r))}+
[(1+T3GST(c,s,q)/100)*V3MAR(c,s,q,r)  *(a3marg(q,r) + acom(r,q) + natacom(r)) +
    V5MAR(c,s,q,r)  *(a5marg(q,r) + acom(r,q) + natacom(r)) +
    V6MAR(c,s,q,r)  *(a6marg(q,r) + acom(r,q) + natacom(r))]} +
[(1+T4GST(c,q)/100)*V4MAR(c,q,r)    *(a4marg(q,r) + acom(r,q) + natacom(r))]}}];


Equation E_x0gspfc # Real GSP at factor cost #
(all,q,REGDST)
V0GSPFC(q)*x0gspfc(q) =
    V1LNDINC_I(q)*x1lnd_i(q)  + V1CAPINC_I(q)*x1cap_i(q) +
    sum{o,OCC, V1LABINC_I(q,o)*x1lab_i(q,o)} + V1OCTINC_I(q)*x1oct_i(q) -
sum{k,IND, COSTS(k,q)*a(k,q)} -
sum{c,COM, sum{i,IND, V2PURO(c,i,q)*(a2(q) + acom(c,q) + natacom(c))}} -
[sum{c,COM,
    sum{r,MARGCOM,
        sum{s,ALLSRC,
            sum{i,IND,
(1+T1GST(c,s,i,q)/100)*V1MAR(c,s,i,q,r)*(a1marg(q,r) + acom(r,q) + natacom(r)) +
(1+T2GST(c,s,i,q)/100)*V2MAR(c,s,i,q,r)*(a2marg(q,r) + acom(r,q) + natacom(r))}+
[(1+T3GST(c,s,q)/100)*V3MAR(c,s,q,r)  *(a3marg(q,r) + acom(r,q) + natacom(r)) +
    V5MAR(c,s,q,r)  *(a5marg(q,r) + acom(r,q) + natacom(r)) +
    V6MAR(c,s,q,r)  *(a6marg(q,r) + acom(r,q) + natacom(r))]} +
```

```
[(1+T4GST(c,q)/100)*V4MAR(c,q,r)    *(a4marg(q,r) + acom(r,q) + natacom(r))]}}];
```

4.2.15 National Aggregates (TABLO excerpt 2.5.13)

This set of equations defines economy-wide variables as aggregates of regional variables. As MMRF is a bottom-up regional model, all behavioural relationships are specified at the regional level. Hence, national variables are simply add-ups of their regional counterparts. Note that we depart from our notational conventions when labelling the national GDP variables (e.g., x0gdpinc) by not including the suffix “nat”. It is assumed that the term “GDP” is sufficient to distinguish all such variables as national variables.

```
! Subsection 2.5.13: Components of national GDP, real and nominal
---------------------------------!
Equation E_natw1cap_i # Aggregate payments to capital #
NATV1CAP_I*natw1cap_i = sum{q,REGDST,V1CAP_I(q)*w1cap_i(q)};

Equation E_natw1lab_io # Aggregate payments to labour #
NATV1LAB_io*natw1lab_io = sum{q,REGDST, V1LAB_io(q)*w1lab_io(q)};

Equation E_natw1lnd_i # Aggregate payments to land #
NATV1LND_I*natw1lnd_i = sum{q,REGDST, V1LND_I(q)*w1lnd_i(q)};

Equation E_natw1oct_i # Aggregate other cost ticket payments #
NATV1OCT_I*natw1oct_i = sum{q,REGDST, V1OCT_I(q)*w1oct_i(q)};

Equation E_natw0tar_c # Aggregate tariff revenue #
ID01(NATV0TAR_C)*natw0tar_c = sum{q,REGDST, V0TAR_C(q)*w0tar_c(q)};

Equation E_natx1cap_i # Aggregate usage of capital,rental weights #
NATV1CAP_I*natx1cap_i = sum{q,REGDST, V1CAP_I(q)*x1cap_i(q)};

Equation E_natx1cap # Aggregate usage of capital by industry, rental weights #
(all,i,IND)
ID01(NATV1CAP(i))*natx1cap(i) = sum{q,REGDST, V1CAP(i,q)*x1cap(i,q)};

Equation E_natx1lab_io # Aggregate employment,wage bill weights #
NATV1LAB_io*natx1lab_io = sum{q,REGDST, V1LAB_io(q)*x1lab_io(q)};

Equation E_natx1lnd_i # Aggregate usage of land #
NATV1LND_I*natx1lnd_i = sum{q,REGDST, V1LND_I(q)*x1lnd_i(q)};

Equation E_natx1oct_i # Aggregate usage of other costs #
NATV1OCT_I*natx1oct_i = sum{q,REGDST, V1OCT_I(q)*x1oct_i(q)};

Equation E_natx1tot # Aggregate output: value-added weights #
(all,i,IND)
```

```
ID01(NATV1PRIM(i))*natx1tot(i) = sum{q,REGDST, V1PRIM(i,q)*x1tot(i,q)};

Equation E_natx2tot # National real investment by industry #
(all,i,IND)
ID01(NATV2TOT(i))*natx2tot(i) = sum{q,REGDST, V2TOT(i,q)*x2tot(i,q)};

Equation E_natw3tot # Aggregate nominal consumption #
NATV3TOT*natw3tot = sum{q,REGDST, V3TOT(q)*w3tot(q)};

Equation E_natx3tot # Aggregate real consumption #
NATV3TOT*natx3tot = sum{q,REGDST, V3TOT(q)*x3tot(q)};

Equation E_natw2tot_i # Total nominal investment #
natw2tot_i = natx2tot_i + natp2tot_i;

Equation E_natx2tot_i # Total real investment #
NATV2TOT_I*natx2tot_i = sum{q,REGDST, V2TOT_I(q)*x2tot_i(q)};

Equation E_natx4tot # Export volume index #
sum{q,REGDST, V4TOT(q)}*natx4tot = sum{q,REGDST, V4TOT(q)*x4tot(q)};

Equation E_natw5tot # Aggregate nominal value of reg. government consumption #
natw5tot = natx5tot + natp5tot;

Equation E_natw6tot # Aggregate nominal value of Fed. government consumption #
natw6tot = natx6tot + natp6tot;

Equation E_natx5tot # Aggregate real regional government demands #
NATV5TOT*natx5tot = sum{q,REGDST, V5TOT(q)*x5tot(q)};

Equation E_natx6tot # Aggregate real Federal government demands #
NATV6TOT*natx6tot = sum{q,REGDST, V6TOT(q)*x6tot(q)};

Equation E_natx56tot # Aggregate real government consumption - national #
[NATV5TOT + NATV6TOT]*natx56tot = [NATV5TOT*natx5tot + NATV6TOT*natx6tot];

Equation E_d_natw7tot # Change in aggregate nominal inventory accumulation #
d_natw7tot = sum{q,REGDST, d_w7tot(q)};

Equation E_d_natx7tot # Change in aggregate real inventory accumulation #
d_natx7tot = sum{q,REGDST, d_x7tot(q)};

Equation E_natx0cif_c # Import volume index #
NATV0CIF_C*natx0cif_c = sum{c,COM, NATV0CIF(c)*natx0cif(c)};

Equation E_w0gdpexp # Nominal GDP from the expenditure side #
V0GDPEXP*w0gdpexp = sum{q,REGDST, V0GSPEXP(q)*w0gspexp(q)};

Equation E_x0gdpexp # Real GDP from the expenditure side #
V0GDPEXP*x0gdpexp = sum{q,REGDST, V0GSPEXP(q)*x0gspexp(q)};
```

```
Equation E_p0gdpexp # GDP deflator from expenditure side #
V0GDPEXP*p0gdpexp = sum{q,REGDST, V0GSPEXP(q)*p0gspexp(q)};

Equation E_w0gdpinc # Nominal GDP from the income side #
V0GDPINC*w0gdpinc = sum{q,RegDst, V0GSPINC(q)*w0gspinc(q)};

Equation E_x0gdpinc # Real from the income side #
V0GDPINC*x0gdpinc = sum{q,REGDST, V0GSPINC(q)*x0gspinc(q)};

Equation E_p0gdpinc # GDP deflator from the income side #
V0GDPINC*p0gdpinc = sum{q,REGDST, V0GSPINC(q)*p0gspinc(q)};

Equation E_w0gdpfc # National value of GDP at factor cost #
V0GDPFC*w0gdpfc = sum{q,REGDST, V0GSPFC(q)*w0gspfc(q)};

Equation E_x0gdpfc # Real GDP at factor cost #
V0GDPFC*x0gdpfc = sum{q,REGDST, V0GSPFC(q)*x0gspfc(q)};

Equation E_p0gdpfc # National price of GDP at factor cost #
V0GDPFC*p0gdpfc = sum{q,REGDST, V0GSPFC(q)*p0gspfc(q)};

Equation E_natp0gne # National price of GNE #
sum{q,REGDST,
    [V3TOT(q) + V2TOT_I(q) + V5TOT(q) + V6TOT(q) + V7TOT(q)]}*natp0gne =
sum{q,REGDST,
    [V3TOT(q)*p3tot(q) + V2TOT_I(q)*p2tot_i(q) + V5TOT(q)*p5tot(q) +
     V6TOT(q)*p6tot(q) + V7TOT(q)*p7tot(q)]};

Equation E_nata0mar # National average change in margin specific tech change #
NATV0MAR*nata0mar = sum{q,REGDST, V0MAR(q)*a0mar(q)};
```

4.2.16 Regional and national price indexes (TABLO excerpt 2.5.14)

4.2.16.1 Price indexes for the regional and national expenditure components (E_p3tot to E_natp0imp)

These equations deal with the regional and national price indexes for the expenditure-side components of GDP. For example, p3tot(q), the percentage change in the price of household consumption in region q, is defined in equation *E_p3tot*, while the national equivalent, natp3tot is defined in *E_natp3tot*.

The final equation shown in this excerpt is for the duty-paid price of imports in domestic currency. This is different from the cif-weighted price index defined in equation *E_natp0cif_c*, which is the price used in the calculation of GDP.

4.2.16.2 *Price indexes for the regional and national expenditure aggregates (E_p0gspexp to E_p0gspfc)*

Next are equations for the price indexes of GDP. First are the regional GSP deflators from the expenditure and income sides at market prices. The equation for the expenditure side deflator, *E_p0gspexp*, is analogous to the equation for real GSP from the expenditure-side at market prices, *E_x0gspexp* (see Section 4.2.14.6), with the RHS quantity variables (e.g., x3tot) replaced with corresponding price indexes (e.g., p3tot). A similar relationship exists between the equation for the income side deflator, *E_p0gsipinc*, and the corresponding equation for real GSP, *E_x0gspinc*, except that the technological change variables enter with plus signs, rather than with minus signs.

4.2.16.3 *Other aggregate indexes involving prices (E_p0gne to E_realdev)*

The price of regional Gross National Expenditure (GNE) is defined in equation *E_p0gne*. GNE is the sum of private consumption, government consumption and investment and is equivalent to domestic absorption. This price index is used in section 4.6 to define real Gross National Product (GNP).

The economy-wide terms-of-trade, nattot, is defined in equation *E_nattot*. Australia's terms of trade measures the price of goods and services exported from Australia relative to the price of goods and services imported into Australia. Equation *E_nattot* explains the percentage change in the terms of trade as the difference between the percentage change in the foreign-currency export price index and the percentage change in the foreign-currency import price index.

The final two equations in this section explain movements in the national average basic price for commodity c and in the competitiveness of the national economy. Changes in competitiveness are measured by movements in the real exchange rate: devaluation means improvement; appreciation means deterioration. The real exchange rate is defined as the ratio of the cost of producing tradable products in Australia relative to the foreign cost of producing similar products all in the same currency. The domestic cost of production is proxied using the GDP price deflator. Foreign cost is proxied using the price index of imports expressed in Australian dollars. Equation *E_realdev*, therefore, explains the percentage change in real devaluation (realdev) as the percentage change in domestic-currency price of imports less the percentage change in the GDP price deflator.

```
! Subsection 2.5.14: Regional and national price indices
---------------------------------!
Equation E_p3tot # Consumer price index #
(all,q,REGDST)
V3TOT(q)*p3tot(q) = sum{c,COM, sum(s,ALLSRC, V3PURA(c,s,q)*p3a(c,s,q))};

Equation E_natp3tot # Consumer price index #
NATV3TOT*natp3tot = sum{q,REGDST, V3TOT(q)*p3tot(q)};

Equation E_p2tot_i # Investment price index #
(all,q,REGDST)
V2TOT_I(q)*p2tot_i(q) = sum{i,IND, V2TOT(i,q)*p2tot(i,q)};

Equation E_natp2tot_i # Investment price index #
```

```
NATV2TOT_I*natp2tot_i = sum{q,REGDST, V2TOT_I(q)*p2tot_i(q)};

Equation E_p4r_c # Foreign currency price of foreign exports in region q #
(all,q,REGDST)
V4TOT(q)*p4r_c(q) = sum{c,COM, V4PURR(c,q)*p4r(c,q)};

Equation E_natp4r_c # Foreign currency price of foreign exports #
NATV4TOT*natp4r_c = sum{q,REGDST, V4TOT(q)*p4r_c(q)};

Equation E_p5tot # Regional Other demands price index #
(all,q,REGDST)
V5TOT(q)*p5tot(q) =sum{c,COM, sum(s,ALLSRC, V5PURA(c,s,q)*p5a(c,s,q))};

Equation E_natp5tot # National regional government consumption price index #
NATV5TOT*natp5tot = sum{q,REGDST, V5TOT(q)*p5tot(q)};

Equation E_p6tot # Price index for Federal government consumption #
(all,q,REGDST)
V6TOT(q)*p6tot(q) = sum{c,COM, sum(s,ALLSRC, V6PURA(c,s,q)*p6a(c,s,q))};

Equation E_natp6tot # National price index for Federal government consumption #
NATV6TOT*natp6tot = sum{q,REGDST, V6TOT(q)*p6tot(q)};

Equation E_p7tot # Price index for inventory accumulation #
(all,q,REGDST)
V7TOT(q)*p7tot(q) = sum{c,COM, V7BAS(c,q)*p0a(c,q)};

Equation E_natp7tot # National price index for inventory accumulation #
NATV7TOT*natp7tot = sum{q,REGDST, V7TOT(q)*p7tot(q)};

Equation E_p0cif_c # Foreign-currency import price index, cif, for region q #
(all,q,REGDST)
V0CIF_C(q)*p0cif_c(q) = sum{c,COM, V0CIF(c,q)*natp0cif(c)};

Equation E_natp0cif_c # National foreign-currency import price, cif weights #
NATV0CIF_C*natp0cif_c = sum{q,REGDST, V0CIF_C(q)*p0cif_c(q)};

Equation E_natp0imp # National domestic-currency value of imports, duty paid #
Sum{c,COM, NATV0IMP(c)}*natp0imp = Sum{c,COM, NATV0IMP(c)*p0a(c,"imp")};

Equation E_p0gspexp # Regional GSP deflator from the expenditure side #
(all,q,REGDST)
V0GSPEXP(q)*p0gspexp(q) =
    V3TOT(q)*p3tot(q) + V2TOT_I(q)*p2tot_i(q) + V5TOT(q)*p5tot(q) +
    V6TOT(q)*p6tot(q) + V7TOT(q)*p7tot(q) +
    VSEXP_C(q)*psexp_c(q) - VSIMP_C(q)*psimp_c(q) +
    V4TOT(q)*(p4r_c(q) + phi) - V0CIF_C(q)*(p0cif_c(q) + phi);

Equation E_p0gspinc # Regional GSP deflator from the income side #
(all,q,REGDST)
V0GSPINC(q)*p0gspinc(q) =
```

```
    V1LND_I(q)*p1lnd_i(q)   + V1CAP_I(q)*p1cap_i(q) +
    V1LAB_io(q)*p1lab_io(q) + V1OCT_I(q)*p1oct_i(q) +
sum{c,COM, sum{s,AllSRC, sum{i,IND,
(1 + T1GST(c,s,i,q)/100)*[
    [V1TAXF(c,s,i,q)*p0a(c,s) + V1BAS(c,s,i,q)*d_t1f(c,s,i,q)] +
    [V1TAXS(c,s,i,q)*p0a(c,s) + V1BAS(c,s,i,q)*d_t1s(c,s,i,q)] ] +
    V1GSTBASE(c,s,i,q)*d_t1GST(c,s,i,q) + T1GST(c,s,i,q)/100* {
    V1BAS(c,s,i,q)*p0a(c,s) + sum{r,MARGCOM, V1MAR(c,s,i,q,r)*p0a(r,q)}} +
(1 + T2GST(c,s,i,q)/100)*[
    [V2TAXF(c,s,i,q)*p0a(c,s) + V2BAS(c,s,i,q)*d_t2f(c,s,i,q)] +
    [V2TAXS(c,s,i,q)*p0a(c,s) + V2BAS(c,s,i,q)*d_t2s(c,s,i,q)] ] +
    V2GSTBASE(c,s,i,q)*d_t2GST(c,s,i,q) + T2GST(c,s,i,q)/100* {
    V2BAS(c,s,i,q)*p0a(c,s) + sum{r,MARGCOM, V2MAR(c,s,i,q,r)*p0a(r,q)}} } +
(1 + T3GST(c,s,q)/100)*[
    [V3TAXF(c,s,q)*p0a(c,s) + V3BAS(c,s,q)*d_t3f(c,s,q)] +
    [V3TAXS(c,s,q)*p0a(c,s) + V3BAS(c,s,q)*d_t3s(c,s,q)] ] +
    V3GSTBASE(c,s,q)*d_t3GST(c,s,q) + T3GST(c,s,q)/100* {
    V3BAS(c,s,q)*p0a(c,s) + sum{r,MARGCOM, V3MAR(c,s,q,r)*p0a(r,q)}} } +
(1 + T4GST(c,q)/100)*[
    [V4TAXF(c,q)*p0a(c,q) + V4BAS(c,q)*d_t4f(c,q)] ] +
    V4GSTBASE(c,q)*d_t4GST(c,q) + T4GST(c,q)/100* {
    V4BAS(c,q)*p0a(c,q) + sum{r,MARGCOM, V4MAR(c,q,r)*p0a(r,q)}} +
    [V0TAR(c,q)*(natp0cif(c) + phi) + V0IMP(c,q)*powtar(c)] } +
sum{k,IND, COSTS(k,q)*a(k,q)} +
sum{c,COM, sum{i,IND, V2PURO(c,i,q)*(a2(q) + acom(c,q) + natacom(c))}} +
[sum{c,COM,
    sum{r,MARGCOM,
        sum{s,ALLSRC,
            sum{i,IND,
(1+T1GST(c,s,i,q)/100)*V1MAR(c,s,i,q,r)*(a1marg(q,r) + acom(r,q) + natacom(r)) +
(1+T2GST(c,s,i,q)/100)*V2MAR(c,s,i,q,r)*(a2marg(q,r) + acom(r,q) + natacom(r))}+
[(1+T3GST(c,s,q)/100)*V3MAR(c,s,q,r)  *(a3marg(q,r) + acom(r,q) + natacom(r)) +
    V5MAR(c,s,q,r)  *(a5marg(q,r) + acom(r,q) + natacom(r)) +
    V6MAR(c,s,q,r)  *(a6marg(q,r) + acom(r,q) + natacom(r))]} +
[(1+T4GST(c,q)/100)*V4MAR(c,q,r)    *(a4marg(q,r) + acom(r,q) + natacom(r))]}}];

Equation E_p0gspfc # Regional GSP deflator at factor cost #
(all,q,REGDST)
V0GSPFC(q)*p0gspfc(q) =
    V1LNDINC_I(q)*p1lndinc_i(q)   + V1CAPINC_I(q)*p1capinc_i(q) +
    sum{o,OCC, V1LABINC_I(q,o)}*pwage_io(q)   + V1OCTINC_I(q)*p1octinc_i(q) +
sum{k,IND, COSTS(k,q)*a(k,q)} +
sum{c,COM, sum{i,IND, V2PURO(c,i,q)*(a2(q) + acom(c,q) + natacom(c))}} +
[sum{c,COM,
    sum{r,MARGCOM,
        sum{s,ALLSRC,
            sum{i,IND,
(1+T1GST(c,s,i,q)/100)*V1MAR(c,s,i,q,r)*(a1marg(q,r) + acom(r,q) + natacom(r)) +
(1+T2GST(c,s,i,q)/100)*V2MAR(c,s,i,q,r)*(a2marg(q,r) + acom(r,q) + natacom(r))}+
[(1+T3GST(c,s,q)/100)*V3MAR(c,s,q,r)  *(a3marg(q,r) + acom(r,q) + natacom(r)) +
    V5MAR(c,s,q,r)  *(a5marg(q,r) + acom(r,q) + natacom(r)) +
```

```
    V6MAR(c,s,q,r)  *(a6marg(q,r) + acom(r,q) + natacom(r))]} +
[(1+T4GST(c,q)/100)*V4MAR(c,q,r)    *(a4marg(q,r) + acom(r,q) + natacom(r))]}}];

Equation E_p0gne # Regional GNE deflator #
(all,q,REGDST)
[V3TOT(q) + V2TOT_I(q) + V5TOT(q) + V6TOT(q) + V7TOT(q)]*p0gne(q) =
    V3TOT(q)*p3tot(q) + V2TOT_I(q)*p2tot_i(q) + V5TOT(q)*p5tot(q) +
    V6TOT(q)*p6tot(q) + V7TOT(q)*p7tot(q);

Equation E_nattot # National terms of trade #
nattot = natp4r_c - natp0cif_c;

Equation E_natp0a # Aggregate basic prices by commodities #
(all,c,COM)
ID01(sum{q,REGDST, SALES(c,q)})*natp0a(c) = sum{q,REGDST, SALES(c,q)*p0a(c,q)};

Equation E_realdev # Foreign competitiveness of national economy #
realdev = (natp0cif_c + phi) - p0gdpexp;
```

4.2.17 Money wage settings (TABLO excerpt 2.5.15)

The equations in this section have been designed to provide flexibility in the setting of wage rates. The nominal wage rate paid in industry i in region q for occupation o (PWAGE(i,q,o)) is defined as the wage paid by industry (P1LAB(i,q,o)) after payroll tax. Equation *E_pwage* allows for the indexing of the workers' wage to the state consumer price index (p3tot(q)). The 'fpwage' variables in *E_pwage* allow for deviations in wages relative to the state consumer price index. For example, a value for fpwage_io of 1 for all regions means, with all other shift variables set to zero, that money wage rates in each region will rise by 1 per cent relative to the state consumer price index (ie a 1 per cent increase in real wages).

Equation *E_fpwage_io* is so named because, in one of the model's standard closures (see Chapter 5), it effectively explains fpwage_io(q), rather than the LHS variable, pwage_io(q). In the standard closure wage differentials across regions are fixed so that pwage_io(q) is indexed to the national wage rate, natpwage_io (see Section 4.4). With pwage_io(q) determined in this way, *E_fpwage_io* ensures that the appropriate adding-up conditions holds via endogenous changes in fpwage_io.

The remaining equations in this section define occupational, industry and regional averages of wage rates received by workers and of wage rates paid by producers. *E_p1lab_o*, for example, defines the price of labour for occupation o in industry i of region q.

```
! Subsection 2.5.15: Money wage settings
----------------------------------!
Equation E_pwage # Flexible setting of money wages #
(all,i,IND)(all,q,REGDST)(all,o,OCC)
pwage(i,q,o) = {0 + IF(V1LAB(i,q,o) ne 0, 1)}*[p3tot(q) +
natfpwage_io + natfpwage_i(o) + fpwage_io(q) + fpwage_i(q,o) + fpwage(i,q,o)];
! Notice wages indexed to regional cpi !
```

```
Equation E_pwage_o # Flexible setting of money wages #
(all,i,IND)(all,q,REGDST)
ID01(sum{o,OCC, V1LABINC(i,q,o)})*pwage_o(i,q) =
    sum{o,OCC, V1LABINC(i,q,o)*pwage(i,q,o)};

Equation E_fpwage_io # Region-wide nominal wage received by workers #
(all,q,REGDST)
sum{o,OCC, V1LABINC_I(q,o)}*pwage_io(q) =
    sum{o,OCC, sum{i,IND, V1LABINC(i,q,o)*pwage(i,q,o)}};

Equation E_natpwage_i # National wage rate for occupation o #
(all,o,OCC)
sum{q,REGDST, V1LABINC_I(q,o)}*natpwage_i(o) =
    sum{q,REGDST, sum{i,IND, V1LABINC(i,q,o)*pwage(i,q,o)}};

Equation E_pwage_i # Regional wage rate for occupation o #
(all,q,REGDST)(all,o,OCC)
ID01(V1LABINC_I(q,o))*pwage_i(q,o) =
    sum{i,IND, V1LABINC(i,q,o)*pwage(i,q,o)};

Equation E_p1lab_io # Region-wide nominal wage paid by producers #
(all,q,REGDST)
V1LAB_io(q)*p1lab_io(q) = sum{i,IND, V1LAB_O(i,q)*p1lab_o(i,q)};

Equation E_p1lab_o
(all,i,IND)(all,q,REGDST)
ID01(V1LAB_O(i,q))*p1lab_o(i,q) = sum{o,OCC, V1LAB(i,q,o)*p1lab(i,q,o)};
```

4.2.18 Miscellaneous definitions of factor prices (TABLO excerpt 2.5.16)

The equations in this section define aggregate national and regional prices in the labour and capital markets. Two concepts of the real wage rate are used here. The consumer real wage rate (NATRWAGE_C) is the nominal wage rate deflated by the consumer price index. The producer real wage rate (NATRWAGE_P) is the nominal wage rate deflated by the producer price deflator, i.e., deflated by the GDP deflator.

```
! Subsection 2.5.16: Miscellaneous definitions of factor prices
---------------------------------!
Equation E_natp1cap_i # Aggregate nominal capital rentals #
natp1cap_i = natw1cap_i - natx1cap_i;

Equation E_natpwage_io # Aggregate nominal wages of workers #
sum{o,OCC, sum{q,REGDST, V1LABINC_I(q,o)}}*natpwage_io =
    sum{o,OCC, sum{q,REGDST, V1LABINC_I(q,o)*pwage_i(q,o)}};

Equation E_natp1lab_io # Aggregate nominal wages paid by producers #
NATV1LAB_io*natp1lab_io = sum{q,REGDST, V1LAB_io(q)*p1lab_io(q)};
```

```
Equation E_natp1lab_i # National unit cost of labour by occupation #
(all,o,OCC)
NATV1LAB_i(o)*natp1lab_i(o) =
    sum{i,IND, sum{q,REGDST, V1LAB(i,q,o)*p1lab(i,q,o)}};

Equation E_p1cap_i # Average unit cost of capital in region q #
(all,q,REGDST)
p1cap_i(q) = w1cap_i(q) - x1cap_i(q);

Equation E_p1lnd_i # Average unit cost of agricultural land in region q #
(all,q,REGDST)
p1lnd_i(q) = w1lnd_i(q) - x1lnd_i(q);

Equation E_p1oct_i # Average unit cost of other costs in region q #
(all,q,REGDST)
p1oct_i(q) = w1oct_i(q) - x1oct_i(q);

Equation E_rwage_c # Consumer real wage rate by region #
(all,q,REGDST)
rwage_c(q) = pwage_io(q) - p3tot(q);

Equation E_rwage_p # Real unit cost of labour by region #
(all,q,REGDST)
rwage_p(q) = p1lab_io(q) - p0gspexp(q);

Equation E_natrwage_c # National real wage: consumer #
natrwage_c = natpwage_io - natp3tot;

Equation E_natrwage_i # National real wage for occupation o: consumer #
(all,o,OCC)
natrwage_i(o) = natp1lab_i(o) - natp3tot;

Equation E_natrwage_p # National real unit cost of labour #
natrwage_p = natp1lab_io - p0gdpexp;
```

4.2.19 Employment aggregates (TABLO excerpt 2.5.17)

E_x1lab_i defines regional employment of each of the nine occupational skill groups. *E_natx1lab_i* defines national employment of each of the nine occupations. *E_natx1lab_o* defines national employment by industry.

```
! Subsection 2.5.17: Employment Aggregates
---------------------------------!
Equation E_x1lab_i # Demand for labour by occupation #
(all,o,OCC)(all,q,REGDST)
V1LAB_I(q,o)*x1lab_i(q,o) = sum{i,IND, V1LAB(i,q,o)*x1lab(i,q,o)};

Equation E_natx1lab_i # National demand for labour by occupation #
```

```
(all,o,OCC)
NATV1LAB_I(o)*natx1lab_i(o) = sum{q,REGDST, V1LAB_I(q,o)*x1lab_i(q,o)};

Equation E_natx1lab_o # Aggregate employment- wage bill weights #
(all,i,IND)
ID01(NATV1LAB_O(i))*natx1lab_o(i) = sum{q,REGDST, V1LAB_O(i,q)*x1lab_o(i,q)};
```

4.2.20 Taxes on factors of production (TABLO excerpt 2.5.18)

4.2.20.1 Pre and post tax prices of primary factors (E_p1lab to E_p1octinc_i)

In this section of the code we explain the relationships between the prices of primary factors including indirect taxes like payroll tax and property tax and the prices of primary factors excluding these indirect taxes. The tax-inclusive prices are represented by the unit cost variables, P1LAB, P1CAP, P1LND and P1OCT. The primary-factor tax-exclusive (but pre-income tax) prices — PWAGE, P1CAPINC, P1LNDINC and P1OCTINC — represent unit-income to the owners of the primary factors

We assume for each factor that

$$\mathrm{P1COST} = \mathrm{P1INC} \times (1 + \mathrm{TF}/100 + \mathrm{TS}/100) \qquad (4.48)$$

where P1COST is the tax-inclusive price, P1INC is the tax-exclusive price, TF is the percentage rate of Federal tax (a number like 5.0) and TS is the percentage rate of state tax (a number like 5.0). Note that the base for both taxes is the unit income price.

In percentage-change terms (4.48) is written as

$$\mathrm{p1cost} = \mathrm{p1inc} + \frac{1}{1 + \mathrm{TF}/100 + \mathrm{TS}/100} \times (\mathrm{d\_TF} + \mathrm{d\_TS}) \qquad (4.49)$$

which, after noting from (4.48) that

$$\frac{1}{1 + \mathrm{TF}/100 + \mathrm{TS}/100} = \frac{\mathrm{P1INC}}{\mathrm{P1COST}}$$

is the general form of equations *E_p1lab*, *E_p1capinc*, *E_p1lndinc* and *E_p1octinc*. Note that the equation for the price of labour is labelled E_p1lab and not E_pwage. In one standard closure option (see Chapter 5), the national real wage rate is fixed, as are wage differentials across states, and so via the equations in Section 4.1.16 the percentage changes in money wage rates by region, industry and occupation are determined. Thus E_p1lab puts in place the percentage change in tax-inclusive price (p1lab).

4.2.20.2 Flexibility in setting indirect tax rates on primary factors (E_d_t1capF to E_d_t1octS)

This set of equations allows for flexibility in the setting of the indirect tax rates for primary factors. Their inclusion effectively endogenises each of the tax rates and allows, for example, rates of state payroll tax to move by the same percentage amounts across all industries in a particular state (via changes in d_t1labS_i).

4.2.20.3 Collections of indirect taxes on primary factors (E_d_w1captxF to E_d_natw1octtxS_i)

Equations for the changes in collections of indirect taxes on primary factors are based on the assumption that collection is the product of income and the tax rate. In other words, for some Federal tax we have (with obvious notation)

$$\mathrm{COLLECTION} = \mathrm{P1INC} \times \mathrm{X1INC} \times \mathrm{TF}/100 \qquad (4.50).$$

The change in Federal tax collection is therefore

$$\mathrm{d\_COLLECTION} = \mathrm{TF}/100 \times \mathrm{d\_(P1INC} \times \mathrm{X1INC)} + (\mathrm{P1INC} \times \mathrm{X1INC})/100 \times \mathrm{d\_TF} \qquad (4.51).$$

Equation (4.51) is the general form of the tax collection equations E_d_w1captxF, etc, noting that

$$\mathrm{TF}/100 \times \mathrm{d\_(P1INC} \times \mathrm{X1INC)} = \mathrm{COLLECTION}/100 \times (\mathrm{p1inc} + \mathrm{x1inc}) \qquad (4.52).$$

```
! Subsection 2.5.18: Taxes on factors of production, pre- and post-tax prices
---------------------------------!
Equation E_p1lab
# Price of labour (p1lab) related to the wage rate (pwage) #
(all,i,IND)(all,q,REGDST)(all,o,OCC)
p1lab(i,q,o) = pwage(i,q,o) + If{V1LABINC(i,q,o) ne 0,
    100*[V1LAB(i,q,o)/V1LABINC(i,q,o)]*(d_t1labF(i,q) + d_t1labS(i,q))};

Equation E_p1capinc
# Price of capital (p1cap) related to the unit income on capital (p1capinc) #
(all,i,IND)(all,q,REGDST)
p1cap(i,q) = p1capinc(i,q) + If{V1CAPINC(i,q) ne 0,
    100*[V1CAP(i,q)/V1CAPINC(i,q)]*(d_t1capF(i,q) + d_t1capS(i,q))};

Equation E_p1capinc_i # Unit income on capital by region #
(all,q,REGDST)
V1CAPINC_I(q)*p1capinc_i(q) = sum{i,IND, V1CAPINC(i,q)*p1capinc(i,q)};

Equation E_p1lndinc
# Price of land (p1lnd) related to the unit income on land (p1lndinc) #
(all,i,IND)(all,q,REGDST)
p1lnd(i,q) = p1lndinc(i,q) + If{V1LNDINC(i,q) ne 0,
    100*[V1LND(i,q)/V1LNDINC(i,q)]*(d_t1lndF(i,q) + d_t1lndS(i,q))};

Equation E_p1lndinc_i # Unit income on land by region #
(all,q,REGDST)
```

```
V1LNDINC_I(q)*p1lndinc_i(q) = sum{i,IND, V1LNDINC(i,q)*p1lndinc(i,q)};

Equation E_p1oct
# Price of other cost tickets (p1oct) related to the unit income (p1octinc) #
(all,i,IND)(all,q,REGDST)
p1oct(i,q) = p1octinc(i,q) + If{V1OCTINC(i,q) ne 0,
    100*[V1OCT(i,q)/V1OCTINC(i,q)]*(d_t1octF(i,q) + d_t1octS(i,q))};

Equation E_p1octinc_i # Unit income on other costs by region #
(all,q,REGDST)
V1OCTINC_I(q)*p1octinc_i(q) = sum{i,IND, V1OCTINC(i,q)*p1octinc(i,q)};

Equation E_d_t1capF # %-point change in property tax rate - Federal #
(all,i,IND)(all,q,REGDST)
d_t1capF(i,q) = {0 + IF(V1CAP(i,q) gt 0, 1)}*
    (d_t1capF_i(q) + d_t1capF_iq + d_t0("Federal")) + d_ft1capF(i,q);

Equation E_d_t1capS # %-point change in property tax rate - State #
(all,i,IND)(all,q,REGDST)
d_t1capS(i,q) = {0 + IF(V1CAP(i,q) gt 0, 1)}*
    (d_t1capS_i(q) + d_t1capS_iq + d_t0(q)) + d_ft1capS(i,q);

Equation E_d_t1labS # %-point change in payroll tax rate - Federal #
(all,i,IND)(all,q,REGDST)
d_t1labS(i,q) = {0+ IF(sum{o,OCC, V1LAB(i,q,o)} gt 0,1)}*
    (d_t1labS_i(q) + d_t1labS_iq + d_t0(q)) + d_ft1labS(i,q);

Equation E_d_t1labF # %-point change in payroll tax rate - State #
(all,i,IND)(all,q,REGDST)
d_t1labF(i,q) = {0+ IF(sum{o,OCC, V1LAB(i,q,o)} gt 0,1)}*
    (d_t1labF_i(q) + d_t1labF_iq + d_t0("Federal")) + d_ft1labF(i,q);

Equation E_d_t1lndF # %-point change in tax rate on agricultural land -Federal #
(all,i,IND)(all,q,REGDST)
d_t1lndF(i,q) = {0+ IF(V1LND(i,q) gt 0,1)}*
    (d_t1lndF_i(q) + d_t1lndF_iq + d_t0("Federal")) + d_ft1lndF(i,q);

Equation E_d_t1lndS # %-point change in tax rate on agricultural land - State #
```

```
(all,i,IND)(all,q,REGDST)
d_t1lndS(i,q) = {0+ IF(V1LND(i,q) gt 0,1)}*
    (d_t1lndS_i(q) + d_t1lndS_iq + d_t0(q)) + d_ft1lndS(i,q);

Equation E_d_t1octF # %-point change in tax rate on other costs - Federal #
(all,i,IND)(all,q,REGDST)
d_t1octF(i,q) = {0+ IF(V1OCT(i,q) gt 0,1)}*
    (d_t1octF_i(q) + d_t1octF_iq + d_t0("Federal")) + d_ft1octF(i,q);

Equation E_d_t1octS # %-point change in tax rate on other costs - State #
(all,i,IND)(all,q,REGDST)
d_t1octS(i,q) = {0+ IF(V1OCT(i,q) gt 0,1)}*
    (d_t1octS_i(q) + d_t1octS_iq + d_t0(q)) + d_ft1octS(i,q);

