THE MACROECONOMICS OF THE TRYM
MODEL OF THE AUSTRALIAN ECONOMY

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1. Introduction

This volume is intended to make the Treasury macroeconomic (TRYM) model more accessible by providing an overview of how the model works and how to interpret model results. It contains: (1) a description of the overall structure of the model and a summary of its main relationships; (2) a brief description of sectors and markets embodied in TRYM; (3) a brief introduction to the intuition behind the model results drawing on standard macroeconomic theory; (4) a discussion of how the model relates to some standard macroeconomic propositions; and (5) an explanation of the uses and limitations of the model.

Each section is designed to be read as a self-contained unit, so that the guide can be browsed or read as a whole. Where relevant, related material in different sections is cross referenced. Much of the material will already be familiar to some readers.

The volume is designed to complement the other volumes in this set and some of the material in this volume is covered in greater detail in the other volumes. A more detailed description of the model (including the specification and diagnostics for individual equations) is contained in the related Documentation of the Treasury Macroeconomic (TRYM) Model of the Australian Economy. The User’s Guide - How to Use the Treasury Macroeconomic (TRYM) Model of the Australian Economy with TSP Software - referred to here as the TRYM User’s Guide (with TSP) - provides a practical guide to the running of the model with Time Series Processor (TSP) software. Section 2.1.2 of the TRYM User’s Guide (with TSP) gives a brief overview of what is involved in a TRYM simulation and defines commonly used modelling terms.

Further analysis of the properties of the model and its various sectors is contained in the 1993 TRYM conference volumes and a number of more recent papers referred to in the references section in this volume and in the TRYM User’s Guide (with TSP).

A description of the mnemonics of the variables in the model, which are referred to throughout this volume, is included in Appendix B of the TRYM Documentation. A more detailed description of each mnemonic is included in the data base documentation.

1.1 THE MODEL

The TRYM model has a core of key macroeconomic relationships that are estimated using historical data wherever possible. The estimated equations are linked together by a larger number of accounting identities. There are 25 estimated equations, 3 financial market identities, 2 default response functions for monetary and fiscal policy and about 100 accounting identities linking these key behavioural relationships (see Table 1 in Section 2.2.1 for a summary). In constructing TRYM, effort has been directed towards ensuring consistency between and within sectors. This has partly been in response to the criticisms of Christopher Sims (1980) and others of ‘ad hocery’ in macroeconomic modelling. The focus on internal consistency has led to 16 of the model's 25 behavioural equations being jointly estimated with other equations. Care has also been taken to identify separate demand and supply curves where possible. The simplicity and internal consistency of the model makes the model relatively transparent. Transparency means that key linkages underlying the effects of policy changes and the key factors shaping movements in the macro-economy are easier to identify and explain.
Section 2 describes the key interrelationships and linkages in the model using flow charts, summarises the main influences and assumptions affecting key variables and explains the econometric approach taken in the specification and estimation of the equations in the model.

The model could be described as broadly new Keynesian in its dynamic structure but with an equilibrating long run. Activity is demand determined in the short run but supply determined in the long run (see Section 2.3). The model will eventually return to a supply determined equilibrium growth path in the absence of demand or other shocks.

The model is divided into three sectors and three markets, which are discussed in Section 3. These are: the private business sector, the household sector, and the public sector; and the goods market, the labour market and the financial market. Representative consumers and producers are used in the specification of equations for the business sector and the household sector. The *TRYM Documentation* covers the issues discussed in Section 3 in more detail.

The demand side and supply side of the model conform closely with contemporary expositions of economic theory. The model, therefore, brings to life text book analyses of comparative statics (comparison of equilibrium positions of the theoretical economy) by tracing the changes in economic variables as the economy moves to the supply determined equilibrium growth path.

Section 4 discusses the linkage between contemporary comparative static analysis and the time dependent TRYM results. The section illustrates the operation of the model using practical policy simulations. Section 5 further develops the understanding of the operation of TRYM by discussing the responses and linkages in TRYM relevant to a selection of macroeconomic issues.

Section 6 discusses the limitations associated with TRYM’s demand side responses and supply side equilibrium. Practical policy relevant issues are used to illustrate the limitations.
2. Summary of the Model

This section presents three different ways of looking at the TRYM model. Section 2.1 uses flow charts to provide a non-mathematical description of the overall structure of the model and its main linkages. Section 2.2 summarises the relationships embodied in the model’s equations, briefly discusses important assumptions made in constructing the model and outlines the econometric approach used in estimating the equations. Section 2.3 looks at the overall properties of the model, in particular the stabilising and de-stabilising forces at work in model simulations, and the nature of short run and long run results.

2.1 SUMMARY OF LINKAGES

The desire to keep the model simple and internally consistent has determined many of the decisions taken on the level of aggregation reflected in the model’s data and linkages. The model is not designed to provide fine sectoral detail. It is also not designed for detailed taxation or industry policy analysis or to produce detailed short term forecasts of large numbers of variables. Rather, it is designed to provide internally consistent explanations of the major forces shaping the economy and the major linkages governing the response of the economy to policy changes and how these might change over time.

The model, therefore, works at a high level of aggregation and makes a number of simplifying assumptions, with a focus on internal consistency to extract the maximum amount of information out of the aggregated data - and to ensure transparency.

To understand how the model does this consider a simple flow diagram of a closed economy as in Figure 1.

**Figure 1: Simple Flow Diagram of a Closed Economy**
Summary of the Model

There are two decision units in this simplified economy: the household sector and the business sector. Linking the two sectors are flows of goods, expenditure, output and labour inputs. Balancing each pair of flows (output-expenditure, expenditure-income and income-labour input) is a market. The goods market balances the demand (expenditure) and supply of goods (output). The financial market balances the supply (saving) of, and demand (investment) for, funds - hence balancing income and expenditure. The labour market balances the demand for, and supply of, labour (balancing incomes with input).

The structure of the TRYM model, while being much more complex, has similarities to that of Figure 1. It broadly identifies three decision units (the household sector, the business sector and the government sector) and three markets (the goods market and its sub-components, the labour market and the financial market). The model attempts to treat behaviour within these units and markets in a consistent way. As can be seen from Figure 1, these decision units and markets could be represented as overlapping sets.

Linking the equations together in a transparent and manageable way requires aggregation. For example, the model uses a representative consumer in the consumption equation, a representative worker in the wage equations and a representative business to derive employment, investment and pricing decisions.

Aggregation has advantages in terms of simplicity of interpretation and making the model easier to maintain. It comes at a price, however. In general, it means that all the underlying causes of the behaviour of the aggregates are not necessarily identified (see Section 6.1.2). Effects from changes in composition, changes to expectational processes and structural changes at the microeconomic level are difficult to capture. A number of equations contain unexplained time trends for this reason.

The consumption equation provides an example. In modelling consumption, differences in behaviour over different age and income cohorts are not taken into account. Moreover, some consumers may be credit constrained while others have ready access to finance, some consumers may be forward looking while others are backward looking and some may be saving for a rainy day (buffer stock) while others for retirement (life cycle explanation). Changes in the proportions of these relative groups or changes in the behaviour within the groups may change the consumption relationship. Indeed, aggregation is only really valid in particular circumstances; for example, linearity of individual consumption responses - see, for example, Stiglitz (1994).

The simplifying assumptions required for aggregation are a major source of qualification of the model and should always be kept in mind when interpreting model results.

Aggregation, nevertheless, has the econometric advantage of lending itself to a consistent treatment of what otherwise might seem to be unrelated behavioural relationships. While some information may be lost by ignoring the fine detail, some information may be gained by joint estimation. For example, the household sector in TRYM makes five decisions relating to consumption or saving, rental against non-rental consumption, dwelling investment, labour supply and wages demands. Aggregative consumer behaviour may be affected by underlying changes in the demographic composition of the population (the baby boomer effect) - see FitzGerald (1993). However, these same demographics will also influence dwelling investment and labour supply decisions. The residuals from one seemingly unrelated equation may contain information about another. Moreover, in other cases there are clear theoretical linkages between equations and these can sometimes be estimated with common parameters. For example, the business sector makes joint decisions about employment, investment and prices as a result of changes in demand or productivity. Hence, the investment, employment and price equations are estimated jointly. Common parameters are
derived. Employment, investment and domestic output prices are responding to the same production technology in the long run.

Thus, identifying decision units and markets in the economy enables the modeller to tie the behavioural equations together in a consistent way. Where possible, TRYM attempts to treat decision making in a consistent way and to identify and jointly estimate demand and supply curves. However, the model is far from being perfectly internally consistent and work is continuing to integrate sectoral and market behaviour more fully.

Figure 1 is not meant to be taken as an accurate and comprehensive depiction of the linkages in the model. It does not show other decision units in the economy (for example, the government and the central bank) and it contains no external sector (markets for imports and exports). It also ignores a number of complicating factors in the interactions between the business sector and the household sector. For example, households invest as well as save. Businesses save as well as invest.

A slightly more accurate picture of how the model links various aggregates together, and the intuition behind some of the model results, might be gained from Figures 2, 3 and 4.

Figure 2: Simple Flow Diagram of an Open Economy

Figure 2 expands the closed economy case to include the external sector (imports, exports and net borrowing from overseas). In the closed economy case of Figure 1, income, expenditure and output have to be equal, leading to three definitions of output: GDP(I), GDP(P) and GDP(E) with GDP(I)=GDP(P)=GDP(E). In the open economy case, however, expenditure no longer has to be equal to income with the difference being equal to net exports. This leads to a new definition of GDP(E) as gross national expenditure (GNE) plus exports (X) minus imports (M). The order of the
Summary of the Model

market linkage between the expenditure, output and income aggregates is the same in Figure 2 as in Figure 1 (but Figure 2 omits the decision units). Expenditure GDP(E) is linked to output GDP(P) by the goods market. Output is linked to income GDP(I) by factor markets and income is balanced with expenditure via financial markets. Unlike Figure 1, decision units are ignored and flows into and out of the system are introduced from overseas.