Equation E_d_w1captxF # Change in property tax collections - Federal #
(all,i,IND)(all,q,REGDST)
d_w1captxF(i,q) =
V1CAPTXF(i,q)/100*{p1cap(i,q) + x1cap(i,q)} + V1CAP(i,q)*d_t1capF(i,q);

Equation E_d_w1captxS # Change in property tax collections - State #
(all,i,IND)(all,q,REGDST)
d_w1captxS(i,q) =
V1CAPTXS(i,q)/100*{p1cap(i,q) + x1cap(i,q)} + V1CAP(i,q)*d_t1capS(i,q);

Equation E_d_w1labtxS # Change in payroll tax collections - State #
(all,i,IND)(all,q,REGDST)(all,o,OCC)
d_w1labtxS(i,q,o) =
V1LABTXS(i,q,o)/100*{p1lab(i,q,o) + x1lab(i,q,o)} + V1LAB(i,q,o)*d_t1labS(i,q);

Equation E_d_w1labtxF # Change in payroll tax collections - Federal #
(all,i,IND)(all,q,REGDST)(all,o,OCC)
d_w1labtxF(i,q,o) =
V1LABTXF(i,q,o)/100*{p1lab(i,q,o) + x1lab(i,q,o)} + V1LAB(i,q,o)*d_t1labF(i,q);

Equation E_d_w1lndtxF # Change in agricultural land tax collections - Federal #
(all,i,IND)(all,q,REGDST)
d_w1lndtxF(i,q) =
V1LNDTXF(i,q)/100*{p1lnd(i,q) + x1lnd(i,q)} + V1LND(i,q)*d_t1lndF(i,q);
```

```
Equation E_d_w1lndtxS # Change in agricultural land tax collections - State #
(all,i,IND)(all,q,REGDST)
d_w1lndtxS(i,q) =
V1LNDTXS(i,q)/100*{p1lnd(i,q) + x1lnd(i,q)} + V1LND(i,q)*d_t1lndS(i,q);

Equation E_d_w1octtxF # Change in tax collected on other costs - Federal #
(all,i,IND)(all,q,REGDST)
d_w1octtxF(i,q) =
V1OCTTXF(i,q)/100*{p1oct(i,q) + x1oct(i,q)} + V1OCT(i,q)*d_t1octF(i,q);

Equation E_d_w1octtxS # Change in tax collected on other costs - State #
(all,i,IND)(all,q,REGDST)
d_w1octtxS(i,q) =
V1OCTTXS(i,q)/100*{p1oct(i,q) + x1oct(i,q)} + V1OCT(i,q)*d_t1octS(i,q);

Equation E_d_w1captxF_i # Change in property tax collections - Federal #
(all,q,REGDST)
d_w1captxF_i(q) = Sum{i,IND, d_w1captxF(i,q)};

Equation E_d_w1captxS_i # Change in property tax collections - State #
(all,q,REGDST)
d_w1captxS_i(q) = Sum{i,IND, d_w1captxS(i,q)};

Equation E_d_w1labtxS_i # Change in payroll tax collections - State #
(all,q,REGDST)(all,o,OCC)
d_w1labtxS_i(q,o) = Sum{i,IND, d_w1labtxS(i,q,o)};

Equation E_d_w1labtxF_i # Change in payroll tax collecitons - Federal #
(all,q,REGDST)(all,o,OCC)
d_w1labtxF_i(q,o) = Sum{i,IND, d_w1labtxF(i,q,o)};

Equation E_d_w1lndtxF_i # Change in tax collected on land input - Federal #
(all,q,REGDST)
d_w1lndtxF_i(q) = Sum{i,IND, d_w1lndtxF(i,q)};

Equation E_d_w1lndtxS_i # Change in tax collected on land input - State #
(all,q,REGDST)
```

```
d_w1lndtxS_i(q) = Sum{i,IND, d_w1lndtxS(i,q)};

Equation E_d_w1octtxF_i # Change in tax collected on other costs - Federal #
(all,q,REGDST)
d_w1octtxF_i(q) = Sum{i,IND, d_w1octtxF(i,q)};

Equation E_d_w1octtxS_i # Change in tax collected on other costs - State #
(all,q,REGDST)
d_w1octtxS_i(q) = Sum{i,IND, d_w1octtxS(i,q)};

Equation E_d_natw1captxF_i # Change in property tax collections - Federal #
d_natw1captxF_i = sum{q,REGDST, sum{i,IND, d_w1captxF(i,q)}};

Equation E_d_natw1captxS_i # Change in property tax collections - State #
d_natw1captxS_i = sum{q,REGDST, sum{i,IND, d_w1captxS(i,q)}};

Equation E_d_natw1labtxS_i # Change in payroll tax collections - State #
d_natw1labtxS_i = sum{o,OCC, sum{q,REGDST, Sum{i,IND, d_w1labtxS(i,q,o)}}};

Equation E_d_natw1labtxF_i # Change in payroll tax collections - Federal #
d_natw1labtxF_i = sum{o,OCC, sum{q,REGDST, Sum{i,IND, d_w1labtxF(i,q,o)}}};

Equation E_d_natw1lndtxF_i # Change in tax collected on land input - Federal #
d_natw1lndtxF_i = sum{q,REGDST, Sum{i,IND, d_w1lndtxF(i,q)}};

Equation E_d_natw1lndtxS_i # Change in tax collected on land input - State #
d_natw1lndtxS_i = sum{q,REGDST, Sum{i,IND, d_w1lndtxS(i,q)}};

Equation E_d_natw1octtxF_i # Change in tax collected on other costs - Federal #
d_natw1octtxF_i = sum{q,REGDST, Sum{i,IND, d_w1octtxF(i,q)}};

Equation E_d_natw1octtxS_i # Change in tax collected on other costs - State #
d_natw1octtxS_i = sum{q,REGDST, Sum{i,IND, d_w1octtxS(i,q)}};
```

4.2.21 Rates of return and investment to capital ratios (comparative statics) (TABLO excerpt 9.3)

MMRF can be run in two modes: comparative static; and year-to-year dynamic. These modes require alternative treatments of capital formation. In this section of the code we examine only the comparative static options. Section 4.8.1 deals with year-to-year mechanisms.

4.2.21.1 After tax rates of return (E_d_r1cap)

Equation *E_d_r1cap* explains the ordinary change in the actual rate of return on capital in industry j formed under the assumption of static expectations (d_r1cap). To explain this equation, we start with an expression for the present value (PV) of purchasing a unit of physical capital for use in industry j in region q in the current solution year, year t

$$PV_t(i,q) = -\Pi_t(i,q) + \frac{\left[(1-T_{t+1})\times Q_{t+1}(i,q)\right] + \left((1-D(i,q))\times \Pi_{t+1}(i,q)\right) + \left\{T_{t+1}\times D(i,q)\times \Pi_{t+1}(i,q)\right\}}{\left[1+INT_t\times(1-T_{t+1})\right]}$$

i∈IND q∈REGDST (4.53)

where:

Π_t is the cost of buying or constructing a unit of industry i's capital in year t;

T_t is the company-income tax rate in year t;

Q_t is the rental rate for the industry's capital in year t (equivalent to the cost of using a unit of capital in year t);

D is the rate of depreciation (a number like 0.05); and

INT_t is the nominal rate of interest in year t.

It is assumed that units of capital in year t yield to their owner three benefits in year t+1: an after-tax rental (the term in square brackets); a depreciated re-sale value (the term in round brackets) and a tax-deduction (the term in curly brackets). These benefits are converted to a present value in year t by discounting using the after-tax nominal interest rate.

The present-value sum of benefits as defined above is converted to a rate of return by dividing through by the cost of buying capital in year t. Thus we define

$$ROR\_ACT_t(i,q) = -1 + \frac{\left[(1-T_{t+1})\times Q_{t+1}(i,q)\right] + \left((1-D(i,q))\times \Pi_{t+1}(i,q)\right) + \left\{T_{t+1}\times D(i,q)\times \Pi_{t+1}(i,q)\right\}}{\Pi(i,q)\times\left[1+INT_t\times(1-T_{t+1})\right]}$$

i∈IND q∈REGDST (4.54)

to be the "actual" rate of return in year t for units of capital invested in industry i.

In MMRF we make allowance only for static expectations.[21] This means that investors expect no change in the tax rate, and expect that rental rates and asset prices will increase uniformly by the current rate of inflation (INF). It is also assumed that investors expect the real after-tax rate of interest to be zero, leaving the nominal after-tax interest rate equal to INF. Under these assumptions, the static-expectation of ROR_ACT is

$$ROR_t(i,q) = (1 - T_t) \times \left\{ \frac{Q_t(i,q)}{\Pi_t(i,q)} - D(i,q) \right\} \qquad i \in IND \; q \in REGDST \quad (4.55)$$

E_d_r1cap is the change form of (4.55). The mapping between the TABLO notation and the notation used in (4.55) is as follows.

- d_r1cap is the ordinary change in ROR;
- p1capinc is the percentage change in Q;
- p2tot is the percentage change in Π;
- d_tgosinc is the ordinary change in T;
- TGOSINC is equivalent to T;
- V1CAPINC/VCAP is equivalent to Q/Π; and
- DEPR is equivalent to D.

Equation *E_d_r1cap_i* defines the ordinary change in the average rate of return for region q as a weighted average of the ordinary changes in rates of return for industries in q.

4.2.21.2 Distribution of after-tax rates of return in long-run comparative-static simulations (E_d_fr1cap)

In long-run comparative-static simulations the equation allows changes in industry rates of return to be positively correlated with percentage changes in industry capital stocks. Industries experiencing relatively strong growth in capital (indicated by a large positive value for x1cap(i,q) – x1cap_i(q)) will require relatively large increases in rates of return (indicated by a large positive value for d_r1cap(i,q)-d_natr1cap). Conversely, industries experiencing relatively weak capital growth will require relatively small increases or decreases in rates of return. The equation could be interpreted as a risk-related relationship with relatively fast/slow growing industries requiring premia/accepting discounts on their rates of return. The parameter BETA_R specifies the strength of this relationship.

This equation has no role in year-to-year simulations, and can be turned off by endogenising the shift variable d_fr1cap.

4.2.21.3 Ratios of investment to capital (E_r_inv_cap_iq)

In comparative-static mode, there is no fixed relationship between capital and investment. The user decides the required relationship on the basis of the requirements of the specific simulation. For example, it is often assumed that the percentage changes in capital and investment are equal, implying that

$$x2tot(i,q) = x1cap(i,q) \qquad i \in IND \; q \in REGDST \quad (4.56)$$

[21] MONASH allows for two possibilities - static expectations and forward-looking expectations.

Rule (4.56) can be implemented using equation *E_r_inv_cap_iq*. This equation defines the percentage change in the ratio of investment to capital for industry i in region q. To invoke (4.6.4), the ratio is made exogenous and set to zero change, leaving rates of capital growth in the solution year undisturbed by the exogenous shock under investigation. Note that several shift variables are included in *E_r_inv_cap_iq* to allow for extraneous shifts in investment/capital ratios. These can be specific to the industry and region, or specific to the region only, or specific to the industry only, or not specific to any industry or region.

```
! Section 9.3: Equations
=================================!
Equation E_d_r1cap # Definition of after-tax rates of return to capital #
(all,i,IND)(all,q,REGDST)
d_r1cap(i,q) =
 {1 + If[VCAP(i,q) ne 0.0, (-1 + {(1 - TGOSINC)*V1CAPINC(i,q)/VCAP(i,q)})]}*
       [p1capinc(i,q) - p2tot(i,q)] -
    100*If[VCAP(i,q) ne 0.0, (V1CAPINC(i,q)/VCAP(i,q) - DEPR(i))]*d_tgosinc;

Equation E_d_r1cap_i # Region-wide after-tax rate of return #
(all,q,REGDST)
d_r1cap_i(q) =
    If(VCAP_I(q) ne 0.0, {[1 - TGOSINC]*V1CAPINC_I(q)/VCAP_I(q)})*
        [p1capinc_i(q) - p2tot_i(q)] -
    100*If[VCAP_I(q) ne 0.0, {V1CAPINC_I(q)/VCAP_I(q) - DEPR_I(q)}]*
        d_tgosinc;

Equation E_d_fr1cap # Distribution of after-tax rates of return for LR CS #
(all,i,IND)(all,q,REGDST)
100*{d_r1cap(i,q) - d_natr1cap - d_fr1cap(i,q)} =
    BETA_R(i,q)*[x1cap(i,q) - x1cap_i(q)] ;
! Notice regional subscript on kT but not on d_nat_ror !

Equation E_r_inv_cap_iq # Ratios of investment to capital- comparative statics #
(all,i,IND)(all,q,REGDST)
x2tot(i,q) - x1cap(i,q) =
    r_inv_cap(i,q) + r_inv_cap_i(q) + r_inv_cap_q(i) + r_inv_cap_iq;
```

4.3 *Government financial accounts*

In this block of equations, we determine the financial positions of the State, Territory and Commonwealth governments. The financial position of State and Territory governments in MMRF includes any Local government in that jurisdiction. The core input-output data provide information on indirect tax revenues from commodities sales and primary-factor usage, and on current government expenditures (government final demand). To these data we need to add information on direct taxation receipts, on government transfer payments (e.g. unemployment benefits), and on a range of miscellaneous items such as interest payments/receipts and current and capital grants from the Commonwealth to the States and Territories.

The accounts are structured on the ABS's *Government Financial Statistics* (GFS) framework (Cat. no. 5512.0) and are calibrated on a standardised basis across jurisdictions for the 2005-06 financial year. Calibration is based solely on GFS statistics and data from the ABS's *Taxation Revenue Australia* (Cat. no. 5506.0).[22]

The module consists of three broad components. First, the module details the various sources of tax and non-tax revenue received by each government (Table 4.4). It identifies revenue from:

- Income taxes (individuals, enterprises and non-residents);
- Taxes on goods and services (the GST, excises and levies, taxes on international trade, gambling, insurance, use of motor vehicles and other);
- Taxes on factor inputs (payroll tax and property tax);
- Commonwealth grants to the States (GST-tied and other current);
- Sales of goods and services;
- Interest received; and
- Other sources.

The second part of the module details government expenditure (Table 4.5). It separately identifies:

- Gross operating expenses (which covers, in aggregate, depreciation, employee expenses and other operating expenses);
- Personal benefit payments (unemployment benefits, disability support pensions, age pensions and other personal benefits);
- Grant expenses:

[22] The ABS Government Finance Statistics provide a consistent and comprehensive coverage of the Australian, State, Territory and local government finances. However, the inability to reconcile data from the ABS Government Finance Statistics with the government consumption and taxation data in the ABS Input-Output tables — the basis of the MMRF core database — prevent the government finance module from being fully integrated into the model in a completely consistent manner. For example, ABS (5506.0) shows that revenue collected from federal taxes on the provision of goods and services amounted to $67,822 million in 2005-06, while the core IO data values show total commodity taxes net of subsidies at a little under $60,000 million. Because of these inconsistencies, we chose to populate the fiscal model only with data from ABS (5512.0) and ABS (5506.0), so that the resultant numbers for budget balances matched exactly the balances recorded in the GFS. Note, though, that the drivers for each cell in the fiscal account are taken, wherever possible, from the core model.

- For the Commonwealth: GST-tied grants to the States and Territories, other current grants to the States and Territories, grants to local government and grants to universities;
- For State, Territory and Commonwealth governments: grants to the private sector;

- Property expenses;
- Subsidy expenses;
- Capital transfers; and
- Other expenditure.

The final part of the government finance module draws together the changes in government revenue and government expenditure to report the net operating balance, net acquisition of non-financial assets and net lending or borrowing balance for each jurisdiction (Table 4.6).

4.3.1 Government revenues (TABLO excerpt 3.1.3)

Dollar ($m) changes in government revenues are denoted by the prefix d_wgfsi_ where the next 3 digits denote the source of government income. For example, the change in payroll tax revenue for Victoria is given by the variable d_wgfsi_121(“Vic”).

Table 4.7 shows the drivers of each item of government revenue. As far as practicable, changes in taxation revenue in the government finance module are indexed to changes in appropriate tax collections from the CGE core of the model. This is facilitated by having in the core commodity taxes separately identified by type: Commonwealth non-GST, State/Territory non-GST and Commonwealth GST.

The GST is treated in the same way as it is in the Government Finance Statistics; it is levied by the Commonwealth government and redistributed in entirety to the States and Territories through GST-tied grants. The distribution of GST revenue to the States and Territories in the model database reflects the actual payments made in 2005-06. The equation determining the allocation of GST-tied grants to each State and Territory includes a region-specific shift-term to allow for changes in the CGC relativities. However, the model does not explicitly model the process by which the Commonwealth Grants Commission determines the GST (or any other) relativities.

As can be seen from Table 4.7, there are three types of income tax identified in the model. All accrue to the federal government (see Table 4.4). Taxes on individuals are linked to salaried labour income via a single average tax rate. The tax rate is likened to the average PAYE rate. No allowance is made for thresholds, or for a schedule of marginal tax rates. Taxes on enterprises are linked to income from capital, land and ‘other costs’. Income from these sources is calculated by deducting property taxes from the cost of capital, land and ‘other costs’. Again, no allowance is made for tax-free thresholds or marginal tax rates. Finally, taxes on non-residents are linked, simply, to changes in nominal GDP.

Equations *E_tlabinc*, *E_d_tgosinc*, *E_d_tlabinc0* and *E_d_tgosinc0* enable the application of uniform percentage point change in the tax rates on labour income and income from enterprises through the variable d_tinc.

```
! Subsection 3.1.3: Equations for government income
---------------------------------!
! Total GFSI revenue !
Equation E_d_wgfsi_000A # GFSI: Total #
(all,g,REGDST)
d_wgfsi_000(g) =
    d_wgfsi_100(g) + d_wgfsi_200(g) + d_wgfsi_300(g) + d_wgfsi_400(g) +
        d_wgfsi_500(g);
Equation E_d_wgfsi_000B # GFSI: Total #
d_wgfsi_000("Federal") =
    d_wgfsi_100("Federal") + d_wgfsi_200("Federal") + d_wgfsi_300("Federal") +
    d_wgfsi_400("Federal") + d_wgfsi_500("Federal");

! Total taxation revenue !
Equation E_d_wgfsi_100 # GFSI: Taxation revenue - total #
(all,g,GOVT)
d_wgfsi_100(g) = d_wgfsi_110(g) + d_wgfsi_120(g) + d_wgfsi_130(g);

! Taxes on provision of goods and services !
Equation E_d_wgfsi_110 # GFSI: Taxes on the provision of goods and services #
(all,g,GOVT)
d_wgfsi_110(g) =
    d_wgfsi_111(g) + d_wgfsi_112(g) + d_wgfsi_113(g) + d_wgfsi_114(g) +
    d_wgfsi_115(g) + d_wgfsi_116(g) + d_wgfsi_117(g) + d_wgfsi_118(g);

! Radical start !
! General taxes (sales tax) !
Equation E_d_wgfsi_111A  # GFSI: Taxes on goods and services - general taxes #
(all,g,REGDST)
100*d_wgfsi_111(g) = VGFSI_111(g)*wtaxs_c(g);
Equation E_taxF # Federal collection of general sales tax #
{sum{q,REGDST, VTAXF_C(q)} - [VGFSI_113("Federal") + VGFSI_115("Federal") +
    VGFSI_116("Federal") + VGFSI_117("Federal")]}*taxF =
100*{sum{q,REGDST, VTAXF_C(q)}/100*wnattaxf - [d_wgfsi_113("Federal") +
    d_wgfsi_115("Federal") + d_wgfsi_116("Federal") + d_wgfsi_117("Federal")]};
Equation E_d_wgfsi_111B  # GFSI: Taxes on goods and services - general taxes #
100*d_wgfsi_111("Federal") = VGFSI_111("Federal")*taxF;
! Radical end !

! Goods and Services Tax (GST) !
Equation E_d_wgfsi_112A # GFSI: Taxes on goods and services - GST #
(all,q,REGDST)
100*d_wgfsi_112(q) = 0;
Equation E_d_wgfsi_112B # GFSI: Taxes on goods and services - GST #
100*d_wgfsi_112("Federal") = VGFSI_112("Federal")*natwgst;

! Excises and levies !
Equation excA
(all,g,REGDST)
ID01[sum{i,EXCISE,V1TAXS_SI(i,g)+V2TAXS_SI(i,g)+V3TAXS_S(i,g)}]*
```

```
    exc(g) =
sum{c,EXCISE, V1TAXS_SI(c,g)*w1taxs_si(c,g) + V2TAXS_SI(c,g)*w2taxs_si(c,g) +
    V3TAXS_S(c,g)*w3taxs_s(c,g)};
Equation E_d_wgfsi_113A # GFSI: Taxes on goods and services - excises #
(all,q,REGDST)
100*d_wgfsi_113(q) = VGFSI_113(q)*exc(q);
Equation excB
ID01[sum{q,REGDST,sum{i,EXCISE,V1TAXF_SI(i,q)+V2TAXF_SI(i,q)+V3TAXF_S(i,q)}}]*
    exc("Federal") =
sum{q,REGDST, sum{c,EXCISE, V1TAXF_SI(c,q)*w1taxf_si(c,q) +
    V2TAXF_SI(c,q)*w2taxf_si(c,q) + V3TAXF_S(c,q)*w3taxf_s(c,q)}};
Equation E_d_wgfsi_113B # GFSI: Taxes on goods and services - excises #
100*d_wgfsi_113("Federal") = VGFSI_113("Federal")*exc("Federal");

! Taxes on international trade !
Equation E_d_wgfsi_114 # GFSI: Taxes on goods and services - int. trade #
(all,g,GOVT)
100*d_wgfsi_114(g) = VGFSI_114(g)* [
IF{g NE "Federal", 0*natp3tot} + IF{g EQ "Federal", natw0tar_c + f_wgfsi_114}];

! Taxes on gambling !
Equation gamA
(all,g,REGDST)
ID01[sum{i,GAMBLE,V1TAXS_SI(i,g)+V2TAXS_SI(i,g)+V3TAXS_S(i,g)}]*
    gam(g) =
sum{c,GAMBLE, V1TAXS_SI(c,g)*w1taxs_si(c,g) + V2TAXS_SI(c,g)*w2taxs_si(c,g) +
    V3TAXS_S(c,g)*w3taxs_s(c,g)};
Equation E_d_wgfsi_115A # GFSI: Taxes on goods and services - gambling #
(all,q,REGDST)
100*d_wgfsi_115(q) = VGFSI_115(q)*gam(q);
Equation gamB
ID01[sum{q,REGDST,sum{i,GAMBLE,V1TAXF_SI(i,q)+V2TAXF_SI(i,q)+V3TAXF_S(i,q)}}]*
    gam("Federal") =
sum{q,REGDST, sum{c,GAMBLE, V1TAXF_SI(c,q)*w1taxf_si(c,q) +
    V2TAXF_SI(c,q)*w2taxf_si(c,q) + V3TAXF_S(c,q)*w3taxf_s(c,q)}};
Equation E_d_wgfsi_115B # GFSI: Taxes on goods and services - gambling #
100*d_wgfsi_115("Federal") = VGFSI_115("Federal")*gam("Federal");

! Taxes on insurance !
Equation insA
(all,g,REGDST)
ID01[sum{i,INSURE,V1TAXS_SI(i,g)+V2TAXS_SI(i,g)+V3TAXS_S(i,g)}]*
    ins(g) =
sum{c,INSURE, V1TAXS_SI(c,g)*w1taxs_si(c,g) + V2TAXS_SI(c,g)*w2taxs_si(c,g) +
    V3TAXS_S(c,g)*w3taxs_s(c,g)};
Equation E_d_wgfsi_116A # GFSI: Taxes on goods and services - insurance #
(all,q,REGDST)
100*d_wgfsi_116(q) = VGFSI_116(q)*ins(q);
Equation insB
ID01[sum{q,REGDST,sum{i,INSURE,V1TAXF_SI(i,q)+V2TAXF_SI(i,q)+V3TAXF_S(i,q)}}]*
    ins("Federal") =
```

```
sum{q,REGDST, sum{c,INSURE, V1TAXF_SI(c,q)*w1taxf_si(c,q) +
    V2TAXF_SI(c,q)*w2taxf_si(c,q) + V3TAXF_S(c,q)*w3taxf_s(c,q)}};
Equation E_d_wgfsi_116B # GFSI: Taxes on goods and services - insurance #
100*d_wgfsi_116("Federal") = VGFSI_116("Federal")*ins("Federal");

! Taxes on motor vehicles !
Equation motA
(all,g,REGDST)
ID01[sum{i,MOTOR,V1TAXS_SI(i,g)+V2TAXS_SI(i,g)+V3TAXS_S(i,g)}]*
    mot(g) =
sum{c,MOTOR, V1TAXS_SI(c,g)*w1taxs_si(c,g) + V2TAXS_SI(c,g)*w2taxs_si(c,g) +
    V3TAXS_S(c,g)*w3taxs_s(c,g)};
Equation E_d_wgfsi_117A # GFSI: Taxes on goods and services - motor vehicles #
(all,q,REGDST)
100*d_wgfsi_117(q) = VGFSI_117(q)*mot(q);
Equation motB
ID01[sum{q,REGDST,sum{i,MOTOR,V1TAXF_SI(i,q)+V2TAXF_SI(i,q)+V3TAXF_S(i,q)}}]*
    mot("Federal") =
sum{q,REGDST, sum{c,MOTOR, V1TAXF_SI(c,q)*w1taxf_si(c,q) +
    V2TAXF_SI(c,q)*w2taxf_si(c,q) + V3TAXF_S(c,q)*w3taxf_s(c,q)}};
Equation E_d_wgfsi_117B # GFSI: Taxes on goods and services - motor vehicles #
100*d_wgfsi_117("Federal") = VGFSI_117("Federal")*mot("Federal");

! Other taxes on the provision of goods and services !
Equation E_d_wgfsi_118A # GFSI: Taxes on goods and services - other #
(all,g,REGDST)
100*d_wgfsi_118(g) =
    VGFSI_118(g)*(p3tot(g) + f_wgfsi_118(g));
Equation E_d_wgfsi_118B # GFSI: Taxes on goods and services - other #
100*d_wgfsi_118("Federal") =
    VGFSI_118("Federal")*(natp3tot + f_wgfsi_118("Federal"));

! Total taxes on factor inputs !
Equation E_d_wgfsi_120  # GFSI: Taxes on factor inputs - total #
(all,g,GOVT)
d_wgfsi_120(g) = d_wgfsi_121(g) + d_wgfsi_122(g);

! Tax revenue from factor inputs - payroll !
Equation E_d_w1labtxS_io # State payroll tax collections #
(all,q,REGDST)
sum{i,IND, sum{o,OCC, V1LABTXS(i,q,o)}}*w1labtxS_io(q) =
    100*sum{i,IND, sum{o,OCC, d_w1labtxS(i,q,o)}};
Equation E_d_w1labtxF_io # Federal payroll tax collections #
sum{i,IND, sum{q,REGDST, sum{o,OCC, V1LABTXF(i,q,o)}}}*w1labtxF_io =
    100*sum{i,IND, sum{q,REGDST, sum{o,OCC, d_w1labtxF(i,q,o)}}};
Equation E_d_wgfsi_121A # GFSI: Taxes on factor inputs - payroll #
(all,g,REGDST)
100*d_wgfsi_121(g) =
    VGFSI_121(g)*(w1labtxS_io(g) + f_wgfsi_121(g));
Equation E_d_wgfsi_121B # GFSI: Taxes on factor inputs - payroll #
100*d_wgfsi_121("Federal") =
```

```
    VGFSI_121("Federal")*(w1labtxF_io + f_wgfsi_121("Federal"));

! Tax revenue from factor inputs - property !
Equation E_propA # Property taxes by state #
(all,q,REGDST)
sum{i,IND, [V1CAPTXS(i,q) + V1LNDTXS(i,q) + V1OCTTXS(i,q)]}*prop(q) =
    100*[d_w1captxs_i(q) + d_w1lndtxS_i(q) + d_w1octtxS_i(q)];
Equation E_propB # Property taxes, Federal #
sum{i,IND, sum{q,REGDST,  [V1CAPTXF(i,q) + V1LNDTXF(i,q) + V1OCTTXF(i,q)]}}*
    prop("Federal") =
100*sum{q,REGDST, [d_w1captxF_i(q) + d_w1lndtxF_i(q) + d_w1octtxF_i(q)]};
Equation E_d_wgfsi_122A # GFSI: Taxes on factor inputs - property #
(all,q,REGDST)
100*d_wgfsi_122(q) =
    VGFSI_122(q)*(prop(q) + f_wgfsi_122(q));
Equation E_d_wgfsi_122B # GFSI: Taxes on factor inputs - property #
100*d_wgfsi_122("Federal") =
    VGFSI_122("Federal")*(prop("Federal") + f_wgfsi_122("Federal"));

! Total income tax !
Equation E_d_wgfsi_130  # GFSI: Taxes on income - total #
(all,g,GOVT)
d_wgfsi_130(g) = d_wgfsi_131(g) + d_wgfsi_132(g) + d_wgfsi_133(g);

! Tax revenue from income - individuals !
Equation E_d_wgfsi_131A # GFSI: Taxes on income - individuals #
(All,q,REGDST)
d_wgfsi_131(q) = 0;
Equation E_d_wgfsi_131B
100*d_wgfsi_131("Federal") = VGFSI_131("Federal")*
[natpwage_io + natx1lab_io + 100/TLABINC*d_tlabinc + f_wgfsi_131];

! Tax revenue from income - enterprises !
Equation E_d_wgfsi_132A # GFSI: Taxes on income - enterprises #
(all,q,REGDST)
d_wgfsi_132(q) = 0;
Equation E_natw1gos_i # National value for w1gos_i #
sum{q,REGDST, V1GOS_I(q)}*natw1gos_i =
sum{q,REGDST, V1CAPINC_I(q)*w1capinc_i(q) + V1LNDINC_I(q)*w1lndinc_i(q) +
    V1OCTINC_I(q)*w1octinc_i(q)};
Equation E_d_wgfsi_132B # GFSI: Taxes on income - enterprises #
100*d_wgfsi_132("Federal") = VGFSI_132("Federal")*[
    natw1gos_i + 100/TGOSINC*d_tgosinc + f_wgfsi_132 ];

! Tax revenue from income - non-residents !
Equation E_d_wgfsi_133A # GFSI: Taxes on income - non-residents #
(all,q,REGDST)
d_wgfsi_133(q) = 0;
Equation E_d_wgfsi_133B # GFSI: Taxes on income - non-residents #
100*d_wgfsi_133("Federal") = VGFSI_133("Federal")*
    [w0gdpinc + f_wgfsi_133];
```

```
! Total federal grants to states !
Equation E_d_wgfsi_200  # GFSI: Federal grants to states - total #
(all,g,GOVT)
d_wgfsi_200(g) = d_wgfsi_210(g) + d_wgfsi_220(g);

! Total federal grants to states - GST tied !
Equation E_d_wgfsi_210A # GFSI: Federal grants to states - GST tied #
(all,q,REGDST)
100*d_wgfsi_210(q) = VGFSI_210(q)*[natwgst + f_wgfsi_210(q)];
Equation E_d_wgfsi_210B # GFSI: Federal grants to states - GST tied #
d_wgfsi_210("Federal") = 0;

! To ensure that GST grants to states add to total GST collections !
E_f_wgfsi_210
sum{q,REGDST, VGFSI_210(q)*f_wgfsi_210(Q)} = 0;

! Total federal grants to states - Other !
Equation E_d_wgfsi_220A # GFSI: Federal grants to states - Other #
(all,q,REGDST)
100*d_wgfsi_220(q) = VGFSI_220(q)*[natp3tot + f_wgfsi_220(q)];
Equation E_d_wgfsi_220B # GFSI: Federal grants to states - Other #
d_wgfsi_220("Federal") = 0;

! Sales of goods and services !
Equation E_d_wgfsi_300A # GFSI: Sales of goods and services #
(all,q,REGDST)
100*d_wgfsi_300(q) = VGFSI_300(q)*[w5tot(q) + f_wgfsi_300(q)];
Equation E_d_wgfsi_300B # GFSI: Sales of goods and services #
100*d_wgfsi_300("Federal") =
    VGFSI_300("Federal")*[natw6tot + f_wgfsi_300("Federal")];

! Interest receipts !
Equation E_d_wgfsi_400A # Interest receipts #
(all,q,REGDST)
100*d_wgfsi_400(q) = VGFSI_400(q)*[w0gspinc(q) + f_wgfsi_400(q)];
Equation E_d_wgfsi_400B # Interest receipts #
100*d_wgfsi_400("Federal") = VGFSI_400("Federal")*[
    w0gdpinc + f_wgfsi_400("Federal")];

! Other revenues !
Equation E_d_wgfsi_500A # Other revenues #
(all,q,REGDST)
100*d_wgfsi_500(q) = VGFSI_500(q)*[w0gspinc(q) + f_wgfsi_500(q)];
Equation E_d_wgfsi_500B # Other revenues #
100*d_wgfsi_500("Federal") = VGFSI_500("Federal")*[
    w0gdpinc + f_wgfsi_500("Federal")];

! Flexible handling of income tax rates !
Equation E_d_tlabinc # Uniform setting for deltalb and deltgos #
d_tlabinc = d_tinc + d_ftlabinc;
```

```
Equation E_d_tgosinc # Uniform setting for deltlab and deltgos #
d_tgosinc = d_tinc + d_ftgosinc;

Equation E_d_tlabinc0 # Labour income tax setting #
d_tlabinc = d_t0("federal") + d_tlabinc0;

Equation E_d_tgosinc0 # non-labour income adjustment #
d_tgosinc = d_t0("federal") + d_tgosinc0;
```

4.3.2 Government expenditure (TABLO excerpt 3.2.3)

Dollar ($m) changes in government expenditures are denoted by the prefix d_wgfse_ where the next 3 digits denote the source of government expenditure. For example the change in age pension payments from the Federal government is given by the variable d_wgfsi_230("Federal").[23]

[23] The federal government is the only source of age pension payments. However, for the sake of completeness variables such as d_wgfsi_230 are defined over all governments – State/Territory and Federal. In the case of age pension payments, the elements corresponding to the states and territories are set to zero.

Table 4.8 shows the drivers of each item of government expenditure. Government operating expenses are linked to the MMRF core in equations *E_d_wgfse_100A* and *E_d_wgfse_100B*. Government expenditure is generally indexed to changes in population, unemployment or economic activity, and, where appropriate, government benefit rates. We assume that States do not pay personal benefits.

Four key welfare payments by the Federal government are identified:

- unemployment benefits;
- disability support pensions;
- and age pensions; and
- residual other personal benefit payments.

Modelling of each is predicated on the simplifying assumption that there is a single average benefit rate for each type of payment and that the proportion of the population receiving each payment does not change. That is,

payment - cpi = driver + ratio + rate

where

payment is the percentage change in payments;

cpi is the percentage change in the national CPI;

driver is the percentage change in driver variable – such as population or number of persons unemployed;

ratio is an exogenous ratio representing the ratio of driver eligible for payment; and

rate is the average benefit rate.

So, for example, disability support pensions are simply indexed to the population (the driver), the average real benefit rate and the CPI (to preserve the homogeneity properties of the model). The ratio term does not enter the equation because it is always assumed to be exogenous. Equations *E_d_wgfse_210A* to *E_d_wgfse_240A* cover the four welfare payments.

Each of these welfare payments in the government finance statistics accounts are linked to the corresponding changes in the household income account (see Section 4.4.1).

```
! Subsection 3.2.3: Equations for government expenditure
---------------------------------!
! Total GFS expenditure !
Equation E_d_wgfse_000 # GFSE: Total #
(all,g,GOVT)
d_wgfse_000(g) =
    d_wgfse_100(g) + d_wgfse_200(g) + d_wgfse_300(g) + d_wgfse_400(g) +
    d_wgfse_500(g) + d_wgfse_600(g) + d_wgfse_700(g) + d_wgfse_800(g);
```

```
! Gross operating expenses !
Equation E_d_wgfse_100A # GFSE: Gross operating expenses #
(all,g,REGDST)
100*d_wgfse_100(g) = VGFSE_100(g)*(w5tot(g) + f_wgfse_100(g));
Equation E_d_wgfse_100B # GFSE: Gross operating expenses #
100*d_wgfse_100("Federal") =
    VGFSE_100("Federal")*(natw6tot + f_wgfse_100("Federal"));

! Personal benefit payments - total !
Equation E_d_wgfse_200 # GFSE: Personal benefit payments - total #
(all,g,GOVT)
d_wgfse_200(g) =
    d_wgfse_210(g) + d_wgfse_220(g) + d_wgfse_230(g) + d_wgfse_240(g);

! Unemployment benefits !
Equation E_d_wgfse_210A # GFSE: Personal benefit payments - unemployment #
(all,q,REGDST)
d_wgfse_210(q) = 0;
Equation E_d_wgfse_210B # GFSE: Personal benefit payments - unemployment #
100*d_wgfse_210("Federal") = VGFSE_210("Federal")* [
    natp3tot + natunemp + benefitrate1];

! Disability payments !
Equation E_d_wgfse_220A # GFSE: Personal benefit payments - disability #
(all,q,REGDST)
d_wgfse_220(q) = 0;
Equation E_d_wgfse_220B # GFSE: Personal benefit payments - disability #
100*d_wgfse_220("Federal") = VGFSE_220("Federal")*[
    natp3tot + natpop + benefitrate2];

! Age benefit payments !
Equation E_d_wgfse_230A # GFSE: Personal benefit payments - age #
(all,q,REGDST)
d_wgfse_230(q) = 0;
Equation E_d_wgfse_230B # GFSE: Personal benefit payments - age #
100*d_wgfse_230("Federal") = VGFSE_230("Federal")*[
    natp3tot + natpop + benefitrate3];

! Other personal benefit payments !
Equation E_d_wgfse_240A # GFSE: Personal benefit payments - other #
(all,q,REGDST)
d_wgfse_240(q) = 0;
Equation E_d_wgfse_240B # GFSE: Personal benefit payments - other #
100*d_wgfse_240("Federal") = VGFSE_240("Federal")*[
    natp3tot + natpop + benefitrate4];

! Total grant expenses !
Equation E_d_wgfse_300 # GFSE: Grant expenses - total #
(all,g,GOVT)
d_wgfse_300(g) =
```

```
    d_wgfse_310(g) + d_wgfse_320(g) + d_wgfse_330(g) + d_wgfse_340(g);

! Total federal grants to states !
Equation E_d_wgfse_310 # GFSE: Federal to states - total #
(all,g,GOVT)
d_wgfse_310(g) = d_wgfse_311(g) + d_wgfse_312(g);

! Federal grants to states - GST tied !
Equation E_d_wgfse_311A # GFSE: Federal to states - GST-tied #
(all,q,REGDST)
d_wgfse_311(q) = 0;
Equation E_d_wgfse_311B # GFSE: Federal to states - GST-tied #
d_wgfse_311("Federal") = sum{q,REGDST, d_wgfsi_210(q)};

! Federal grants to states - other !
Equation E_d_wgfse_312A # GFSE: Federal to states - Other #
(all,q,REGDST)
d_wgfse_312(q) = 0;
Equation E_d_wgfse_312B # GFSE: Federal to states - Other #
100*d_wgfse_312("Federal") = VGFSE_312("Federal")*[
    natp3tot + natpop];

! Grants to local government !
Equation E_d_wgfse_320A # GFSE: Federal to local government #
(all,q,REGDST)
d_wgfse_320(q) = 0;
Equation E_d_wgfse_320B # GFSE: Federal to local government #
100*d_wgfse_320("Federal") = VGFSE_320("Federal")*[
    w0gdpexp + f_wgfse_320];

! Grants to universities !
Equation E_d_wgfse_330A # GFSE: Federal to universities #
(all,q,REGDST)
d_wgfse_330(q) = 0;
Equation E_d_wgfse_330B # GFSE: Federal to universities #
100*d_wgfse_330("Federal") = VGFSE_330("Federal")*[
    w0gdpexp + f_wgfse_330];

! Grants to private industries !
Equation E_d_wgfse_340A # GFSE: Governments to private industries #
(all,q,REGDST)
100*d_wgfse_340(q) = VGFSE_340(q)*[
    w0gspinc(q) + f_wgfse_340(q)];
Equation E_d_wgfse_340B # GFSE: Federal to private universities #
100*d_wgfse_340("Federal") = VGFSE_340("Federal")*[
    w0gdpexp + f_wgfse_340("Federal")];

! Property expenses !
Equation E_d_wgfse_400A # GFSE: Property expenses #
(all,q,REGDST)
100*d_wgfse_400(q) = VGFSE_400(q)*[
```

```
    w0gspinc(q) + f_wgfse_400(q)];
Equation E_d_wgfse_400B # GFSE: Property expenses #
100*d_wgfse_400("Federal") = VGFSE_400("Federal")*[
    w0gdpexp + f_wgfse_400("Federal")];

! Subsidy expenses !
Equation E_d_wgfse_500A # GFSE: Subsidy expenses #
(all,q,REGDST)
100*d_wgfse_500(q) = VGFSE_500(q)*[
    w0gspinc(q) + f_wgfse_500(q)];
Equation E_d_wgfse_500B # GFSE: Subsidy expenses #
100*d_wgfse_500("Federal") = VGFSE_500("Federal")*[
    w0gdpexp + f_wgfse_500("Federal")];

! Capital transfers !
Equation E_d_wgfse_600A # GFSE: Capital transfers #
(all,q,REGDST)
100*d_wgfse_600(q) = VGFSE_600(q)*[
    w0gspinc(q) + f_wgfse_600(q)];
Equation E_d_wgfse_600B # GFSE: Capital transfers #
100*d_wgfse_600("Federal") = VGFSE_600("Federal")*[
    w0gdpexp + f_wgfse_600("Federal")];

Equation E_d_wgfse_700A # GFSE: Other #
(all,q,REGDST)
100*d_wgfse_700(q) = VGFSE_700(q)*[
    w0gspinc(q) + f_wgfse_700(q)];
Equation E_d_wgfse_700B # GFSE: Capital transfers #
100*d_wgfse_700("Federal") = VGFSE_700("Federal")*[
    w0gdpexp + f_wgfse_700("Federal")];
```

4.3.3 Government budget balances (TABLO excerpt 3.3)

The excess of government income (GFSI_000) over government expenditure (GFSE_000) is defined in the GFS operating statement as the "Net Operating Balance". This is the first concept of government budget balance reported in the model (Table 4.6). The change in net operating balance for government g is denoted by d_wgfsnob(g) and is determined by equation *E_d_wgfsnob* .

Deducting "Net acquisition of non-financial assets" from the "Net Operating Balance" yields the "Net lending/borrowing balance", the second concept of government budget balance that is reported. The change in net lending/borrowing balance for government g is denoted by d_gfsbud(g) and is determined by equation *E_d_gfsbud*.

The net acquisition of non-financial assets (net capital investment) measures the change in each government's stock of non-financial assets due to transactions. As such, it measures the net effect of purchases, sales and consumption (for example, depreciation of fixed assets and use of inventory) of non-financial assets. Another way to think of the concept is that it equals gross fixed capital formation, less depreciation, plus changes (investment) in inventories, plus other transactions in non-financial assets. To model this concept, we first define net government investment as

$$\text{V2TOTGOV\_NET}(q) = \sum_{i \in IND} \text{GOVSHR}(i,q) \times (1 - \text{FGOVSHR}(i,q)) \times (\text{V2TOT}(i,q) - \text{DEPR}(i) \times \text{VCAP}(i,q)) \qquad q \in REGDST \qquad (4.57),$$

and

$$\text{V2TOTGOV\_NET}(\text{"Federal"}) = \sum_{q \in REGDST} \sum_{i \in IND} \text{GOVSHR}(i,q) \times \text{FGOVSHR}(i,q) \times (\text{V2TOT}(i,q) - \text{DEPR}(i) \times \text{VCAP}(i,q)) \qquad (4.58)$$

where:

GOVSHR(i,q) is the share of government ownership in regional industry (i,q) (where 1 indicates complete government ownership);

FGOVSHR means the share of the Federal government in government ownership of (i,q) (where 1 indicates 100 per cent federal government ownership);

V2TOT(i,q) is total gross investment in regional industry (i,q); and

DEPR(i)×VCAP(i,q) is the value of depreciation for industry (i,q).

Note that Equation (4.57) is for the state and territory governments, while (4.58) is for the federal government.

Equations *E_d_wgfsnfaA* (state and territory governments) and *E_d_wgfsnfaB* (federal government) define the change in net acquisition of non-financial assets (d_wgfsnfa) by applying the percentage change forms of equations (4.57) and (4.58) to the initial value taken from the Government Financial Statistics for 2001-02.

The final concept of budget balance that we report is the fiscal balance as a fraction of nominal GDP (d_wgfsbudGDP). This is a real variable and is suitable as a target in simulations in which the government budget balance is held fixed.

From a modelling perspective, there are a number of closure choices concerning the budgetary position. The modeller may wish to keep the budget balance of each government exogenous by making a particular tax shifter endogenous. There are a number of such shifters written in the code of the model, but more could be added if required.[24]

[24] From a practical modelling perspective, the modeller must be wary in choosing a suitable tax shifter to be endogenous if the budget deficit is to be exogenous. If the revenue base of a particular tax is small, moderate changes in government outlays or revenues elsewhere could lead to a change in the sign of the level of the revenue assigned an endogenous tax shifter.

```
! Subsection 3.3.3: Equations for government budget balances
--------------------------------!
! Net acquisition of non-financial assets linked to government net investment !
Equation E_d_wgfsnob # Net operating Balances #
(all,g,GOVT)
d_wgfsnob(g) = d_wgfsi_000(g) - d_wgfse_000(g);

Equation E_w2totgov_netA
(all,q,REGDST)
V2TOTGOV_NET(q)*w2totgov_net(q) = sum{i,IND, GOVSHR(i,q)*(1 - FGOVSHR(i,q))* [
    V2TOT(i,q)*(x2tot(i,q) + p2tot(i,q)) -
    DEPR(i)*VCAP(i,q)*(x1cap(i,q) + p2tot(i,q)) ]};
Equation E_w2totgov_netB
V2TOTGOV_NET("Federal")*w2totgov_net("Federal") =
    sum{q,REGDST, sum{i,IND, GOVSHR(i,q)*FGOVSHR(i,q)* [
    V2TOT(i,q)*(x2tot(i,q) + p2tot(i,q)) -
    DEPR(i)*VCAP(i,q)*(x1cap(i,q) + p2tot(i,q)) ]}};

Equation E_d_wgfsnfaA # Net acquistion of non-financial assets - states #
(all,q,REGDST)
d_wgfsnfa(q) = VGFSNFA(q)/100*w2totgov_net(q);
Equation E_d_wgfsnfaB # Net acquistion of non-financial assets - federal #
d_wgfsnfa("Federal") = VGFSNFA("Federal")/100*w2totgov_net("Federal");

Equation E_d_wgfsbud # Net lending/borrowing balance #
(all,g,GOVT)
d_wgfsbud(g) = d_wgfsnob(g) - d_wgfsnfa(g);

Equation E_d_wgfsbudGDPA # Change in Net lending/borrowing balance/GSP - state #
(all,q,REGDST)
d_wgfsbudGDP(q) =
    (1/V0GSPINC(q))*d_wgfsbud(q) - (VGFSBUDGDP(q)/100)*w0gspexp(q);

Equation E_d_wgfsbudGDPB # Change in Net lending/borrowing balance/GDP - fed #
d_wgfsbudGDP("Federal") =
    (1/V0GDPINC)*d_wgfsbud("Federal") - (VGFSBUDGDP("Federal")/100)*w0gdpexp;
```

4.4 *Household accounts*

This module has three sections. In the first, household income is calculated as the sum of income from various sources. In the second, direct taxation is calculated, and in the third, taxation is deducted from household income to yield a measure of household disposable income.

4.4.1 Household income (TABLO excerpt 4.1.3)

Regional household income consists of three broad components: primary factor income, personal benefit payments from the Federal government, and “other income” (Table 4.9). Factor income from labour is calculated in the CGE-core. Calculating factor income for other sources is somewhat more difficult. It is assumed that nationally other factor income equals

$$\text{NATOTHER} = \sum_{q \in regsrc} \sum_{i \in ind} \text{DOM(i)} \times \{\text{V1NCAPINC(i,q)} + \text{V1LNDINC(i,q)} + \text{V1OCTINC(i,q)}\}$$

(4.59)

where:

DOM(i) is a coefficient showing the share of industry i that accrues to Australians, as opposed to foreigners;

V1NCAPINC(i,q) is net capital income after tax from industry i in region q;

V1LNDINC(i,s) is land income after tax from industry i in region q; and

V1OCTINC(i,s) is other cost income after tax from industry i in region q.

Including the DOM term in (4.59) ensures that income from profits accruing to foreigners is excluded from the calculation of household income in Australia.

The distribution of NATOTHER across regions is based on the assumption that a portion of income from industry i accrues to local residents (the first term in equation 4.60), with the remainder spread across regions in line with the size of each region's economy (the second term in equation 4.60). Spreading a portion of income across regions reflects an effort to incorporate the operations of a national share market. Thus for region q, we have

$$\text{OTHER(q)} = \sum_{i \in ind} \text{LOC(i,q)} \times \text{DOM(i)} \times \{\text{V1NCAPINC(i,q)} + \text{V1LNDINC(i,q)} + \text{V1OCTINC(i,q)}\} +$$
$$\sum_{i \in ind} \text{CON(q)} \times (1 - \text{LOC(i,q)}) \times \text{DOM(i)} \times \{\text{V1NCAPINC(i,q)} + \text{V1LNDINC(i,q)} + \text{V1OCTINC(i,q)}\}$$

(4.60)

where:

LOC(i,q) is a coefficient showing the income from industry i in region q accruing to locals; and

CON(q) is the share of consumption in region q in national consumption.

Total payments for each personal-benefit category are calculated in the Government finance module (see Section 4.3). The regional allocation of these payments is assumed to be in line with movements in regional populations shares. Thus, for example, if Victoria's population increases relative to the national population, then the share of all forms of personal benefit payments accruing to Victorians will rise in line with the increase in Victoria's populations share.

```
! Subsection 4.1.3: Equations for household income
---------------------------------!
Equation E_whinc_000 # HINC: Total #
(all,q,REGDST)
VHINC_000(q)*whinc_000(q) =
    VHINC_100(q)*whinc_100(q) + VHINC_200(q)*whinc_200(q) +
    VHINC_300(q)*whinc_300(q) + 100*d_whinc_400(q) + 100*d_whinc_500(q);
```

```
Equation E_whinc_100 # HINC: Factor income #
(all,q,REGDST)
VHINC_100(q)*whinc_100(q) =
    VHINC_110(q)*whinc_110(q) + VHINC_120(q)*whinc_120(q);

Equation E_whinc_110 # HINC: Factor income - labour #
(all,q,REGDST)
whinc_110(q) = w1labinc_i(q);

Equation E_w1ncapinc # Capital income net of depreciation #
(all,i,IND)(all,q,REGDST)
ID01(V1NCAPINC(i,q))*w1ncapinc(i,q) =
    {1 - DEPR(i)}*V1CAP(i,q)*(p1cap(i,q) + x1cap(i,q)) -
        100*(d_w1captxF(i,q) + d_w1captxS(i,q));


Variable (change) (all,q,REGDST)
d_FORINTINC(q) # Change ($m) in net inflow of interest payments #;

! Assume for simplicity that LOCSHR cannot change and that CONSHR is the
  population share that cannot change !
Equation E_whinc_120a # HINC: Factor income - non-labour #
(all,q,REGDST)
VHINC_120(q)*whinc_120(q) =
sum{i,IND,
    DOMSHR(i,q)*LOCSHR(i,q)*
 [V1NCAPINC(i,q)*w1ncapinc(i,q) + V1LNDINC(i,q)*(p1lndinc(i,q) + x1lnd(i,q)) +
  V1OCTINC(i,q) *(p1octinc(i,q) + x1oct(i,q))]} +

C_POP(q)/C_NATPOP*
sum{s,REGDST, sum{i,IND,
    DOMSHR(i,s)*(1 - LOCSHR(i,s))*
 [V1NCAPINC(i,s)*w1ncapinc(i,s) + V1LNDINC(i,s)*(p1lndinc(i,s) + x1lnd(i,s)) +
  V1OCTINC(i,s) *(p1octinc(i,s) + x1oct(i,s))]}} +

100*sum{i,IND,
    LOCSHR(i,q)*
    [V1NCAPINC(i,q) + V1LNDINC(i,q) + V1OCTINC(i,q)]*d_DOMSHR(i,q)} +

100*C_POP(q)/C_NATPOP*
sum{s,REGDST, sum{i,IND,
    (1 - LOCSHR(i,s))*
    [V1NCAPINC(i,s) + V1LNDINC(i,s) + V1OCTINC(i,q)]*d_DOMSHR(i,q)}} +

100*C_POP(q)/C_NATPOP*sum{r,REGDST, d_FORINTINC(r)};

Equation E_whinc_200 # HINC: Personal benefit payments #
(all,q,REGDST)
VHINC_200(q)*whinc_200(q) =
    VHINC_210(q)*whinc_210(q) + VHINC_220(q)*whinc_220(q) +
    VHINC_230(q)*whinc_230(q) + VHINC_240(q)*whinc_240(q);
```

```
Equation E_whinc_210 # HINC: Personal benefit payments - unemployment benefits #
(all,q,REGDST)
whinc_210(q) =
    100/VGFSE_210("Federal")*d_wgfse_210("Federal") + unemp(q) - natunemp;

Equation E_whinc_220 # HINC: Personal benefit payments - disability #
(all,q,REGDST)
whinc_220(q) =
    100/VGFSE_220("Federal")*d_wgfse_220("Federal") + pop(q) - natpop;

Equation E_whinc_230 # HINC: Personal benefit payments - age #
(all,q,REGDST)
whinc_230(q) =
    100/VGFSE_240("Federal")*d_wgfse_240("Federal") + pop(q) - natpop;

Equation E_whinc_240 # HINC: Personal benefit payments - other #
(all,q,REGDST)
whinc_240(q) =
    100/VGFSE_240("Federal")*d_wgfse_240("Federal") + pop(q) - natpop;

Equation E_whinc_300 # HINC: Other income #
(all,q,REGDST)
whinc_300(q) = w0gspinc(q);

Equation E_d_whinc_500 # HINC: Direct government handback #
(all,q,REGDST)
d_whinc_500(q) = d_wgfse_800(q) + C_POP(q)/C_NATPOP*d_wgfse_800("Federal") +
    VGFSE_800("Federal")/100*(C_POP(q)/C_NATPOP)*(pop(q) - natpop);

Equation E_d_DOMSHR
(all,i,IND)(all,q,REGDST)
d_DOMSHR(i,q) = -d_FORSHR(i,q);
```

4.4.2 Household taxation (TABLO excerpt 4.2.3)

Total direct taxes paid by households are calculated in the Government finance module (see Section 4.3) as part of federal government taxation income. Taxes are allocated across regions in line with before-tax income.

```
! Subsection 4.2.3: Equations for household taxation
---------------------------------!
Equation E_whtax_000 # HTAX: Total #
(all,q,REGDST)
VHTAX_000(q)*whtax_000(q) = VHTAX_100(q)*whtax_100(q);

Equation E_whtax_100 # HTAX: Tax on income #
(all,q,REGDST)
```

```
VHTAX_100(q)*whtax_100(q) =
    VHTAX_110(q)*whtax_110(q) + VHTAX_120(q)*whtax_120(q);

Equation E_whtax_110 # HTAX: Tax on income - labour #
(all,q,REGDST)
VHTAX_110(q)*whtax_110(q) =
    TLABINC*VHINC_110(q)*whinc_110(q) + 100*VHINC_110(q)*d_tlabinc;

Equation E_whtax_120 # HTAX: Tax on income - non-labour #
(all,q,REGDST)
VHTAX_120(q)*whtax_120(q) =
    TGOSINC*VHINC_120(q)*whinc_120(q) + 100*VHINC_120(q)*d_tgosinc;
```

4.4.3 Household disposable income (TABLO excerpt 4.3.3)

Deducting direct tax payments from household income yields household disposable income (Table 4.10). Household disposable income is linked to household expenditure via the average propensity to consume (APC). Changes in the APC may be peculiar to a state (apc(q)) or uniform over all states (natapc).

```
! Subsection 4.3.3: Equations for household disposable income
---------------------------------!
Equation E_whinc_dis # Household disposable income #
(all,q,REGDST)
VHINC_DIS(q)*whinc_dis(q) =
    VHINC_000(q)*whinc_000(q) - VHTAX_000(q)*whtax_000(q);

Equation E_natwhinc_dis # National household disposable income #
sum{q,REGDST, VHINC_DIS(q)}*natwhinc_dis =
    sum{q,REGDST, VHINC_000(q)*whinc_000(q) - VHTAX_000(q)*whtax_000(q)};

Equation E_apc # Average propensity to consume #
(all,q,REGDST)
w3tot(q) = apc(q) + natapc + whinc_dis(q);
```

4.5 *Regional labour markets and demography (comparative statics) (tablo excerpt 5.3)*

This block of equations includes various regional demographic and labour market relationships designed to account for the various labour market and demographic variables given in Table 4.11. The equations can be grouped into the following categories: definitions; equations imposing arbitrary assumptions; and national aggregates based on summing regional variables.

Two sets of assumptions must be considered. These are:

- the relationship between the regional populations and the labour market; and
- the relationship between the regional and national wage rates.

For each region and occupation, the following relationship exists between hours worked and population.

$$X1LAB\_I_{qo} = \frac{X1LAB\_I_{qo}}{X1EMP\_I_{qo}} \times \frac{X1EMP\_I_{qo}}{LAB_{qo}} \times \frac{LAB_{qo}}{WPOP_{q}} \times \frac{WPOP_{q}}{POP_{q}} \times \frac{POP_{q}}{NATPOP} \times NATPOP \qquad (4.61)$$

where for each region,

$\frac{X1LAB_{qo}}{X1EMP_{qo}}$ represents hours worked per employee (usually considered exogenous);

$\frac{X1EMP_{qo}}{LAB_{qo}}$ is the ratio of employed persons to labour supply, or the employment rate (the inverse of the unemployment rate);

$\frac{LAB_{qo}}{WPOP_{q}}$ is the ratio of the labour supply to the working age population (the participation rate);

$\frac{WPOP_{q}}{POP_{q}}$ is the ratio of the working age population to the total population (usually considered exogenous);

$\frac{POP_{q}}{NATPOP}$ is the ratio of the region's population to the national population; and

$NATPOP$ is the national population (usually considered exogenous).

Various labour market closures can be used. If X1LAB_I(q,o) is determined in the CGE core, then one of the ratios or quantities on the RHS of (4.61) must be endogenous. Therefore, for each region the system allows for either:

1. An exogenous determination of regional population, with an endogenous determination of either regional unemployment rates, regional labour supply or regional participation rates, or
2. An exogenous determination of regional unemployment rates and participation rates and an endogenous determination of regional population (which may be interpreted as regional migration).[25]

Alternatively, all the RHS variables in (4.61) may be determined exogenously. In this case, X1LAB_I(q,o) is determined by the relationship in (4.61), and regional wages (or regional wage relativities, if the national wage is exogenous) are determined endogenously in the CGE core.

Equation *E_x1emp* is a key definitional equation. It links the percentage change in employment (in hours) (x1lab) to the percentage change in employment (in persons) (x1emp) via change in the ratio of persons employed per hour worked (r_x1emp_x1lab). The ratio is typically exogenous. Another key definitional equation is *E_d_unr*, which explains the percentage-point change in the regional unemployment rate (d_unr(q)) in terms of the percentage change in regional labour supply (lab_o(q)) and persons employed (x1emp_io(q)). The final definitional equation of note is *E_lab_o*. This equation defines the percentage change in regional labour supply (lab_o(q)) in terms of the regional supply of labour by occupation (lab(q,o)). The percentage changes in the national supply of labour by occupation (natlab(o)) is linked to the changes in the regional participation rate (r_lab_wpop(q)), the regional population of working age (wpop(q)) and state population (pop(q)). The exogenous shift term (f_natlab(o)) is included to maintain a valid closure, as the national supply of labour is also linked through equation E_natlab to the regional supply of labour.

The equations of this block have been designed with sufficient flexibility to allow variations on the two general methods described above. Importantly, the block allows for some regions to be subject to method (1) and other regions to be subject to method (2) in the same simulation.

Three options are given for setting the movements in regional wage differentials. There are:

1. Regional wage moves with national wage;
2. Regional wage moves with national wage for occupation o; or
3. Regional real wage moves with regional employment (upward sloping supply curve).

Equation *E_pwage_io* allows flexibility in setting movements in regional wage differentials. The percentage change in the nominal wage differential in region q (r_wage_natwage1(q)) is defined as the difference between the percentage change in the regional nominal wage received by workers (pwage_io(q)) and the percentage change in the nominal wage received by workers across all regions (natpwage_io). In the standard closure of the model (see Section 5), r_wage_natwage1 is set exogenous for all but one region, with the adding up condition E_natpwage_io (see Section 4.2.18) ensuring that the condition holds for the remaining region. Thus, in this closure, average nominal

[25] A dynamic closure in which regional populations are endogenous is discussed further in Section 4.9.4 on population dynamics. In comparative static simulations where regional populations are endogenous, the changes in regional population may be interpreted as regional migration.

wage rates across regions move together (Option 1). Equation *E_r_wage_natwage2* is similar to *E_pwage_io*, except that it applies to wage rates by occupation (Option 2). Equation E_f_x1emp_natemp invokes Option 3. If the shifter f_x1emp_natemp(q) is made exogenous in any region q, an increase of 1 per cent in the ratio of regional employment to national employment will produce an (arbitrarily chosen) increase of 0.5 per cent in the ratio of the regional real wage to the national real wage.

Equation *E_qhous* imposes the assumption that regional household formation is proportional to regional population by setting the percentage change in regional household formation (qhous(q)) equal to the percentage change in regional population (pop(q)) when the shift variable r_qhous_pop(q) is exogenous and set to zero change. The default option can be overridden by setting r_qhous_pop(q) to non-zero values.

Many of the remaining equations of this section, *E_natpop*, *E_natlab*, *E_natx1emp_io*, and *E_natunr* determine national aggregate variables by summing the corresponding regional variables.

```
! Section 5.3: Equations
  Naming of equations is based on the idea that population (pop) by region is
  exogenous. Thus working age populaiton by region is determined by equation
  E_wpop via exogenous setting for variable r_wpop_pop, etc.
==================================!
Equation E_wpop # Ratio of working age population to population by region #
(all,q,REGDST)
wpop(q) = pop(q) + r_wpop_pop(q);

Equation E_qhous # Ratio of households to population by region #
(all,q,REGDST)
qhous(q) = pop(q) + r_qhous_pop(q);

Equation E_lab # Ratio of labour supply to working age population #
(all,q,REGDST)(all,o,OCC)
lab(q,o) = wpop(q) + r_lab_wpop(q,o);

! Option 1 !
Equation E_pwage_io # Ratio of wage in region q to national wage #
(all,q,REGDST)
r_wage_natwage1(q) = pwage_io(q) - natpwage_io;

! Option 2 !
Equation E_r_wage_natwage2 # Ratio of wage in region q to national wage #
(all,q,REGDST)(all,o,OCC)
r_wage_natwage2(q,o) = pwage_i(q,o) - natpwage_i(o);

! Option 3 !
Equation E_r_employ_natemp # Ratio of employment in q to national employment #
(all,q,REGDST)
r_employ_natemp(q) = x1emp_io(q) - natx1emp_io;
```

```
Equation E_f_x1emp_natemp # Real wage/Employment trade off for regions #
(all,q,REGDST)
r_employ_natemp(q) = 0.5*{r_wage_natwage1(q) - p3tot(q) + natp3tot} +
                            f_x1emp_natemp(q);


Equation E_x1emp # Employment (hours) linked to employment (persons) #
(all,i,IND)(all,q,REGDST)(all,o,OCC)
x1emp(i,q,o) = x1lab(i,q,o) + r_x1emp_x1lab(i,q,o);

Equation E_d_unr # %-point change in regional unemployment rate by occ #
(all,q,REGDST)(all,o,OCC)
LABSUP(q,o)*d_unr(q,o) = EMPLOY_I(q,o)*[lab(q,o) - x1emp_i(q,o)];

! Remaining equations are summary variables !
Equation E_x1emp_i # Regional employment by occupation (persons) #
(all,q,REGDST)(all,o,OCC)
EMPLOY_I(q,o)*x1emp_i(q,o) = sum{i,IND, EMPLOY(i,q,o)*x1emp(i,q,o)};

Equation E_unemp # %-change in persons unemployed by region #
(all,q,REGDST)
{LABSUP_O(q)-EMPLOY_IO(q)}*unemp(q) =
    {LABSUP_O(q)*lab_o(q) - EMPLOY_IO(q)*x1emp_io(q)};

Equation E_natunemp # %-change in persons unemployed - national #
sum{q,REGDST, [LABSUP_O(q)-EMPLOY_IO(q)]}*natunemp =
    sum{q,REGDST, [LABSUP_O(q)*lab_o(q) - EMPLOY_IO(q)*x1emp_io(q)]};

Equation E_d_unr_o # %-point changes in regional unemployment rate #
(all,q,REGDST)
LABSUP_O(q)*d_unr_o(q) = EMPLOY_IO(q)*[lab_o(q) - x1emp_io(q)];

Equation E_d_natunr_o # %-point change in national unemployment rate #
NATLABSUP_O*d_natunr_o = NATEMPLOY_IO*[natlab_o - natx1emp_io];

Equation E_d_natunr # %-point change in national unemployment rate by occ #
(all,o,OCC)
NATLABSUP(o)*d_natunr(o) = NATEMPLOY_I(o)*[natlab(o) - natx1emp_i(o)];

Equation E_natpop # National population #
sum{q,REGDST, C_POP(q)}*natpop = sum{q,REGDST, C_POP(q)*pop(q)};

Equation E_natwpop # National working aged population #
sum{q,REGDST, C_WPOP(q)}*natwpop = sum{q,REGDST, C_WPOP(q)*wpop(q)};

Equation E_lab_o # Regional labour supply #
(all,q,REGDST)
LABSUP_O(q)*lab_o(q) = sum{o,OCC, LABSUP(q,o)*lab(q,o)};

Equation E_natlab # National labour supply by occupation #
(all,o,OCC)
```

```
NATLABSUP(o)*natlab(o) = sum{q,REGDST, LABSUP(q,o)*lab(q,o)};

Equation E_natlab_o # National labour supply #
NATLABSUP_O*natlab_o = sum{o,OCC, sum{q,REGDST, LABSUP(q,o)*lab(q,o)}};

Equation E_x1emp_o # Regional employment by industry: persons #
(all,i,IND)(all,q,REGDST)
ID01(EMPLOY_O(i,q))*x1emp_o(i,q) = sum{o,OCC, EMPLOY(i,q,o)*x1emp(i,q,o)};

Equation E_natx1emp_o # National employment by industry: persons #
(all,i,IND)
ID01(NATEMPLOY_O(i))*natx1emp_o(i) =
    sum{q,REGDST, sum{o,OCC, EMPLOY(i,q,o)*x1emp(i,q,o)}};

Equation E_natx1emp_i # National employment by occupation: persons #
(all,o,OCC)
ID01(NATEMPLOY_I(o))*natx1emp_i(o) =
    sum{i,IND, sum{q,REGDST, EMPLOY(i,q,o)*x1emp(i,q,o)}};

Equation E_x1emp_io # Regional employment (persons) #
(all,q,REGDST)
EMPLOY_IO(q)*x1emp_io(q) = sum{i,IND, EMPLOY_O(i,q)*x1emp_o(i,q)};

Equation E_natx1emp_io # National employment (persons) #
sum{q,REGDST, EMPLOY_IO(q)}*natx1emp_io =
    sum{q,REGDST, EMPLOY_IO(q)*x1emp_io(q)};
```

4.6 *Foreign Accounts and Gross National Product (tablo excerpt 6.3)*

This section of the code contains a detailed description of the balance of payments accounts (see Table 4.12), allowing the calculation of Gross National Product (GNP)[26].

By definition, the balance on current account (CAB) equals the balance on trade account (TAB) plus the balance on income account (IAB) plus net foreign transfers from foreigners to Australians (NCT). The balance on income account is the net income to Australians from foreign assets less the costs of servicing Australia's net foreign liabilities. Net foreign transfers include foreign aid and social security payments, gifts, alimony, inheritances and labour income.

Equation *E_d_TAB* defines the change in the balance on trade account in region q as the change in value of foreign exports from region q less the change in value of foreign imports into region q, both valued in Australian dollars. Changes in exports and imports come from the CGE-core. The change in national trade account balance is explained by equation *E_d_NatTAB*, while the change in national trade account balance as a proportion of GDP is explained by *E_d_NATTABGDP*.

Equation *E_d_IAB* defines the change in change in the balance on the income account in region q as the sum of changes in net interest payments (FORINTINC) and in net inflow of factor income (FORCAPINC). Note that initial data for FORINTINC and FORCAPINC for Australia as a whole come from the ABS's *Balance of Payments* statistics. These numbers are allocated across states and territories using GSP shares.

We do not attempt the type of detailed modelling of the credit and debit sides of FORINTINC and FORCAPINC as is undertaken, for example, in the MONASH model.[27] Instead, we model just the net flows.

The change in FORINTINC is determined in equation *E_d_FORINTINC* as a function of changes in the exogenous foreign rate of interest on debt and the net stock of foreign debt. Net foreign liabilities comprise net foreign debt plus net foreign equity. It is assumed that the net stock of foreign debt is a fixed share of total net foreign liabilities. The share of debt is given by the coefficient SHDEBT.

We assume, in Equation *E_d_FORCAPINC,* that FORCAPINC moves with the net flow of income from capital and land accruing to foreigners less the Australian income tax paid on that income. All the variables and coefficients on the right hand side of this equation come from elsewhere in the model: income flows from the CGE-core, tax rates from the Government finance module, and foreign ownership from the Net Foreign Liability accounts.

We define nominal GNP for state q as nominal GSP plus the balance on income account for region q. The percentage change in nominal GNP for region q is given in Equation *E_w0gnp*, while the percentage change in national GNP is given in equation *E_natw0gnp*.

Real GNP is deduced by deflating nominal GNP using the price deflator for Gross National Expenditure (GNE). Deflating by an expenditure deflator yields a real measure of income accruing to

---

[26] GNP is GDP less net factor income to foreigners.

[27] See Section 25 of Dixon and Rimmer (2002).

Australians in terms of their purchasing power over goods and services purchased. *E_x0gnp* is the percentage change-form of the equation for regional real GNP, and *E_natx0gnp* is the percentage change-form of the equation for national real GNP.

The remaining equations in this section of the code relate to Net National Product (NNP), which is defined as GNP less depreciation of fixed capital. Nominal and real NNP at the regional and national levels are explained in equations *E_w0nnp* to *E_natx0nnp*.

```
! Section 6.3: FOREIGN ACCOUNTS AND GNP/NNP
==================================!
Equation E_d_TAB # Change ($m) in balance on trade account #
(all,q,REGDST)
100*d_TAB(q) = V4TOT(q)*(p4r_c(q) + phi + x4tot(q)) -
               V0CIF_C(q)*(p0cif_c(q) + phi + x0cif_c(q));

Equation E_d_NATTAB # Change ($m) in balance on national trade account #
d_NATTAB = sum{q,REGDST, d_TAB(q)};

Equation E_d_NATTABGDP # Change in trade-account balance to GDP ratio #
d_NATTABGDP = 1/V0GDPINC*d_NATTAB - (NATTABGDP/100)*w0gdpexp;

Equation E_d_IAB # Change ($m) in balance on foreign income account #
(all,q,REGDST)
d_IAB(q) = d_FORINTINC(q) + d_FORCAPINC(q);

Equation E_d_NATIAB # Change ($m) in balance on national foreign income account#
d_NATIAB = sum{q,REGDST, d_IAB(q)};

Equation E_d_NATIABGDP # Change in income-account balance to GDP ratio #
d_NATIABGDP = 1/V0GDPINC*d_NATIAB - (NATIABGDP/100)*w0gdpexp;

Equation E_d_NCT # Change ($m) in net current transfers into Australia #
(all,q,REGDST)
d_NCT(q) = NCT(q)/100*w0gspinc(q) + d_FNCT(q) + d_FNATNCT;

Equation E_d_NATNCT # Change ($m) in national net current transfers #
d_NATNCT = sum{q,REGDST, d_NCT(q)};

Equation E_d_CAB # Change ($m) in balance on current account #
(all,q,REGDST)
d_CAB(q) = d_TAB(q) + d_IAB(q) + d_NCT(q);

Equation E_d_NATCAB # Change ($m) in balance on national current account #
d_NATCAB = sum{q,REGDST, d_CAB(q)};

Equation E_d_NATCABGDP # Change in current-account balance to GDP ratio #
d_NATCABGDP = 1/V0GDPINC*d_NATCAB - (NATCABGDP/100)*w0gdpexp;

! Modelling of net inflow of foreign income from equity (capital). Note that
  in the database this is typically a minus number.
```

```
  We assume simply that the net inflow of capital income
  (FORCAPINC) moves with minus the flow of after-tax profit sent overseas,
  with an allowance for exogenous valuation effects (VALE).
  In the levels

        FORCAPINC(q) = -VALE*TGOSINCFAC*sum{i,IND, FORSHR(i,q))*
            [V1NCAPINC(i,q) + V1LNDINC(i,q) + V1OCTINC(i,q)]}

  where:
    VALE (an exogneous variables) accounts for valuation effects;
    TGOSINCFAC is 1 minus the Australian company tax rate;
    FORSHR is the foreign share in ownership of industry i in region q; and
    the term in square brackets is the profit for industry i in region q.
 !