The figure also introduces some transmission levers which are meant to indicate the link between net borrowing from overseas, the financial market and imports and exports. If there is an exogenous increase in exports relative to imports (due to faster growth in world export markets say), then borrowing from overseas will fall (reducing the supply of $A) tending to make the exchange rate rise. The exchange rate, in turn, will exercise leverage over import outflows and export inflows. Similarly, if domestic demand increases and domestic interest rates rise, the exchange rate will also tend to rise as foreigners take advantage of the higher real Australian interest rates (increasing the demand for $A). As opposed to Figure 1, where the financial markets simply balance domestic expenditure and income flows (savings and investment), in Figure 2 they balance the supply and demand for Australian dollars.

It is immediately apparent that any increase in demand (expenditure) in this system will have very different effects than a similar increase in the closed system of Figure 1. An increase in expenditure (eg fiscal expansion) will lead to a greater inflow of imports (outflow of income) and possibly some switching of production to the domestic goods market (lower exports and lower inflow of income). As in Figure 1, it will also lead to rising interest rates in the financial markets but with the added effects of the exchange rate being pushed up. A rising exchange rate reduces the export outflow while opening up the import inflow (see the transmission levers). If import and export flows are very large, any increase in internal circulation coming from an expenditure increase (eg fiscal expansion) will quickly be ‘crowded out’ by net exports.

Figure 3: Components of Income, Expenditure and Output

In contrast, an injection of funds into the financial market (monetary expansion) will, in the short term, lead to lower interest rates and a lower exchange rate. The lower interest rates lead to a higher level of expenditure (as in the case of the fiscal policy expansion). However, the monetary expansion is associated with a lower, rather than a higher, exchange rate. The falling exchange rate reduces the import inflow while at the same time releasing a larger export outflow. Thus, the increase in demand is not crowded out by net exports. A monetary expansion is more effective than
a fiscal expansion in increasing output in the short to medium term. Clearly, the greater the openness of the economy the greater will be the effect of monetary policy relative to fiscal policy and the more important the financial market compared to the other balancing markets.

The overall structure of the model and the intuition behind the results are similar in essence to those derived from Figure 2. However, the model is far more complicated with a diverse range of linkages, the inclusion of the government and public enterprise sector as decision units and explicit modelling of the linkages between stocks and flows. Figures 3 and 4 summarise the linkages of the TRYM model. Figure 3 provides a simple disaggregation of the components of GDP(E), GDP(I) and GDP(P) but without explicit linkages.

Figure 4 shows how these components are classified in the TRYM model. It also introduces classifications and linkages for the government sector and shows the linkage between exports and imports and the various components of GDP (rather than the simple schemas in Figures 2 and 3). The logic of the diagram is, nevertheless, essentially the same as that of Figure 2. Reading down the page, expenditure and output are linked by the goods market, output and income by factor markets and income and expenditure by the financial market.

A full description of the linkages shown in Figure 4 is not attempted here and the user should refer to the TRYM Documentation for details. The diagram may, however, be useful as an ‘at a glance’ guide to where individual variables enter the model.
Summary of the Model

Figure 4: Classification and Linkage of Income, Expenditure and Output in the TRYM Model

Note: The cells shown do not mesh exactly with the variables in TRYM. For example, business stockbuilding (SNN) excludes farm stockbuilding, which combines with public marketing authority stockbuilding to form (SFM). Public market purchases (DGM) include separate components such as public enterprise investment (IGE).

2.1.1 Measurement Approach

As mentioned, Figure 4 provides an indication of the main variables used in TRYM. The selection of data series has been driven by the desire for consistency and simplicity. The desire for simplicity has meant that in places more effort than normal has been devoted to defining and, where necessary, compiling new data series.

Particular focus in TRYM has been given to deriving estimates of private business output and prices. The approach taken is to jointly estimate the business investment, employment and price equations so that these three core equations could be estimated in a theoretically consistent basis. As a result, capacity utilisation, real wages and trend productivity growth are defined for the business sector rather than the economy as a whole.

The model is also careful to analyse household consumption and investment decisions on a consistent basis. As a result, rental consumption is split off from total consumption and modelled jointly with dwelling investment. The National Accounts measure of household income includes the gross operating surplus of unincorporated business enterprises, returns from interest and
dividends and the gross operating surplus of dwellings (all of which constitute property income). However, TRYM attempts to distinguish between consumption and investment behaviour (essentially business decisions) and, hence, measures household income with property income stripped out. It measures household income as after-tax labour income plus transfers. To capture property income and wealth valuation effects, the consumption equation explicitly includes a private wealth term. The wealth term captures not only current income but expectational (confidence) effects about future property income. This led to construction of a consistent time series for private sector wealth.

Some, but not all, of the variables can be seen in Figure 4. More details are provided in the TRYM ABS data base documentation and the *TRYM Documentation*.

### 2.2 SUMMARY OF EQUATIONS AND RELATIONSHIPS

Another way of representing the model is to list the equations. Behavioural modelling in TRYM (reflecting ‘main stream’ economic theory) concentrates mainly on the goods market expenditure components of GDP(E). Of the model's 25 estimated behavioural equations, 16 deal with quantities and relative prices of the expenditure components. Another six determine wages, employment, vacancies, average hours worked and participation in the labour market. The remaining three determine interest rates, the overall price level and output of business enterprises. The exchange rate is based on an uncovered interest parity condition (that is, the position of the exchange rate relative to its long run equilibrium is determined by the domestic long bond rate relative to the world long bond rate). The expenditure and income aggregates are linked to the other items shown in Table 1 by a series of identities. Similarly, identities are used to identify saving, investment and net lending by sector, to cumulate saving and investment flows into capital stock and wealth estimates and to ensure model closure.

The behavioural equations and important identities are shown in Table 1. Full details of the equations and identities are provided in the *TRYM Documentation*.1

#### 2.2.1 Description

In broad terms, the first four equations of Table 1 (consumption, dwelling investment, business investment and non-farm stockbuilding) drive the dynamics of the model via the investment accelerator and the inventory cycle. In particular, the presence of significant lagged dependent variables imparts inertia on the movement of both dwelling and business investment. This is an important part of the reason why the model tends to overshoot the return to equilibrium following a ‘shock’.2 The timing of adjustments on the supply side also play a role - for example, the slow adjustment of employment to changes in real wages.

The next three equations (5 to 7) play a large role in determining the effect of world demand, commodity prices and fluctuations in rainfall on the economy. Equation 8 determines imports, which are an important source of leakage from the demand components. Exports and imports also react to changes in the foreign exchange market to stabilise demand fluctuations. The first eight equations are followed by three sets of equations which determine the reaction of the public sector.

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1 As in Figure 4, financial market and net lending relationships are linked to aggregate demand in the goods market. Similarly, factor markets and technology determine aggregate domestic supply.

2 The model ensures both asset market and flow equilibriums in the long run. Asset market equilibrium requires that capital stocks return to control (eg that the capital to output ratio returns to normal following a temporary demand shock). As higher investment leads to a higher capital stock, a period of higher investment following a temporary stimulus must be followed by a period of lower investment when the stimulus is removed so that the effect on the capital stock is unwound. Thus, a temporary stimulus will tend to set up stock adjustment cycles in the model.
Summary of the Model

the domestic money market and the exchange rate to any change in the economy. Together, all these equations determine movements in aggregate demand.

The supply side assumes constant elasticity of substitution (CES) production technology, constant Harrod neutral technical progress and treats imports as final goods rather than inputs to production. The CES parameters are derived indirectly from first order conditions in the labour demand, investment and price setting equations. The wage equation is in the form of an expectations augmented Phillip's curve. Hence, the aggregate supply curve is vertical in the long term at a level of employment and production consistent with the estimated NAIRU (non-accelerating inflation rate of unemployment). More precisely, in long run equilibrium the economy grows along a steady state growth path consistent with the NAIRU. There is a wide confidence interval around the NAIRU leading to a degree of uncertainty on the supply side - a problem which is discussed in more detail in Section 6.

2.2.2 Important Assumptions

The modelling of TRYM inevitably involves the imposition of a number of assumptions, particularly in relation to how economic agents might react in certain circumstances. The implications of some of the assumptions in TRYM are discussed in Section 2.1 and Section 6. The effect of alternative assumptions can easily be explored with the model.

The assumptions in the model are working assumptions designed to allow the modelling to proceed. This is particularly the case with the assumptions relating to the formation of expectations and government policy responses.

Formation of Expectations

An important aspect in the specification of the demand side of the model, not clearly shown in the figures or tables above, relates to expectations.

Expectations are modelled in TRYM in two distinct fashions. Wage earners and consumers are assumed to have adaptive (backward looking) expectations whereas agents in the financial markets are assumed to have ‘quasi-rational’ expectations. That is, agents in the financial markets are assumed to have a mixture of forward looking and adaptive behaviour.3

3 This is a description of the expectational arrangement in the standard version of TRYM.
### Table 1: TRYM - Summary of Main Relationships

<table>
<thead>
<tr>
<th>Variable</th>
<th>Influenced by:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demand - Goods Market (IS)</strong></td>
<td></td>
</tr>
<tr>
<td>Consumption</td>
<td>After-tax labour income, transfers (pensions, benefits), market value of private wealth (confidence, interest rates) ..1</td>
</tr>
<tr>
<td>Business Investment</td>
<td>Capacity utilisation, inertia, expected return given real wages, real interest rates ..2</td>
</tr>
<tr>
<td>Dwelling Investment</td>
<td>Cyclical dynamics, rental prices relative to construction prices, real interest rates ..3</td>
</tr>
<tr>
<td>Non-Farm Stocks</td>
<td>Sales growth, and adjustment to desired stock levels from trend stocks to sales ratio ..4</td>
</tr>
<tr>
<td>Farm Stocks</td>
<td>Commodity exports, rain, time trend ..5</td>
</tr>
<tr>
<td>Commodity Exports</td>
<td>(Supply driven) Bus potential output, rain, AS export prices / domestic prices ..6</td>
</tr>
<tr>
<td>Non-Comm Exports</td>
<td>(Demand driven) World demand, FS non-comm export prices / world prices ..7</td>
</tr>
<tr>
<td>Imports</td>
<td>Domestic demand and import prices / domestic prices ..8</td>
</tr>
</tbody>
</table>

| Demand - Government Balance | |
| Government Demand | Exogenous |
| Income Taxation | Reaction function - responds to target public debt to GDP ratio ..1 |
| Indirect Taxation | Rates are exogenous ..1 |
| Transfers | Benefit rates are exogenous ..1 |

| Demand - Money Market (LM) | |
| Money Supply | Set to grow at a rate equal to underlying supply growth plus exogenous inflation target ..1 |
| 90 Day Bank Bills | Inverted money demand - react to nominal GNE relative to money supply ..9 |
| 10 Year Bonds | 90 day bill rates, quasi rational inflation expectations, world bonds, risk ..1 |

| Exchange Rate | |
| TWI | Domestic/world 10 year bonds, risk, equilibrium TWI in 10 years time (in turn dependant on commodity prices, savings and desired capital stock) ..1 |

| Supply - Output | |
| Bus Potential Output | Business capital and labour, given estimated CES production function ..1 |
| Public Ent Output | Public enterprise capital and labour given CES production function, private output ..10 |
| Government Output | Transformation of government capital and labour ..1 |
| Dwelling Output | Constant ratio to dwelling stock ..1 |

| Supply - Labour Market | |
| Labour Supply | Encouraged worker effect (employment ratio), adult pop growth, after-tax real wage ..11 |
| Labour Demand | Demand for business output, real labour costs (adj for on-costs, trend productivity) ..12 |
| Av Hours Worked | Change in vacancy rate, lagged changes in hours worked, time trend ..13 |
| Public Ent Employees | Public capital (which is exogenous) ..14 |
| Gov Employees | Exogenous ..1 |
| Wages | Adaptive inflation expectations, unemployment less NAIRU, change in unemployment ..15 |
| Vacancies | Unemployment rate, change in unemployment, logistic trend ..16 |

| Prices | Nominal labour costs (adj for on-costs, trend productivity) demand/supply imbalances ..17 |
| Import Prices | World industrial prices / TWI, with lagged pass through ..18 |
| Dom Final Good Prices | Lags of desired output prices and import prices 19-23 |
| Commodity Prices | World prices, world activity and the exchange rate ..24 |
| Dwelling Rental Prices | Non rent consumption prices, and dwelling demand/dwelling supply imbalances ..25 |

| Wealth, Capital Stock, Foreign Debt Identities | |
| Capital Stocks | Cumulated investment less depreciation (ie perpetual inventory methodology) ..1 |
| Private Wealth | Cumulated private saving, valuation from real interest rates, expected rates of return ..1 |
| Public Debt | Cumulated net PSBRs, valuation effects on public foreign debt and reserve assets ..1 |
| Net Foreign Liabilities | Cumulated CADs with valuation effects from exchange rate and interest rate movements ..1 |

Notes: Numbers 1-25 refer to behavioural equations. I stands for identity. In general the most important influences for short run movements are shown first. A large number of identities linking the aggregates shown in Figure 1 are not shown.
Summary of the Model

Financial market agents are assumed not to be affected by money illusion. They form their expectations for inflation by assessing the effect of a shock on the equilibrium price level 10 years into the future (derived from the steady state model⁴). These price level expectations also affect their expectations for the equilibrium exchange rate. Hence, the nominal exchange rate jumps in response to a monetary shock, as does to that of the simple model set out by Dornbusch (1976) — see Section 5.4.⁵

Financial market agents are also assumed to assess the effect of changes in commodity prices (and other variables such as the government's public debt to GDP target) on the future (equilibrium) real exchange rate. For example, expectations regarding the equilibrium exchange rate will rise with a permanent increase in commodity prices (see Section 3.2.3). The effects will be assessed and the real exchange rate will jump to a new level as a result. Any difference between this new level and the expected future exchange rate is assumed to be due to differences between Australian and world real long bond yields (financial capital is assumed to be perfectly mobile).

Real long bond yields are assumed to be adaptive or backward looking, only rising as real short term interest rates rise. This assumption implies that agents in the financial markets do not know or understand the dynamic path that domestic demand takes after a shock. However, it is assumed that they anticipate the long run effects of monetary and other shocks on nominal variables.

In brief, expectations are set up in TRYM so that there is no money illusion in the financial market. Financial market agents can also assess the impact of a real shock on the future real equilibrium exchange rate. All other expectations in the financial market, the labour market and the goods markets are adaptive.

Policy Reaction Functions

Policy reaction functions also play an important role in shaping the demand responses and simulation properties of the model. They provide a mechanism for introducing fiscal and monetary responses to disturbances arising elsewhere in the economy.

TRYM has default policy reaction functions, but there is flexibility in the use of these policy reactions. Whether the default reactions are used depends on the purpose for which the model is being used. In fact, the default reaction functions are rarely used within Treasury. For example, when TRYM is being used in the Treasury forecasting process the default policy reaction functions are switched off and the profiles for monetary and fiscal policy variables are specified by assumption. Similarly, when TRYM is used in policy analysis, it is possible to use an optimal control algorithm to determine policy responses. The use of the optimal control algorithm allows the policy response to be specified with reference to a range of factors that are relevant to policy formulation rather than the more simplistic default functions. This algorithm is a procedure for undertaking a constrained simulation of TRYM. The constraint arises from specifying desired paths for particular target variables such as unemployment and inflation, and the procedure involves minimising a social loss function given the targets specified.⁶

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⁴ As the model should be close to the steady state ten years after a shock, the expectations of the nominal variables will be almost model consistent.

⁵ The nominal exchange rate does not, however, display Dornbusch-type overshooting behaviour but rather jumps to a value close to the new equilibrium with a monetary shock. This is because the uncovered interest parity condition is imposed using 10 year bonds rather than 90 day bills. A monetary shock has an ambiguous effect on the nominal 10 year bond rate because real rates and inflationary expectations are moving in different directions. See Section 5.4 for more details.

⁶ Refer to Louis (1995) for a more detailed discussion of the optimal control algorithm.
Where neither forecasting assumptions are specified nor the optimal control procedure is used, the
default policy reactions can be used. The default policy reaction functions are specified by
assumption rather than by estimation and are shown as identities in Table 1. They allow
comparisons to be more easily made between different simulations by ensuring that the long-run
equilibrium is comparable between model runs (that is, not changing due to unintended changes in
long-run policy settings).

The default reaction functions are a highly simplified representation of possible policy formation.
They do not necessarily represent how policy makers would, or should, act.

- The default fiscal policy rule allows ‘fiscal drag’ to occur but gradually adjusts income tax
  rates in the medium term so that a long run target public debt to GDP ratio is achieved.
  Government expenditure, pension and benefit rates and indirect tax rates are set exogenously.

- The default monetary policy rule hinges around the assumption that the money supply grows
  at the same rate as underlying supply (population growth plus trend labour productivity
  growth) plus an exogenous inflation target.

2.2.3 Econometric Approach

The econometric principles and practices that have guided the specification and estimation of the
equations in the TRYM model broadly follow those described by Pagan (1987) as the ‘Hendry
methodology’. This methodology is otherwise known as the ‘general to specific’ approach or the
London School of Economics (LSE) approach - which in turn owes much to Sargan (1964). In
recognition of the critique by Sims (1980) of ad hocery in macroeconomic models, an emphasis has
been placed on consistency between equations and joint estimation where possible.

The methodology employed and the resulting estimations can by no means be regarded as ‘perfect’.
The Hendry methodology has been departed from at times either for the sake of simplicity or
convenience or where data series have not been sufficiently long or of sufficient quality to yield
acceptable parameters. For example, the assumption is made that underlying growth (GR) is the
same across all sectors of the model to simplify the estimation of the steady state/long run version of
the model. Public trading enterprises are assumed to employ the same technology as the private
sector and parameters in the exchange rate and bond yield equations are simply imposed due to the
difficulty of obtaining reasonable parameters on the basis of available data.

Specification and Estimation

Most equations have been specified in an error correction model (ECM) format7. The remaining
equations use a partial adjustment model or other equilibrating mechanisms.

The extensive use of ECMs means that clear distinctions are made between an equation's short and
long run properties. The long run relationship and the short run dynamics are separately identified
and estimated in an integrated way. Some variables can affect short run behaviour, without being a
determinant in the long run. These variables and the size of their impact are largely determined by
the data. Parameters are usually freely determined (data determined) in the short run, while theory
is often used to guide and restrict long run specifications.

The labour demand equation is an example of the use of an ECM. The long run relationship is
based on the economic theory of a firm that seeks to maximise its profits subject to input costs and

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7 Engle and Granger (1991) provides an overview of the theory behind cointegration and error correction models and includes some practical
examples.
production technology. Labour demand is thus driven by the demand for the firm's output, hours worked by existing employees, real wages and underlying efficiency in the economy. The speed with which firms move towards a desired level of employment and the importance of the various factors in the short term are determined by the data.

All equations are specified to ensure that the TRYM model exhibits balanced growth along a steady state path when in equilibrium. As a result, the model has a steady state representation of the long run behaviour of the economy. This shows what the structure of the economy would be if adjustment to equilibrium was simultaneous and instantaneous in all sectors of the economy.

The non-linear least squares estimation technique has been extensively used to estimate equations. Equations have also been estimated jointly wherever possible to ensure consistency within decision units or within markets (see Section 2.1). This has lead to jointly estimated demand and supply equations where possible or jointly estimated common parameters. For example:

- The quantity and price of imports are determined by demand and supply curves, respectively. The simplifying assumption is made that import supply is perfectly elastic in the long run. Hence, supply determines the price level while import volumes are determined by demand. The import price (supply) and volume (demand) equations are estimated jointly.