Equation E_d_FORCAPINC # Change ($m) in net inflow of foreign income #
(all,q,REGDST)
100*d_FORCAPINC(q) =
-100*TGOSINCFAC*sum{i,IND, FORSHR(i,q)*
    [V1NCAPINC(i,q) + V1LNDINC(i,q) + V1OCTINC(i,q)]}*d_VALE +

-VALE*TGOSINCFAC*sum{i,IND, FORSHR(i,q)*
[V1NCAPINC(i,q)*w1ncapinc(i,q) + V1LNDINC(i,q)*(p1lndinc(i,q) + x1lnd(i,q)) +
 V1OCTINC(i,q)*(p1octinc(i,q) + x1oct(i,q))]} +

-100*VALE*sum{i,IND, FORSHR(i,q)*
[V1NCAPINC(i,q) + V1LNDINC(i,q) + V1OCTINC(i,q)]}*d_TGOSINC +

-100*VALE*TGOSINCFAC*sum{i,IND,
[V1CAPINC(i,q) + V1LNDINC(i,q) + V1OCTINC(i,q)]*d_FORSHR(i,q)};

Equation E_d_NATFORCAPINC # Change ($m) in national FORCAPINC #
d_NATFORCAPINC = sum{q,REGDST, d_FORCAPINC(q)};

! Modelling of net inflow of foreign income from debt. Note that in the database
  this is typically a minus number.

  We assume simply that the net inflow of interest payments
  (FORINTINC) is determined by applying an exogenous foreign rate of
  interest to the debt (as opposed to equity), with an allowance for exogenous
  valuation effects (VALD). In the levels

    FORINTINC = -NFD*FORINT*VALD,

  where
    VALD (an exogenous variable) accounts for valuation effects across the
    portfolio of debt instruments;
    NFD is net foreign debt;
    FORINT is the foreign interest rate on Australian debt.
```

```
  !
Equation E_d_FORINTINC # Change ($m) in net inflow of interest payments #
(all,q,REGDST)
d_FORINTINC(q) = -{NFD(q)*VALD*d_FORINT + FORINT*VALD*d_NFD(q) +
                   NFD(q)*FORINT*d_VALD};

Equation E_d_NATFORINTINC # Change ($m) in national FORINTINC #
d_NATFORINTINC = sum{q,REGDST, d_FORINTINC(q)};

Equation E_d_NATNFLGDP # National change in NFL to GDP ratio #
d_NATNFLGDP = 1/V0GDPINC*sum{q,REGDST, d_NFL(q)} - (NATNFLGDP/100)*w0gdpexp;

Equation E_w0gnp # Value of GNP by region #
(all,q,REGDST)
V0GNP(q)*w0gnp(q) = V0GSPINC(q)*w0gspinc(q) + 100*d_IAB(q);

Equation E_natw0gnp # Value of national GNP #
NATV0GNP*natw0gnp = sum{q,REGDST, V0GNP(q)*w0gnp(q)};

Equation E_x0gnp # Real GNP by region #
(all,q,REGDST)
x0gnp(q) = w0gnp(q) - p0gne(q);

Equation E_natx0gnp # Real national GNP by region #
natx0gnp  = natw0gnp - natp0gne;

Equation E_w0nnp # Value of NNP by region #
(all,q,REGDST)
V0NNP(q)*w0nnp(q) = V0GNP(q)*w0gnp(q) -
    sum{i,IND, DEPR(i)*CAPSTOCK(i,q)*(p2tot(i,q) + x1cap(i,q))};

Equation E_natw0nnp # Value of national NNP #
NATV0NNP*natw0nnp = sum{q,REGDST, V0NNP(q)*w0nnp(q)};

Equation E_x0nnp # Real NNP by region #
(all,q,REGDST)
x0nnp(q) = w0nnp(q) - p0gne(q);

Equation E_natx0nnp # Real national NNP by region #
natx0nnp  = natw0nnp - natp0gne;
```

4.7 *Decompositions and Reporting Variables*

In this section we describe some of the variables which are useful in presenting and understanding the results generated in an MMRF simulation. None of the equations in this section have an impact on MMRF results. Their purpose is only to assist with summarising and interpreting the results.

Decompositions enable the modeller to attribute changes in a variable to the driving factors behind it. The general principle behind a decomposition is as follows.

Suppose X = A + B.

Then dX = dA + dB,

or in percentage changes, $x = S_A a + S_B b$

where lowercase denotes percentage change, and S denotes a share of X.

Because X is a linear combination of A and B, there is no linearisation error in the percentage change relationship. Therefore, a single step solution or a multistep solution both lead to an exact result.

Dividing through by X_0, the initial value of X, the contributions of A and B to the change in X are

$contA = dA/X_0$ and

$contB = dB/X_0$.

Importantly, contA and contB are ordinary change variables, not percentage change. The contributions should not be defined as

$contA = S_A a$ and

$contB = S_B b$

because the multi-step procedure will introduce linearisation error in the calculation of contA and contB such that they will not add exactly to x. This is because the shares will be recalculated at each step and the solutions to each step will be compounded instead of added together.

4.7.1 Decomposition of Real GDP and Real GSP (TABLO excerpt 7.1)

A decomposition of GDP is given from the expenditure side, into Consumption, Investment, Government, Stocks, Exports and Imports. For GSP, foreign and interstate Imports and Exports are separate categories. From the income side, results for GDP and GSP are decomposed into Labour, Capital, Land, Other costs, Taxes on producers, Taxes on investment, Taxes on households, Taxes on exports, Technological change in production, and Technological change in margin usage.

The coefficient INITGDP is defined as for X_0 above, and only updated by its price component.

```
! Section 7.1: Decompositions of real GSP and real GDP from the expenditure
  and income sides
=================================!
Set GDPEXP # Expenditure Aggregates - GDP #
(Consumption, Investment, Government, Stocks, Exports, Imports);
Set GSPEXP # Expenditure Aggregates - GSP #
(Consumption, Investment, Government, Stocks, ForExports, IntExports,
    ForImports, IntImports);

Variable (change)(all,e,GDPEXP)
cont_GDPEXP(e) # Contributions to real expenditure-side GDP #;
Coefficient
```

```
INITGDP # Initial real GDP at current prices #;
Formula (initial)
INITGDP = V0GDPEXP;
Update
INITGDP = p0gdpexp;

Equation E_cont_GDPEXPA # Households #
INITGDP*cont_GDPEXP("Consumption") = NATV3TOT*natx3tot;

Equation E_cont_GDPEXPB # Investment #
INITGDP*cont_GDPEXP("Investment") = NATV2TOT_I*natx2tot_i;

Equation E_cont_GDPEXPC # Government #
INITGDP*cont_GDPEXP("Government") = NATV5TOT*natx5tot + NATV6TOT*natx6tot;

Equation E_cont_GDPEXPD # Stocks #
INITGDP*cont_GDPEXP("Stocks") = 100*sum{q,REGDST, LEVP7R_C(q)*d_x7tot(q)};

Equation E_cont_GDPEXPE # Exports #
INITGDP*cont_GDPEXP("Exports") = NATV4TOT*natx4tot;

Equation E_cont_GDPEXPF # Imports #
INITGDP*cont_GDPEXP("Imports") = -NATV0CIF_C*natx0cif_c;

Variable (change)(all,e,GSPEXP)(all,q,REGDST)
cont_GSPEXP(e,q) # Contributions to real expenditure-side GSP #;
Coefficient (all,q,REGDST)
INITGSP(q) # Initial real GSP at current prices #;
Formula (initial)(all,q,REGDST)
INITGSP(q) = V0GSPEXP(q);
Update (all,q,REGDST)
    INITGSP(q) = p0gspexp(q);

Equation E_cont_GSPEXPA # Households #
(all,q,REGDST)
INITGSP(q)*cont_GSPEXP("Consumption",q) = V3TOT(q)*x3tot(q);

Equation E_cont_GSPEXPB # Investment #
(all,q,REGDST)
INITGSP(q)*cont_GSPEXP("Investment",q) = V2TOT_I(q)*x2tot_i(q);

Equation E_cont_GSPEXPC # Government #
(all,q,REGDST)
INITGSP(q)*cont_GSPEXP("Government",q) = V5TOT(q)*x5tot(q) + V6TOT(q)*x6tot(q);

Equation E_cont_GSPEXPD # Stocks #
(all,q,REGDST)
INITGSP(q)*cont_GSPEXP("Stocks",q) = 100*LEVP7R_C(q)*d_x7tot(q);

Equation E_cont_GSPEXPE # Foreign Exports #
(all,q,REGDST)
```

```
INITGSP(q)*cont_GSPEXP("ForExports",q) = V4TOT(q)*x4tot(q);

Equation E_cont_GSPEXPF # Foreign Imports #
(all,q,REGDST)
INITGSP(q)*cont_GSPEXP("ForImports",q) = -V0CIF_C(q)*x0cif_c(q);

Equation E_cont_GSPEXPG # Interstate Exports #
(all,q,REGDST)
INITGSP(q)*cont_GSPEXP("IntExports",q) = VSEXP_C(q)*xsexp_c(q);

Equation E_cont_GSPEXPH # Intersate Imports #
(all,q,REGDST)
INITGSP(q)*cont_GSPEXP("IntImports",q) = -VSIMP_C(q)*xsimp_c(q);


Set GDPINC # Income Aggregates - GDP #
(Labour, Capital, Land, OtherCost, Tax1, Tax2, Tax3, Tax4, TechInd, TechMar);

Set GSPINC # Income Aggregates - GSP #
(Labour, Capital, Land, OtherCost, Tax1, Tax2, Tax3, Tax4, TechInd, TechMar);

Variable (change)(all,i,GDPINC)
cont_GDPINC(i) # Contributions to real income-side GDP #;
Variable (change)(all,i,GDPINC)(all,q,REGDST)
cont_GSPINC(i,q) # Contributions to real income-side GSP #;

Equation E_cont_GDPINCA # Labour #
INITGDP*cont_GDPINC("Labour") = NATV1LAB_io*natx1lab_io;

Equation E_cont_GDPINCB # Capital #
INITGDP*cont_GDPINC("Capital") = NATV1CAP_I*natx1cap_i;

Equation E_cont_GDPINCC # Land #
INITGDP*cont_GDPINC("Land") = NATV1LND_I*natx1lnd_i;

Equation E_cont_GDPINCD # Other costs #
INITGDP*cont_GDPINC("OtherCost") = NATV1OCT_I*natx1oct_i;

Equation E_cont_GDPINCE # Tax - intermediate inputs #
INITGDP*cont_GDPINC("Tax1") =
    sum{c,COM, sum{s,AllSRC, sum{i,IND, sum{q,REGDST,
    (V1TAXF(c,s,i,q) + V1TAXS(c,s,i,q))*x1a(c,s,i,q) +
    T1GST(c,s,i,q)/100 * {
        V1BAS(c,s,i,q)*x1a(c,s,i,q) +
        (V1TAXF(c,s,i,q) + V1TAXS(c,s,i,q))*x1a(c,s,i,q) +
        sum{r,MARGCOM, V1MAR(c,s,i,q,r)*x1marg(c,s,i,q,r)}}}}}};

Equation E_cont_GDPINCF # Tax - investment inputs #
INITGDP*cont_GDPINC("Tax2") =
    sum{c,COM, sum{s,AllSRC, sum{i,IND, sum{q,REGDST,
    (V2TAXF(c,s,i,q) + V2TAXS(c,s,i,q))*x2a(c,s,i,q) +
```

```
    T2GST(c,s,i,q)/100 * {
        V2BAS(c,s,i,q)*x2a(c,s,i,q) +
        (V2TAXF(c,s,i,q) + V2TAXS(c,s,i,q))*x2a(c,s,i,q) +
        sum{r,MARGCOM, V2MAR(c,s,i,q,r)*x2marg(c,s,i,q,r)}}}}}};

Equation E_cont_GDPINCG # Tax - consumption inputs #
INITGDP*cont_GDPINC("Tax3") =
    sum{c,COM, sum{s,AllSRC, sum{q,REGDST,
    T3GST(c,s,q)/100 * {
        V3BAS(c,s,q)*x3a(c,s,q) +
        (V3TAXF(c,s,q) + V3TAXS(c,s,q))*x3a(c,s,q) +
        sum{r,MARGCOM, V3MAR(c,s,q,r)*x3marg(c,s,q,r)}}}}};

Equation E_cont_GDPINCH # Tax - exports #
INITGDP*cont_GDPINC("Tax4") =
    sum{c,COM, sum{q,REGDST,
    V4TAXF(c,q)*x4r(c,q) + V0TAR(c,q)*x0imp(c,q) +
    T4GST(c,q)/100 * {
        V4BAS(c,q)*x4r(c,q) +
        V4TAXF(c,q)*x4r(c,q) +
        sum{r,MARGCOM, V4MAR(c,q,r)*x4marg(c,q,r)}}}};

Equation E_cont_GDPINCJ # Technological change - direct usage #
INITGDP*cont_GDPINC("Techind") =
    -sum{q,REGDST, [sum{i,IND, COSTS(i,q)*a(i,q)} +
       sum{c,COM, sum{i,IND, V2PURO(c,i,q)*(a2(q) + acom(c,q) + natacom(c))}}]};

Equation E_cont_GDPINCK # Technological change - indirect usage #
INITGDP*cont_GDPINC("TechMar") = -sum{q,REGDST,
[sum{c,COM,
    sum{r,MARGCOM,
        sum{s,ALLSRC,
            sum{i,IND,
(V1MAR(c,s,i,q,r)*(1+T1GST(c,s,i,q)/100))*(a1marg(q,r)+acom(r,q)+natacom(r)) +
(V2MAR(c,s,i,q,r)*(1+T2GST(c,s,i,q)/100))*(a2marg(q,r)+acom(r,q)+natacom(r))} +
[(V3MAR(c,s,q,r)*(1+T3GST(c,s,q)/100))   *(a3marg(q,r)+acom(r,q)+natacom(r)) +
 V5MAR(c,s,q,r)  *(a5marg(q,r) + acom(r,q) + natacom(r)) +
 V6MAR(c,s,q,r)  *(a6marg(q,r) + acom(r,q) + natacom(r))]} +
[(V4MAR(c,q,r)*(1+T4GST(c,q)/100))     *(a4marg(q,r)+acom(r,q)+natacom(r))]}}]};

Equation E_cont_GSPINCA # Labour #
(all,q,REGDST)
INITGSP(q)*cont_GSPINC("Labour",q) = V1LAB_io(q)*x1lab_io(q);

Equation E_cont_GSPINCB # Capital #
(all,q,REGDST)
INITGSP(q)*cont_GSPINC("Capital",q) = V1CAP_I(q)*x1cap_i(q);

Equation E_cont_GSPINCC # Land #
(all,q,REGDST)
INITGSP(q)*cont_GSPINC("Land",q) = V1LND_I(q)*x1lnd_i(q);
```

```
Equation E_cont_GSPINCD # Other costs #
(all,q,REGDST)
INITGSP(q)*cont_GSPINC("OtherCost",q) = V1OCT_I(q)*x1oct_i(q);

Equation E_cont_GSPINCE # Tax - intermediate inputs #
(all,q,REGDST)
INITGSP(q)*cont_GSPINC("Tax1",q) =
    sum{c,COM, sum{s,AllSRC, sum{i,IND,
    (V1TAXF(c,s,i,q) + V1TAXS(c,s,i,q))*x1a(c,s,i,q) +
    T1GST(c,s,i,q)/100 * {
        V1BAS(c,s,i,q)*x1a(c,s,i,q) +
        (V1TAXF(c,s,i,q) + V1TAXS(c,s,i,q))*x1a(c,s,i,q) +
        sum{r,MARGCOM, V1MAR(c,s,i,q,r)*x1marg(c,s,i,q,r)}}}}};

Equation E_cont_GSPINCF # Tax - investment inputs #
(all,q,REGDST)
INITGSP(q)*cont_GSPINC("Tax2",q) =
    sum{c,COM, sum{s,AllSRC, sum{i,IND,
    (V2TAXF(c,s,i,q) + V2TAXS(c,s,i,q))*x2a(c,s,i,q) +
    T2GST(c,s,i,q)/100 * {
        V2BAS(c,s,i,q)*x2a(c,s,i,q) +
        (V2TAXF(c,s,i,q) + V2TAXS(c,s,i,q))*x2a(c,s,i,q) +
        sum{r,MARGCOM, V2MAR(c,s,i,q,r)*x2marg(c,s,i,q,r)}}}}};

Equation E_cont_GSPINCG # Tax - consumption inputs #
(all,q,REGDST)
INITGSP(q)*cont_GSPINC("Tax3",q) =
    sum{c,COM, sum{s,AllSRC,
    T3GST(c,s,q)/100 * {
        V3BAS(c,s,q)*x3a(c,s,q) +
        (V3TAXF(c,s,q) + V3TAXS(c,s,q))*x3a(c,s,q) +
        sum{r,MARGCOM, V3MAR(c,s,q,r)*x3marg(c,s,q,r)}}}};

Equation E_cont_GSPINCH # Tax - exports #
(all,q,REGDST)
INITGSP(q)*cont_GSPINC("Tax4",q) =
    sum{c,COM,
    V4TAXF(c,q)*x4r(c,q) + V0TAR(c,q)*x0imp(c,q) +
    T4GST(c,q)/100 * {
        V4BAS(c,q)*x4r(c,q) +
        V4TAXF(c,q)*x4r(c,q) +
        sum{r,MARGCOM, V4MAR(c,q,r)*x4marg(c,q,r)}}};

Equation E_cont_GSPINCJ # Technological change - direct usage #
(all,q,REGDST)
INITGSP(q)*cont_GSPINC("Techind",q) =
    -[sum{i,IND, COSTS(i,q)*a(i,q)} +
        sum{c,COM, sum{i,IND, V2PURO(c,i,q)*(a2(q) + acom(c,q) + natacom(c))}}];

Equation E_cont_GSPINCK # Technological change - indirect usage #
```

```
(all,q,REGDST)
INITGSP(q)*cont_GSPINC("TechMar",q) = -
[sum{c,COM,
    sum{r,MARGCOM,
        sum{s,ALLSRC,
            sum{i,IND,
(V1MAR(c,s,i,q,r)*(1+T1GST(c,s,i,q)/100))*(a1marg(q,r)+acom(r,q)+natacom(r)) +
(V2MAR(c,s,i,q,r)*(1+T2GST(c,s,i,q)/100))*(a2marg(q,r)+acom(r,q)+natacom(r))} +
[(V3MAR(c,s,q,r)*(1+T3GST(c,s,q)/100))   *(a3marg(q,r)+acom(r,q)+natacom(r)) +
 V5MAR(c,s,q,r)  *(a5marg(q,r) + acom(r,q) + natacom(r)) +
 V6MAR(c,s,q,r)  *(a6marg(q,r) + acom(r,q) + natacom(r))]} +
[(V4MAR(c,q,r)*(1+T4GST(c,q)/100))      *(a4marg(q,r)+acom(r,q)+natacom(r))]}}];
```

4.7.2 Decompositions of commodity sales (TABLO excerpt 7.2)

In this decomposition, sales of each commodity are attributed to their buyers. The sales categories are Intermediate demand, Investment, Households, Exports, Government, Stocks and Margins. The variable cont_NATSALES(c,d) gives the contribution of sales category *d* to national sales of domestically produced commodity *c*, without distinguishing the regional element of the producer or the user. The variable cont_SALES(c,s,d) gives the contribution of sales category *d* to sales of commodity *c* produced in region *s*, without distinguishing the region of the user.

```
! Section 7.2: Decompositions of commodity sales - national and regional
=================================!
Set DEST # Sale categories #
(Interm, Invest, HouseH, Export, Govern, Stocks, Margins, Total);

Variable (change)(all,c,COM)(all,d,DEST)
cont_NATSALES(c,d) # National sales decomposition #;
Coefficient (all,c,COM)
INITNATSALES(c) # Initial volumne of national sales at current prices #;
Formula (initial)(all,c,COM)
INITNATSALES(c) = tiny + sum{q,REGDST, SALES(c,q)};
Update (all,c,COM)
INITNATSALES(c) = natp0a(c);

Equation E_cont_NATSALESA # Intermediate #
(all,c,COM)
INITNATSALES(c)*cont_NATSALES(c,"Interm") =
    sum{s,REGSRC, sum{i,IND, sum{q,REGDST, V1BAS(c,s,i,q)*x1a(c,s,i,q)}}} ;

Equation E_cont_NATSALESB # Investment #
(all,c,COM)
INITNATSALES(c)*cont_NATSALES(c,"Invest") =
    sum{s,REGSRC, sum{i,IND, sum{q,REGDST, V2BAS(c,s,i,q)*x2a(c,s,i,q)}}} ;

Equation E_cont_NATSALESC # HouseH #
(all,c,COM)
INITNATSALES(c)*cont_NATSALES(c,"HouseH") =
    sum{s,REGSRC, sum{q,REGDST, V3BAS(c,s,q)*x3a(c,s,q)}} ;
```

```
Equation E_cont_NATSALESD # Export #
(all,c,COM)
INITNATSALES(c)*cont_NATSALES(c,"Export") =
    sum{s,REGSRC, V4BAS(c,s)*x4r(c,s)} ;

Equation E_cont_NATSALESE # Government #
(all,c,COM)
INITNATSALES(c)*cont_NATSALES(c,"Govern") =
    sum{s,REGSRC, sum{q,REGDST,
                        [V5BAS(c,s,q)*x5a(c,s,q) + V6BAS(c,s,q)*x6a(c,s,q)]}} ;

Equation E_cont_NATSALESF # Stocks #
(all,c,COM)
INITNATSALES(c)*cont_NATSALES(c,"Stocks") =
    sum{s,REGSRC, 100*LEVP7R(c,s)*d_x7r(c,s)};

Equation E_cont_NATSALESHA # Margin #
(all,c,MARGCOM)
INITNATSALES(c)*cont_NATSALES(c,"Margins") =
        sum{i,IND, sum{r,COM, sum{s,ALLSRC, sum{q,REGDST,
V1MAR(r,s,i,q,c)*x1marg(r,s,i,q,c) + V2MAR(r,s,i,q,c)*x2marg(r,s,i,q,c)}}}} +
        sum{r,COM, sum{s,ALLSRC, sum{q,REGDST,
                              [V3MAR(r,s,q,c) *x3marg(r,s,q,c) +
                              V5MAR(r,s,q,c) *x5marg(r,s,q,c) +
                              V6MAR(r,s,q,c) *x6marg(r,s,q,c)]}}} +
                   sum{r,COM, sum{s,REGSRC,
                              V4MAR(r,s,c) *x4marg(r,s,c)}};

Equation E_cont_NATSALESHB # Margin #
(all,c,NONMARGCOM)
INITNATSALES(c)*cont_NATSALES(c,"Margins") = 0*natp3tot;

Equation E_cont_NATSALESI # Total #
(all,c,COM)
INITNATSALES(c)*cont_NATSALES(c,"Total") =
                                    sum{s,REGSRC, SALES(c,s)*x0com_i(c,s)};


Variable (change)(all,c,COM)(all,s,REGSRC)(all,d,DEST)
cont_SALES(c,s,d) # Sales decomposition #;
Coefficient (all,c,COM)(all,s,REGSRC)
INITSALES(c,s) # Initial volumne of sales at current prices #;
Formula (initial)(all,c,COM)(all,s,REGSRC)
INITSALES(c,s) = tiny + SALES(c,s);
Update (all,c,COM)(all,s,REGSRC)
INITSALES(c,s) = p0a(c,s);

Equation E_cont_SALESA # Intermediate #
(all,c,COM)(all,s,REGSRC)
INITSALES(c,s)*cont_SALES(c,s,"Interm") =
```

```
    sum{i,IND, sum{q,REGDST, V1BAS(c,s,i,q)*x1a(c,s,i,q)}} ;

Equation E_cont_SALESB # Investment #
(all,c,COM)(all,s,REGSRC)
INITSALES(c,s)*cont_SALES(c,s,"Invest") =
    sum{i,IND, sum{q,REGDST, V1BAS(c,s,i,q)*x2a(c,s,i,q)}} ;

Equation E_cont_SALESC # HouseH #
(all,c,COM)(all,s,REGSRC)
INITSALES(c,s)*cont_SALES(c,s,"HouseH") =
    sum{q,REGDST, V3BAS(c,s,q)*x3a(c,s,q)} ;

Equation E_cont_SALESD # Export #
(all,c,COM)(all,s,REGSRC)
INITSALES(c,s)*cont_SALES(c,s,"Export") = V4BAS(c,s)*x4r(c,s) ;

Equation E_cont_SALESE # Government #
(all,c,COM)(all,s,REGSRC)
INITSALES(c,s)*cont_SALES(c,s,"Govern") =
    sum{q,REGDST, [V5BAS(c,s,q)*x5a(c,s,q) + V6BAS(c,s,q)*x6a(c,s,q)]} ;

Equation E_cont_SALESF # Stocks #
(all,c,COM)(all,s,REGSRC)
INITSALES(c,s)*cont_SALES(c,s,"Stocks") = 100*LEVP7R(c,s)*d_x7r(c,s);

Equation E_cont_SALESHA # Margin #
(all,c,MARGCOM)(all,s,REGSRC)
INITSALES(c,s)*cont_SALES(c,s,"Margins") =
        sum{i,IND, sum{r,COM, sum{ss,ALLSRC,
V1MAR(r,ss,i,s,c)*x1marg(r,ss,i,s,c) + V2MAR(r,ss,i,s,c)*x2marg(r,ss,i,s,c)}}} +
                   sum{r,COM, sum{ss,ALLSRC,
                            [V3MAR(r,ss,s,c) *x3marg(r,ss,s,c) +
                             V5MAR(r,ss,s,c) *x5marg(r,ss,s,c) +
                             V6MAR(r,ss,s,c) *x6marg(r,ss,s,c)]}} +
                   sum{r,COM, V4MAR(r,s,c) *x4marg(r,s,c)};

Equation E_cont_SALESHB # Margin #
(all,c,NONMARGCOM)(all,s,REGSRC)
INITSALES(c,s)*cont_SALES(c,s,"Margins") = 0*natp3tot;

Equation E_cont_SALESI # Total #
(all,c,COM)(all,s,REGSRC)
INITSALES(c,s)*cont_SALES(c,s,"Total") = SALES(c,s)*x0com_i(c,s);
```

4.7.3 Fan decomposition of commodity output (TABLO excerpt 7.3)

The Fan decomposition attributes a change in sales to three factors. Firstly, growth in the local market for commodity c will lead to an increase in sales of both domestic and imported commodity c. Secondly, sales of commodity c will be affected by a change in import penetration, or the share of domestic production in the consumption of commodity c. Thirdly, sales will be affected by exports. That is, SALES(c) = DOMSHR(c) * LOCSALES(c) + EXPORT(c) (4.62).

In change form,

dSALES(c) = dDOMSHR(c) . LOCSALES(c) + dLOCSALES(c) . DOMSHR(c) + d_EXPORT(c)

(4.63).

Dividing through by the initial value of SALES(c), the contributions of these sources of change are respectively,

- the local market effect, or dDOMSHR(c) . LOCSALES(c)/SALES0(c);
- the domestic market share effect, or locsales(c) * (SALES(c)-EXPORT(c))/SALES0(c); and
- the export effect, or export(c) * EXPORT(c)/SALES0(c)

where lowercase represents percentage change and SALES0(c) is the initial value of SALES(c).

```
! Section 7.3: Fan decomposition of commodity output - national and regional
==================================!
Set NATFAN # Fan categories at national level #
(LocalMarket, DomShare, Export, Total);

Variable (change)(all,c,COM)(all,f,NATFAN)
cont_NATFAN(c,f) # National Fan Decomposition  #;
Variable (all,c,COM)
natx0loc(c) # Growth in national market (dom + imp) #;
Variable (change)(all,c,COM)
d_natx0dom(c) # Growth in national domestic sales of domestic product #;

Coefficient (all,c,COM)
NATDOMSALES(c) # Total national domestic sales of domestic product #;
Formula (all,c,COM)
NATDOMSALES(c) = tiny + sum{s,REGSRC, SALES(c,s) - V4BAS(c,s)};

Coefficient (all,c,COM)
NATLOCSALES(c) # Total national sales of domestic and imported product #;
Formula (all,c,COM)
NATLOCSALES(c) = NATDOMSALES(c) + NATV0IMP(c);

Equation E_d_natx0dom # Growth in domestic sales of domestic product #
(all,c,COM)
100*d_natx0dom(c) =
    sum{s,REGSRC, SALES(c,s)*x0com_i(c,s) - V4BAS(c,s)*x4r(c,s)};

Equation E_natx0loc # Growth national market #
(all,c,COM)
NATLOCSALES(c)*natx0loc(c) =
    100*d_natx0dom(c) + sum{s,REGSRC, V0IMP(c,s)*x0imp(c,s)};

Equation E_cont_NATFANA # Local market effect #
(all,c,COM)
INITNATSALES(c)*cont_NAtFAN(c,"LocalMarket") = NATDOMSALES(c)*natx0loc(c);
```

```
Equation E_cont_NATFANB # Export effect #
(all,c,COM)
INITNATSALES(c)*cont_NATFAN(c,"Export") = sum{s,REGSRC, V4BAS(c,s)*x4r(c,s)};

Equation E_cont_NATFANC # Dom share #
(all,c,COM)
cont_NATFAN(c,"DomShare") =
cont_NATFAN(c,"Total") - cont_NATFAN(c,"LocalMarket") - cont_NATFAN(c,"Export");

Equation E_cont_NATFAND # Total #
(all,c,COM)
INITNATSALES(c)*cont_NATFAN(c,"Total") = sum{s,REGSRC, SALES(c,s)*x0com_i(c,s)};


Set FAN # Fan categories at regional level #
(LocalMarket, ExportFOR, ExportINT, DomShrFOR, DomShrINT,  Total);

Variable (change)(all,c,COM)(all,s,REGSRC)(all,f,FAN)
cont_FAN(c,s,f) # Fan decomposition at regional level  #;
Variable (all,c,COM)(All,s,REGSRC)
x0loc(c,s) # Growth in regional market (dom + imp) #;
Variable (change)(all,c,COM)(all,s,REGSRC)
d_x0dom(c,s) # Growth in regional sales of regional product #;

Coefficient (all,c,COM)(all,s,REGSRC)
DOMSALES(c,s) # Total local sales of local product #;
Formula (all,c,COM)(all,s,REGSRC)
DOMSALES(c,s) = tiny + SALES(c,s) - V4BAS(c,s) -
                            [sum{q,REGDST, VSFLO(c,s,q)} - VSFLO(c,s,s)];

Coefficient (all,c,COM)(all,s,REGSRC)
LOCSALES(c,s) # Total regional sales of domestic and imported product #;
Formula (all,c,COM)(all,s,REGSRC)
LOCSALES(c,s) = tiny + DOMSALES(c,s) + V0IMP(c,s) +
                            [sum{q,REGDST, VSFLO(c,q,s)} - VSFLO(c,s,s)];

Equation E_d_x0dom # Growth in regional sales of regional product #
(all,c,COM)(all,s,REGSRC)
100*d_x0dom(c,s) =
    SALES(c,s)*x0com_i(c,s) - V4BAS(c,s)*x4r(c,s) -
    [sum{q,REGDST, VSFLO(c,s,q)*xsflo(c,s,q)} - VSFLO(c,s,s)*xsflo(c,s,s)];

Equation E_x0loc # Growth in regional market #
(all,c,COM)(all,s,REGSRC)
LOCSALES(c,s)*x0loc(c,s) =
    100*d_x0dom(c,s) + V0IMP(c,s)*x0imp(c,s) +
    [sum{q,REGDST, VSFLO(c,q,s)*xsflo(c,q,s)} - VSFLO(c,s,s)*xsflo(c,s,s)];

Equation E_cont_FANA # Local market effect #
(all,c,COM)(all,s,REGSRC)
```

```
INITSALES(c,s)*cont_FAN(c,s,"LocalMarket") = 0*natp3tot +
IF(INITSALES(c,s) gt 0.001,
    DOMSALES(c,s)*x0loc(c,s) );

Equation E_cont_FANB # Foreign export effect #
(all,c,COM)(all,s,REGSRC)
INITSALES(c,s)*cont_FAN(c,s,"ExportFor") = 0*natp3tot +
IF(INITSALES(c,s) gt 0.001,
    V4BAS(c,s)*x4r(c,s) );

Equation E_cont_FANC # Interstate export effect #
(all,c,COM)(all,s,REGSRC)
INITSALES(c,s)*cont_FAN(c,s,"ExportINT") = 0*natp3tot +
IF(INITSALES(c,s) gt 0.001,
    [sum{q,REGDST, VSFLO(c,s,q)*xsflo(c,s,q)} - VSFLO(c,s,s)*xsflo(c,s,s)] );

Equation E_cont_FAND # Domestic share - inter-state import pressure #
(all,c,COM)(all,s,REGSRC)
INITSALES(c,s)*cont_FAN(c,s,"DomShrINT") = 0*natp3tot +
IF(INITSALES(c,s) gt 0.001,
    -[sum{q,REGDST, VSFLO(c,q,s)*xsflo(c,q,s)} - VSFLO(c,s,s)*xsflo(c,s,s)] );

Equation E_cont_FANE # Domestic share - foreign import pressure #
(all,c,COM)(All,s,REGSRC)
cont_FAN(c,s,"DomShrFOR") =
    cont_FAN(c,s,"Total") - cont_FAN(c,s,"DomShrINT") -
    cont_FAN(c,s,"ExportFOR") - cont_FAN(c,s,"ExportINT");

Equation E_cont_FANF # Total #
(all,c,COM)(all,s,REGSRC)
INITSALES(c,s)*cont_FAN(c,s,"Total") = 0*natp3tot +
IF(INITSALES(c,s) gt 0.001,
    SALES(c,s)*x0com_i(c,s) );
```

4.7.4 Reporting Variables (TABLO excerpt 8)

Reporting variables are simply useful summary measures that have no impact on model results. Variables calculated in this section include:

Absolute changes in important percentage change variables. The correct interpretation for these terms is dollar value changes in the prices of the base year;

Regional aggregation. The mapping given in this version of MMRF is for Victoria and the Rest of Australia, but this can easily be changed;[28] and

Useful summary tables based on the initial (pre-simulation) data for each year. These may be viewed in the CHECK header array file after a simulation has been run successfully, and include:

- Cost shares faced by industries;

[28] For an explanation of the TABLO mapping syntax, readers are referred to the GEMPACK documentation.

- Sales shares for all commodities;
- The income and expenditure elements of GDP and GSP;
- Matrix of household income and taxation;
- Input Output table in basic prices;
- Summary of the Balance of Payments accounts; and
- Summary of the demographic variables population, working age population, employment, unemployment, unemployment rate and labour supply.

```
! PART 8: REPORTING VARIABLES AND COEFFICIENTS
=================================!

! This module contains code for variables and coefficients used for reporting !

! Section 8.1: Absolute changes in important percentage-change variables.
=================================!
! The following code is arranged in self-contained blocks. Each block contains
   a coefficient declaration, followed by read and update statements. Then
   follows the variable declaration and associated equation. !