- Private business firms make decisions concerning employment, investment and prices based on common production function parameters (common technology). Therefore, these three equations are estimated jointly.

Equations are specified so that orders of integration of economic variables are respected in accordance with the literature on cointegration - see, for example, Engle and Granger (1987). Special care has been taken to avoid steady state bias in individual equations - see Salmon (1982). For example, all equations for real variables are constrained to grow at a rate equal to underlying supply in the long run. Non-linear solution procedures have been used to estimate ECMs rather than the two step Engle Granger approach. Non-linear estimation of ECMs with TSP software provides estimates of the significance of long run parameters. In searching for the preferred equation specifications, these estimates are often used as a guide to whether a co-integrating relationship exists.
Table 2 shows that of the 25 equations estimated in the TRYM model, 16 have been jointly estimated and the remaining 9 individually estimated.

### Table 2: Individual and Joint Estimation

#### Jointly Estimated Equations

<table>
<thead>
<tr>
<th>Equation Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour demand, investment and prices</td>
<td>(3)</td>
</tr>
<tr>
<td>Import quantities and prices</td>
<td>(2)</td>
</tr>
<tr>
<td>Commodity export quantities* and prices</td>
<td>(2)</td>
</tr>
<tr>
<td>Dwelling investment and the price of rents</td>
<td>(2)</td>
</tr>
<tr>
<td>Relative Prices of Expenditure Components</td>
<td>(5)</td>
</tr>
<tr>
<td>Public Enterprise Employment and Output</td>
<td>(2)</td>
</tr>
<tr>
<td><strong>Sub-Total</strong></td>
<td><strong>(16)</strong></td>
</tr>
</tbody>
</table>

#### Separately Estimated Equations

<table>
<thead>
<tr>
<th>Equation Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Consumption</td>
<td>(1)</td>
</tr>
<tr>
<td>Non-Farm Stockbuilding</td>
<td>(1)</td>
</tr>
<tr>
<td>Farm Stockbuilding</td>
<td>(1)</td>
</tr>
<tr>
<td>Money Demand</td>
<td>(1)</td>
</tr>
<tr>
<td>Labour Supply</td>
<td>(1)</td>
</tr>
<tr>
<td>Wages</td>
<td>(1)</td>
</tr>
<tr>
<td>Beveridge Curve</td>
<td>(1)</td>
</tr>
<tr>
<td>Hours Worked</td>
<td>(1)</td>
</tr>
<tr>
<td>Non-commodity export prices</td>
<td>(1)</td>
</tr>
<tr>
<td><strong>Sub Total</strong></td>
<td><strong>(9)</strong></td>
</tr>
</tbody>
</table>

* The long run component of the commodity export equation is first estimated separately.

### Steady State Model

The short run and long run properties of the TRYM model can easily be examined separately because of the way the model has been constructed. Effectively, there are two versions of the model: a dynamic version that incorporates short run behaviour and the adjustment towards the long run; and the long run or steady state version which is used to derive the long run equilibrium growth path for the model. The steady state version is simulated before running the dynamic version of the model to provide 10 year ahead equilibrium values for forward looking variables in the financial markets (inflationary expectations and the exchange rate). Section 4.3 uses simulations of the model to illustrate the dynamic adjustment to the steady state growth path. The *TRYM User’s Guide (with TSP)* discusses these concepts in more detail and provides a detailed guide to the running of dynamic and steady state simulations.

### 2.3 MODEL PROPERTIES

#### 2.3.1 Dynamic versus Stabilising Forces

In broad terms, the first four equations in Table 1 can be thought of as determining the short run dynamics of the model. The equations contain cyclical, or destabilising, influences (more details of which are given in the *TRYM Documentation*):

- the dwelling cycle (driven by time-to-build factors and coordination failure);
Summary of the Model

- the investment accelerator (driven by time-to-build factors, uncertainty and the interaction of investment with growth in demand); and
- the inventory cycle (driven by a transaction, rather than buffer-stock, model and the interaction of stockbuilding with sales growth).

These destabilising reactions are dampened and offset by a range of stabilising factors. These include:

- the direct short term leakage of demand into imports;
- the short term reaction of the government sector to cyclical movements (discretionary changes and fiscal drag);
- the labour market response - real wages rise as unemployment falls below the NAIRU, lowering employment demand relative to labour supply;
- the goods market response - aggregate prices rise as demand outstrips desired supply; and
- the financial market response - interest rates and the exchange rate rise as demand accelerates.

The three main demand components (consumption, dwelling investment and business investment) all respond to higher interest rates in the medium to long term. The higher exchange rate increases imports and reduces exports.

The first two responses dampen the demand cycles. However, it is the last three that ensure the economy eventually returns to equilibrium (the steady state growth path). These are the key mechanisms that equilibrate demand and supply in the three markets in Figures 1 and 2.

The reaction of demand is slow in all three markets. Investment and net exports respond to interest rates and the exchange rate, respectively, only with a lag and tend to overshoot because of those lags. The response of employment demand to changes in real wages is slow in the short term as is the response of aggregate demand in the goods market (especially if real wages are rising, offsetting the income effect). As a result, the level of activity in the model tends to be dominated by the demand side in the short term and simulations tend to be characterised by overshooting that is dampened with time.

2.3.2 Overall Model Characteristics

Overall, the TRYM model can be characterised as being broadly Keynesian (demand driven) in the short run but having a neo-classical (supply driven) long run. The model is estimated at the aggregate level and does not therefore identify all of the details of the market structures and decision processes that underlie behaviour either on the demand side or the supply side.

- On the demand side, the model simply observes that there are persistent lags and slow adjustments to relative price changes in the goods and labour market without precisely explaining the reasons for the particular pattern of lags or the timing of adjustments. More importantly, the reasons for the short run behaviour of the exchange rate and interest rates are not identified in the financial market. Rather, an uncovered interest parity condition is imposed. While the interest parity condition must hold in the long run, the difficulty in modelling exchange rate behaviour (and the importance of the effects on the economy of exchange rate movements following policy changes) is a major source of uncertainty for policy analysis on the demand side of the model.
Similarly, on the supply side, the model does not identify the market structures or the sources of innovation that underlie the equilibrium (supply side) growth path. The long run is introduced largely for convenience and it may be, for example, that parts of the supply side assumed to be exogenous are partly endogenous (eg the NAIRU and trend labour productivity growth). The model does not necessarily imply that markets are clearing except in a superficial way. For example, the labour market is in equilibrium at the NAIRU but it may not be a market clearing equilibrium because of various institutional factors in the labour market. Similarly, the goods and financial markets are not ‘perfect’. In fact, they must have imperfections in the short term to explain the lag structures and inertia observed.

Thus, as noted in Section 2.1, the assumptions involved in working at the aggregate level are a major source of qualification to the model results and should always be kept in mind. They also provide a strong argument for modelling work to be backed up by more detailed empirical work at the disaggregated level - to assist with the judgements required for forecasting and policy analysis.

### 2.3.3 Demand Driven Short Run

In the short run, production in the economy is largely demand driven. This is because of the demand side dynamics (inertia and slow pace of adjustment) mentioned above. It is also because supply is very responsive in the short run\(^8\). Short run fluctuations in demand are met by variations in capacity utilisation and short term variations in labour input. This is possible, in part, because the elasticity of substitution between labour and capital is very high in the short run. The capital stock is slow to adjust and the utilisation of capital can be varied by adding or subtracting labour. Business will initially respond to a demand shock by employing more labour, increasing the hours worked of existing employees and by increasing work intensity. The investment response and the adjustment of the capital stock only takes place with a lag.\(^9\)

While output is demand determined in the short term there are several factors that tend to pull the economy back towards the supply determined equilibrium in the medium run (see Sections 2.1 and 2.3.1). Increases in demand relative to income are equivalent to increases in the demand for funds relative to the domestic supply of funds and lead to increasing interest and exchange rates in the financial market. Any gap between unemployment and the NAIRU in the labour market affects real wages and inflation. Similarly, any disequilibrium between demand and supply in the goods market affects the price level and inflation (in turn leading to a financial market reaction).

Overall, the short run dynamics in the model imply slow adjustment in prices and wages in response to imbalances in the goods and labour markets (they do not immediately jump to their equilibrium levels). There are further lags in the adjustment of real variables (eg employment demand, investment) to these changes in wages and prices. However, variables do eventually converge, in the absence of further shocks to the economy, to their desired long run levels.

In the short run, therefore, goods and labour markets are often in disequilibrium, but are moving at varying rates towards equilibrium. The rate of adjustment is generally determined by the data. Some price variables such as import prices move relatively quickly towards their desired levels. Demand for labour and capital stocks adjust slowly.

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\(^8\) Supply must equal demand by definition, even in the short run.

\(^9\) Take the example of a store owner faced with an increase in demand. His initial response may be to hire temporary employees to service the extra customers (eg more assistants per counter, more employees per unit of capital). However, if the increase in demand persists he may wish to extend his store - increase his counter space, and his storage space etc. In aggregate, in the medium term, the capital labour ratio returns to some equilibrium level. Obviously, the short term ability of employers to substitute labour for capital will vary across industries and compositional change at the microeconomic level may affect how the economy responds in aggregate in the face of any shock.
Summary of the Model

2.3.4 Supply Driven Long Run

In the long run, in the absence of shocks or policy changes, capacity utilisation returns to normal levels and unemployment returns to the NAIRU. In equilibrium, the economy is assumed to grow along a balanced, stable path. Growth in output is determined by technology (productivity growth) and the supply of labour inputs (population growth, given that labour force participation and hours worked are in equilibrium in the long run).

Decision units ultimately adjust the prices and quantities they control to some equilibrium level.

- Firms set prices consistent with input costs and technology, adjust the capital stock so that the expected rate of return on further investment equals the user cost of capital (risk adjusted interest rate plus depreciation), achieve a desired stocks to sales ratio and employ labour to the point that the marginal product of labour equals the real wage.
- Households invest in dwellings to the point that the imputed rate of return on dwelling capital is equal to the user cost of dwelling capital and adjust their saving so that a desired level of wealth to household income is achieved.
- Governments set income tax rates at a level consistent with a given target public debt to GDP ratio and set the money supply to grow at a rate consistent with growth in underlying supply and a given inflation target.

The three markets shown in Figures 1 and 2 ensure that the decisions of the various units are consistent with one another. Thus, the level of the steady state path is determined by equilibrium in the three markets - the financial market, the labour market and the goods market. In the financial market, equilibrium domestic interest rates are determined by world interest rates, an adjustment for a differential between domestic and world rates and any difference between world and domestic inflation (perfect capital mobility is assumed\(^\text{10}\)). Thus, the world real interest rate ultimately determines the real cost of funds for the household and business sectors. The equilibrium inflation rate is determined by the difference between the growth rates of the money supply (set exogenously) and real output. The real exchange rate is constant in the steady state and risk adjusted domestic and foreign real interest rates are equal.

In the goods market, demand curves are relatively elastic in the long run. This follows from the openness of the economy. Net export volumes are elastic with respect to relative prices and the real exchange rate. The investment components of demand are relatively sensitive in the long run to movements in relative prices and real interest rates. Financial markets therefore play a key role in determining demand in the goods market in the long run. In particular, the long run real exchange rate ultimately balances aggregate demand and aggregate supply.

Factor markets have a significant impact on supply to the goods market. Supply in the TRYM model is largely determined by the supply of the factors of production, which are assumed to be capital and labour, and the efficiency with which these inputs are used. The supply of these factors, in turn, is influenced by factor incomes, the cost of funds (equilibrium in the financial market) and the 'natural' rate of unemployment (equilibrium in the labour market).

\(^{10}\) Capital mobility seems a reasonably safe assumption given the removal of exchange controls in 1983 and the development in the international economy of large and highly mobile funds. The Industry Commission (1991) concluded that with deregulation and removal of exchange controls there was 'no strong evidence against the proposition that supply of foreign capital to Australia is virtually unlimited'. Blundell-Wignall et al (1993) find that the covered interest parity condition holds for the period since the removal of exchange controls. That is, arbitrage is virtually instantaneous in the exchange market.
• The supply of labour is not sensitive to changes in real wages in the model except in the very short term (that is, the labour supply curve is vertical in the long run). As a result, the NAIRU determines the long run equilibrium in the labour market and, hence, the level of employment and output in the long run.

• The supply of private capital is relatively price sensitive. International capital mobility ensures that the cost of borrowing funds is effectively determined by world capital markets in the long run. The expected rate of return from investing in capital must equal the risk adjusted cost of borrowing funds (plus capital depreciation). Therefore, the international cost of funds affects how capital intensive Australia will be in the long run. Other determinants include factors that effect the expected rate of return on an investment (eg the real wage and the price of the investment good). For example, a permanent rise in the terms of trade will increase the equilibrium exchange rate and, hence, the long run capital stock because investment goods become cheaper relative to output prices.

As already emphasised, in the long run, output is supply determined. Changes that affect the supply side of the Australian economy include: changes in technology and world output growth in the goods market (which affect productivity growth and commodity prices, respectively); changes in the equilibrium in the labour market (affected by population growth and the NAIRU); and changes in world real interest rates and equilibrium in the financial market (changing the cost of funds and hence the equilibrium capital stock). All of these changes will have a permanent effect on the level of output and incomes. In contrast, developments on the demand side, such as an increase in money supply, usually only have temporary effects on real variables (money neutrality holds in the medium to long term).

The adjustment path from the short run to the long run is characterised by a series of dampened oscillations. These oscillations are due to inertia in a number of the equations (particularly those for business and dwelling investment), inertia which tends to result in demand overshooting the equilibrium position.

The point of interest here is not that an equilibrium exists in TRYM (which is largely by construction) but how long it takes to get there. Typically, it will take up to a decade for demand oscillations to dampen down to the steady state path (see simulation examples in Section 4). Given the wide variety of influences that can impinge on output and demand growth, this suggests that at any one time movements in demand are the result of an extremely complex mix of current and past events. This suggests that no one cycle will be like another and detailed examination of the causes of any change in activity or inflation is required before any forecasts are made or policy conclusions drawn.
3. **Sectoral and Market Detail**

This section provides a brief summary of the model’s three sectors and three markets and the relationships embodied in them. The TRYM Documentation contains much more detailed reference material on each sector and market, including specifications, results and diagnostics for each behavioural equation.

There are three decision units in the TRYM model and three markets which balance the decisions made by those units. The decision units are assumed to be: the private business sector; the household sector; and the public sector. The three markets are the labour market, the goods market (domestic and international) and the financial market. The specification of these sectors and markets in TRYM are discussed briefly below.

### 3.1 SECTORS

#### 3.1.1 Private Business Sector

The private business sector in the model includes all private, non-dwelling production. The main focus in this sector is to ensure a consistent approach is taken in analysing the factors influencing supply. Three equations in this sector are jointly specified and estimated: the demand for labour by private businesses; business fixed investment; and the price of non-commodity output. A representative firm is assumed to maximise profits by producing goods and services using capital and labour as inputs into a CES production process. Imported goods and services are assumed to be 'final goods' and are therefore not included as inputs into the production process.

The production process determines labour demand, investment and prices in the long run. In the long run, returns to employment and investment are equated to their marginal product. Prices are a function of nominal unit labour costs. In the short to medium term, however, these key aggregates are assumed to adjust toward their long run equilibrium in accordance with adjustment costs, expectations and the extent of any aggregate demand-supply imbalances. For example, labour demand will respond relatively quickly to a demand shock while prices and the capital stock adjust more slowly.

**Labour Demand**

In both the short and long run, labour demanded by private sector firms is a function of the demand for business output, real wages and the underlying efficiency of labour. An increase in the demand for output increases the level of labour demanded, while an increase in real wages results in a fall in labour demand. The TRYM approach to modelling labour demand makes the distinction between the quantity of labour demanded by firms (NEBD) and business employment (NEB). Unfilled vacancies (NVA) capture the difference between these two concepts. Labour demand is measured on an hours worked rather than heads basis (consistent with labour supply).
Non-Commodity Output Prices

Domestic demand and supply factors have little effect on commodity price movements (PXC)\(^{11}\). Hence, to ensure consistency with domestic investment and employment decisions, pricing decisions are modelled for non-commodity output alone. That is, business is assumed to have little control over commodity output prices (PXC) but has some control over non-commodity output prices (PNC). The decision over non-commodity output prices is assumed to be made jointly with investment and employment. In disequilibrium, prices, investment and employment are adjusted to move the business sector back towards equilibrium.

Domestic non-commodity output prices are mainly modelled as a function of the firm's desired supply price of output (PSTAR). Import prices are assumed to have a marginal effect in the short run and no effect in the medium run. This is because imports are treated as final goods in the model rather than inputs into production. As a result, import price changes affect expenditure prices such as the price of private consumption (PCON), which includes an imported component, rather than output prices. Thus, the domestic non-commodity output price (PNC) is assumed not to be directly affected by import prices in the medium to long term. Rather, PNC is dependent on the costs of labour (including payroll tax), demand pressures and the level of productivity (in turn dependent on production technology). These three factors are captured by PSTAR. PSTAR is derived from the production function parameters and moves with nominal wages, adjusted for trend productivity levels and capacity utilisation (or the output to capital ratio). Of these influences, it is movements in wages which have had the largest influence in history. However, PSTAR also responds to changes in aggregate demand and supply. Excess demand or high capacity utilisation will increase inflation and excess supply will reduce it (see Section 5.8). The estimated results also indicate that there is considerable inertia in PNC. Five lags of PSTAR are included in the equation and there is further gradual adjustment after the fifth quarter to ensure PNC equals PSTAR in the long run.

Business Investment

In the long run, business investment (IB) is assumed to adjust to a point where the expected rate of return on the capital stock is equal to the required rate of return. This steady state equilibrium is achieved by the Q-ratio term (the expected rate of return over the required rate of return) in the business investment equation. The expected rate of return is derived from the production function parameters given the current capital stock and the current real wage (adjusted for trend productivity). The required rate of return is assumed to be equal to the real user cost of capital - the real long term bond rate adjusted for risk plus capital depreciation.

In the short term, capacity utilisation and inertia in investment are important determinants of investment. When potential short run supply is greater than demand, the immediate short term return from additions to capacity will be low. Hence, capacity utilisation appears to have significant effects on the timing of investment (although uncertainty or cash flow constraints may also be playing a role). At the same time, there are significant time-to-build lags in some components of business investment, such as office building. A single project may stretch over a number of years. As a result, there is a significant correlation between investment in the current quarter with investment in the previous quarter. Lagged dependent variables are introduced into the equation to capture this inertia.

\(^{11}\) Domestic factors mainly determine non-commodity output and prices while external factors exert a strong influence over commodities. The price of commodities is determined by the price Australian exporters of commodities receive on world commodity 'auction' markets. That is, commodity prices are typically volatile and clear the market for commodities.
Capacity utilisation and inertia dominate the short term movements in business investment in TRYM. A given change in capacity utilisation will have roughly ten times the effect of an equivalent change in the Q-ratio in the short term. However, in the long term, the Q-ratio pulls investment and the capital stock back to their equilibrium level. Together with the capacity utilisation term, the Q-ratio ensures that in the steady state the capital stock is growing in line with adult population and underlying productivity of the economy as a whole.

**Stockbuilding**

Investment in inventories is estimated separately from the investment, employment and price equations. Two categories of inventories are examined - private non-farm stocks and farm and public authority stocks. The first responds mainly to domestic factors and is modelled on a transactions basis (meaning that sales are the main determinant). Farm stocks, on the other hand, are affected by external factors and play a buffering role in the face of volatile output.