Coefficient (all,q,REGDST)
VOL_C(q);
Read VOL_C from file YDATA header "VCON";
Update (all,q,REGDST)
VOL_C(q) = x3tot(q);
Variable (change)(all,q,REGDST)
d_x3tot(q) # Ordinary change in real household consumption #;
Equation E_d_x3tot
(all,q,REGDST)
100*d_x3tot(q) = VOL_C(q)*x3tot(q);

Coefficient (all,q,REGDST)
VOL_OTH5(q);
Read VOL_OTH5 from file YDATA header "VOT5";
Update (all,q,REGDST)
VOL_OTH5(q) = x5tot(q);
Variable (change)(all,q,REGDST)
d_x5tot(q) # Ordinary change in real government consumption - Regional #;
Equation E_d_x5tot
(all,q,REGDST)
100*d_x5tot(q) = VOL_OTH5(q)*x5tot(q);

Coefficient (all,q,REGDST)
VOL_OTH6(q);
Read VOL_OTH6 from file YDATA header "VOT6";
Update (all,q,REGDST)
VOL_OTH6(q) = x6tot(q);
Variable (change)(all,q,REGDST)
d_x6tot(q) # Ordinary change in real government consumption - Federal #;
Equation E_d_x6tot
```

```
(all,q,REGDST)
100*d_x6tot(q) = VOL_OTH6(q)*x6tot(q);

Coefficient (all,q,REGDST)
VOL_INV(q);
Read VOL_INV from file YDATA header "VINV";
Update (all,q,REGDST)
VOL_INV(q) = x2tot_i(q);
Variable (change)(all,q,REGDST)
d_x2tot_i(q) # Ordinary change in real investment #;
Equation E_d_x2tot_i
(all,q,REGDST)
100*d_x2tot_i(q) = VOL_INV(q)*x2tot_i(q);

Coefficient (all,q,REGSRC)
VOL_XS4(q);
Read VOL_XS4 from file YDATA header "VXS4";
Update (all,q,REGSRC)
VOL_XS4(q) = xsexp_c(q);
Variable (change)(all,q,REGDST)
d_xs4(q) # Ordinary change in real inter-state exports #;
Equation E_d_xs4
(all,q,REGDST)
100*d_xs4(q) = VOL_XS4(q)*xsexp_c(q);

Coefficient (all,q,REGDST)
VOL_XSM(q);
Read VOL_XSM from file YDATA header "VXSM";
Update (all,q,REGDST)
VOL_XSM(q) = xsimp_c(q);
Variable (change) (all,q,REGDST)
d_xsm(q) # Ordinary change in real inter-state imports #;
Equation E_d_xsm
(all,q,REGDST)
100*d_xsm(q) = VOL_XSM(q)*xsimp_c(q);

Coefficient (all,q,REGSRC)
VOL_X4(q);
Read VOL_X4 from file YDATA header "VXX4";
Update (all,q,REGSRC)
VOL_X4(q) = x4tot(q);
Variable (change) (all,q,REGDST)
d_x4tot(q) # Ordinary change in real international exports #;
Equation E_d_x4tot
(all,q,REGDST)
100*d_x4tot(q) = VOL_X4(q)*x4tot(q);

Coefficient (all,q,REGDST)
VOL_XM(q);
Read VOL_XM from file YDATA header "VXXM";
Update (all,q,REGDST)
```

```
VOL_XM(q) = x0cif_c(q);
Variable (change)(all,q,REGDST)
d_x0cif_c(q) # Ordinary change in real interational imports #;
Equation E_d_x0cif_c
(all,q,REGDST)
100*d_x0cif_c(q) = VOL_XM(q)*x0cif_C(q);

Coefficient (all,q,REGDST)
VOL_GSP(q);
Read VOL_GSP from file YDATA header "VGDP";
Update (all,q,REGDST)
VOL_GSP(q) = x0gspexp(q);
Variable (change)(all,q,REGDST)
d_GSP(q) # Ordinary change in real GSP #;
Equation E_d_gsp
(all,q,REGDST)
100*d_gsp(q) = VOL_GSP(q)*x0gspexp(q);

Variable (change)(all,q,REGDST)
d_x1emp_i(q) # Ordianry change in number of people employed #;
Equation E_d_x1emp_i
(all,q,REGDST)
100*d_x1emp_i(q) = EMPLOY_IO(q)*x1emp_io(q);

Variable (change)(all,i,IND)(all,q,REGDST)
d_x1emp(i,q) # Ordianry change in number of people employed #;
Equation E_d_x1emp
(all,i,IND)(all,q,REGDST)
100*d_x1emp(i,q) = EMPLOY_O(i,q)*x1emp_o(i,q);

! Section 8.2: Aggregation across regions for reporting variables
=================================!
Set AGGREG # Aggregated regions # (VIC, ROA);

Coefficient (all,q,AGGREG)
ORD2(q);
Coefficient (all,q,REGDST)
MAP8_2(q);

Formula
ORD2("VIC")    = 1.0;
ORD2("ROA")   = 2.0;
MAP8_2("NSW") = 2.0;
MAP8_2("VIC") = 1.0;
MAP8_2("QLD") = 2.0;
MAP8_2("SA")  = 2.0;
MAP8_2("WA")  = 2.0;
MAP8_2("TAS") = 2.0;
MAP8_2("ACT") = 2.0;
MAP8_2("NT")  = 2.0;
```

```
Variable (all,s,AGGREG)
agg_x3tot(s) # Aggregated real private consumption  #;
Variable (change)(all,s,AGGREG)
d_agg_x3tot(s) # Change in aggregated real consumption #;
Variable (all,s,AGGREG)
agg_x5tot(s) # Aggregated real public consumption - regional government  #;
Variable (change)(all,s,AGGREG)
d_agg_x5tot(s) # Change in aggregated real public consumption - reg gov #;
Variable (all,s,AGGREG)
agg_x6tot(s) # Aggregated real public consumption - federal government  #;
Variable (change)(all,s,AGGREG)
d_agg_x6tot(s) # Change in aggregated real public consumption - fed gov #;
Variable (all,s,AGGREG)
agg_x2tot(s) # Aggregated real investment #;
Variable (change)(all,s,AGGREG)
d_agg_x2tot(s) # Change in aggregated real investment #;
Variable (all,s,AGGREG)
agg_xs4(s) # Aggregated real interstate exports #;
Variable (change)(all,s,AGGREG)
d_agg_xs4(s) # Change in aggregated real interstate exports #;
Variable (all,s,AGGREG)
agg_xsm(s) # Aggregated real interstate imports #;
Variable (change)(all,s,AGGREG)
d_agg_xsm(s) # Change in aggregated real interstate imports #;
Variable (all,s,AGGREG)
agg_x4tot(s) # Aggregated real international exports #;
Variable (change)(all,s,AGGREG)
d_agg_x4tot(s) # Change in aggregated real international exports #;
Variable (all,s,AGGREG)
agg_x0cif(s) # Aggregated real international imports #;
Variable (change)(all,s,AGGREG)
d_agg_x0cif(s) # Change in aggregated real international imports #;
Variable (all,s,AGGREG)
agg_gsp(s) # Aggregated real GDP #;
Variable (change)(all,s,AGGREG)
d_agg_gsp(s) # Change in aggregated real GDP #;
Variable (all,s,AGGREG)
agg_emp(s) # Aggregated employment - person weights #;
Variable (change)(all,s,AGGREG)
d_agg_emp(s) # Change in aggregated employment - person weights #;

Equation E_agg_x3tot # Aggregate real household consumption #
(all,s,AGGREG)
Sum{q,REGDST:MAP8_2(q)=ORD2(s),
            V3TOT(q)*(x3tot(q) - agg_x3tot(s))} = 0;

Equation E_d_agg_x3tot # Change in aggregate real household consumption #
(all,s,AGGREG)
Sum{q,REGDST:MAP8_2(q)=ORD2(s), d_x3tot(q)} = d_agg_x3tot(s);

Equation E_agg_x5tot # Aggregate real regional government consumption #
```

```
(all,s,AGGREG)
Sum{q,REGDST:MAP8_2(q)=ORD2(s),
            V5TOT(q)*(x5tot(q) - agg_x5tot(s))} = 0;

Equation E_d_agg_x5tot # Change in aggegate real reg government consumption #
(all,s,AGGREG)
Sum{q,REGDST:MAP8_2(q)=ORD2(s), d_x5tot(q)} = d_agg_x5tot(s);

Equation E_agg_x6tot # Aggregate real federal government consumption #
(all,s,AGGREG)
Sum{q,REGDST:MAP8_2(q)=ORD2(s),
            V6TOT(q)*(x6tot(q) - agg_x6tot(s))} = 0;

Equation E_d_agg_x6tot # Change in aggegate real fed government consumption #
(all,s,AGGREG)
Sum{q,REGDST:MAP8_2(q)=ORD2(s), d_x6tot(q)} = d_agg_x6tot(s);

Equation E_agg_x2tot # Aggregate real investment #
(all,s,AGGREG)
Sum{q,REGDST:MAP8_2(q)=ORD2(s),
            V2TOT_I(q)*(x2tot_i(q) - agg_x2tot(s))} = 0;

Equation E_d_agg_x2tot # Change in aggegate real investment #
(all,s,AGGREG)
Sum{q,REGDST:MAP8_2(q)=ORD2(s), d_x2tot_i(q)} = d_agg_x2tot(s);

Equation E_agg_xs4 # Aggregate real inter-state exports #
(all,s,AGGREG)
Sum{q,REGSRC:MAP8_2(q)=ORD2(s),
            VSEXP_C(q)*(xsexp_c(q) - agg_xs4(s))} = 0;

Equation E_d_agg_xs4 # Change in aggregate real inter_state exports #
(all,s,AGGREG)
Sum{q,REGSRC:MAP8_2(q)=ORD2(s), d_xs4(q)} = d_agg_xs4(s);

Equation E_agg_xsm # Aggregate real inter-state imports #
(all,s,AGGREG)
Sum{q,REGSRC:MAP8_2(q)=ORD2(s),
            VSIMP_C(q)*(xsimp_c(q) - agg_xsm(s))} = 0;

Equation E_d_agg_xsm # Change in aggregate real inter_state imports #
(all,s,AGGREG)
Sum{q,REGSRC:MAP8_2(q)=ORD2(s), d_xsm(q)} = d_agg_xsm(s);

Equation E_agg_x4tot # Aggregate real foreign exports #
(all,s,AGGREG)
Sum{q,REGDST:MAP8_2(q)=ORD2(s),
            V4TOT(q)*(x4tot(q) - agg_x4tot(s))} = 0;

Equation E_d_agg_x4tot # Change in aggegate real foreign exports #
(all,s,AGGREG)
```

```
Sum{q,REGDST:MAP8_2(q)=ORD2(s), d_x4tot(q)} = d_agg_x4tot(s);

Equation E_agg_x0cif # Aggregate real foreign imports #
(all,s,AGGREG)
Sum{q,REGDST:MAP8_2(q)=ORD2(s),
            V0CIF_C(q)*(x0cif_c(q) - agg_x0cif(s))} = 0;

Equation E_d_agg_x0cif # Change in aggegate real foreign imports #
(all,s,AGGREG)
Sum{q,REGDST:MAP8_2(q)=ORD2(s), d_x0cif_c(q)} = d_agg_x0cif(s);

Equation E_agg_gsp # Aggregate real GSP #
(all,s,AGGREG)
Sum{q,REGDST:MAP8_2(q)=ORD2(s),
            V0GSPEXP(q)*(x0gspexp(q) - agg_gsp(s))} = 0;

Equation E_d_agg_gsp # Change in aggegate real GSP #
(all,s,AGGREG)
Sum{q,REGDST:MAP8_2(q)=ORD2(s), d_gsp(q)} = d_agg_gsp(s);

Equation E_agg_emp # Aggregate employment (persons) #
(all,s,AGGREG)
Sum{q,REGDST:MAP8_2(q)=ORD2(s),
            EMPLOY_IO(q)*(x1emp_io(q) - agg_emp(s))} = 0;

Equation E_d_agg_emp # Change in aggegate employment (persons) #
(all,s,AGGREG)
Sum{q,REGDST:MAP8_2(q)=ORD2(s), d_x1emp_i(q)} = d_agg_emp(s);

! Section 8.3: Aggregation across regions of household income variables
==================================!
Variable
natwhinc_000 # HINC: Total #;
Variable
natwhinc_100 # HINC: Factor income #;
Variable
natwhinc_110 # HINC: Factor income - individuals #;
Variable
natwhinc_120 # HINC: Factor income - enterprises #;
Variable
natwhinc_200 # HINC: Personal benefit payments #;
Variable
natwhinc_210 # HINC: Personal benefit payments - unemployment benefits #;
Variable
natwhinc_220 # HINC: Personal benefit payments - disability support pension #;
Variable
natwhinc_230 # HINC: Personal benefit payments - age pension #;
Variable
natwhinc_240 # HINC: Personal benefit payments - other #;
Variable
natwhinc_300 # HINC: Other income #;
```

```
Variable (change)
d_natwhinc_400 # Exogenous change in household income #;
Variable (change)
d_natwhinc_500 # Government handbacks #;
Variable
natwhtax_000 # HTAX: Total #;
Variable
natwhtax_100 # HTAX: Tax on income #;
Variable
natwhtax_110 # HTAX: Tax on income - labour #;
Variable
natwhtax_120 # HTAX: Tax on income - non-labour #;

Equation E_natwhinc_000
sum{q,REGDST, VHINC_000(q)}*natwhinc_000 =
    sum{q,REGDST, VHINC_000(q)*whinc_000(q)};
Equation E_natwhinc_100
sum{q,REGDST, VHINC_100(q)}*natwhinc_100 =
    sum{q,REGDST, VHINC_100(q)*whinc_100(q)};
Equation E_natwhinc_110
sum{q,REGDST, VHINC_110(q)}*natwhinc_110 =
    sum{q,REGDST, VHINC_110(q)*whinc_110(q)};
Equation E_natwhinc_120
sum{q,REGDST, VHINC_120(q)}*natwhinc_120 =
    sum{q,REGDST, VHINC_120(q)*whinc_120(q)};
Equation E_natwhinc_200
sum{q,REGDST, VHINC_200(q)}*natwhinc_200 =
    sum{q,REGDST, VHINC_200(q)*whinc_200(q)};
Equation E_natwhinc_210
sum{q,REGDST, VHINC_210(q)}*natwhinc_210 =
    sum{q,REGDST, VHINC_210(q)*whinc_210(q)};
Equation E_natwhinc_220
sum{q,REGDST, VHINC_220(q)}*natwhinc_220 =
    sum{q,REGDST, VHINC_220(q)*whinc_220(q)};
Equation E_natwhinc_230
sum{q,REGDST, VHINC_230(q)}*natwhinc_230 =
    sum{q,REGDST, VHINC_230(q)*whinc_230(q)};
Equation E_natwhinc_240
sum{q,REGDST, VHINC_240(q)}*natwhinc_240 =
    sum{q,REGDST, VHINC_240(q)*whinc_240(q)};
Equation E_natwhinc_300
ID01[sum{q,REGDST, VHINC_300(q)}]*natwhinc_300 =
    sum{q,REGDST, VHINC_300(q)*whinc_300(q)};
Equation E_d_natwhinc_400
d_natwhinc_400 = sum{q,REGDST, d_whinc_400(q)};
Equation E_d_natwhinc_500
d_natwhinc_500 = sum{q,REGDST, d_whinc_500(q)};
Equation E_natwhtax_000
sum{q,REGDST, VHTAX_000(q)}*natwhtax_000 =
    sum{q,REGDST, VHTAX_000(q)*whtax_000(q)};
Equation E_natwhtax_100
```

```
sum{q,REGDST, VHTAX_100(q)}*natwhtax_100 =
    sum{q,REGDST, VHTAX_100(q)*whtax_100(q)};
Equation E_natwhtax_110
sum{q,REGDST, VHTAX_110(q)}*natwhtax_110 =
    sum{q,REGDST, VHTAX_110(q)*whtax_110(q)};
Equation E_natwhtax_120
sum{q,REGDST, VHTAX_120(q)}*natwhtax_120 =
    sum{q,REGDST, VHTAX_120(q)*whtax_120(q)};

! Section 8.4: Database Summary
=================================!
! Subsection 8.4.1: Cost shares
---------------------------------!
Set COSTCAT # Cost Categories #
(IntOZ, IntImp, Margin, IndTax, Labour, Capital, Land, OtherCost);

Coefficient (all,i,IND)(all,co,COSTCAT)(all,q,REGDST)
COSTMAT(i,co,q) # Matrix of costs #;

Formula (all,q,REGDST) (All,i,IND)
COSTMAT(i,"IntOZ",q) = sum{c,COM, sum{s,REGSRC, V1BAS(c,s,i,q)}};
Formula (all,q,REGDST)(All,i,IND)
COSTMAT(i,"IntImp",q) = sum{c,COM, V1BAS(c,"Imp",i,q)};
Formula (all,q,REGDST)(all,i,IND)
COSTMAT(i,"Margin",q) =
sum{c,COM, sum{s,ALLSRC, sum{r,MARGCOM, V1MAR(c,s,i,q,r)}}};
Formula (all,q,REGDST)(all,i,IND)
COSTMAT(i,"IndTax",q) =
sum{c,COM, sum{s,ALLSRC, [V1TAXF(c,s,i,q) + V1TAXS(c,s,i,q) + V1GST(c,s,i,q)]}};
Formula (all,q,REGDST)(all,i,IND)
COSTMAT(i,"Labour",q) = sum{m,OCC, V1LAB(i,q,m)};
Formula (all,q,REGDST)(all,i,IND)
COSTMAT(i,"Capital",q) = V1CAP(i,q);
Formula (all,q,REGDST)(all,i,IND)
COSTMAT(i,"Land",q) = V1LND(i,q);
Formula(all,q,REGDST)(all,i,IND)
COSTMAT(i,"OtherCost",q) = V1OCT(i,q);

Write COSTMAT to file CHECK header "COSL" Longname "Costs ($m) Matrix";

Formula (all,q,REGDST)(all,i,IND)(all,co,COSTCAT)
COSTMAT(i,co,q) = 100*COSTMAT(i,co,q)/ID01(COSTS(i,q));

Write COSTMAT to file CHECK header "COSS" Longname "Costs (%) Matrix";

! Subsection 8.4.2: Sales Shares
---------------------------------!
Set SALECAT # SALE Categories #
(Interm, Invest, HouseH, Export, GovReg, GovFed, Stocks);

Coefficient (all,c,COM)(all,sa,SALECAT)(all,s,REGSRC)
```

```
SALEMAT(c,sa,s) # Matrix of Sales #;

Formula (all,s,REGSRC)(all,c,NONMARGCOM)
SALEMAT(c,"Interm",s) = sum(i,IND, sum(q,REGDST, V1BAS(c,s,i,q)));
Formula (all,s,REGSRC)(all,r,MARGCOM)
SALEMAT(r,"Interm",s) = sum(i,IND, sum(q,REGDST, V1BAS(r,s,i,q))) +
       Sum(c,COM, sum(ss,ALLSRC, Sum(i,IND, V1MAR(c,ss,i,s,r))));
Formula (all,s,REGSRC)(all,c,COM)
SALEMAT(c,"Invest",s) = sum(i,IND, sum(q,REGDST, V2BAS(c,s,i,q)));
Formula (all,q,REGDST)(all,r,MARGCOM)
SALEMAT(r,"Invest",q) = SALEMAT(r,"Invest",q) +
        sum(c,COM, sum(s,ALLSRC, sum(i,IND, V2MAR(c,s,i,q,r))));
Formula (all,s,REGSRC)(all,c,COM)
SALEMAT(c,"HouseH",s) = sum(q,REGDST, V3BAS(c,s,q));
Formula (all,q,REGDST)(all,r,MARGCOM)
SALEMAT(r,"HouseH",q) = SALEMAT(r,"HouseH",q) +
        sum(c,COM, sum(s,ALLSRC, V3MAR(c,s,q,r)));
Formula (all,q,REGDST)(all,c,COM)
SALEMAT(c,"Export",q) = V4BAS(c,q);
Formula (all,q,REGDST)(all,r,MARGCOM)
SALEMAT(r,"Export",q) = SALEMAT(r,"Export",q) + sum(c,COM, V4MAR(c,q,r));

Formula (all,s,REGSRC)(all,c,COM)
SALEMAT(c,"GovReg",s) = sum(q,REGDST, V5BAS(c,s,q));
Formula (all,q,REGDST)(all,r,MARGCOM)
SALEMAT(r,"GovReg",q) = SALEMAT(r,"GovReg",q) +
        sum(c,COM, sum(s,ALLSRC, V5MAR(c,s,q,r)));
Formula (all,s,REGSRC)(all,c,COM)
SALEMAT(c,"GovFed",s) = sum(q,REGDST, V6BAS(c,s,q));
Formula (all,q,REGDST)(all,r,MARGCOM)
SALEMAT(r,"GovFed",q) = SALEMAT(r,"GovFed",q) +
        sum(c,COM, sum(s,ALLSRC, V6MAR(c,s,q,r)));
Formula (all,s,REGSRC)(all,c,COM)
SALEMAT(c,"Stocks",s) = V7BAS(c,s);

Write SALEMAT to file CHECK header "SALL" Longname "Sales ($m) Matrix";

Formula (all,c,COM)(all,s,REGSRC)(all,sl,SALECAT)
SALEMAT(c,sl,s) = 100*SALEMAT(c,sl,s)/ID01(SALES(c,s));

Write SALEMAT to file CHECK header "SALS" Longname "Sales (%) Matrix";

! Subsection 8.4.3: Elements of GDP/GSP
---------------------------------!
Set ExpElements # Elements of expenditure-side GDP at market prices #
(C, I, GS, GF, delS, XF, MF, XD, MD);

Set IncElements # Elements of income-side GDP at market prices #
(Labour, Capital, Land, OtherCosts, Tax1, Tax2, Tax3, Tax4, GST, TAR);

Coefficient (all,e,ExpElements)(all,q,REGDST)
```

```
GSPEParts(e,q) # Elements of GSP at market prices from the expenditure side #;
Coefficient (all,e,ExpElements)
GDPEParts(e) # Elements of GDP at market prices from the expenditure side #;

Formula (all,q,REGDST)
GSPEParts("C",q) = V3TOT(q);
Formula (all,q,REGDST)
GSPEParts("I",q) = V2TOT_I(q);
Formula (all,q,REGDST)
GSPEParts("GS",q) = V5TOT(q);
Formula (all,q,REGDST)
GSPEParts("GF",q) = V6TOT(q);
Formula (all,q,REGDST)
GSPEParts("delS",q) = V7TOT(q);
Formula (all,q,REGDST)
GSPEParts("XD",q) = VSEXP_C(q);
Formula (all,q,REGDST)
GSPEParts("MD",q) = -VSIMP_C(q);
Formula (all,q,REGDST)
GSPEParts("XF",q) = V4TOT(q);
Formula (all,q,REGDST)
GSPEParts("MF",q) =  -V0CIF_C(q);
Formula (all,e,ExpElements)
GDPEParts(e) = sum{q,REGDST, GSPEParts(e,q)};

Coefficient (all,i,IncElements)(all,q,REGDST)
GSPIParts(i,q) # Elements of GSP at market prices from the income side #;
Coefficient (all,i,IncElements)
GDPIParts(i) # Elements of GDP at market prices from the income side #;

Formula (all,q,REGDST)
GSPIParts("Labour",q) = V1LAB_io(q);
Formula (all,q,REGDST)
GSPIParts("Capital",q) = V1CAP_I(q);
Formula (all,q,REGDST)
GSPIParts("Land",q) = V1LND_I(q);
Formula (all,q,REGDST)
GSPIParts("OtherCosts",q) = V1OCT_I(q);
Formula (all,q,REGDST)
GSPIParts("Tax1",q) = V1TAXF_CSI(q) + V1TAXS_CSI(q);
Formula (all,q,REGDST)
GSPIParts("Tax2",q) = V2TAXF_CSI(q) + V2TAXS_CSI(q);
Formula (all,q,REGDST)
GSPIParts("Tax3",q) = V3TAXF_CS(q) + V3TAXS_CS(q);
Formula (all,q,REGDST)
GSPIParts("Tax4",q) = V4TAXF_C(q);
Formula (all,q,REGDST)
GSPIParts("GST",q) = V1GST_CSI(q) + V2GST_CSI(q) + V3GST_CS(q) + V4GST_C(q);
Formula (all,q,REGDST)
GSPIParts("TAR",q) = sum{c,COM, V0TAR(c,q)};
Formula (all,i,IncElements)
```

```
GDPIParts(i) = sum{q,REGDST, GSPIParts(i,q)};

Write GSPEParts to file CHECK header "GSPE";
Write GDPEParts to file CHECK header "GDPE";
Write GSPIParts to file CHECK header "GSPI";
Write GDPIParts to file CHECK header "GDPI";

! Subsection 8.4.4: Elements of Household Disposable Income
---------------------------------!
Set HINC # Elements of Household Income #
(H000,H100,H110,H120,H200,H210,H220,H230,H240,H300,H400,H500);

Set HTAX # Elements of Taxation #
(T000,T100,T110,T120);

Coefficient (all,i,HINC)(all,q,REGDST)
HOUSEINC(i,q) # Elements of Household Income #;
Formula (all,i,HINC)(all,q,REGDST)
HOUSEINC(i,q) = 0;
Formula (all,q,REGDST)
HOUSEINC("H000",q) = VHINC_000(q);
Formula (all,q,REGDST)
HOUSEINC("H100",q) = VHINC_100(q);
Formula (all,q,REGDST)
HOUSEINC("H110",q) = VHINC_110(q);
Formula (all,q,REGDST)
HOUSEINC("H120",q) = VHINC_120(q);
Formula (all,q,REGDST)
HOUSEINC("H200",q) = VHINC_200(q);
Formula (all,q,REGDST)
HOUSEINC("H210",q) = VHINC_210(q);
Formula (all,q,REGDST)
HOUSEINC("H220",q) = VHINC_220(q);
Formula (all,q,REGDST)
HOUSEINC("H230",q) = VHINC_230(q);
Formula (all,q,REGDST)
HOUSEINC("H240",q) = VHINC_240(q);
Formula (all,q,REGDST)
HOUSEINC("H300",q) = VHINC_300(q);
Formula (all,q,REGDST)
HOUSEINC("H400",q)  = VHINC_400(q);
Formula (all,q,REGDST)
HOUSEINC("H500",q)  = VHINC_500(q);

Coefficient (all,t,HTAX)(all,q,REGDST)
HOUSETAX(t,q) # Elements of Household taxation #;
Formula (all,t,HTAX)(all,q,REGDST)
HOUSETAX(t,q) = 0;
Formula (all,q,REGDST)
HOUSETAX("T000",q) = VHTAX_000(q);
Formula (all,q,REGDST)
```

```
HOUSETAX("T100",q) = VHTAX_100(q);
Formula (all,q,REGDST)
HOUSETAX("T110",q) = VHTAX_110(q);
Formula (all,q,REGDST)
HOUSETAX("T120",q) = VHTAX_120(q);

Write HOUSEINC to file CHECK header "HOSI";
Write HOUSETAX to file CHECK header "HOST";

! Subsection 8.4.5: Summary of database in standard Input/Output form
---------------------------------!
Set BIGSALECAT = IND + SALECAT;
Set CostCats (Labour, GOS);
Set BIGCOSTCAT = COM + COSTCATS;

Coefficient (all,c,BIGCOSTCAT)(all,u,BIGSALECAT)
IOTABLE(c,u) # IO table - national in basic values #;

Formula (all,c,BIGCOSTCAT)(all,u,BIGSALECAT)
IOTABLE(c,u) = 0;

Formula (all,c,NONMARGCOM)(all,i,IND)
IOTABLE(c,i) = sum{q,REGDST, sum{s,ALLSRC, V1BAS(c,s,i,q)}};
Formula (all,r,MARGCOM)(all,i,IND)
IOTABLE(r,i) = sum{q,REGDST, sum{s,ALLSRC, V1BAS(r,s,i,q)}} +
       sum{q,REGDST, sum{c,COM, sum{ss,ALLSRC, V1MAR(c,ss,i,q,r)}}};
Formula (all,c,NONMARGCOM)
IOTABLE(c,"Interm") = sum{i,IND, sum{q,REGDST, sum{s,ALLSRC, V1BAS(c,s,i,q)}}};
Formula (all,r,MARGCOM)
IOTABLE(r,"Interm") = IOTABLE(r,"Interm") +
       sum{i,IND, sum{q,REGDST, sum{c,COM, sum{ss,ALLSRC, V1MAR(c,ss,i,q,r)}}}};
Formula (all,c,COM)
IOTABLE(c,"Invest") = sum{s,ALLSRC, sum{i,IND, sum{q,REGDST, V2BAS(c,s,i,q)}}};
Formula (all,r,MARGCOM)
IOTABLE(r,"Invest") = IOTABLE(r,"Invest") +
        sum{q,REGDST, sum{c,COM, sum{s,ALLSRC, sum{i,IND, V2MAR(c,s,i,q,r)}}}};
Formula (all,c,COM)
IOTABLE(c,"HouseH") = sum{s,ALLSRC, sum{q,REGDST, V3BAS(c,s,q)}};
Formula (all,r,MARGCOM)
IOTABLE(r,"HouseH") = IOTABLE(r,"HouseH") +
        sum{q,REGDST, sum{c,COM, sum{s,ALLSRC, V3MAR(c,s,q,r)}}};
Formula (all,c,COM)
IOTABLE(c,"Export") = sum{q,REGDST, V4BAS(c,q)};
Formula (all,r,MARGCOM)
IOTABLE(r,"Export") = IOTABLE(r,"Export") +
    sum{q,REGDST, sum{c,COM, V4MAR(c,q,r)}};
Formula (all,c,COM)
IOTABLE(c,"GOVREG") = sum{s,ALLSRC, sum{q,REGDST, V5BAS(c,s,q)}};
Formula (all,r,MARGCOM)
IOTABLE(r,"GOVREG") = IOTABLE(r,"GOVREG") +
        sum{q,REGDST, sum{c,COM, sum{s,ALLSRC, V5MAR(c,s,q,r)}}};
```

```
Formula (all,c,COM)
IOTABLE(c,"GOVFED") = sum{s,ALLSRC, sum{q,REGDST, V6BAS(c,s,q)}};
Formula (all,r,MARGCOM)
IOTABLE(r,"GOVFED") = IOTABLE(r,"GOVFED") +
        sum{q,REGDST, sum{c,COM, sum{s,ALLSRC, V6MAR(c,s,q,r)}}};
Formula (all,c,COM)
IOTABLE(c,"Stocks") = sum{s,REGSRC, V7BAS(c,s)};
Formula (all,i,IND)
IOTABLE("Labour",i) = sum{q,REGDST, V1LAB_O(i,q)};
Formula (all,i,IND)
IOTABLE("GOS",i) =
    sum{q,REGDST, V1CAP(i,q) + V1LND(i,q) + V1OCT(i,q)};

Write IOTABLE to file CHECK header "IOTB" Longname "IOTable, basic values";

! Subsection 8.4.6: Summary of Balance of Payments accounts
---------------------------------!
Set FACC # Elements of the foreign accounts #
(BT,BI,TR,BC,NFL);

Coefficient (all,f,FACC)(all,q,REGDST)
FORACC(f,q) # Elements of the Foreign Accounts #;
Formula (all,f,FACC)(all,q,REGDST)
FORACC(f,q) = 0;
Formula (all,q,REGDST)
FORACC("BT",q) = TAB(q);
Formula (all,q,REGDST)
FORACC("BI",q) = IAB(q);
Formula (all,q,REGDST)
FORACC("TR",q) = NCT(q);
Formula (all,q,REGDST)
FORACC("BC",q) = CAB(q);
Formula (all,q,REGDST)
FORACC("NFL",q) = NFL(q);

Write FORACC to file CHECK header "FACC";


! Subsection 8.4.7: Summary of Demographic variables
---------------------------------!
Set DEM # Regional demographics #
(POP,WPOP,EMP,UN,UNR,LABS);

Coefficient (all,d,DEM)(all,q,REGDST)
DEMOGRAPHIC(d,q) # Regional demographics #;
Formula (all,d,DEM)(all,q,REGDST)
DEMOGRAPHIC(d,q) = 0;
Formula (all,q,REGDST)
DEMOGRAPHIC("POP",q) = C_POP(q);
Formula (all,q,REGDST)
DEMOGRAPHIC("WPOP",q) = C_WPOP(q);
```

```
Formula (all,q,REGDST)
DEMOGRAPHIC("EMP",q) = EMPLOY_IO(q);
Formula (all,q,REGDST)
DEMOGRAPHIC("UN",q) = LABSUP_O(q) - EMPLOY_IO(q);
Formula (all,q,REGDST)
DEMOGRAPHIC("UNR",q) = 100*(LABSUP_O(q) - EMPLOY_IO(q))/LABSUP_O(q);
Formula (all,q,REGDST)
DEMOGRAPHIC("LABS",q) = LABSUP_O(q);