- **Non-farm stockbuilding** (SNN) is modelled to be a function of the growth of sales in the short run with the stocks to sales ratio returning to trend levels in the long run. The long run trend stocks to sales ratio is estimated using a logistical growth function (and is thus assumed to be falling but at a slowing rate). Higher or lower than average growth in imports is also found to have had an impact on the non-farm stocks to sales ratio.

- **Farm and public authority stockbuilding** (SFM) is thought to be used to buffer sales in the face of volatile output. As a result, it is modelled as a function of commodity output rather than sales. (Commodity output is approximated by commodity exports plus stockbuilding.) Stocks rise with rising production and fall as production falls. In the long run, stock levels return to a desired stocks to sales ratio. However, the adjustment is much slower than with non-farm stocks (7 per cent a quarter rather than 20 per cent per quarter). Rainfall also affects farm stockbuilding, but with a lag.

3.1.2 **Household Sector**

The household sector in the TRYM model can be divided into two sub-sectors: household decisions about consumption, savings and labour supply; and the dwellings sector.

**Consumption**

Movements in private consumption (CON) are dominated in the short term by fluctuations in household income. The TRYM measure of household income is restricted to after-tax labour income (wages) and government transfers (pensions and benefits). In the long run, consumption adjusts to a level consistent with a desired saving ratio. The equation also contains a wealth term. The inclusion of wealth provides a channel through which fluctuations in the property and financial markets can influence consumption behaviour. For example, a real increase in the market value of dwellings or business assets, which together account for about 80 per cent of wealth, will tend to boost consumption. Thus, when the market valuation of the business and dwelling capital stock is high - that is when Q-ratios are high - consumer confidence will also be high.

The data suggest that the adjustment of consumption towards its long run equilibrium is slow. This may partly be because the consumption definition used includes durable goods and motor vehicles. These investment components of consumption are highly discretionary and can be subject to stock adjustment cycles.

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12 Short run capacity utilisation, GBA/GSTAR, and the Q-ratio are both measured as ratios and are both equal to one in equilibrium.
Sectoral and Market Detail

Rental Consumption and Dwelling Investment

Once households have decided on their total level of consumption, they choose between the consumption of rental services (CRE) and 'other' non-rental consumption (CNR). In the short run, given that the supply of rental services is fixed, these preferences by households drive the relationship for the price of rents. If the demand for rental services increases relative to 'other' consumption, the price of rents will rise relative to the price of non-rental consumption.

The dwellings sector produces rental services from dwelling capital. Consistent with the current practice in the National Accounts, vacancy rates are ignored so that the consumption of rental services is equal to their availability. The supply of rental services is essentially fixed in the short run because the supply of dwellings is fixed in the short run.

It is assumed that the expected rate of return on investing in housing relative to the user cost of dwelling capital (the Q-ratio, QDW) is a key determinant of dwelling investment (IDW) in the long term. In the short term, the level of the capital stock is constrained by time-to-build factors. This leads to a significant amount of inertia in dwelling investment which is captured by a series of lags (up to four quarters). These lead to significant cyclical dynamics (a cobweb cycle).

The rate of return of dwelling investment is assumed to be driven by the price received for rental services relative to the price of business investment. The dwelling user cost of capital is calculated as a weighted average of short term and long term interest rates, adjusted for inflationary expectations, plus dwelling depreciation. The incentive to invest in housing (QDW), based on the ratio of the expected rate of return and the user cost of capital, affects investment with lags of up to one year or more. The dwelling stock adjusts to the point where QDW equals one in the long term.

3.1.3 Public Sector

The public sector is broken down into two subsectors: the government enterprise sector (which consists of government business enterprises and government financial enterprises); and the general government sector (aggregated across all tiers of government).

Government Enterprises

Government enterprises (GEs) are treated separately from private sector firms because they are assumed to have had different objectives and behaviour over most of the historical period used to estimate the model’s equations. Despite these differences, GEs are assumed to have the same underlying production process as private sector firms. GEs' labour demand is largely determined by the available capital stock. Output is determined by demand in the short run but is constrained by supply in the long run. Prices charged by GEs are assumed to move in line with prices charged by the private business sector.

General Government Sector

The general government (GG) sector consists of three areas: expenditure, revenue and the public sector borrowing requirement (PSBR). The former two are analysed explicitly, with the PSBR being determined as a residual. The stock of public debt is determined, in turn, by the PSBR.

Real general government expenditure, with the exception of transfer payments, is usually set exogenously. The value of transfers payments is endogenous. For example, the value of unemployment benefit payments depends on the number of unemployed. The benefit rates are, however, exogenous. Transfer payments identified include: unemployment benefits; pensions and other personal payments; net interest payments; transfers to non-profit institutions for consumption...
purposes; and transfers overseas. Indirect tax rates are also set exogenously. Indirect tax revenue, however, fluctuates with changes in the tax base. The incidence of indirect taxes is consistent with Treasury's microeconomic model, PRISMOD. PRISMOD is the Treasury microeconomic model used for analysing the price effects of tax changes, among other things - see Henry and Wright (1992). The income tax base is determined endogenously and current income tax rates are set exogenously - although default fiscal policy (see below) adjusts these rates endogenously.

Once the expenditure and revenue decisions have been determined, the PSBR is derived. It is split into domestic and foreign debt issues (in turn divided between issues denominated in Australian dollars and foreign currencies) and revenue from overseas reserve assets.

**Default Fiscal Policy Response**

The default fiscal policy response function adjusts income tax rates (on labour income, RTN, and capital income, RTK) in response to movements in public sector debt. It is designed to ensure that the public debt to GDP ratio (RWDGT) returns to its set target value in the long run. A consistent long run fiscal policy target ensures the comparability of model simulations of different economic shocks. It also ensures that there is a unique long run solution to model simulations.

As outlined in Section 2.2.2, the default fiscal policy response is only one possible way of dealing with fiscal policy in the model. There is also ample scope in the TRYM model to alter this response mechanism. It could be re-specified, for example, so that governments reduce a deficit by cutting expenditure in a variety of ways, by raising a variety of indirect and direct taxes or by some combination of expenditure cuts and increases in revenue. Different lags between the decision to change fiscal policy and when policy is actually changed can be incorporated into the response mechanism. Furthermore, the target deficit to GDP ratio and the speed at which policy reacts to achieve this target can be changed.

**3.2 MARKETS**

**3.2.1 Goods Market**

The goods market balances expenditure and output decisions and is split into two components, domestic and international. In the short term, output is assumed to be demand driven. Expenditure on various consumption and investment components is mainly driven by income changes, interest rates and inertia in the short run. There are some small price effects on the supply of different components of expenditure in the short run. However, in the long run supply determined price movements have much larger effects on these components. For example, the Q-ratios used in the business and dwelling investment equations are affected by relative price movements and will have a dominant effect on the supply of business and dwelling capital in the long run. Further, aggregate domestic output prices will respond to any difference between aggregate demand and desired output leading to higher expected profitability (a higher Q-ratio) and an increase in domestically produced prices relative to import price. This movement in relativities is augmented by the response of the exchange rate and, hence, import prices to aggregate demand/supply imbalance via interest rate changes.

Domestic output prices and import prices are assumed to have different effects on consumption, investment and government expenditure prices, reflecting different supply sourcing for different expenditure items. Expenditure prices are, therefore, assumed to be largely supply determined. Where possible, demand and supply equations are estimated jointly (eg dwelling investment and rental consumption).
Section 3.1.2 discusses the factors in the model that influence private rental consumption, non-rental consumption and dwelling investment, while Section 3.1.1 discusses the factors influencing business investment, non-farm stockbuilding and non-commodity output prices. Public expenditure items are exogenous.

### Relative Expenditure Prices

Relative prices are determined in the ‘relative price block’ for the four major expenditure aggregates: non-rental consumption (CNR), government market demand (DGM), business investment (IB) and investment in dwellings (IDW). The prices of these four expenditure components should respond differently to wage and demand pressures and import price increases. Each is affected by its own market structures. Moreover, imports are a more important source of supply for some components than others. Thus, changes in relative domestic expenditure prices are linked to changes in import prices and changes in domestic output prices. The link to import prices ensures that changes in the exchange rate lead to changes in relative expenditure prices and to changes in the composition of domestic demand.

The estimated results (Section 4.1.2 of the *TRYM Documentation*) are consistent with weights derived from input-output data using PRISMOD. Import prices have the greatest effect on business investment and government market demand, an average effect on non-rental consumption and the least effect on dwelling investment.

### Exports

In the TRYM model, exports (XGS) are separated into commodity exports (XC - consisting primarily of mining and agricultural products) and non-commodity exports (XNC - consisting primarily of manufactured goods and services).

The two components of exports are modelled in very different ways. For commodity exports (XC) the assumption is made that world demand for commodities is perfectly elastic. That is, Australia only supplies a small proportion of the total world demand for commodities and, hence, can sell as much as it can supply at a given price. Hence, commodity exports are determined by supply side factors. Domestic commodity suppliers are assumed not only to respond to the normal factors which determine desired output (GSTAR) but also to the price they receive for the commodity export (world commodity price in $A) in comparison with the domestic output price (PNC). This is also known as internal competitiveness (export price in $A relative to domestic price). The world price of commodities is endogenous in TRYM and modelled as a function of output of our major trading partners (WGTM).14

In contrast, non-commodity exports (XNC) are assumed to face a downward sloping world demand curve and to have a perfectly elastic supply curve. That is, local non-commodity exporters are assumed to be able to supply any amount at a given price. Hence, non-commodity exports are determined by world demand given the domestic price of non-commodities. World demand, in turn, is driven by world output (WGTM) and the foreign dollar price of Australian non-commodity exports compared to world prices. This last factor is known as external competitiveness (the ratio of export price in foreign dollars to the world price).

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13 The price of real estate transfer expenses PIRET is also included in the relative price block.

14 Growth in WGMT accounts for about a quarter of the movement of world commodity price movements in TRYM. This is somewhat less than for OECD output or industrial production, which typically accounts for about a third.
Imports

Imports of goods and services (MGS) are also modelled using a demand and supply framework. The supply of imports is assumed to be infinitely elastic. Australian importers can purchase any amount at the current world price. Hence, imports are determined by factors which effect the demand for imports with the world supply price being set exogenously. The price of imports is modelled as a function of world prices, the exchange rate and the world price of oil.

Growth in domestic demand is the main factor driving imports in the short term. A one per cent increase in the weighted import demand term (DDMGS) results in a 1.6 per cent increase in imports immediately. However, the exchange rate exerts a dominant effect on import demand in the medium to long term via its effect on landed import prices relative to domestic prices (import price competitiveness). In the long run, the import penetration ratio - the ratio of imports to a weighted measure of demand - returns to its desired level, in turn driven by relative import prices and a time trend (included to capture the effect of increasing specialisation in the international economy).

3.2.2 Labour Market

The labour market consists of three aggregate behavioural equations: labour demand and labour supply, which jointly determine the unemployment rate; and a wage equation which is largely dependent on the unemployment rate. In addition, the specification of the labour market includes a unemployment/vacancy relationship (known as a Beveridge curve) to endogenise unfilled vacancy data. A separate equation is also used to estimate hours worked.

- **Beveridge Curve** - The Beveridge curve equation is introduced to provide a summary indicator of the state of the labour market into the wage equation, as well as to help to identify the labour demand equation. The equation uses a logistical growth function to capture the outward movement in the unemployment/vacancy relationship which occurred in the 1970s.

- **Labour Demand (NEBD, NGE, NGG)** - Labour demand is mainly determined in the business sector as a function of aggregate business output and wages relative to trend marginal product. There are also equations for general government and public enterprise employment demand, although these components are effectively exogenous.

- **Hours Worked (NH)** - In deciding on how to respond to short term fluctuations in demand for their product, employers can either adjust the hours of work of current workers or hire additional employees. Changes in average hours worked thus play an important role in translating any short term change in employment demand into numbers of people employed. In the short term, growth in GDP and the vacancy rate are important determinants of average hours worked. In the long term, average hours worked is assumed to be supply determined. Thus, the long term component of hours worked is modelled by a logistical growth trend - called the desired level of hours worked (NHLR). This trend captures the sharp decline in hours worked since 1973 caused by reductions in standard full time hours and a shift to part time work.

- **Labour Supply (NLF)** - The labour supply decision is made by the household sector. To be consistent with labour demand labour supply is measured on an hours, rather than a heads, basis. Thus, the participation rate is adjusted for changes in desired hours worked derived from the average hours worked equation to define labour supply on an hours basis. Short term movements in the participation rate (ratio of labour force to adult population) are dominated by the ‘encouraged worker’ effect where people are encouraged to enter the labour force by increasing employment and declining unemployment. In the model, a 1 per cent increase in the employment to population ratio quickly leads to about a ½ per cent increase in the
participation rate. Population growth and (unexplained) participation trends also enter into the equation. The participation trends are possibly due to a combination of social and demographic factors in the 1970s and 1980s - for example, increases in the female participation rate, falling male participation rates, earlier retirement, higher education participation rates and the increasing availability of part time work.

- **Wage Setting (RWT/NH)** - The wage equation is in the form of a standard expectations augmented Phillip's curve. Expectations are backward looking (adaptive) rather than rational and workers are assumed to respond to the change in unemployment as well as the level of unemployment in making nominal wage demands. Wages rise relative to expected inflation when unemployment falls below its equilibrium level (the NAIRU). The respective role of employers and workers in the bargaining or wage setting process is not identified. An attempt is, however, made to incorporate some of the effects that varying degrees of centralisation of the wages system have had on wages growth since the early 1970s (see Section 5.1 of the *TRYM Documentation*).

The NAIRU used in the model has been estimated from historical data commencing in the early 1970s, with a break allowed in 1974. There are a number of competing theories about why the NAIRU has increased over time; working at a highly aggregative level TRYM does not distinguish between these. However, it does appear to be possible to distinguish between search effectiveness and wage setting explanations of the increase in NAIRU at a very broad level by the use of unfilled vacancy data. This is achieved by introducing into the wage equation a variable which seeks to capture the impact on equilibrium unemployment (unemployment equalling unfilled vacancies) of changes in search effectiveness as evidenced by movements in the Beveridge curve. This, in combination with two wage setting parameters, determine the level of the NAIRU in the model. The wage setting parameters capture the effect on the NAIRU of factors other than search effectiveness associated with the wage bargaining process. For example, it may reflect ‘insider/outsider’ factors (concerned with the wage bargaining power of the employed versus the unemployed) in combination with institutional features of the wage bargaining system. Details are in Section 5.2.4 of the *TRYM Documentation*.

### 3.2.3 Financial Market

The financial market is represented by a money demand equation, a money supply rule, a bond yield equation and an exchange rate equation. The money demand equation is inverted (so that the short term interest rate is a function of money demand) and combined with the money supply rule to form an interest rate reaction function. The exchange rate and bond yield equations are imposed rather than estimated. This has followed from estimation difficulties and the desirability of keeping the model as simple and transparent as possible. The parameters that have been imposed have been calibrated to provide linkages between the exchange rate and interest rates which are broadly consistent with history. The specification of the financial sector is currently under review.

### 90 Day Bill Rates - Default Monetary Policy Response

TRYM uses the interaction of the demand and supply of monetary transaction balances to determine short term interest rates (R190). Increasing expenditure is assumed to lead to an increase in money

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15 The specification of the labour market (in particular, the incorporation of unfilled vacancies data) enables TRYM to be used to explore a wide range of issues relating to the link between labour market imbalances and other areas of the economy. For example, if the user establishes or judges that the NAIRU may move in a given set of circumstances (changes in search effectiveness of the unemployed or wage setting factors), the model can be used to examine the macroeconomic implications of these movements. For an example of the use of the model in this way see Stacey and Downes (1995).

16 See Gregory (1986) for a description of the role of insider/outside factors in Australian wage bargaining.
(transactions) demand. Thus, an increase in GNE in real terms or an increase in the price of GNE (domestic prices) is assumed to increase money demand. Money (transactions) supply is composed of three elements: currency in the hands of the non-bank private sector; non-interest bearing current deposits of all banks; and a fixed proportion of interest bearing current accounts of all banks. Nominal money supply is assumed to grow at a constant rate in simulations. This is equal to equilibrium supply side growth (productivity and population growth) plus an exogenous inflation target. The default monetary policy setting, therefore, reflects non-accommodating monetary policy - whereby, in the face of a demand shock, the monetary authorities maintain the specified rate of growth in the money supply, allowing short term interest rates to adjust. As noted, the money demand equation is inverted and combined with the money supply rule to form the interest rate reaction.

There are a large number of problems in modelling money demand, given institutional changes in the financial market in history. There is also a range of different approaches that can be taken in setting the money supply. The interest rate response is, thus, impossible to tie down precisely and should be interpreted with caution.

Moreover, while the interest rate response is estimated using a money demand equation, it could have alternative interpretations. For example, it could be interpreted as reflecting endogenous movements in saving and investment (the demand and supply of funds). The reaction function should not, of course, be interpreted as a Treasury view of how monetary policy actually works. Ultimately, it is no more than a simple, transparent and stable way of allowing interest rates to respond to changes in the economy and to possible interventions by the monetary authorities. As outlined in Section 2.2.2, the default monetary policy response is only one possible way of dealing with monetary policy in the model.

As with the default fiscal policy mechanism, there is scope to change the relationships between money supply, money demand and interest rates. For example, the user could change the speed at which changes in money supply or money demand affect short term interest rates. Alternatively, the money demand function could be respecified; for example, re-estimated to be a function of nominal GDP rather than nominal GNE. The default specification has been chosen for convenience and for its simplicity and transparency. It represents a simple mechanism that enables short term interest rates to reflect developments in the demand and supply of funds (savings and investment), possible changes in monetary policy, inflation and real activity.

10 Year Bond Rates and Inflation Expectations

Real 10 year bond rates (RIGL) are assumed to be a weighted average of real domestic short term rates and real world long term bond rates. In all cases, real rates are derived by subtracting inflationary expectations (FIE) from nominal rates. Domestic inflationary expectations are measured in history by the difference between the yield on non-indexed and indexed 10 year Treasury bonds. The domestic real short term rate must ultimately equal real world long rates. In the absence of monetary or other shocks the world lending rate ultimately determines our borrowing rate. Therefore, the domestic long term rate also ultimately moves to equal the world long rate (adjusted for risk).

The nominal bond rate is equal to the real rate plus inflationary expectations. The 10 year inflation expectations derived by the model are close to being ‘model consistent’ in most simulations. The expectation for the price level in 10 years time is based on the equilibrium price level in 10 years time (derived from the steady state model). Because the price level usually would not have reached equilibrium in the simulation within 10 years, the inflation expectations assumed will usually therefore not be precisely model consistent - but should usually be close to being so.
The nominal 10 year bond rate ‘jumps’ with any shock that affects the equilibrium price level. The real bond rate, however, only moves gradually with real 90 day bill rates. The real component is adaptive or backward looking, while the nominal component is forward looking.

The above solution to bond rate determination is largely adopted for convenience. It is possible to alter simulation procedures to solve the model using rational expectations and various modifications thereof. Ryder et al (1993) provide an example of a world trade shock with model consistent expectations in the financial market.