Write DEMOGRAPHIC to file CHECK header "DEMG";
```

4.8 *Year-to-year equations*

This section of the TABLO code contains equations that are essential for year-to-year simulations (i.e. dynamic simulations tracing out the paths for variables for successive years). In MMRF, solutions are expressed as percentage changes or ordinary changes from an initial solution. The initial solution is provided by a database, based on data from official government statistics and other sources, for a given year. In recursive dynamic simulations, the initial solution for the second and subsequent years is found by updating the previous solution according to the model results. In this section, four sets of equations that are required to update the model's database are given. These are:

1. Equations describing the relationship between capital and investment, and between capital growth and expected rates of return (we assume static expectations);
2. Equations that allow for real wages to be sticky in the short run and flexible in the long run;
3. Equations that describe the relationship between the stock of Net Foreign Liabilities (NFL) and the balance on current account; and
4. Equations that describe the relationship between population and demographic flow variables such as natural growth and migration.

In this section there are several instances where stock variables are updated according to corresponding flow variables. It is important to clarify the timing of these variables. If the initial solution for the model is based on Year 0, the initial solution includes data for stock variables at the beginning of Year 0, and data for flow variables during the Year 0. As always, the model contains equations to move the database from its initial solution to its final solution. These relationships must hold in their levels form in both the initial and final solutions.

These concepts are emphasised in Figure 4.5 below. The following points should be noted:

- The Year 1 initial solution values are equal to the Year 0 database values;
- The Parameters (denoted @1) do not change between the Year 1 initial and final solutions;
- A special exogenous variable known as the homotopy variable is introduced and assigned an initial value of 0 and a final value of 1;
- The relationship between Opening Stock and Flow is
- STOCK_T = STOCK_T@1 + FLOW@1 * UNITY (4.64)
  which holds in both the initial and final solutions for Year 1;
- The change form of the Opening Stock and Flow relationship is
  d_STOCK_T = FLOW@1.d_UNITY where d_UNITY =1; and (4.65)
- The calculation of Closing Stock (STOCK_T1 = STOCK_T + FLOW) is relatively trivial. Note that the final solution for FLOW is obtained from the core model.

Figure 4.5: Example of a stock and flow relationship

	Year 0 database	*Year 1 initial solution*	*Year 1 final solution*
Opening Stock (STOCK_T)	100	100	120
Flow (FLOW)	20	20	30
Opening Stock Parameter (STOCK@1)	100	100	100
Flow Parameter (FLOW@1)	20	20	20
Homotopy variable (UNITY)	0	0	1

4.8.1 Capital, investment and expected rates of return (TABLO excerpt 10.1.3)

In year-to-year dynamics, we interpret a model solution as a vector of changes in the values of variables between two adjacent years. Thus, there is a fixed relationship between capital and investment. As outlined in Section 2.2, capital available for production in the current forecast year (year t) is given by initial conditions, with the rate of return in year t adjusting to accommodate the given stock of capital.

In this section of the code, we introduce equations to allow the percentage change in capital available for production in year t (i.e. the percentage change in capital at the start of year t) to be determined inside the model. We also specify capital supply functions that determine industries' capital growth rates through year t (and thus investment in year t). The functions specify that investors are willing to supply increased funds to industry i in response to increases in i's expected rate of return (we assume static expectations). However, investors are cautious. In any year, the capital supply functions limit the growth in industry i's capital stock so that disturbances in i's rate of return are eliminated only gradually.

4.8.1.1 On/off switch for capital in year-to-year simulations (E_f_x1cap)

In comparative static simulations, x1cap(i,q) is either exogenous (short-run) or determined by some rule governing changes in rates of return (long-run). In year-to-year simulations, x1cap(i,q) is set equal to capital available for production in the solution year, cap_t(i,q). Equation *E_f_x1cap* turns on the year-to-year explanation of x1cap, with the shift variable, f_x1cap, exogenous and set to zero change. In comparative static simulations, f_x1cap is endogenous, with one of x1cap or d_r1cap exogenous.

4.8.1.2 Shocks to starting capital in year-to-year simulations (E_cap_t)

Capital available for production in the solution year, year t, is the capital stock existing at the start of the year, which corresponds to that available at the end of the previous year, year t-1. We denote this stock as QCAP. The corresponding percentage-change variable is cap_t.

The appropriate value for cap_t in a year-to-year computation is the growth rate of capital between the start of year t-1 and the start of year t. Algebraically, using a notation that emphasises the timing of each variable, we want

$$cap\_t_t(i,q) = 100 \times \left(\frac{QCAP_t(i,q)}{QCAP_{t-1}(i,q)} - 1\right) \qquad i \in IND\ q \in REGDST \qquad (4.66)$$

where $QCAP_t(i,q)$ is the quantity of capital available for production in industry i in region q at the start of the current solution year t. Equation (4.66) can be rewritten as

$$cap\_t_t(i,q) = 100 \times \left(\frac{QINV_{t-1}(i,q) - DEPR(i,q) \times QCAP_{t-1}(i,q)}{QCAP_{t-1}(i,q)}\right) \qquad i \in IND\ q \in REGDST \qquad (4.67)$$

where $QINV_{t-1}(i,q)$ is the quantity of investment in industry i in year t-1 and DEPR is a fixed parameter representing the rate of capital depreciation for industry i.

In making the computation for year t, we could treat $\mathrm{cap\_t}_t(i)$ as an exogenous variable and compute its value outside the model in accordance with equation (4.67). It is more convenient, however, to compute values for $\mathrm{cap\_t}_t(i)$ inside the model. This is done using equation E_cap_t.

To understand the levels form of E_cap_t., we start by re-writing (4.67) as

$$\mathrm{QCAP}_t(i,q) - \mathrm{QCAP}_{t-1}(i,q) = (\mathrm{QINV}_{t-1}(i,q) - \mathrm{DEPR}(i,q) \times \mathrm{QCAP}_{t-1}(i,q)) \quad i \in \mathrm{IND} \; q \in \mathrm{REGDST} \quad (4.68).$$

In year-to-year simulations, we want the initial solution for year t to reflect values for year t-1, since the changes we are simulating are from year t-1 to year t. If this is the case then the initial value of $\mathrm{QCAP}_t(i)$ is $\mathrm{QCAP}_{t-1}(i)$. The Euler solution method requires that the initial (database) values for variables form a solution to the underlying levels form of the model. Equation (4.68) makes it clear that unless net investment in year t-1 is zero in industry i, then the initial data for a year-t computation will not be a solution to (4.68).

We solve this problem of initial-value by the purely technical device of augmenting equation (4.68) with an additional exogenous variable UNITY as follows:

$$\begin{aligned}\mathrm{QCAP}_t(i,q) - \mathrm{QCAP}_{t-1}(i,q) &= \\ \mathrm{UNITY} \times (\mathrm{QINV}_{t-1}(i,q) &- \mathrm{DEPR}(i,q) \times \mathrm{QCAP}_{t-1}(i,q))\end{aligned} \quad i \in \mathrm{IND} \; q \in \mathrm{REGDST} \quad (4.69)$$

We choose the initial value of UNITY to be 0, so that (4.69) is satisfied when $\mathrm{QCAP}_t(i)$ takes its initial value regardless of the initial value of net investment in industry i. UNITY is often referred to as a “homotopy parameter”. By moving UNITY to one, we cause the correct deviation in the opening capital stock for year t from its value in the initial solution (i.e., from its value in year t-1).

Equation E_cap_t is the change form of (4.69), after changes in notation. On the right hand side of the TABLO equation, the coefficients $\mathrm{QINV@1}(i,q)$ and $\mathrm{QCAP@1}(i,q)$ are the levels of $\mathrm{QINV}(i,q)$ and $\mathrm{QCAP}(i,q)$ in the initial solution for year t. Provided that the initial solution is drawn from values for year t-1, then $\mathrm{QINV@1}(i,q)$ corresponds to $\mathrm{QINV}_{t-1}(i,q)$ in (4.7.4) and $\mathrm{QCAP@1}(i,q)$ corresponds to $\mathrm{QCAP}_{t-1}(i,q)$. The variable d_unity is the ordinary change in UNITY. In year-to-year simulations, d_unity is always set to 1.

4.8.1.3 Capital available in year t+1 related to investment in year t (E_cap_t1)

Equation E_cap_t1 explains the percentage change in the capital stock of industry i in region q at the end of the solution year. The levels form of this equation (with time made explicit) is

$$\mathrm{QCAP\_T1}_t(i,q) = \mathrm{QINV}_t(i,q) + (1 - \mathrm{DEPR}(i,q)) \times \mathrm{QCAP\_T}_t(i,q) \quad i \in \mathrm{IND} \; q \in \mathrm{REGDST} \quad (4.70)$$

where $\mathrm{QCAP\_T1}_t(i,q)$ is the stock of capital in industry i in region q at the end of year t (or the start of year t+1). Note that equation (4.70) is satisfied by the initial solution for year t, and so there is no need to introduce the homotopy variable.

Taking ordinary changes of the left-hand side and the right hand side of (4.70) gives, after dropping the time index, equation *E_cap_t1*.

4.8.1.4 Capital growth between the start and end of the solution year (E_d_k_gr)

In year-to-year simulations, growth in capital between the start and end of year t is determined by the expected rate of return on capital (see equation (2.2). This relationship is modelled below. Here we define the level of the growth rate in capital for industry i

$$K\_GR_t(i,q) = \frac{QCAP\_T1_t(i,q)}{QCAP\_T_t(i,q)} - 1 \qquad i \in IND \; q \in REGDST \quad (4.71)$$

and in equation *E_d_k_gr* explain the change in that growth rate in terms of the percentage-change variables cap_t(i,q) and cap_t1(i,q).

4.8.1.5 Expected rate of return equals expected equilibrium rate of return plus expected disequilibrium rate of return (E_d_eeqror)

It is assumed that the expectation held in period t by owners of capital in industry i for industry i's rate of return in period t+1 can be separated into two parts. One part is called the expected equilibrium rate of return. This is the expected rate of return required to sustain indefinitely the current rate of capital growth in industry j. The second part is a measure of the disequilibrium in i's current expected rate of return. In terms of the notation in the TABLO code

$$EROR(i,q) = EEQROR(i,q) + DISEQROR(i,q) \qquad i \in IND \; q \in REGDST \quad (4.72)$$

where EROR(i,q), EEQROR(i,q) and DISEQROR(i,q) are the levels in year t of the expected rate of return, the expected equilibrium rate of the return and the disequilibrium in the expected rate of return. E_d_eeqror is the change form of (4.72).

4.8.1.6 Expected equilibrium rates of return (E_d_feeqror)

The theory of investment in year-to-year simulations relates the expected equilibrium rate of return for industry i (EEQROR(i,q)) to the current rate of growth of capital in industry i (K_GR(i,q)). As shown in Figure 4.5, the relationship has an inverse logistic form, which has the algebraic form

$$\begin{aligned} EEQROR(i,q) &= RORN(i,q) + F\_EEQROR(i,q) + \\ &\frac{1}{CAP\_SLOPE(i,q)} \times \\ &\left\{ \begin{array}{l} \left[Log\left(K\_GR(i,q) - K\_GR\_MIN(i,q)\right) \quad - Log\left(K\_GR\_MAX(i,q) - K\_GR(i,q)\right) \right] - \\ \left[Log\left(TREND\_K(i,q) - K\_GR\_MIN(i,q)\right) - Log\left(K\_GR\_MAX(i,q) - TREND\_K(i,q)\right) \right] \end{array} \right\} \end{aligned}$$

$$i \in IND \; q \in REGDST \quad (4.73)$$

where:

RORN is a coefficient representing the industry's historically normal rate of return;

F_EEQROR allows for vertical shifts in the capital supply curves (in the TABLO code there are three shift variables allowing for a nation-wide shift, region-wide shifts and shifts that are industry and region specific);

CAP_SLOPE is a coefficient which is correlated with the inverse of the slope of the capital supply curve (Figure 4.6) in the region of K_GR = TREND_K (for further details see Dixon and Rimmer, 2002);

K_GR_MIN is a coefficient, which sets the minimum possible rate of growth of capital;

K_GR_MAX is a coefficient, set to the maximum possible rate of growth of capital; and

TREND_K is a coefficient, set to the industry's historical normal rate of capital growth.

Equation (4.73) is explained in Dixon and Rimmer (2002) as follows. Suppose that F_EEQROR and DISEQROR are initially zero. Then according to (4.73) and (4.72), for an industry to attract sufficient investment in year t to achieve a capital growth rate of TREND_K it must have an expected rate of return equal to its long-term average (RORN) For the industry to attract sufficient investment in year t for its capital growth to exceed its long-term average (TREND_K), its expected rate of return must be greater than RORN. Conversely, if the expected rate of return on the industry's capital falls below RORN, then investors will restrict their supply of capital to the industry to a level below that required to sustain capital growth at the rate of TREND_K.

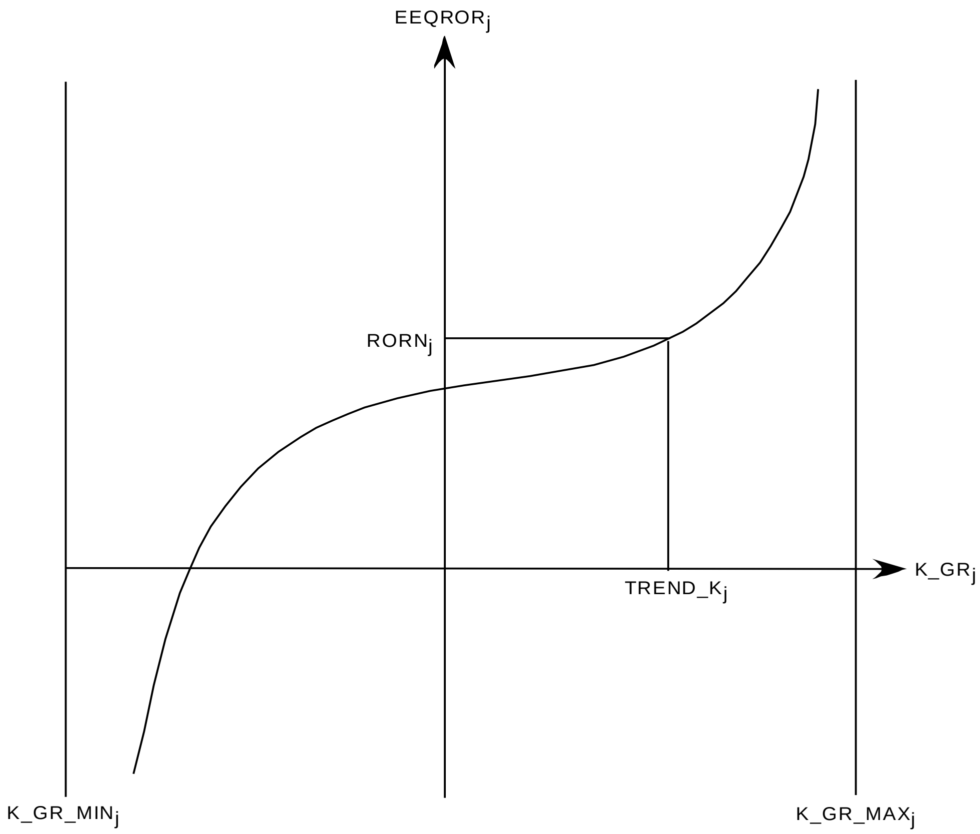

Figure 4.6: The equilibrium expected rate of return schedule for industry j

The change version of (4.73) is *E_d_feeqror*.

4.8.1.7 Adjustment of disequilibrium in expected rate of return towards zero (E_d_diseqror)

The initial disequilibrium in the expected rate of return (DISEQROR) is gradually eliminated over time according to the rule

$$\begin{aligned}&\mathrm{DISEQROR}(i,q) - \mathrm{DISEQROR@1}(i,q) = \\ &\quad -\mathrm{ADJ\_COEFF}(i,q) \times \mathrm{DISEQROR@1}(i,q) \times \mathrm{UNITY}\end{aligned} \qquad i \in \mathrm{IND}\ q \in \mathrm{REGDST} \qquad (4.74)$$

where DISEQROR@1 is the initial value of DISEQROR in a simulation for year t; and ADJ_COEFF is a positive parameter (less than one) determining the speed at which DISEQROR moves towards zero. E_d_diseqror is the change form of (4.74).

4.8.1.8 Expected rate of return equals actual rate of return under static expectations (E_d_eror)

This equation enforces the rule that the expected rate of return on capital in industry i in region q in year t equals industry i's actual rate of return in year t under static expectations.

```
! Subsection 10.1.3: Equations: Investment, capital and ROR
---------------------------------!
Equation E_f_x1cap # Explains x1cap in year-to-year sims - standard #
(all,i,IND)(all,q,REGDST)
x1cap(i,q) = cap_t(i,q) + f_x1cap(i,q);

Equation e_cap_t # Capital available for production in yr-to-yr simulations #
(all,i,IND)(all,q,REGDST)
cap_t(i,q) =
[0 + IF[QCAP(i,q) NE 0,
    100*{QINV@1(i,q) - DEPR(i)*QCAP@1(i,q)}/QCAP(i,q)]]*d_unity;

Equation E_cap_t1 # Capital at end of year in yr-to-yr simulations #
(all,i,IND)(all,q,REGDST)
cap_t1(i,q) =
    (1-DEPR(i))*QCAP(i,q)/ID01(QCAP_T1(i,q))*cap_t(i,q) +
      {1 + IF(QINV(i,q) NE 0, -1 + QINV(i,q)/ID01(QCAP_T1(i,q)))}*x2tot(i,q);

Equation E_d_k_gr
    # Capital growth rate (%) between start and end of solution year #
(all,i,IND)(all,q,REGDST)
d_k_gr(i,q) =
    ID01(QCAP_T1(i,q))/ID01(QCAP(i,q))*[cap_t1(i,q) - cap_t(i,q)] +
                                   d_fk_gr(i,q);

Equation E_d_eeqror # Change in EROR = change in EEROR + change in DISEQROR #
(all,i,IND)(all,q,REGDST)
d_eror(i,q) = d_eeqror(i,q) + d_diseqror(i,q);

Equation E_d_feeqror # Change in expected equilibrium rate of return #
(all,i,IND)(all,q,REGDST)
d_eeqror(i,q) = d_feeqror_iq + d_feeqror_i(q) + d_feeqror(i,q) +
    [1/CAP_SLOPE(i,q)] *
 [1/[K_GR(i,q) - K_GR_MIN(i,q)] + 1/[K_GR_MAX(i,q) - K_GR(i,q)]]*d_k_gr(i,q);

Equation E_d_diseqror # Moves disequilibrium rate of return to zero #
(all,i,IND)(all,q,REGDST)
d_diseqror(i,q) = - ADJ_COEFF(i,q)*DISEQROR(i,q)*d_unity;
```

```
Equation E_d_eror # Static expectations: EROR = ROR #
(all,i,IND)(all,q,REGDST)
d_eror(i,q) = d_r1cap(i,q);
```

4.8.2 National employment and real wage in dynamic policy simulations (TABLO excerpt 10.2.3)

In most CGE analyses, one of the following two assumptions is made:

1. Real wages adjust to a shock so there is no effect on (national) employment; or
2. Real wages remain unaffected and (national) employment adjusts.

In this section of the code, equations are introduced that allow for a third, intermediate position. We assume that the deviation in the real wage rate from its basecase forecast level increase in proportion to the deviation in national employment from its basecase-forecast level. The coefficient of proportionality is chosen so that the employment effects of a shock are largely eliminated after about 5 years.

4.8.2.1 Consumer's real wage rate, after tax (E_natrwage_ct)

This section begins with an equation that explains movements in the national real after-tax wage rate received by consumers. On the right hand side of *E_natrwage_ct*, natrwage_c is the percentage change in the national real before-tax wage rate received by consumers and d_labinc is the ordinary change in the tax rate applied to labour income. The level of the tax rate is denoted TLABINC.

4.8.2.2 Deviations in the consumer's real wage rate, after tax related to deviations in employment (E_d_frwage_ct)

Algebraically, the national employment/wage trade-off equation in MMRF is written as:

$$\frac{\mathrm{C\_RWDEV}}{\mathrm{C\_RWFOR}} - 1 = \left\{ \frac{\mathrm{C\_RWDEV\_L}}{\mathrm{C\_RWFOR\_L}} - 1 \right\} + \mathrm{LAB\_SLOPE} \times \left\{ \frac{\mathrm{C\_EMPDEV}}{\mathrm{C\_EMPFOR}} - 1 \right\} \qquad (4.75)$$

where:

C_RWDEV is the level of the consumer's real after-tax wage rate in the deviation simulation;

C_RWFOR is the level of the consumer's real after-tax wage rate in the basecase-forecast simulation;

C_RWDEV_L is the initial level of the consumer's real after-tax wage rate in the deviation simulation;

C_RWFOR_L is the initial level of the consumer's real after-tax wage rate in the basecase-forecast simulation;

LAB_SLOPE is a positive coefficient;

C_EMPDEV is the level of aggregate employment in the deviation simulation; and ;

C_EMFOR is the level of aggregate employment in the basecase-forecast simulation.

Equation (4.75) says that the percentage deviation in the real wage rate in year t from its basecase forecast value equals the percentage deviation in the real wage rate in year t-1 plus a coefficient (LAB_SLOPE) times the percentage deviation in employment in year t. The coefficient LAB_SLOPE is chosen so that the employment effects of a shock to the economy are largely eliminated after 5 years. In other words, after about 5 years, the benefits of favourable shocks, such as outward shifts in export demand curves, are realised almost entirely as increases in real wage rates.

The change form of (4.75) is

$$\frac{C\_RWDEV}{C\_RWFOR}\times\left(rwdev-rwfor\right)=\frac{C\_RWDEV\_L}{C\_RWFOR\_L}\times\left(rwdev\_l-rwfor\_l\right)+ LAB\_SLOPE\times\frac{C\_EMDEV}{C\_EMPFOR}\times\left(empdev-empfor\right) \quad (4.76)$$

where:

rwdev is the percentage change in the consumer’s real after-tax wage rate between years t-1 and t with the policy shock in place;

rwfor is the percentage change in the consumer’s real after-tax wage rate between years t-1 and t in the basecase forecast simulation;

rwdev_l is the percentage change in the consumer’s real after-tax wage rate between years t-2 and t-1 with the policy shock in place;

rwfor_l is the percentage change in the consumer’s real after-tax wage rate between years t-2 and t-1 in the basecase forecast simulation;

empdev is the percentage change in national employment between years t-1 and t with the policy shock in place; and

empfor is the percentage change in national employment between years t-1 and t in the basecase forecast simulation.

E_d_frwage_ct is based on (4.76), with the addition of the on/off switch variable d_frwage_ct.

4.8.2.3 Equations to transfer forecast simulation results to a policy simulation (E_f_emp, E_f_rw)

E_f_emp and *E_f_rw* allow us to transfer basecase forecast values of variables through to the policy simulation. They are of the form

$$r\_x = x - bf\_x \quad (4.77)$$

where:

x is a variable (e.g., real wage growth) for which we need forecast results in policy simulations;

bf_x is the variable which, in policy simulations, is given the forecast simulation value of x; and

r_x is the difference between x and bf_x.
These equations operate in conjunction with the GEMPACK software used to run year-to-year simulations with MMRF. With this software, a policy simulation for year t is run by:

1. Reading the results generated in the forecast simulation for year t;
2. Reading the list of exogenous variables to be used in a policy simulation for year t;
3. Forming a CMF file in which exogenous variable r in the policy simulation is assigned the value that it had (either endogenously or exogenously) in the forecast simulation; and
4. Adding a supplementary file of shocks for variables that are exogenous and shocked in the policy simulation.

Aided by this software, equation (4.77) transfers basecase forecast values for x to the policy simulation. In the forecasting simulation, the shift variable r_x is set exogenously at zero change, resulting in the forecast result for bf_x being the same as that for x. In the policy simulation, the closure is changed to make bf_x exogenous and r_x endogenous. Thus, the forecast result for x is correctly passed to bf_x in the policy simulation.

4.8.2.4 Equations to explain values of variables lagged one year (E_rwdev_l, E_rwfor_l, E_empdev_l, E_empfor_l)

These equations are of the form

$$x\_l = 100 \times \left(\frac{X@1}{X\_L@1} - 1 \right) \times d\_unity \qquad (4.78)$$

where:

x_l is the percentage change in X lagged one year (i.e., the percentage change in X in t-1);

X@1 is the initial value of X in a simulation for year t (i.e., the value of X at the end of t-1);

X_L@1 is the initial value of X in a simulation for year t-1 (i.e., the value of X at the end of t-2, or the start of t-1); and

d_unity is the homotopy variable which has the value of 1 in year-to-year simulations.

In (4.78) the coefficients X@1 and X_L@1 respectively are updated using the percentage change variables x and x_l.

```
! Subsection 10.2.3: Equations: wage/employment
--------------------------------!
Equation E_natrwage_ct # National consumer real wage rate, after income tax #
natrwage_ct = natrwage_c - 100/(1-TLABINC)*d_tlabinc;

Equation E_empdev # Equates empdev with natx1lab_io #
empdev = natx1lab_io;

Equation E_rwdev # Equates rwdev with natrwage_ct #
rwdev = natrwage_ct;

Equation E_rwdev_l # Equation explaining rwdev lagged one year #
rwdev_l = 100*(C_RWDEV@1/C_RWDEV_L@1- 1)*d_unity;
```

```
Equation E_rwfor_l # Equation explaining rwfor lagged one year #
rwfor_l = 100*(C_RWFOR@1/C_RWFOR_L@1- 1)*d_unity;

Equation E_empdev_l # Equation explaining empdev lagged one year #
empdev_l = 100*(C_EMPDEV@1/C_EMPDEV_L@1- 1)*d_unity;

Equation E_empfor_l # Equation explaining empfor lagged one year #
empfor_l = 100*(C_EMPFOR@1/C_EMPFOR_L@1- 1)*d_unity;

Equation E_d_frwage_ct # Relates %devrw to %devemp in year-to-year sims. #
(C_RWDEV/C_RWFOR)*[rwdev - rwfor] = (C_RWDEV_L/C_RWFOR_L)*[rwdev_l - rwfor_l] +
        LAB_SLOPE*(C_EMPDEV/C_EMPFOR)*[empdev - empfor] + 100*d_frwage_ct;

Equation E_f_emp # Introduces forecast employment into deviation simulation #
empfor = natx1lab_io + f_emp;

Equation E_f_rw # Introduces real wage rate (after tax) into deviation sims. #
rwfor = natrwage_ct + f_rw;

! The next two equations force the deviation in national employment to zero.
  They are generally put in place via a closure swap 7-8 years after the
  exogenous shock to ensure that the long-run condition of zero change in
  national employment is met !
Equation E_d_empdampen # Forces the long-run employment deviation to zero #
(C_EMPDEV/C_EMPFOR)*[empdev - empfor] =
   0.5*(C_EMPDEV_L/C_EMPFOR_L)*[empdev_l - empfor_l] + 100*d_empdampen;

Equation E_d_fempdampen # Forces EMPDAMPEN back to zero #
d_empdampen = -0.5*EMPDAMPEN@1*d_unity + d_fempdampen;
```

4.8.3 Net Foreign Liabilities and the Balance of Current Account (TABLO excerpt 10.3)

This section of code explains changes in the stock of net foreign liabilities in year-to-year simulations. It is assumed that at the end of the solution year (year t)

$$\mathrm{NFL}(t+1) = \mathrm{NFL}(t) - \mathrm{CAB}(t) + \text{Valuation changes} \tag{4.79}$$

where:

NFL(t+1) is the value of the stock of net foreign liabilities at the end of the solution year (i.e., the value of NFL at the end of t);

NFL(t) is the initial value of the stock of net foreign liabilities in the solution for year t (i.e., the value of NFL at the end of t-1, or the start of t); and

CAB(t) is the balance on current account in year t, which is assumed to equal the negative of the balance on financial account; and

Valuation changes are the price and exchange rate effects that affect the Australian dollar value of the net stock of foreign liabilities in year t.[29]

We assume that the debt and equity components of the stock of net foreign liabilities occur in fixed proportions. Two coefficients are defined, called ACTIVE and PASSIVE, which are respectively the equity and debt components of the current account balance. With valuation omitted, the stock of foreign-owned capital (NFE) in Australia at the start of year t is given by equation *E_d_NFE_T* and the stock of debt is given by equation *E_d_NFD_T*. In principle these equations operate the same way as the capital accumulation relationship or the stock and flow example given on page **Error! Bookmark not defined.**.

Finally, equation *E_d_FFORSHR* is used to find the change in the foreign ownership share of capital in each industry and region. In the initial solution, each industry and region has a unique share of foreign ownership. Changes in the foreign ownership share are assumed to be indexed to the national change in the foreign ownership share. For any industry i in region q, we define FFORSHR(i,q) such that

FORSHR(i,q) = NFE/VCAP * FFORSHR(i,q).

Taking the changes on both sides,

d_FORSHR(i,q) = FORSHR(i,q) * (d_NFE/NFE – vcap/100) + NFE/VCAP * d_FFORSHR(i,q)

where vcap is the percentage change of VCAP. The variable d_FFORSHR(i,q) is normally exogenously set to 0, so that d_FORSHR(i,q) shifts uniformly for all i and q.

```
! Subsection 10.3.2: Coefficients, reads, updates and formulae for equity
--------------------------------!
Coefficient (all,q,REGDST)
ACTIVE(q) # Value of active (equity) accumulation #;
Coefficient (parameter)
EQUITYSHR # Share of equity in new foreign liabilities #;
Read EQUITYSHR from file Ydata header "EQSH";
Formula (all,q,REGDST)
ACTIVE(q) = -EQUITYSHR*CAB(q);
Coefficient (parameter)(all,q,REGDST)
ACTIVE@1(q) # Initial value of active (equity) accumulation #;
```

[29] At this point of MMRF's development, we ignore valuation changes. We note, though, that for work in the future, valuation changes can be broken into two parts: that due to changes in equity prices in Australia and that due to changes in the exchange rate (see Dixon and Rimmer, 2002, Section 25). Price effects could be handled via equations of the form

$$\text{Price effects} = \text{NFL}(t) \times (1 - \text{SHDEBT}) \times \text{change in Australian equity price} \qquad (4.7.15)$$

where SHDEBT is the share of debt in Australia's stock of foreign liabilities.

While exchange rate effects could be handled via

$$\text{Price effects} = \text{NFL}(t) \times \text{SHFOR} \times \text{change in Australia's exchange rate} \qquad (4.7.16)$$

where SHFOR is the share of Australia's net stock of foreign liabilities denominated in foreign currency.

```
Formula (initial)(all,q,REGDST)
ACTIVE@1(q) = ACTIVE(q);

Coefficient
NATNFEGDP_T1 # Ratio of NATNFE_T1 to GDP #;
Formula
NATNFEGDP_T1 = sum{q,REGDST, NFE(q) + ACTIVE(q)}/V0GDPINC;

! Subsection 10.3.3: Equations for equity
---------------------------------!
Equation E_d_FNFE # Turns off/on the dynamic foreign equity mechanisms #
(all,q,REGDST)
d_NFE(q) = d_NFE_T(q) + d_FNFE(q);

Equation E_d_NFE_T # Change in stock of NFE, start of t #
(all,q,REGDST)
d_NFE_T(q) = ACTIVE@1(q)*d_unity;

Equation E_d_NATNFE_T # Change in national stock of NFE, start of t #
d_NATNFE_T = sum{q,REGDST, d_NFE_T(q)};

Equation E_d_NFE_T1 # Change in stock of NFE, end of t #
(all,q,REGDST)
d_NFE_T1(q) = d_NFE_T(q) + d_ACTIVE(q);

Equation E_d_NATNFE_T1 # National change in stock of NFE, end of year #
d_NATNFE_T1 = sum{q,REGDST, d_NFE_T1(q)};

Equation E_d_NATNFEGDP # Change in NATNFE_T1 to GDP ratio #
d_NATNFEGDP_T1 = 1/V0GDPINC*d_NATNFE_T1 - (NATNFEGDP_T1/100)*w0gdpexp;

Equation E_d_ACTIVE
(all,q,REGDST)
d_ACTIVE(q) = -NFE(q)/ID01[(NFD(q) + NFE(q))]*d_CAB(q);


! Subsection 10.3.5: Coefficients, reads, updates and formulae for debt
---------------------------------!
Coefficient (all,q,REGDST)
PASSIVE(q) # Value of passive (debt) accumulation #;
Formula (all,q,REGDST)
PASSIVE(q) = -(1-EQUITYSHR)*CAB(q);
Coefficient (parameter)(all,q,REGDST)
PASSIVE@1(q) # Initial value of passive (debt) accumulation #;
Formula (initial)(all,q,REGDST)
PASSIVE@1(q) = PASSIVE(q);
```

```
Coefficient
NATNFDGDP_T1 # Ratio of NATNFD_T1 to GDP #;
Formula
NATNFDGDP_T1 = sum{q,REGDST, NFD(q) + PASSIVE(q)}/V0GDPINC;

! Subsection 10.3.6: Equations for debt
---------------------------------!
Equation E_d_FNFD # Turns off/on the dynamic foreign debt mechanisms #
(all,q,REGDST)
d_NFD(q) = d_NFD_T(q) + d_FNFD(q);

Equation E_d_NFD_T # Change in stock of NFD, start of t #
(all,q,REGDST)
d_NFD_T(q) = PASSIVE@1(q)*d_unity;

Equation E_d_NATNFD_T # Change in national stock of NFD, start of t #
d_NATNFD_T = sum{q,REGDST, d_NFD_T(q)};

Equation E_d_NFD_T1 # Change in stock of NFD, end of t #
(all,q,REGDST)
d_NFD_T1(q) = d_NFD_T(q) + d_PASSIVE(q);

Equation E_d_NATNFD_T1 # National change in stock of NFD, end of year #
d_NATNFD_T1 = sum{q,REGDST, d_NFD_T1(q)};

Equation E_d_NATNFDGDP # Change in NATNFD_T1 to GDP ratio #
d_NATNFDGDP_T1 = 1/V0GDPINC*d_NATNFD_T1 - (NATNFDGDP_T1/100)*w0gdpexp;

Equation E_d_NFL
(all,q,REGDST)
d_NFL(q) = d_NFD(q) + d_NFE(q);

Equation E_d_PASSIVE
(all,q,REGDST)
d_PASSIVE(q) = -NFD(q)/ID01[(NFD(q) + NFE(q))]*d_CAB(q);


! Subsection 10.3.7: Change in domestic ownership of capital!

Variable (all,i,IND)(all,q,REGDST)
fforshr(i,q) # On/off switch #;
Equation E_d_FFORSHR # Change in foreign capital share #
(all,i,IND)(all,q,REGDST)
100/ID01[FORSHR(i,q)]*d_FORSHR(i,q) =
  100/sum{s,REGDST, NFE(s)}*sum{w,REGDST, d_NFE(w)} - natp2tot_i - natx1cap_i +
        fforshr(i,q);
```

4.8.4 Regional population (TABLO excerpt 10.4.3)

The equation *E_pop_t* is used to find pop_t (the percentage change in population at the start of the solution year) using a standard stock and flow relationship as illustrated on page 135. The flow of population is attributed to three sources, natural growth, net foreign migration and net interstate migration.

This module provides some flexibility in the modelling of regional population in the comparative static part of the model (pop). The first equation, *E_f_pop*, links the percentage change in regional population to the year-to-year variable pop_t. As such, movements in the population are determined exogenously. The second equation, *E_f_popmid* links pop to pop_tmid, the population at the mid point of the year. This enables regional populations to be determined endogenously in the labour market section of the model, as in Option 2 on page 102. At least one of the variables f_pop and f_popmid must be endogenous.

The mid-year population is defined as the geometric average between the beginning and end of year population.

Endogenous regional population changes are normally attributed to regional migration. The sum of regional migration is found in equation *E_d_natpop_rm* and should always be zero.

```
! Subsection 10.4.3: Equations: Population
---------------------------------!
Equation E_f_pop # Explains population in year-to-year simulations #
(all,q,REGDST)
pop(q) = pop_t(q) + f_pop(q);

Equation E_f_popmid # Explains population in year-to-year simulations #
(all,q,REGDST)
pop(q) = pop_tmid(q) + f_popmid(q);

Equation E_pop_t # Population at start of year #
(all,q,REGDST)
C_POP_T(q)*pop_t(q) =
    100*[C_POP_RM@1(q) + C_POP_FM@1(q) + C_POP_G@1(q)]*d_unity;

Equation E_natpop_t # National population at start of year t #
sum{q,REGDST, C_POP_T(q)}*natpop_t = sum{s,REGDST, C_POP_T(s)*pop_t(s)};

Equation E_pop_t1 # Population at end of year t #
(all,q,REGDST)
C_POP_T1(q)*pop_t1(q) - C_POP_T(q)*pop_t(q) =
    100*[d_pop_rm(q) + d_pop_fm(q) + d_pop_g(q)];

Equation E_natpop_t1 # National population at end of year t #
sum{q,REGDST, C_POP_T1(q)}*natpop_t1 = sum{s,REGDST, C_POP_T1(s)*pop_t1(s)};

Equation E_pop_tmid # Population at mid point of year t #
```

```
(all,q,REGDST)
pop_tmid(q) = 0.5*pop_t(q) + 0.5*pop_t1(q);

Equation E_natpop_tmid # National population at mid point of year t #
sum{q,REGDST, C_POP_Tmid(q)}*natpop_tmid =
    sum{s,REGDST, C_POP_Tmid(s)*pop_tmid(s)};

Equation E_d_natpop_fm # Ordinary change in foreign migration, Australia #
d_natpop_fm = sum{q,REGDST, d_pop_fm(q)};

Equation E_d_natpop_g # Ordinary change in natural population, Australia #
d_natpop_g = sum{q,REGDST, d_pop_g(q)};

Equation E_d_natpop_rm # Ordinary change in regional migration, Australia #
d_natpop_rm = sum{q,REGDST, d_pop_rm(q)};
! Should always be zero !
```

4.9 *Regional disaggregation (tablo excerpt 11.2)*

This section contains a simple top-down regional disaggregation facility for output at the statistical division level. It is kept simple to minimise the requirements for data and computer memory.

The only data required for the regional disaggregation is a matrix of output by division[30] and industry. This is used to derive value added and employment for each division as proportions of regional industry value added and employment.

The first step in the disaggregation is to allocate each of the MMRF industries to one of two groups: national and local. Industries classed as national are traded extensively across regional borders. Examples are agricultural and mining commodities. Local commodities are those for which demand in each region is satisfied mainly from production in each region. Examples include wholesale trade, dwelling ownership and repairs.

The theory is that results for national industries follow regional results, regardless of division, while results for local industries follow results in the local division. Thus the effect on a region's overall level of activity of a favourable mix of "national" industries is multiplied through induced effects on the output and employment of the region's local industries. Note that at all times we ensure that adding-up constraints hold. That is, the sum across regions in state r of changes in output and employment for industry i must equal the changes in output and employment for industry i in state r as generated by the core model. The regional disaggregation model can be summarised by the following equations:

National industries: $divx(i,d) = x(i) + f(i), i \in NATIND$ (4.80)

Local industries: $divx(i,d) = x\_i(d) - x(i) + f(i), i \in LOCIND$ (4.81)

Adding up: $sum(d,DIV,DIVX(i,d) * divx(i,d)) = X(i) * x(i), i \in IND$ (4.82)

Definition of x_i(d): $sum(i,IND,DIVX(i,d) * divx(i,d)) = SUM(i,IND,DIVX(i,d)) * x\_i(d)$ (4.83)

where

NATIND and LOCIND are mutually exclusive and exhaustive subsets of IND, denoting national industries and local industries respectively;

x(i) indicates a measure of regional activity such as employment or output for industry i generated by the core model;

divx(i,d) indicates activity in industry i in division d;

f(i) is a shifter enabling the adding-up constraint to hold; and

x_i(d) is aggregate activity in division d;

[30] The term "division" is used here to indicate statistical division, which is not to be confused with "region" which often indicates State.

For national industries, equation 4.80 and the adding up constraint in 4.82 ensure that f(i) = 0.

Equation *E_divx1totA* is equivalent to equation 4.80. For local industries output is linked to the change in aggregate regional employment in equation *E_divx1totB*, which is equivalent to equation 4.81.

```
! Section 11.2: Equations for industry output and employment at statistical
    division level
=================================!

! Theory for "national" industry output
   DIVX1TOT(i,d) proportional to X1TOT(q)*OUTADJUST(i,q) (d belongs to q),

  where OUTADJUST adjusts to ensure that the adding up condition E_outadjust
  holds !
Equation E_divx1totA # National industry outputs #
(All,i,NATIND)(All,d,STATDIV)
divx1tot(i,d) = Sum{r,STATES:RMAP(d,r) NE 0, (x1tot(i,r) + outadjust(i,r))};

Equation E_divx1totB # Local industry outputs #
(All,i,LOCIND)(All,d,STATDIV)
divx1tot(i,d) - Sum{r,STATES:RMAP(d,r) NE 0, x1tot(i,r)} =
 divx1emp_i(d) - Sum{r,STATES:RMAP(d,r) NE 0, (x1emp_io(r) + outadjust(i,r))};

Equation E_divx1emp # Industry employment by industry and region #
(All,i,IND)(All,d,STATDIV)
divx1emp(i,d) - divx1tot(i,d) =
    Sum{r,STATES:RMAP(d,r) NE 0, (x1emp_o(i,r) - x1tot(i,r) + empadjust(i,r))};

Equation E_d_divx1tot
(All,i,IND)(All,d,STATDIV)
100*d_divx1tot(i,d) = DIVV1PRIM(i,d)*divx1tot(i,d);

Equation E_d_divx1emp
(All,i,IND)(All,d,STATDIV)
100*d_divx1emp(i,d) = DIVEMPLOY(i,d)*divx1emp(i,d);

Equation E_outadjust # Adding up condition for division industry output #
(All,i,IND)(All,r,STATES)
(tiny + V1PRIM(i,r))*x1tot(i,r) = Sum{d,STATDIV:RMAP(d,r) NE 0,
    ID01(DIVV1PRIM(i,d))*divx1tot(i,d)};

Equation E_empadjust # Adding up conditions for division industry employment #
(All,i,IND)(All,r,STATES)
(tiny + EMPLOY_O(i,r))*x1emp_o(i,r) = Sum{d,STATDIV:RMAP(d,r) NE 0,
    ID01(DIVEMPLOY(i,d))*divx1emp(i,d)};

Equation E_x0grp
```

```
(All,d,STATDIV)
GRP(d) *[x0grp(d) + sum{q,STATES:RMAP(d,q) NE 0, grpadjust(q)}] =
    sum{q,STATES:RMAP(d,q) NE 0, sum{i,IND, GRPSHR(i,d)*[
    V1LNDINC(i,q)*x1lnd(i,q) + V1CAPINC(i,q)*x1cap(i,q) +
    sum{o,OCC, V1LABINC(i,q,o)*x1lab(i,q,o)} + V1OCTINC(i,q)*x1oct(i,q) -
COSTS(i,q)*a(i,q) - sum{c,COM, V2PURO(c,i,q)*(a2(q)+acom(c,q)+natacom(c))}]}};

Equation E_d_grpadjust
(all,q,STATES)
V0GSPFC(q)*x0gspfc(q) = sum{d,STATDIV:RMAP(d,q) NE 0, GRP(d)*x0grp(d)};

Equation E_d_x0grp
(All,d,STATDIV)
100*d_x0grp(d) = VOL_GRP(d)*x0grp(d);

Equation E_divx1emp_i
(All,d,STATDIV)
ID01(DIVEMP_I(d))*divx1emp_i(d) = sum{i,IND, DIVEMPLOY(i,d)*divx1emp(i,d)};

Equation E_d_divx1emp_i
(All,d,STATDIV)
100*d_divx1emp_i(d) = DIVEMP_I(d)*divx1emp_i(d);
```

4.10 *Miscellaneous additions to MMRF*

The final section of this chapter contains miscellaneous additions to the model that are self contained modules designed for specific projects. These are:

- cost neutralisation in commodity specific technical change;
- dollar value (ordinary change) shocks for output and capital;
- an indicator of negative values in BAS1 and BAS2;
- the possibility substitution between road freight and rail freight; and
- enforced convergence of the balances on the trade account and income account to zero in long term base case forecasts.

Other, more significant extensions to MMRF, which are not included in this version of the model, are documented in Chapter 7. These are:

- The national electricity market (NEM);
- greenhouse gas accounting;
- inter-fuel substitution in electricity generation; and
- endogenous take-up of greenhouse gas abatement measures.

4.10.1 Cost neutralisation in input-saving technological change (TABLO exceprt 12.1)

Equations *E_a1* and *E_a2* provide cost neutralisation mechanisms for current production and investment goods. Using current production as an example, if this mechanism is turned on (d_fa1(i,q) exogenous, a1(i,q) endogenous) then the commodity mix used for production in industry i in region q can be changed without having an undesired effect on overall technical change in industry i in region q.

```
Variable (change)(all,i,IND)(all,q,REGDST)
d_fa1(i,q)
    # Allows for production input-saving technological change to offset ac(i) #;
Equation E_a1
(all,i,IND)(all,q,REGDST)
-ID01(COSTS(i,q))*a1(i,q) =
sum{c,COM, V1PURO(c,i,q)*[acom(c,q) + acomind(c,i,q) + natacom(c)]} +
    100*d_fa1(i,q);

Variable (change)(all,q,REGDST)
d_fa2(q)
    # Allows for investment input-saving technological change to offset ac(i) #;
Equation E_a2
(all,q,REGDST)
-sum(c,COM, sum(i,IND, V2PURO(c,i,q)))*a2(q) =
  sum(c,COM, sum(i,IND, V2PURO(c,i,q)*(acom(c,q) + natacom(c)))) + 100*d_fa2(q);
```

4.10.2 Dollar value shocks for output and capital (TABLO excerpt 12.2)

In this section, some ordinary change variables are defined for variables that are in percentage change form in the core model. This can be helpful for implementation of shocks or presentation of results. Note that all financial variables are measured in millions of dollars.

```
! Section 12.2: To allow $m change shocks for output and capital
==================================!
Variable (change)(all,i,IND)(all,q,REGDST)
d_x1tot(i,q) # Change equivalent of x1tot #;
Variable (change)(all,i,IND)(all,q,REGDST)
d_capital_t1(i,q) # Change equivalent of cap_t1 #;
Variable (change)(all,i,IND)(all,q,REGDST)
d_x2tot(i,q) # Change equivalent of x2tot #;
Variable (change)(all,c,COM)(all,s,REGSRC)
d_x4r(c,s) # Change equivalent of x4r #;

Coefficient(all,i,IND)(all,q,REGDST)
Q1TOT(i,q) # Level of real output #;
Read Q1TOT from file YDATA header "PRDQ";
Update (change)(all,i,IND)(all,q,REGDST)
Q1TOT(i,q) = d_x1tot(i,q);

Coefficient(all,i,IND)(all,q,REGDST)
QCAPITAL_T1(i,q) # Level of real Capital available for production next year #;
Read QCAPITAL_T1 from file YDATA header "CAPQ";
Update (change)(all,i,IND)(all,q,REGDST)
QCAPITAL_T1(i,q) = d_capital_t1(i,q);

Coefficient(all,c,COM)(all,s,REGSRC)
QEXP(c,s) # Level of real exports #;
Read QEXP from file YDATA header "QEXP";
Update (change)(all,c,COM)(all,s,REGSRC)
QEXP(c,s) = d_x4r(c,s);

Equation E_d_x1tot
(all,i,IND)(all,q,REGDST)
100*d_x1tot(i,q) = Q1TOT(i,q)*x1tot(i,q);

Equation E_d_capital_t1
(all,i,IND)(all,q,REGDST)
100*d_capital_t1(i,q) = QCAPITAL_T1(i,q)*cap_t1(i,q);

Equation E_d_x2tot
(all,i,IND)(all,q,REGDST)
100*d_x2tot(i,q) = QINV(i,q)*x2tot(i,q);

Equation E_d_x4r
(all,c,COM)(all,s,REGSRC)
100*d_x4r(c,s) = QEXP(c,s)*x4r(c,s);
```

4.10.3 Locate negatives in V1BAS and V2BAS (TABLO excerpt 12.3)

The purpose of this section is to flag negative values in V1BAS and V2BAS. Negative values for these flows are problematic in MMRF because the model is based on percentage change equations. The implication is that a negative flow in the initial database will remain negative in all subsequent databases.

```
! Section 12.3: Locate negatives in BAS1 and BAS2
====================================!
Coefficient (all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
ZERO1(c,s,i,q);
Formula (all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
ZERO1(c,s,i,q) = 0 + IF(V1BAS(c,s,i,q) Lt 0, -1);

Coefficient (all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
ZERO2(c,s,i,q);
Formula (all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
ZERO2(c,s,i,q) = 0 + IF(V2BAS(c,s,i,q) Lt 0, -1);

Write ZERO1 to file CHECK header "ZER1" ;
Write ZERO2 to file CHECK header "ZER2" ;
```

4.10.4 Road-Rail substitution in margin use (TABLO excerpt 12.4)

In MMRF, substitution between road and rail freight in margin use is possible. Specifically, for a flow from region s to region q, substitution is allowed between road freight and rail freight provided by region q. The substitution is based on relative prices. If in region q, the price of road freight increases relative to the price of rail freight, then there will be substitution away from road freight towards rail freight in all margin uses of the two in region q.

The substitution effects are modelled by introducing the substitution terms modalsub1 to modalsub6 into equations *E_x1marg* to *E_x6marg* in Section 4.2.9. The calculations for the substitution terms for each of the six users are essentially the same, and are given by the equations *E_modalsub1* to *E_modalsub6*. In equation *E_modalsub1*, modalsub1(c,s,i,q,r) depends on a relative price term involving the price of margin r (r = 'RoadTrans' or 'RailTrans') in region q relative to the average price of road and rail transport in region q. The coefficient ISROADRAIL(r) equals one when r is 'RoadTrans' or 'RailTrans', and is zero otherwise, so that modalsub1(c,s,i,q,r) = 0 for margins other than road and rail freight transport. SIGROADRAIL is the inter-modal substitution elasticity for road and rail freight. If the price of road freight transport increases relative to the price of rail freight transport for margin use on the flow of commodity c from source s to industry i in region q, then modalsub(c,s,i,q,"RoadTrans") will be negative, and have a negative effect on the use of road transport to facilitate the flow of commodity c from source s to industry i in region q (x1marg(c,s,i,q,"RoadTrans").

Movements in the average prices of road and rail freight for each user of freight (P1MODALSUB(c,s,i,q), P2MODALSUB (c,s,i,q), P3MODALSUB (c,s,q), P4MODALSUB (c,q), P5MODALSUB(c,s,q) and P6MODALSUB(c,s,q)) are explained by equations *E_p1modalsub* to

E_p6modalsub. In these equations, the 'MAR' coefficients are matrices of data showing the cost of the margins services on the flows of goods, both domestically produced and imported, to users.

```
! Section 12.4: Inter-modal substitution
==================================!
Coefficient (all,r,MARGCOM)
ISROADRAIL(r) #=1 for margins between which sub. is allowed, =0 otherwise #;
Formula (all,r,MARGCOM)
ISROADRAIL(r) = 0.0;
Formula (all,t,MODALSUB)
ISROADRAIL(t) = 1;

Coefficient (parameter)
SIGROADRAIL # Substitution elasticity between road and rail freight #;
Read SIGROADRAIL from file MDATA header "SMOD";

Variable (all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
p1modalsub(c,s,i,q) # Ave. price of margins for inter-modal sub., user 1 #;
Equation E_p1modalsub # Average price of margins which substitute, user 1 #
(all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
ID01[sum{r,MARGCOM,ISROADRAIL(r)*V1MAR(c,s,i,q,r)}]*p1modalsub(c,s,i,q) =
    sum{r,MARGCOM,ISROADRAIL(r)*V1MAR(c,s,i,q,r)*p0a(r,q)};

Variable (all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
p2modalsub(c,s,i,q) # Ave. price of margins for inter-modal sub., user 2 #;
Equation E_p2modalsub # Average price of margins which substitute, user 2 #
(all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)
ID01[sum{r,MARGCOM,ISROADRAIL(r)*V2MAR(c,s,i,q,r)}]*p2modalsub(c,s,i,q) =
    sum{r,MARGCOM,ISROADRAIL(r)*V2MAR(c,s,i,q,r)*p0a(r,q)};

Variable (all,c,COM)(all,s,ALLSRC)(all,q,REGDST)
p3modalsub(c,s,q) # Ave. price of margins for inter-modal sub., user 3 #;
Equation E_p3modalsub # Average price of margins which substitute, user 3 #
(all,c,COM)(all,s,ALLSRC)(all,q,REGDST)
ID01[sum{r,MARGCOM,ISROADRAIL(r)*V3MAR(c,s,q,r)}]*p3modalsub(c,s,q) =
    sum{r,MARGCOM,ISROADRAIL(r)*V3MAR(c,s,q,r)*p0a(r,q)};

Variable (all,c,COM)(all,q,REGSRC)
p4modalsub(c,q) # Ave. price of margins for inter-modal sub., user 4 #;
Equation E_p4modalsub # Average price of margins which substitute, user 4 #
(all,c,COM)(all,q,REGSRC)
ID01[sum{r,MARGCOM,ISROADRAIL(r)*V4MAR(c,q,r)}]*p4modalsub(c,q) =
    sum{r,MARGCOM,ISROADRAIL(r)*V4MAR(c,q,r)*p0a(r,q)};

Variable (all,c,COM)(all,s,ALLSRC)(all,q,REGDST)
p5modalsub(c,s,q) # Ave. price of margins for inter-modal sub., user 5 #;
Equation E_p5modalsub # Average price of margins which substitute, user 5 #
(all,c,COM)(all,s,ALLSRC)(all,q,REGDST)
ID01[sum{r,MARGCOM,ISROADRAIL(r)*V5MAR(c,s,q,r)}]*p5modalsub(c,s,q) =
    sum{r,MARGCOM,ISROADRAIL(r)*V5MAR(c,s,q,r)*p0a(r,q)};
```

```
Variable (all,c,COM)(all,s,ALLSRC)(all,q,REGDST)
p6modalsub(c,s,q) # Ave. price of margins for inter-modal sub., user 6 #;
Equation E_p6modalsub # Average price of margins which substitute, user 6 #
(all,c,COM)(all,s,ALLSRC)(all,q,REGDST)
ID01[sum{r,MARGCOM,ISROADRAIL(r)*V6MAR(c,s,q,r)}]*p6modalsub(c,s,q) =
    sum{r,MARGCOM,ISROADRAIL(r)*V6MAR(c,s,q,r)*p0a(r,q)};

Equation E_modalsub1 # Road/rail substitution in demand for production #
(all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)(All,r,MARGCOM)
modalsub1(c,s,i,q,r) = -ISROADRAIL(r)*SIGROADRAIL*
    [p0a(r,q) - p1modalsub(c,s,i,q)];

Equation E_modalsub2 # Road/rail substitution in demand for investment #
(all,c,COM)(all,s,ALLSRC)(all,i,IND)(all,q,REGDST)(All,r,MARGCOM)
modalsub2(c,s,i,q,r) = -ISROADRAIL(r)*SIGROADRAIL*
    [p0a(r,q) - p2modalsub(c,s,i,q)];

Equation E_modalsub3 # Road/rail substitution in demand for consumption #
(all,c,COM)(all,s,ALLSRC)(all,q,REGDST)(All,r,MARGCOM)
modalsub3(c,s,q,r) = -ISROADRAIL(r)*SIGROADRAIL*
    [p0a(r,q) - p3modalsub(c,s,q)];

Equation E_modalsub4 # Road/rail substitution in export #
(all,c,COM)(all,s,REGSRC)(All,r,MARGCOM)
modalsub4(c,s,r) = -ISROADRAIL(r)*SIGROADRAIL*
    [p0a(r,s) - p4modalsub(c,s)];

Equation E_modalsub5 # Road/rail substitution in demand for reg government #
(all,c,COM)(all,s,ALLSRC)(all,q,REGDST)(All,r,MARGCOM)
modalsub5(c,s,q,r) = -ISROADRAIL(r)*SIGROADRAIL*
    [p0a(r,q) - p5modalsub(c,s,q)];

Equation E_modalsub6 # Road/rail substitution in demand for fed government #
(all,c,COM)(all,s,ALLSRC)(all,q,REGDST)(All,r,MARGCOM)
modalsub6(c,s,q,r) = -ISROADRAIL(r)*SIGROADRAIL*
    [p0a(r,q) - p6modalsub(c,s,q)];
```

4.10.5 Force TAB & IAB to zero in long term base case forecasts (TABLO excerpt 12.5)

The purpose of this section is to invoke the theory that a non-zero balance on the current account cannot persist indefinitely. Rather than being calculated in the core model, the balances on the trade account and income account in year t are assumed to be a fixed proportion of the balances in year t-1, so that they eventually fall to zero and remain at zero.

```
! Section 12.5: Force TAB and IAB and hence CAB slowly to zero for
    long-term basecase forecasts
==================================!
Coefficient
SLOW_ADJUST # Rate of adjustment of TAB and IAB back to zero #;
```

```
Formula
SLOW_ADJUST = 0.2;

Variable (change)
d_TABADJUST # On-off switch variable #;
Variable (change)
d_INTADJUST # On-off switch variable #;
Variable (change)
d_CAPADJUST # On-off switch variable #;

Coefficient (parameter)
TABGDP@1;
Formula (initial)
TABGDP@1 = NATTABGDP;

Coefficient (parameter)
INTGDP@1;
Formula (initial)
INTGDP@1 = sum{q,REGDST, FORINTINC(q)}/V0GDPINC;

Coefficient (parameter)
CAPGDP@1;
Formula (initial)
CAPGDP@1 = sum{q,REGDST, FORCAPINC(q)}/V0GDPINC;

Equation E_d_TABADJUST
d_NATTABGDP = -SLOW_ADJUST*TABGDP@1*d_unity + d_TABADJUST;

Equation E_d_INTADJUST
1/V0GDPINC*d_NATFORINTINC - (sum{q,REGDST, FORINTINC(q)}/V0GDPINC/100)*w0gdpexp
     = -SLOW_ADJUST*INTGDP@1*d_unity + d_INTADJUST;

Equation E_d_CAPADJUST
1/V0GDPINC*d_NATFORCAPINC - (sum{q,REGDST, FORCAPINC(q)}/V0GDPINC/100)*w0gdpexp
     = -SLOW_ADJUST*CAPGDP@1*d_unity + d_CAPADJUST;
```

4.11 ***Tables***

Table 4.1: Names and definitions of selected sets in MMRF

COM	Commodities
IND	Industries
MARGCOM	Margin commodities (a subset of COM)
MARGIND	Margin industries (a subset of IND)
TEXP	Traditional Exports (a subset of COM)
NTEXP1	Non-traditional exports (a subset of COM)
TOUR	Tourism Exports (a subset of COM)
REGDST	Regional destinations of goods (the states of Australia)
ALLSRC	All sources of goods (the states of Australia plus foreign imports)
REGSRC	Domestic sources of goods (a subset of ALLSRC)
OCC	Occupation types.

Table 4.2: Commodities in MMRF

MMRF name	Full name	Sales of Domestically produced commodity (%)						Export set	Taxes[31]
		Inter-mediate	*Invest-ment*	*House-hold*	*Export*	*Govern-ment*	*Stocks*		
1 SheepCattle	Sheep and Cattle	67.1	0.0	0.4	13.7	0.0	0.0	TEXP	
2 Dairy	Dairy	83.8	0.0	0.0	0.0	0.0	0.0	NTEXP	
3 OtherAnimal	Other Animal Agriculture	80.0	0.0	13.7	0.1	0.0	0.0	NTEXP	
4 Grains	Grains	66.8	0.0	5.4	19.8	0.0	0.0	TEXP	
5 BioFuel	Biofuel	100.0	0.0	0.0	0.0	0.0	0.0	NTEXP	
6 OtherAg	Other Agriculture	47.4	0.0	42.5	8.2	0.0	0.0	TEXP	
7 AgServFish	Services to Agriculture, Fisheries	69.5	0.6	9.3	17.9	1.0	0.4	TEXP	
8 Forestry	Forestry	80.1	0.0	0.7	5.7	8.3	3.5	TEXP	
9 Coal	Coal	14.9	0.0	0.1	88.0	0.0	0.0	TEXP	
10 Oil	Oil	18.4	0.0	0.0	79.5	0.0	0.0	TEXP	
11 Gas	Gas	81.6	0.0	0.0	17.6	0.0	0.0	TEXP	
12 IronOre	Iron Ore	6.7	0.0	0.0	93.8	0.0	0.0	TEXP	
13 NonIronOre	Non-iron Ore	68.4	0.0	0.4	30.1	0.0	0.0	TEXP	
14 OtherMining	Other Mining	72.9	8.2	0.1	20.3	0.5	0.2	TEXP	
15 MeatProds	Meat Products	37.7	0.0	30.0	26.2	0.0	0.0	TEXP	
16 OtherFood	Other Food	34.1	0.0	51.2	13.7	0.0	0.0	TEXP	E
17 TCF	Textiles, Clothing, Footwear	33.5	4.4	35.9	23.2	0.0	0.0	TEXP	
18 WoodProds	Wood Products	92.4	0.1	0.2	9.3	0.0	0.0	TEXP	
19 PaperProds	Paper Products	89.8	0.0	5.4	9.2	0.0	0.0	TEXP	
20 Printing	Printing	79.2	2.6	12.2	2.3	0.4	0.2	NTEXP	
21 Gasoline	Gasoline	92.7	0.0	7.3	0.0	0.0	0.0	NTEXP	E
22 Diesel	Diesel	51.7	0.0	1.2	37.2	0.0	0.0	TEXP	E
23 LPG	Liquid Petroleum Gas	57.9	0.0	1.1	32.4	0.0	0.0	NTEXP	E
24 AirFuel	Aviation Fuel	100.0	0.0	0.0	0.0	0.0	0.0	NTEXP	E
25 OtherFuel	Other Fuel	69.3	0.0	4.1	21.0	0.0	0.0	TEXP	E

[31] Some products face special sales taxes. These are denoted E: Excise, M: Motor Vehicle, G: Gambling, and I: Insurance.

26 Chemicals	Chemicals	66.4	0.0	11.9	14.7	4.7	2.0	TEXP	
27 RubbPlastic	Rubber and Plastic	83.3	4.3	6.7	5.3	0.0	0.0	TEXP	
28 NonMetalCon	Non Metal Construction Materials	98.6	0.0	2.0	4.1	0.0	0.0	NTEXP	
29 Cement	Cement	103.0	0.0	0.0	0.3	0.0	0.0	NTEXP	
30 Steel	Steel	93.8	0.0	0.1	6.7	0.0	0.0	TEXP	
31 Alumina	Alumina	10.7	0.0	0.0	89.9	0.0	0.0	TEXP	
32 Aluminium	Aluminium	26.5	0.0	0.0	74.3	0.0	0.0	TEXP	
33 OtherMetals	Other Metals	23.8	0.0	0.0	76.6	0.0	0.0	TEXP	
34 MetalProds	Metal Products	84.6	12.2	2.1	2.8	0.0	0.0	TEXP	
35 MVandParts	Motor Vehicles and Parts	35.3	55.3	0.0	11.8	0.0	0.0	TEXP	M
36 OtherMan	Other Manufacturing	41.5	37.2	7.8	15.4	0.0	0.0	TEXP	
37 ElecCoal	Electricity (Coal)	100.0	0.0	0.0	0.0	0.0	0.0	NTEXP	
38 ElecGas	Electricity (Gas)	100.0	0.0	0.0	0.0	0.0	0.0	NTEXP	
39 ElecOil	Electricity (Oil)	100.0	0.0	0.0	0.0	0.0	0.0	NTEXP	
40 ElecNuclear[32]	Electricity (Nuclear)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	NTEXP	
41 ElecHydro	Electricity (Hydro)	100.0	0.0	0.0	0.0	0.0	0.0	NTEXP	
42 ElecOther	Electricity (Other)	100.0	0.0	0.0	0.0	0.0	0.0	NTEXP	
43 ElecSupply	Electricity Supply	99.2	0.0	0.0	0.0	0.5	0.2	NTEXP	
44 GasSupply	Gas Supply	96.4	0.0	0.0	3.5	0.0	0.0	NTEXP	
45 WaterSupply	Water Supply	61.3	0.0	36.8	0.1	1.3	0.6	NTEXP	
46 Construction	Construction	36.2	61.7	0.0	0.1	1.5	0.6	NTEXP	
47 Trade	Trade	50.6	17.2	24.0	7.1	0.9	0.4	NTEXP	
48 AccomHotels	Accommodation and Hotels	25.9	0.0	65.1	9.1	0.0	0.0	TOUR	G
49 RoadPass	Road Passenger Services	46.6	0.1	30.3	10.9	7.6	3.2	TOUR	
50 RoadFreight	Road Freight Services	56.0	4.6	18.8	16.6	2.6	1.1	NTEXP	
51 RailPass	Rail Passenger Services	4.7	0.1	70.6	25.3	0.0	0.0	NTEXP	
52 RailFreight	Rail Freight Services	28.0	0.6	24.7	46.9	0.0	0.0	NTEXP	
53 WaterTrans	Water Transport Services	71.7	1.4	4.0	10.3	9.1	3.8	WATTRANS	

[32] This is a dummy commodity in MMRF with no output.

54 AirTrans	Air Transport Services	26.6	15.5	20.9	41.1	1.0	0.4	TOUR	
55 Commun	Communication	70.8	0.0	26.5	2.3	0.3	0.1	COMMU NIC	
56 FinServ	Financial Services	76.6	0.0	21.3	2.1	0.0	0.0	NTEXP	I
57 BusServ	Business Services	84.6	12.0	0.8	1.8	0.6	0.2	NTEXP	
58 Dwelling	Ownership of Dwellings	0.0	0.0	99.5	0.3	0.1	0.0	NTEXP	
59 PubServ	Public Services	7.8	0.2	22.0	1.6	41.1	27.3	NTEXP	
60 OthServ	Other Services	18.4	0.3	69.1	0.7	8.0	3.5	TOUR	G
61 PrivTran	Private Transport	0.0	0.0	100.0	0.0	0.0	0.0	NTEXP	
62 PrivElec	Private Electricity	0.0	0.0	100.0	0.0	0.0	0.0	NTEXP	
63 PrivHeat	Private Heating	0.0	0.0	100.0	0.0	0.0	0.0	NTEXP	

Table 4.3: Industries in MMRF

MMRF Name	Full name	Industry costs (%)					Output Commodity/ies[33]
		Inter-mediate inputs[34]	*Labour*	*Capital*	*Land*	*Other Costs*	
1 SheepCattle	Sheep and Cattle	40.4	9.1	12.5	37.0	1.0	Sheep and Cattle
2 Dairy	Dairy	59.0	8.8	6.1	25.6	0.5	Dairy
3 OtherAnimal	Other Animal Agriculture	65.4	9.9	13.9	8.1	2.6	Other Animal Agriculture
4 Grains	Grains	55.3	6.8	9.7	27.4	0.9	**Grains, Biofuel**
5 OtherAg	Other Agriculture	48.2	13.9	9.3	27.3	1.4	Other Agriculture
6 AgServFish	Services to Agriculture, Fisheries	69.1	12.9	16.8	0.0	1.2	Services to Agriculture, Fisheries
7 Forestry	Forestry	63.6	17.6	11.7	5.0	2.1	Forestry
8 Coal	Coal	26.0	12.1	59.4	0.0	2.5	Coal
9 Oil	Oil	7.3	4.0	85.2	0.0	3.5	Oil
10 Gas	Gas	22.1	3.4	71.7	0.0	2.9	Gas
11 IronOre	Iron Ore	18.4	9.9	68.6	0.0	3.1	Iron Ore
12 NonIronOre	Non-iron Ore	43.0	14.5	40.0	0.0	2.4	Non-iron Ore
13 OtherMining	Other Mining	32.6	25.1	40.6	0.0	1.7	Other Mining
14 MeatProds	Meat Products	83.2	13.7	2.8	0.0	0.3	Meat Products
15 OtherFood	Other Food	75.2	11.5	11.7	0.0	1.6	Other Food
16 TCF	Textiles, Clothing, Footwear	74.8	17.6	6.0	0.0	1.6	Textiles, Clothing, Footwear
17 WoodProds	Wood Products	62.3	19.8	15.6	0.0	2.3	Wood Products
18 PaperProds	Paper Products	66.9	13.4	18.2	0.0	1.4	Paper Products
19 Printing	Printing	60.2	22.4	15.7	0.0	1.7	Printing
20 Refinery	Refinery	89.0	5.3	5.5	0.0	0.2	**Gasoline, Diesel, LPG, Aviation Fuel, Other Fuel**
21 Chemicals	Chemicals	74.3	13.5	10.5	0.0	1.6	Chemicals
22 RubbPlastic	Rubber and Plastic	69.2	20.4	8.5	0.0	1.9	Rubber and Plastic
23 NonMetalCon	Non Metal Construction	63.1	18.9	16.5	0.0	1.5	Non Metal Construction Materials

[33] Multi-product industries denoted in bold.

[34] Costs include indirect taxes and margins on domestic and imported intermediate inputs.

	Materials						
24 Cement	Cement	74.8	9.6	14.3	0.0	1.3	Cement
25 Steel	Steel	76.9	14.7	7.0	0.0	1.4	Steel
26 Alumina	Alumina	58.6	8.2	25.5	0.0	7.7	Alumina
27 Aluminium	Aluminium	65.8	8.8	25.4	0.0	0.0	Aluminium
28 OtherMetals	Other Metals	89.2	2.9	7.1	0.0	0.9	Other Metals
29 MetalProds	Metal Products	72.6	18.9	6.9	0.0	1.6	Metal Products
30 MVandParts	Motor Vehicles and Parts	78.8	12.4	7.7	0.0	1.1	Motor Vehicles and Parts
31 OtherMan	Other Manufacturing	70.7	21.6	6.1	0.0	1.5	Other Manufacturing
32 ElecCoal	Electricity (Coal)	38.0	12.0	27.9	0.0	22.0	Electricity (Coal)
33 ElecGas	Electricity (Gas)	67.9	9.4	21.8	0.0	0.9	Electricity (Gas)
34 ElecOil	Electricity (Oil)	105.9	8.5	21.8	0.0	-36.2	Electricity (Oil)
35 ElecNuclear[35]	Electricity (Nuclear)	n.a.	n.a.	n.a.	n.a.	n.a.	Electricity (Nuclear)
36 ElecHydro	Electricity (Hydro)	27.7	20.9	49.3	0.0	2.1	Electricity (Hydro)
37 ElecOther	Electricity (Other)	30.8	15.9	51.7	0.0	1.6	Electricity (Other)
38 ElecSupply	Electricity Supply	61.7	11.2	25.9	0.0	1.2	Electricity Supply
39 GasSupply	Gas Supply	48.0	11.8	38.7	0.0	1.5	Gas Supply
40 WaterSupply	Water Supply	36.6	20.3	41.9	0.0	1.2	Water Supply
41 Construction	Construction	66.4	16.3	16.6	0.0	0.7	Construction
42 Trade	Trade	56.3	28.2	13.9	0.0	1.6	Trade
43 AccomHotels	Accommodation and Hotels	61.7	24.4	12.1	0.0	1.7	Accommodation and Hotels
44 RoadPass	Road Passenger Services	89.0	8.2	2.3	0.0	0.5	Road Passenger Services
45 RoadFreight	Road Freight Services	57.6	31.7	8.8	0.0	1.9	Road Freight Services
46 RailPass	Rail Passenger Services	72.1	15.0	11.7	0.0	1.3	Rail Passenger Services
47 RailFreight	Rail Freight Services	46.3	28.8	22.5	0.0	2.4	Rail Freight Services
48 WaterTrans	Water Transport Services	65.0	17.8	15.8	0.0	1.4	Water Transport Services
49 AirTrans	Air Transport Services	73.5	18.0	7.5	0.0	1.0	Air Transport Services
50 Commun	Communication	52.3	15.2	30.4	0.0	2.0	Communication
51 FinServ	Financial Services	34.8	31.0	33.1	0.0	1.1	Financial Services
52 BusServ	Business Services	60.9	25.1	13.8	0.0	0.2	Business Services
53 Dwelling	Ownership of Dwellings	26.5	0.1	73.5	0.0	0.0	Ownership of Dwellings

[35] This is a dummy industry in MMRF with no output.

54 PubServ	Public Services	35.6	56.5	6.9	0.0	1.0	Public Services
55 OthServ	Other Services	64.1	28.4	5.9	0.0	1.5	Other Services
56 PrivTran	Private Transport	11.6	0.0	88.4	0.0	0.0	Private Transport
57 PrivElec	Private Electricity	27.8	0.0	72.2	0.0	0.0	Private Electricity
58 PrivHeat	Private Heating	39.4	0.0	60.6	0.0	0.0	Private Heating

Table 4.4: Sources of Government Revenue in MMRF, 2005-06 ($ million)

	TABLO name	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Federal
Taxation revenue	GFSI_100	18,507	13,344	9,186	3,764	6,122	905	439	781	245,223
Taxes on goods and services	GFSI_110	5,097	3,821	2,428	1,041	1,208	251	114	178	68,641
General taxes	GFSI_111	-	-	-	-	-	-	-	-	1,202
GST	GFSI_112	-	-	-	-	-	-	-	-	38,884
Excises and levies	GFSI_113	-	-	-	-	-	-	-	-	22,748
International trade	GFSI_114	-	-	-	-	-	-	-	-	4,988
Gambling	GFSI_115	1,520	1,460	841	400	146	79	57	47	-
Insurance	GFSI_116	1,403	1,048	385	284	326	51	21	41	-
Use of motor vehicles	GFSI_117	1,899	1,242	1,084	357	736	121	36	90	-
Other[(a)]	GFSI_118	275	71	118	-	-	-	-	-	819
Factor inputs	GFSI_120	13,410	9,523	6,758	2,723	4,914	654	325	603	4,467
Payroll	GFSI_121	5,169	3,302	1,903	792	1,355	211	125	204	4,453
Property	GFSI_122	8,241	6,221	4,855	1,931	3,559	443	200	399	14
Income taxes	GFSI_130	-	-	-	-	-	-	-	-	172,115
Individuals	GFSI_131	-	-	-	-	-	-	-	-	114,624
Enterprises	GFSI_132	-	-	-	-	-	-	-	-	56,394
Non-residents	GFSI_133	-	-	-	-	-	-	-	-	1,097
Commonwealth grants to states[(b)]	GFSI_200	18,725	13,935	12,789	5,562	6,905	2,170	2,255	1,119	-
GST-tied	GFSI_210	10,427	7,865	7,721	3,822	3,449	1,501	723	1,833	-
Other-current	GFSI_220	8,298	6,071	5,068	1,740	3,456	669	1,532	-714	-
Sales of goods and services	GFSI_300	15,919	9,900	13,034	3,677	8,363	2,306	643	609	34,698
Interest received	GFSI_400	1,764	1,109	4,329	602	601	274	103	85	4,601
Other	GFSI_500	4,452	3,757	4,534	936	2,639	342	275	173	3,519
GFS Revenue	GFSI_000	59,367	42,045	43,872	14,541	24,630	5,997	3,715	2,767	288,041

(a) Taxes not elsewhere classified adjusted for the difference in total taxation revenue between the ABS Government Finance Statistics and Taxation Revenue, Australia. (b) Actual grants scaled to match the corresponding grant expenditure.

Sources: ABS (*Government Finance Statistics, 2005-06*, Cat. no. 5512.0), ABS (*Taxation Revenue, Australia, 2005-06*, Cat. no. 5506.0).

Table 4.5: Government Expenditure in MMRF, 2005-06 ($ million)

	TABLO name	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Federal
Gross operating expenses	GFSE_100	47,407	35,617	31,663	11,026	17,957	4,888	2,961	2,435	90,646
Personal benefit payments	GFSE_200	-	-	-	-	-	-	-	-	77,336
Unemployment benefits[(a)]	GFSE_210	-	-	-	-	-	-	-	-	5,665
Disability support pensions[(b)]	GFSE_220	-	-	-	-	-	-	-	-	8,257
Age pensions[(c)]	GFSE_230	-	-	-	-	-	-	-	-	21,407
Other[(d)]	GFSE_240	-	-	-	-	-	-	-	-	42,007
Grant expenses	GFSE_300	4,327	2,624	3,281	1,005	1,939	347	394	403	76,822
Commonwealth to state	GFSE_310	-	-	-	-	-	-	-	-	61,394
GST-tied[(e)]	GFSE_311	-	-	-	-	-	-	-	-	37,340
Other current	GFSE_312	-	-	-	-	-	-	-	-	24,054
Local governments	GFSE_320	-	-	-	-	-	-	-	-	100
Universities	GFSE_330	-	-	-	-	-	-	-	-	5,556
Private sector	GFSE_340	4,327	2,624	3,281	1,005	1,939	347	394	403	9,772
Property expenses	GFSE_400	2,242	1,535	2,041	1,065	1,063	474	264	199	13,381
Subsidy expenses	GFSE_500	415	36	517	396	5	77	14	8	6,090
Capital transfers	GFSE_600	489	684	588	115	172	22	58	33	4,730
Other[(f)]	GFSE_700	481	56	166	191	308	-	21	-	-
GFS Expenditure	GFSE_000	55,361	40,552	38,256	13,798	21,444	5,808	3,712	3,078	269,005

(a) Newstart, Mature age allowance, Widow allowance and non-full-time students receiving youth allowance. (b) Disability support pension. (c) Age pension, Wife pension (partner DSP), Widow pension (partner age pension) and Widow B pension. (d) The balance of other current transfers not accounted for by unemployment benefits, DSP and age pensions. (e) Tied to GST revenue collections to remove the effect of timing differences. (f) Taxes expenses plus other current transfers.

Sources: ABS (*Government Finance Statistics, 2005-06*, Cat. no. 5512.0) and ABS (*Taxation Revenue, Australia, 2005-06*, Cat. no. 5506.0).

Table 4.6: Fiscal balances in MMRF, 2005-06 ($ million)

	TABLO name	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Federal
Net operating balance[(a)]	GFSNOB	4,006	1,493	5,616	743	3,186	189	3	-311	19,036
Net acquisition of non-financial assets	GFSNFA	4,243	2,993	5,058	125	2,109	229	128	-133	2,089
Net lending (+)/Net borrowing (-)	GFSBUD	-237	-1,500	558	618	1,077	-40	-125	-178	16,947

(a) GFS revenue less GFS expenditure.

Source: ABS (*Government Finance Statistics, 2005-06*, Cat. no. 5512.0) and ABS (*Taxation Revenue, Australia, 2005-06,* Cat. no. 5506.0).

Table 4.7: Drivers of Government Revenue in MMRF

	TABLO name	Driver
Taxation revenue	GFSI_100	GFSI_110 + GFSI_120 + GFSI_130.
Taxes on goods and services	GFSI_110	GFSI_111 + GFSI_112 + GFSI_113 + GFSI_114 + GFSI_115 + GFSI_116 + GFSI_117 + GFSI_118.
General taxes	GFSI_111	Nominal non-GST commodity-sales tax collections for federal and state governments from the CGE-core. All such taxes are *ad valorem* and levied on the basic value of the underlying flow.
GST	GFSI_112	Nominal GST tax collection for the federal government from the CGE-core. GST taxes are modelled as *ad valorem* taxes on the basic + margin values of underlying flows, primarily for consumption and investment.
Excises and levies	GFSI_113	Nominal tax collections from the CGE-core on products subject to excise tax (see Table 4.2). In the current version, such taxes are *ad valorem*, not specific (i.e., not rated per unit of quantity).
International trade	GFSI_114	Nominal import-duty collections from the CGE-core.
Gambling	GFSI_115	Nominal tax collections from the CGE-core on products subject to state and federal gambling (see Table 4.2).
Insurance	GFSI_116	Nominal tax collections from the CGE-core on products subject to state and federal insurance taxes (see Table 4.2).
Use of motor vehicles	GFSI_117	Nominal tax collections from the CGE-core on products subject to state and federal taxes on motor vehicles (see Table 4.2).
Other	GFSI_118	This item includes miscellaneous items in the GFS accounts. Essentially exogenous, it is indexed to the CPI to maintain the homogeneity property of the model.
Factor inputs	GFSI_120	GFSI_121 + GFSI_122.
Payroll	GFSI_121	Nominal payroll tax collections from the CGE-core. Payroll tax collections are modelled simply using a state-specific average tax rate applied to pre-payroll-tax wage costs in all industries. Thresholds are not accounted for.
Property	GFSI_122	Nominal property tax collections from the CGE core. Property tax collections are modelled simply using a state-specific average tax rate applied to pre-property-tax capital costs in all industries.
Income taxes	GFSI_130	GFSI_131 + GFSI_132 + GFSI_133.
Individuals	GFSI_131	Product of a PAYE average tax rate and pre-tax labour income Thresholds and different marginal tax rates are not accounted for.
Enterprises	GFSI_132	Product of a Corporate average tax rate and pre-tax capital income. Thresholds and different marginal tax rates are not accounted for.
Non-residents	GFSI_133	Moves in line with changes in nominal GDP.
Commonwealth grants to states[(b)]	GFSI_200	GFSI_210 + GFSI_220.
GST-tied	GFSI_210	Total GST tax collections from the CGE-core.
Other-current	GFSI_220	Essentially exogenous, but indexed to the CPI to preserve the homogeneity properties of the model.
Sales of goods and services	GFSI_300	Comprises revenue earned through the direct provision of goods and services by general government (government departments and agencies) and public enterprises. Indexed to nominal public consumption from the CGE-core.
Interest received	GFSI_400	Moves in line with nominal GSP/GDP from the CGE-core.
Other	GFSI_500	Moves in line with nominal GSP/GDP from the CGE-core.
GFS Revenue	GFSI_000	GFSI_100 + GFSI_200 + GFSI_300 + GFSI_400 + GFSI_500.

Table 4.8: Drivers of Government Expenditure in MMRF

	TABLO name	Driver
Gross operating expenses	GFSE_100	Comprises expenses incurred through the direct provision of goods and services by general government (government departments) and public enterprises. Indexed to nominal public consumption from the CGE-core.
Personal benefit payments	GFSE_200	GFSE_210 + GFSE_220 + GFSE_230 + GFSE_240.
Unemployment benefits	GFSE_210	Indexed to changes in the number of persons unemployed, an average benefit rate and the national CPI (to preserve homogeneity). Number of persons unemployed comes from the regional labour market and population module.
Disability support pensions	GFSE_220	Indexed to changes in population, an average benefit rate and the national CPI (to preserve homogeneity).
Age pensions	GFSE_230	Indexed to changes in population, an average benefit rate and the national CPI (to preserve homogeneity).
Other	GFSE_240	Indexed to changes in population, an average benefit rate and the national CPI (to preserve homogeneity).
Grant expenses	GFSE_300	GFSE_310 + GFSE_320 + GFSE_330 + GFSE_340.
Commonwealth to state	GFSE_310	GFSE_311 + GFSE_312.
GST-tied	GFSE_311	Nominal value of GST tax collections from the CGE-core.
Other current	GFSE_312	National population and national CPI (to preserve homogeneity).
Local governments	GFSE_320	Nominal GDP
Universities	GFSE_330	Nominal GDP
Private sector	GFSE_340	Nominal GSP/GDP
Property expenses	GFSE_400	Nominal GSP/GDP
Subsidy expenses	GFSE_500	Nominal GSP/GDP
Capital transfers	GFSE_600	Nominal GSP/GDP
Other	GFSE_700	Nominal GSP/GDP
GFS Expenditure	GFSE_000	GFSE_100 + GFSE_200 + GFSE_300 + GFSE_400 +GFSE_500 + GFSE_600 + GFSE_700 + GFSE_800

Table 4.9: Components of Household Income in MMRF, 2005-06 ($ million)

	TABLO name	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	National
Factor income	HINC_100	271,099	197,755	149,913	57,057	82,599	16,774	9,796	17,831	802,825
Labour	HINC_110	151,047	111,224	81,171	30,738	48,000	8,807	5,662	11,176	447,823
Other	HINC_120	120,052	86,531	68,742	26,319	34,600	7,967	4,135	6,655	355,001
Personal benefit payments	HINC_200	25,682	19,167	14,649	7,036	6,961	2,395	699	747	77,336
Unemployment benefits	HINC_210	1,716	1,267	1,225	471	591	197	146	52	5,665
Disability support pension	HINC_220	2,757	1,970	1,584	801	700	293	85	67	8,257
Age pensions	HINC_230	7,267	5,589	3,775	2,057	1,830	623	72	194	21,407
Other benefit payments	HINC_240	13,942	10,341	8,065	3,707	3,840	1,282	396	434	42,007
Other	HINC_300	-	-	-	-	-	-	-	-	-
Household income	HINC_000	296,781	216,922	164,562	64,093	89,560	19,169	10,495	18,578	880,161

Source: MMRF Database

Table 4.10: Calculation of Household Disposable Income in MMRF, 2005-06 ($ million)

	TABLO name	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	National
Household Income	HINC_000	296,781	216,922	164,562	64,093	89,560	19,169	10,495	18,578	880,161
Direct taxation	HTAX_000	53,668	39,285	29,369	11,157	16,611	3,250	1,966	3,692	158,998
Household Disposable Income	HINC_DIS	243,113	177,637	135,193	52,935	72,950	15,919	8,529	14,886	721,162

Source: MMRF Database

Table 4.11: Labour Markets and Demography in MMRF, 2005-06 ('000 persons)

	TABLO name	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Australia
Population	C_POP	6,759	5,051	3,997	1,553	2,017	486	207	330	20,400
Working-age population[(a)]	C_WPOP	5,433	4,079	3,178	1,265	1,613	389	155	266	16,376
Labour force	LABSUP_O	3,493	2,639	2,074	814	1,050	250	101	171	10,591
Employment	EMPLOY_IO	3,319	2,508	1,970	773	993	237	95	163	10,058
Unemployment		174	131	103	41	57	13	6	9	533
Unemployment rate (%)		5.0	5.0	5.0	5.0	5.4	5.2	5.5	5.1	5.3

(a) Total civilian population aged 15 and over.

Source: Based on ABS (*Australian Demographic Statistics*, Cat. no. 3101.0, Tables 4 and 12).

Table 4.12: Balance of Payments in MMRF, 2005-06 ($ million)

	TABLO name	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Australia
Balance on foreign trade account	TAB	-15,319	-18,218	9,148	-4,654	17,936	27	1,047	-2,538	-12,570
Balance on foreign income account	IAB	-9,721	-7,864	-8,299	-2,477	-6,042	-611	-526	-358	-35,899
Net current transfers	NCT	-140	-103	-81	-29	-52	-8	-6	-9	-426
Balance on current account	CAB	-25,180	-26,185	768	-7,160	11,843	-592	516	-2,905	-48,895
Net foreign liabilities	NFL	170,909	125,384	98,536	35,708	63,383	9,875	6,975	10,446	521,216

Source: MMRF Database

5. Closing the Model

As explained in Chapter 3, the number of variables (n) in the model specified in Chapter 4 exceeds the number of equations (m). Thus, to solve the model, (n-m) variables must be made exogenous. This choice determines the model's closure.

Table 5.1 lists the exogenous variables in the model's standard closure. This is a long-run comparative-static closure (see Section 3.2), with national aggregate employment and national rates of return on capital determined by the BETA-mechanism (see Section 4.2.21). By swapping variables between exogenous and endogenous categories[36] the standard long-run closure can be converted to a comparative static short-run closure. Forecasting and policy closures are developed in a similar way, by a series of swaps applied to the short-run comparative static closure.

5.1 *The standard (long-run) comparative static closure*

5.1.1 Technological change and other exogenous variables constraining real Gross State Product from the supply side

The first group of exogenous variables listed in Table 5.1 are concerned with the supply side of the regional economies. Most of the variables are technological-change terms relating to primary factors and intermediate inputs at the regional and national levels. MMRF does not explain changes in technology. However, the inclusion of these terms allows the user to simulate the effects of a wide variety of exogenously given changes in technology.

Included in this first group of variables is national employment (natx1lab_io). In this long-run closure, we assume that the exogenous shock under investigation does not affect aggregate employment in Australia. In the long-run, demographic variables, participation rates and the natural rate of employment determine aggregate employment. The national real wage rate (natrwage_c) is assumed to vary to accommodate this assumption.[37] Note that although the shock may not affect national employment, it does affect the regional distribution of employment (see below).

Because this closure is a long-run closure, we allow for capital reallocation effects. For example, in simulating the effects of increased government expenditure in Victoria, we allow Victorian industries' capital stocks to deviate from their basecase levels. We assume that, in the long run, the average rate of return on capital over all regional industries will be same with and without the shock under investigation. Thus, the variable d_natr1cp is exogenous. We do, however, allow increase rates of return to persist in regional industries experiencing relatively large stimuli to activity relative to those industries experiencing relatively small stimuli. Making exogenous the variable d_fr1cap, and thus activating equation *E_d_fr1cap*, achieves this.

The stock of agricultural land (xllnd) is a naturally exogenous variable to MMRF.

---

[36] This is done in the GEMPACK Command File with a command such as "swap x = y;". In this case, if the standard closure had x exogenous and y endogenous, the swap command would make x endogenous and y exogenous.

[37] Wage rates by occupation, industry and region are related to the regional CPIs via equation E_pwage. In this closure of the model, all shift terms on the RHS of E_pwage are exogenous except for the region-specific shifters, fpwage_io(q). The weighted average of fpwage_io(q) moves to achieve the change in national real wage rate necessary to accommodate the exogenous setting for national employment.

Finally, technical change terms relating to primary factors and inputs to production and investment are exogenous. The labour-capital twist terms also fall into this group.

5.1.2 Determination of real Gross State Product expenditure-side aggregates

The variables listed under this heading relate to the size and composition of aggregate domestic absorption in each region. The apc (along with the national shifter natapc), is the average propensity to consume out of household disposable income. Setting this exogenously to zero activates equation *E_w3lux*, linking changes in nominal private consumption (w3tot) to changes in household disposable income (whinc_dis) in each region. The taste terms (a3tot and nata3tot) refer to the composition of household expenditure.

We assume that the ratio of state government consumption to private consumption is fixed. Hence natf5tot and f5tot appear in the exogenous list. Similarly, for the federal government, we assume that the deviations in its expenditure are in line with nation-wide deviation in private consumption expenditure. Hence, natf6tot and f6tot appear in the exogenous list. The composition of state and federal consumption expenditure is fixed by the inclusion of f5a and f6a as exogenous variables.

Fixing the variable d_fx7r forces stocks to be indexed to domestic output via equation E_d_x7r.

We assume that in the long-run year, investment in each regional industry will deviate from the basecase in line with deviations in the industry's capital stock. Thus the ratio variables, r_inv_cap_i, r_inv_cap_q, r_inv_cap_iq, and r_inv_cap are exogenous and typically set to zero. The implication of this assumption is that the *rates of growth of industries' capital stocks do* not deviate from basecase rates of growth (see Section 4.2.21).

Finally the twistsrc variables are naturally exogenous and ensure that the volume of imports is determined by Armington substitution with domestic commodities.

5.1.3 Foreign conditions: import prices fixed; export demand curves fixed in quantity and price axes

MMRF contains no equations describing movements in foreign demand schedules and changes in foreign supply conditions. Thus the various export demand shifters and the foreign currency prices of imports (natp0cif) are treated as exogenous variables.

5.1.4 Tax rates are exogenous

The variables in this section are tax terms on commodity sales and factor incomes. Although these variables are naturally exogenous to a model like MMRF, one can imagine a computation in which some tax rates are treated endogenously. For example, in many simulations it is appropriate to assume that the federal government's budget balance is unaffected by the shock. To achieve this, we could fix the budget balance exogenously at zero change and allow income tax rates (on labour and capital) to be endogenous. The closure swap would be: budget balance exogenous and the general shift in income tax rates d_tinc endogenous; d_tlabinc and d_tgosinc endogenous, and d_ftlabinc and d_ftgosinc exogenous (see equations *E_d_tla*binc and *E_d_tgosinc*).

5.1.5 Regional population, labour market and wages: exogenous wage differentials and exogenous population

We assume that interregional differentials in wages are exogenous as is population by region. This is achieved by fixing exogenously the regional nominal wage differentials r_wage_natwage1 for all but one state and the regional population variables pop, d_pop_g, d_pop_fm, d_pop_rm and r_qhous_pop. Note that fixing wage differentials in all but one state effectively fixes the wage differential in the remaining state.

With wage rates, and hence unit costs of employment, determined at the regional levels, employment (hours) is also set. With the ratio of persons employment to hours worked (r_x1emp_x1lab) fixed, determining employment (hours) also determines employment (persons). On the demographic side, with the ratio of working-age population to total population in each region (r_wpop_pop) fixed, as are participation rates (r_lab_wpop), fixing regional populations also effectively fixes the endogenous regional labour supply (lab). Thus regional unemployment rates are determined endogenously.

5.1.6 Household income

The variables listed in this section are naturally exogenous.

5.1.7 Government accounts

The variables listed in this section are naturally exogenous.

5.1.8 Foreign accounts

The variables listed in this section are naturally exogenous.

5.1.9 Variables relating to dynamics

The variables listed in this section are not required for comparative statics. These variables are discussed when the dynamic closures are developed later in this chapter.

5.1.10 Numeraire assumption

We have to exogenously set a price. In this closure we have chosen the national CPI (natp3tot). An obvious alternative is the exchange rate (phi). Note that the results for real variables are unaffected by this decision.

5.2 *From Long-run to Short run*

In the short run, we assume that labour and capital markets do not have time to adjust. Capital is assumed to be fixed in every industry and region, and rates of return are endogenous.

The real consumer wage is assumed to be fixed in the short run, so national labour is endogenous. This reflects conditions in the Australian labour market where in the short run, real wages are largely determined independently of market forces.

These two changes are introduced via the “swap” command in a GEMPACK command file (cmf). This simple mechanism ensures that the modeller can make incremental changes starting from an understood closure that produces a solution.

In this closure, where capital is exogenous and the ratio of investment to capital is also exogenous, investment is effectively fixed.

```
! Capital exogenous and rates of return endogenous.
swap d_fr1cap   = x1cap ;

! National employment endogenous and the national real wage rate exogenous.
swap natx1lab_io= natrwage_c ;
```

5.3 *From Short run to Dynamic*

A recursive dynamic simulation works like a series of short run simulations, except that some variables which are exogenous in a short run simulation are determined by accumulation relationships instead. For example, capital in industry i in region q (x1cap(i,q)) is determined by investment in the previous year. This change is implemented with a swap:

```
swap x1cap  = f_x1cap;
```

effectively activating equation e_f_x1cap:

```
x1cap(i,q) = cap_t(i,q) + f_x1cap(i,q);
```

where cap_t(i,q) is given by the accumulation relationship:

```
cap_t(i,q) =
[0 + IF[QCAP(i,q) NE 0,
100*{QINV@1(i,q) - DEPR(i)*QCAP@1(i,q)}/QCAP(i,q)]]*d_unity;
```

and d_unity is exogenously given the value of 1.

The variable d_unity plays a necessary role in accumulation relationships for capital, net foreign liabilities and population. While it is exogenous in all closures, including comparative static, in year-on-year mode it is necessary to implement the shock:

```
shock d_unity= 1.0;
```

The full list of swaps required to implement year-on-year mode follows:

```
! Year-to-year closure
!-------------------------------------
! Capital in year t determined by capital and investment in year t-1
swap x1cap  = f_x1cap;

! Investment in year t determined by expected rate of return
swap r_inv_cap  = d_feeqror;
swap d_k_gr = d_fk_gr;

! Net stocks of foreign equity and debt updated by balance on capital account
swap d_NFE  = d_FNFE;
swap d_NFD  = d_FNFD;

! Regional population
swap pop= f_pop;
```

5.4 *Special Closures in MMRF*

Dynamic simulations in MMRF are based on two special closures. The purpose of the first, “Base”, is to produce a baseline, or counterfactual set of forecasts, in which business continues as usual. The second closure, “Policy”, is the closure in which a shock or shocks are applied to some aspect of the economy. A new series of year-on-year simulations is produced, and results are then reported in terms of cumulative deviations from the baseline.

While there are almost limitless possibilities for the “Policy” closure, relating to the many questions that can be asked of the model, the same “Base” may be used in many instances.

5.4.1 Forecast closure: Base

The purpose of the “Base” closure is to produce a business-as-usual forecast over the medium to long term which is consistent with expert forecasts of economic growth and structural and demographic changes. In order to incorporate these forecasts, each forecast variable, which is usually considered endogenous, must be swapped with an appropriate instrument. At this stage it is useful to introduce a “back of the envelope” (“bote”) model which captures the macroeconomic relationships in MMRF. The following nine equations include four identities (expenditure side GDP, income side GDP, the GDP price level and the terms of trade), and five theories (the CES production function, and a theory for each of the major components of GDP expenditure – consumption, investment, exports and imports).

$l - k = -\sigma(p_L - p_K) + (1 - \sigma)(a_L - a_K) + \gamma$	CES production function (1)
$y = (S_L l + S_K k) - (S_L a_L + S_K a_K)$	GDP supply identity (2)
$p = (S_L p_L + S_K p_K) + (S_L a_L + S_K a_K)$	GDP price level identity (3)
$y = S_C c + S_I i + S_G g + S_X x - S_M m$	GDP expenditure identity (4)
$c = y + \mu$	Consumption function (5)
$i = \rho(ror) + \omega$	Investment function (6)
$x = -\varepsilon(toft) + f4$	Export function (7)
$m = y + \alpha(toft) + \theta$	Import function (8)
$toft = p - (p_M + \varphi)$	Terms of trade (9)

The nine endogenous variables in this system of nine equations are labour (l), capital rental (p_K), GDP (y), the price level (p), consumption (c), investment (i), exports (x), imports (m) and the terms of trade (toft). The rate of return (ror) is also usually endogenous in MMRF but may be considered exogenous (or closely linked to p_K via another equation) in this back-of-the-envelope model. The other exogenous variables are capital (k), the nominal wage (p_L), government expenditure (g), labour and capital saving technology (a_L and a_K), the labour-capital twist (γ), the average propensity to consume (μ), an investment confidence parameter (ω), the export demand shifter (f4) and the import-domestic twist (θ).

We may wish to build a baseline consistent with forecasts for many of the naturally endogenous variables in this bote model. To do so, we must exogenise each of these variables and endogenise the appropriate instrument. For example, to incorporate an external forecast of consumption, we would endogenise μ, the average propensity to consume, and exogenise c and shock it with the appropriate forecast value. Equation (5) will now solve for μ instead of c. Now the model will find the value for μ which is consistent with the external forecast for c.

The table below suggests appropriate swaps for building in forecasts for each of the major macroeconomic aggregates. The suggested instrument may not be appropriate in every case, particularly if a forecasts for a only a subset of these variables is available. For example, if there is no forecast for the terms of trade it is more suitable to use a_L or a_K as an instrument for labour and leave γ exogenous. Furthermore, if no forecast exists for the wage rate, it should be used instead of γ as the instrument for labour, so that it is not inadvertently forecast to remain fixed over the forecast period.

If the modeller attempts to incorporate GDP and every component of expenditure on GDP, the GDP identity (equation 4) will be overidentified. For this reason, there is no swap for y (GDP). If the modeller would like to incorporate y, then one of the components of expenditure must act as a residual (for example, investment), so y must be swapped with this component.

In MMRF (but not this bote model) a similar overidentification problem exists if regional and national forecasts are both imposed for the same variable. For example, if forecasts for GSP are built in for every state, then the national forecast for GDP should not also be included.

Forecast available for:	**Suggested swap:**	**Comments**
l	*γ*	Other possibilities are a_L or p_L.
k		Exogenous (endogenously determined by previous year's investment in MMRF)
p_L		Exogenous (the real wage is exogenous in the MMRF year to year closure). Must not be inadvertently kept fixed in the forecast.
c	μ	
i	ω	
g		Exogenous. Must not be inadvertently kept fixed in the forecast. Various options exist in MMRF.
x	*f4*	
m	θ	
toft	a_L or a_K	A good candidate in MMRF is nata1prim_i, the Hicks-neutral technical change term
y	*c, i, x or m*	One of the expenditure terms may act as a residual if GDP is to be forecast explicitly.

5.4.2 Policy closure

In the Policy closure, we return to a "natural" economic modelling environment, in which structural variables are exogenous. Two simulations are run: "Base Rerun" and "Policy".

Having solved the model for structural variables such as those equivalent to the bote model's μ, ω and a_L in the "Base" simulation, in the Policy closure these variables are exogenised. In the "Base Rerun" simulation, these variables perturbed with the solution values found in the "Base" simulation. The solution to the "Base Rerun" simulation thus reproduces the forecasts imposed in the "Base" simulation.

In addition, the Policy closure may contain swaps to facilitate policy analysis. This is not essential, and depends on the type of policy to be simulated. For example, tax rates are exogenous in "Base", so changes to tax rates may not require any swaps.[38] However, to run a simulation of an increase in demand for exports of iron ore, for example, exports of iron ore will need to be exogenised and perturbed with the appropriate shock, and a shift variable will need to be endogenised. In this case, the Policy closure includes the necessary swap.

In the "Base Rerun" simulation, all exogenous variables, including those exogenised by policy-specific swaps, are perturbed with their solution values from the "Base" simulation.

The result of the second simulation, "Policy", is a forecast in which additional shocks are applied to one or several variables, such as tax rates or exports of iron ore, as well as the shocks applied in "Base Rerun". As the Policy closure is used for both the "Policy" and "Base Rerun" simulations, the only difference between the two simulations is the shock(s) that are applied in "Policy".

The set of swaps applied in the Policy closure enables the operation of the equations required to carry base case values through to the policy simulation. This is necessary for the medium-run treatment of the real wage and employment (Section 4.8.2). An example from the TABLO code is equation E_f_emp:

```
Equation E_f_emp # Introduces forecast employment into deviation simulation #
empfor = natx1lab_io + f_emp;
```

Suppose the "Base" solution for employment is natx1lab_io = 2. In the "Base" closure, f_emp is exogenous, so E_f_emp is effectively:

```
empfor = natx1lab_io;
```

That is, empfor = 2.

In the Policy *closure*, empfor is exogenous, and f_emp is endogenous, so E_f_emp is effectively:

```
empfor = natx1lab_io + f_emp;
```

where, in the "Base Rerun" *simulation*, empfor = 2 exogenously; and natx1lab_io = 2 (either endogenously or exogenously). The solution to the equation is f_emp = 0, but this is unimportant.

In the "Policy" *simulation*, again empfor = 2 exogenously. The value for natx1lab_io is solved in the core model (perhaps natx1lab_io = 3). Therefore, this equation, with its closure swaps, has enabled a solution from the Base to be transferred into the Policy simulation. As discussed in Section 4.8.2, this enables deviations between the baseline and policy trajectories for variables such as wages and employment to be incorporated into simulation solutions.

The final swap in this section enables the operation of equation E_d_frwage_ct (Section 4.8.2). By exogenising d_frwage_ct, this swap effectively activates the equation that solves for the policy real wage as a function of the deviation in employment from its baseline level.

---

[38] Swaps may be required if uniform changes to tax rates are implemented.

```
Equation E_d_frwage_ct # Relates %devrw to %devemp in year-to-year sims. #
(C_RWDEV/C_RWFOR)*[rwdev - rwfor] = (C_RWDEV_L/C_RWFOR_L)*[rwdev_l - rwfor_l] +
LAB_SLOPE*(C_EMPDEV/C_EMPFOR)*[empdev - empfor] + 100*d_frwage_ct;
```

```
! Year-to-year Policy closure
!======================
! Put in place the medium-run treatment of real wage and employment
swap f_rw    = rwfor;
swap f_emp   = empfor;
swap natrwage_c = d_frwage_ct;
```

5.4.3 Historical and Decomposition simulations

A special case of a simulation run using the Forecast closure is the historical simulation. In this simulation, the model generates a baseline that corresponds to a period of history, say year t-n to t-(n-k). Because it covers a period in the past, the external "forecasts" in this simulation correspond to observations of macroeconomic variables over the period. The model solves for structural change over the k-year period.

The results from the historical simulation can then be used for an historical decomposition simulation. The Policy closure is used for this simulation. The structural change parameters are perturbed with their solution values from the historical simulation, one at a time. The results from each shock are interpreted as the changes attributable to that aspect of structural change. In this way, we can attribute growth in output or incomes to changes in: technology, domestic preferences, world prices or preferences, taxation or tariffs, or other elements. Dixon and Rimmer (2002) have an example of this type of simulation uncovering factors behind the performance of the motor vehicle industry from 1987 to 1994.

5.5 *Conclusion*

In this chapter, the standard closures of MMRF are described. Starting with the long run comparative static closures, we work through a series of alternative closures, each corresponding to a logical economic environment. Changes to closures are achieved via "swaps" in GEMPACK.

The chain of closures in MMRF is as follows. Starting with a long run comparative static closure, the first set of swaps produces a short run comparative static closure. The next set of swaps turns on the accumulation relationships, and produces the year-to-year closure which is used for dynamic simulations. The first important year-to-year closure is the Base, used to generate a business-as-usual baseline incorporating macroeconomic forecasts. In this closure, naturally endogenous economic variables are exogenised. The second important year-to-year closure is the Policy closure, used to generate deviations from the baseline which occur as a result of external shocks to the model.

Table 5.1: Exogenous variables in MMRF Long Run Comparative Static Closure

1. GDP supply side, factor price and technical change variables	
natx1lab_io	National employment (long-run assumption)
x1lnd	Agricultural land
f1oct	Ratio of P1OCT(j,q) to P3TOT(q)
natfpwage_io	National ratio of PWAGE to P3TOT
fpwage_i	Ratio of PWAGE to P3TOT, specific to q and o
fpwage	General shift in pwage/P3TOT ratio
natfpwage_i	Occupation shift in pwage/P3TOT ratio
d_natr1cap	Shifter in rate of return beta mechanism
d_fr1cap	shifter in mechanism for distributing ROR in long-run CSS
twistlk	Twist in labour/capital ratio
twistlk_i	Region specific general shift in labour/capital ratio
nattwistlk_i	
a1lab_o	Labour-saving technological change (- means improvement)
a1cap	Capital-saving technological change (- means improvement)
a1lnd	Land-saving technological change (- means improvement)
a1oct	Other-cost-saving technological change (- means improvement)
a1prim	All-factor-saving technological change (- means improvement)
a1prim_i	State-wide all-factor-saving technological change (- means improvement)
nata1lab_oi	Labour-saving, all industry, all region technological change (- means improvement)
nata1lab_o	Labour-saving, all region technological change (- means improvement)
nata1prim_i	National equivalent of a1prim_i (- means improvement)
acom	Commodity c-using technical change
acomind	Commodity c-using, industry-specific technical change
natacom	All-region shift in acom
nata1prim	All-region shift in a1prim
d_fa1	Exogenous to ensure acom is production-cost neutral
d_fa2	Exogenous to ensure acom is investment-cost neutral
2. Expenditure on GDP	
apc	Average propensity to consume (could be swapped with x3tot)
natapc	National shift in apc(q)
a3tot	Consumer tastes
nata3tot	All-region shift in a3tot
natf5tot	Overall shift term for state government consumption
natf6tot	Overall shift term in federal government consumption
f5tot	Shift term for regional government consumption
f5a	Shift term for regional government consumption by c
f6tot	Shift term for federal government consumption
f6a	Shift term for federal government consumption by c
d_fx7r	Shift in d_x7r
r_inv_cap_i	Shifts in ratio of investment to capital, specific to q
r_inv_cap_q	Shifts in ratio of investment to capital, specific to i
r_inv_cap_iq	Shifts in ratio of investment to capital, specific to nothing
r_inv_cap	Shifts in ratio of investment to capital, specific to i and q
twistsrc	Twist in import/domestic ratio
twistsrc_c	Region specific general shift in import/domestic ratio
nattwistsrc_c	
nattwistsrc	
3. Foreign Demand conditions	
natp0cif	Foreign prices of imports
f4p	Vertical (price) shift in individual export demand function
f4q	Horizontal (quantity) shift in individual export demand function
natf4p	Commodity-specific vertical (price) shift in export demand function
natf4q	Commodity-specific horizontal (quantity) shift in export demand

	function
natf4p_c	*National vertical (price) shift in export demand*
natf4q_c	*National horizontal (quantity) shift in export demand*
f4p_c	*Region-specific vertical (price) shift in export demand*
f4q_c	*Region-specific horizontal (quantity) shift in export demand*
f4q_ntrad	*Horizontal (quantity) shift in non-traditional export function*
f4p_ntrad	*Vertical (price) shift in non-traditional export function*
fntrad	*Shift in composition of non-traditional bundle*
f4q_tour	*Horizontal (quantity) shift in tourism export demand function*
f4p_tour	*Vertical (price) shift in tourism export demand function*
ftour	*Shifts in composition of tourism export bundle*
natf4q_ntrad	
natf4q_tour	
fcommunic	*Shift in communications export function*
fwattrans	*Shift in water transport export function*
4. Taxes	
d_t1F_csiq	*%-point change in Federal sales tax rate(not GST)*
d_t2F_csiq	*%-point change in Federal sales tax rate(not GST)*
d_t3F_csq	*%-point change in Federal sales tax rate(not GST)*
d_t4f_cs	*%-point change in Federal sales tax rate(not GST)*
d_tF	*%-point change in Federal sales tax rate(not GST)*
d_tFq	*%-point change in Federal sales tax rate(not GST), by region*
d_tSq	*%-point change in State sales tax rate, by region*
d_tFc	*%-point change in Federal sales tax rate(not GST), by commodity*
d_tSc	*%-point change in State sales tax rate, by commodity*
d_tScq	*%-point change in State sales tax rate, by commodity and region*
d_t1F_siq	*%-point change in Federal sales tax rate(not GST), user 1, specific to c*
d_t1S_siq	*%-point change in State sales tax rate, user 1, specific to c*
d_t1F_si	*%-point change in Federal sales tax rate(not GST), user 1, specific to c*
d_t1S_si	*%-point change in State sales tax rate, user 1, specific to c*
d_t2F_siq	*%-point change in Federal sales tax rate(not GST), user 2, specific to c*
d_t2S_siq	*%-point change in State sales tax rate, user 2, specific to c*
d_t2F_si	*%-point change in Federal sales tax, user 2, specific to c*
d_t2S_si	*%-point change in State sales tax rate, user 2, specific to c*
d_t3F_sq	*%-point change in Federal sales tax rate(not GST), user 3, specific to c*
d_t3S_sq	*%-point change in State sales tax rate, user 3, specific to c*
d_t3F_s	*%-point change in Federal sales tax rate(not GST), user 3, specific to c*
d_t3S_s	*%-point change in State sales tax rate, user 3, specific to c*
d_t4f_s	*%-point change in Federal tax rate(not GST) on exports, specific to c*
d_tGST	*%-point change in GST all regions*
d_tGSTq	*%-point change in GST, specific to q*
powtar	*Percentage change in the power of the tariff*
d_t1capF_i	*%-point change in tax on capital input in region q - Federal*
d_t1capS_i	*%-point change in tax on capital input in region q - State*
d_t1labS_i	*%-point change in payroll tax in region q*
d_t1labF_i	*%-point change in fringe-benefit tax in region q*
d_t1lndF_i	*%-point change in tax on land input in region q - Federal*
d_t1lndS_i	*%-point change in tax on land input in region q - State*
d_t1octF_i	*%-point change in other-cost tax (Federal) in region q*
d_t1octS_i	*%-point change in other-cost tax (state) in region q*
d_t1capF_iq	*%-point change in tax rate on capital input - Federal*
d_t1capS_iq	*%-point change in tax rate on capital input - State*
d_t1labS_iq	*%-point change in payroll tax rate*
d_t1labF_iq	*%-point change in fringe-benefit tax rate*
d_t1lndF_iq	*%-point change in tax on land tax rate - Federal*
d_t1lndS_iq	*%-point change in tax on land tax rate - State*

d_t1octF_iq	*%-point change in other-cost tax rate (Federal)*
d_t1octS_iq	*%-point change in other-cost tax rate (state)*
d_tlabinc	*%-point change in tax on labour income*
d_tgosinc	*%-point change in tax on non-labour income*
d_tinc	*%-point uniform shift in tax on labour and non-labour income*
d_ft1capF	*Allows for flexible handling of d_t1capF*
d_ft1capS	*Allows for flexible handling of d_t1capS*
d_ft1labS	*Allows for flexible handling of d_t1labP*
d_ft1labF	*Allows for flexible handling of d_t1labF*
d_ft1lndF	*Allows for flexible handling of d_t1lndF*
d_ft1lndS	*Allows for flexible handling of d_t1lndS*
d_ft1octF	*Allows for flexible handling of d_t1octF*
d_ft1octS	*Allows for flexible handling of d_t1octS*
d_t0	*Allows for fixing of payroll tax and income tax rates*

5. Labour market and demographics

r_wage_natwage1(rostate)	*region wage differential*
pop	*Population*
d_pop_g	*Change in regional population due to nat. growth*
d_pop_fm	*Change in regional population due to foreign migration*
d_pop_rm	*Change in regional population due to regional migration*
r_qhous_pop	*Ratio of number of households to population*
r_wpop_pop	*Ratio of working age population to changes in population*
r_lab_wpop	*Ratio of labour supply by region and occupation*
r_x1emp_x1lab	*Ratio of persons employed to hours worked fixed by region*

6. Exogenous household income

d_whinc_400	

7. Shift variables in the GFS module

benefitrate1	*Average rate of unemployment benefit*
benefitrate2	*Average rate of disability-pension benefit*
benefitrate3	*Average rate of age-pension benefit*
benefitrate4	*Average rate of other-benefit*
f_wgfse_100	
f_wgfse_320	
f_wgfse_330	
f_wgfse_340	
f_wgfse_400	
f_wgfse_500	
f_wgfse_600	
f_wgfse_700	
d_wgfse_800	*GFSE: Government handouts #;*
f_wgfsi_114	
f_wgfsi_118	
f_wgfsi_121	
f_wgfsi_122	
f_wgfsi_131	
f_wgfsi_132	
f_wgfsi_133	
f_wgfsi_210(rostate)	
f_wgfsi_220	
f_wgfsi_300	
f_wgfsi_400	
f_wgfsi_500	

8. Foreign accounts

d_FORINT	*Foreign rate of interest on net stock of foreign liabilities*
d_NFE	*Net stock of foreign equity*
d_NFD	*Net stock of foreign debt*

d_FNCT	*Exogenous shift in net current transfers from abroad*
d_FNATNCT	*Exogenous shift in net current transfers - National*
d_VALD	*Change in valuation effect for income from foreign debt*
d_VALE	*Change in valuation effect for income from foreign equity*
fforshr	*Turns off/off changes in domestic shares of industries*
9. Variables for dynamic simulations	
d_unity	*Dummy (homotopy) variable set to one for year-to-year simulations*
d_k_gr	*d_k_gr mechanism turned off for comparative static simulations*
d_feeqror_iq	*Shifter in EROR/K_GR trade off equation, specific to nothing*
d_feeqror_i	*Shifter in EROR/K_GR trade off equation, specific to q*
f_emp	*Ratio of forecast value of labour to deviation value of labour*
f_rw	*Ratio of forecast value of real wage to deviation value of real wage*
10. Numeraire	
natp3tot	*National CPI is the numeraire*

6. Bibliography

Armington, P. S. “Adjustment of Trade Balances: Some Experiments with a Model of Trade Among Many Countries.” *IMF Staff Papers, XVII*, 1970: 488-523.

Armington, P. S. “The Geographic Pattern of Trade and the Effects of Price Changes.” *IMF Staff Papers, XVI*, 1969: 176-199.

Australian Bureau of Statistics. *Australian National Accounts: Input-Output Tables, 2005-06 (Cat. No. 5209.0).* Commonwealth of Australia, 2010.

Australian Bureau of Statistics. *Balance of Payments and International Investment Position, Australia (Cat. No. 5302.0).* Commonwealth of Australia, 2007.

Australian Bureau of Statistics. *Government Finance Statistics, Australia, 2009-10 (Cat. no. 5512.0).* Commonwealth of Australia, 2011.

Australian Bureau of Statistics. *Taxation Revenue, Australia 2005-06 (Cat. No. 5506.0).* Commonwealth of Australia, 2007.

Dixon, P. B., and M. T. Rimmer. *Dynamic General Equilibrium Modelling for Forecasting and Policy: A Practical Guide and Documentation of MONASH.* North Holland Publishing Company, 2002.

Dixon, P. B., B. R. Parmenter, J. Sutton, and D. P. Vincent. *ORANI: A Multisectoral Model of the Australian Economy.* North Holland Publishing Company, 1982.

Dixon, P. B., S. Bowles, and D. Kendrick. *Notes and Problems in Microeconomic Theory.* North Holland Publishing Company, 1980.

Giesecke, J. A., and J. R. Madden. *Uncovering the Factors behind Comparative Regional Economic Performance: a Dynamic CGE Approach.* General Working Paper No. G-165, Centre of Policy Studies, Monash University, 2006.

Harrison, W. J., and K. R. Pearson. “Computing Solutions for Large General Equilibrium Models Using GEMPACK.” *Computational Economics*, 1996: 83-127.

Hinchy, M., and K. Hanslow. *The MEGABARE Model: Interim Documentation.* Canberra: Australian Bureau of Agricultureal and Resource Economics, 1996.

Horridge, J. M., B. R. Parmenter, and K. R. Pearson. “ORANI-F: A General Equilibrium Model of the Australian Economy.” *Economic and Financial Computing*, 1993: 71-140.

Johansen, L. *A Multisectoral Model of Economic Growth.* North Holland Publishing Company, 1960.

Meagher, G. A., and B. R. Parmenter. “Monash-MR: A Multiregional CGE Model of Australia.” *Venice Workshop on Transportation and Spatial CGE Models.* Venice, 1993. 25.