Exchange Rate

As with the money demand equation and the bond yield equation, obtaining satisfactory explanations for the behaviour of the exchange rate is fraught with difficulty. Theory suggests that expected exchange rate movements (the difference between the current and expected future exchange rate) should be related to the difference between domestic and overseas interest rates. However, in practice, it is difficult to produce a satisfactory fit of the exchange rate using this simple uncovered interest parity (UIP) situation (although covered interest parity is found to hold17). In particular, there is great uncertainty associated with the reasons for short term movements in the exchange rate (possibly due to the activity of ‘noise traders’ and chartists). Part of the problem in obtaining a model of the exchange rate which is consistent with UIP relates to the difficulty of modelling the future equilibrium rate. In theory, the equilibrium rate should be affected by a range of factors such as commodity prices (and therefore mineral discoveries), inflation and inflation expectations here and overseas and domestic savings and investment balances. However, it is difficult to know whether movements in some of these variables (commodity prices in particular) are (or are judged to be) permanent or transitory. Moreover, because of the possibility of time varying risk premia it is difficult in practice to measure directly the expected future course of either real interest rates or inflation. There are further measurement problems with world interest rate and inflationary expectations. There is also only a relatively short period of data since the floating of the exchange rate in Australia upon which the uncovered interest parity theory can be tested.

The approach taken in TRYM is to impose an uncovered interest parity condition so that the exchange rate (RETWI) is determined by the ‘risk-adjusted’ differential between domestic and world 10 year bond rates and the expected equilibrium exchange rate in 10 years time. A 10 year time horizon is chosen to be consistent with the bond yield equation. This is represented by the following equation.

\[ RETWI(t) = 10^* (RIGL(t) - WRIGL(t) - RIP) + RETWIX(t+10) \]

where: 
- RIGL = Australian 10 year bond rate
- WRIGL = world 10 year bond rate
- RIP = interest rate differential on Australian debt
- RETWI = $A trade weighted index (log*100)
- RETWIX = equilibrium RETWI (log*100)
- and time (t) is in years

The equilibrium exchange rate (RETWIX) in TRYM is calculated using the steady state version of the model. In equilibrium, the exchange rate achieves internal balance and a stable ratio of net external liabilities to GDP.

\[ RETWIX(t) = \frac{1}{10} \left( \frac{1}{10} \cdot (RIGL(t) + RIP) \right) \]

17 For example, see Blundell-Wignall et al (1993).
Under the framework in TRYM, a wide range of factors can influence the current exchange rate either through the equilibrium exchange rate or through the 10 year bond rate. For example, a permanent increase in the terms of trade will raise the equilibrium exchange rate. It will also raise domestic demand and, hence, domestic interest rates. Both effects will tend to raise the current exchange rate.
4. Intuition Behind TRYM Results

The intuition behind the results of TRYM simulations can be understood by comparing the results with those from standard text book IS/LM aggregate demand/aggregate supply models. This section compares TRYM with such text book models and illustrates TRYM interrelationships using a monetary expansion, a fiscal expansion and a reduction in the NAIRU. The section concludes with an example of a dynamic path taken by TRYM towards long run equilibrium, which helps to illustrate both the dynamic and long run properties of the model.

4.1 IS/LM RESULTS

Some of the intuition behind the TRYM model's results can be gained by recalling the results from the standard text book IS/LM aggregate demand/supply model.

Paul Krugman (1993) outlines some simple generic models he alleges many economists carry around in their heads. He refers to these as Massachusetts Avenue models or modified Mundell Fleming models. These are simple dynamic versions of the IS/LM aggregate demand/supply framework. Gruen and Shuetrim (1994) and Debelle and Stevens (1995) contain some interesting examples of similar simple three and four equation models of the Australian economy. With many simulations, the results from TRYM have similarities with those from these simple generic models. However, by containing a comprehensive range of linkages and relationships, TRYM sets a firm basis on which to analyse results and establish the importance of particular assumptions or mechanisms to those results.

The standard Mundell Fleming effects of policy changes in a small open economy with a floating exchange rate and free capital flows are shown in Figure 5. The intuition behind the results of TRYM policy simulations is essentially the same as that underlying the effects of policy changes shown in Figure 5. The TRYM results in Section 4.2, expressed in deviation from baseline terms, have many of the same essential features, but with the addition of a time dimension.

The comparative statics of Figure 5 - the comparison of the equilibrium position of the economy after a shock with the initial equilibrium position - therefore need to be related to the time dependent dynamics of TRYM. The initial equilibrium points (A) in Figure 5 correspond with the TRYM baseline in Section 4.2 with its growing prices and quantities. This growing baseline is removed by showing results in terms of deviations from the baseline in Figures 6 to 8 in Section 4.2 to put them on a comparable basis with Figure 5. The vertical long run aggregate supply curve in Figure 5 corresponds with the steady state growth path in TRYM.

The short run aggregate supply curve is deliberately drawn relatively flat in Figure 5 as wage and price pressures take some time to react to excess demand pressures in the model. There is very little effect on prices in the first one or two quarters. As a result, output is largely demand determined in the short term. As mentioned in Section 2.3.4, underlying supply growth in the model is equal to adult population growth plus trend growth in labour productivity. If there are no changes in

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18 A simple explanation of what is involved in a simulation of the model, together with commonly used modelling terms, is given in Section 2.1.2 of the TRYM User’s Guide (with TSP). The steps involved in a simulation are explained in more detail in Section 2.1.4 of that guide.
Intuition Behind TRYM Results

exogenous variables, such as world commodity prices or world interest rates or domestic agricultural

**Figure 5: Monetary and Fiscal Expansion in a Small Open Economy with a Floating Exchange Rate and Free Capital Flows**

**Fiscal Expansion** - Increased public spending shifts the IS curve (representing goods market equilibrium) to the right, increasing aggregate demand (AD), including investment demand. The increased level of activity and increased public borrowing requirement lead to higher interest rates. Higher interest rates ‘crowd out’ investment. Higher interest rates are also associated with a higher exchange rate (as foreign investors take advantage of the higher Australian interest rates, thus increasing the demand for Australian dollars). The higher exchange rate leads to a worsening of the trade deficit and a net export detraction from growth. With a permanent fiscal expansion, the fundamental equilibrium exchange rate will be higher unless the deficit is fully offset by higher private saving in the long term. In the medium term, the initial stimulus is fully crowded out by the effect of the exchange rate appreciation on net exports. Aggregate demand (AD) returns to its original position and the initial increase in prices is unwound in the medium term.

**Monetary Expansion** - The initial monetary expansion (injection of liquidity) shifts the LM curve (representing money market equilibrium) to the right, leading to lower interest rates. Lower interest rates stimulate investment and lead to a lower exchange rate, an improvement in the trade balance and a positive contribution from net exports. The IS curve moves to the right augmenting the initial shift in the LM curve. Aggregate demand moves to the right. As the starting point A is on the long run (LR) supply curve (where unemployment equals the NAIRU), the increase in activity reduces unemployment below the NAIRU. The increase in demand leads to wage pressures in the labour market and price pressures in the product market as demand outstrips supply. With wage pressures in the labour market plus increasing margins in the goods market, general price levels rise. Unless there is a further injection of liquidity, the real money supply falls to the point where the expansionary monetary effects are unwound. If wealth effects or government net bonds are zero the classical dichotomy (money neutrality) holds in the long run.

For the derivation of the IS/LM and aggregate demand curves see any standard macroeconomics text - for example, Branson (1989) and Dornbusch and Fischer (1990). Stevenson, Muscatelli and Gregory (1988) provide a good discussion of the theory, including recent developments. The original analysis illustrating fiscal policy impotence was developed by Mundell (1962) and Fleming (1962). More recent developments have focussed on the effect of different wage institutions on aggregate supply, wealth effects and expectational effects - see Mankiw (1988). The standard balance of payments equilibrium (BP) curve is assumed to be horizontal in the above, reflecting the assumption of perfectly mobile international capital flows.
conditions, and domestic policy settings are stable then the model will eventually settle on the steady state growth path (see Section 2.3.4).

The model (even with its focus on key linkages and simple structure) is far more complex than the normal textbook model. Whereas the standard comparative static model has two or three identities, TRYM has over a hundred. TRYM specifies in detail the relationships between demand, inflation, interest rates, the exchange rate and the current account deficit. Moreover, it has fully articulated linkages between investment and saving flows and wealth and capital stock aggregates. In addition, the behavioural equations have been estimated in such a way as to be able to derive an identifiable long run.

The complexity of the model means that it is impossible to hold all the interrelationships in one's head at any one time. Analysis depends on understanding the various mechanisms and linkages in the model and applying that understanding while carefully analysing and tracing through simulation results. Hence, the importance of consistency and transparency in the model.

The reaction of the model to fiscal and monetary policy changes are shown in Figures 6, 7 and 8 and discussed in the following sub-section.

4.2 SIMULATION EXAMPLES

The simulations below are designed to show how the model's results compare with the standard comparative static results (equilibrium to equilibrium comparisons) outlined in Figure 5. The TRYM User's Guide (with TSP) provides more details of the results of similar simulations, as well as other simulations, which illustrate the properties of the model by showing the model’s responses to various shocks. The TRYM User’s Guide (with TSP) provides a guide to replicating these simulations using the TSP simulation files provided with the TRYM package.

The first two economic shocks discussed below are demand side shocks. The first is a one-off expansion in the money supply of 4 per cent, phased in over the course of a year. This leads in the short term to a fall in interest rates and a falling exchange rate - analogous to the right hand panels in Figure 5.

The second shock is a fiscal policy expansion that increases the PSBR by 1 percentage point of GDP. This shock leads to an expansion of demand in the short term accompanied by rising interest rates and a rising exchange rate - analogous to the left hand panels in Figure 5.

The third shock is a supply shock, where the non-accelerating inflation rate of unemployment (NAIRU) falls by one percentage point. This shock, in common with other supply shocks, has the characteristic of increasing gross domestic product (GDP) while reducing inflation. This is not shown in Figure 5 but is analogous to shifting the long run aggregate supply curve in Figure 5 to the right.

4.2.1 Demand Shocks

Monetary Expansion

The expansion of the money supply leads to a fall in interest rates in the first year (Figure 6A). However, this interest rate decrease is unwound as the price level rises and the real money supply
Intuition Behind TRYM Results

falls back towards its original level. The interest rate decrease is completely unwound after the second year.\(^{19}\)

The fall in interest rates stimulates gross national expenditure (GNE) - via investment and consumption - and imports. However, the lower real exchange rate accompanying the falling interest rates stimulates net exports, overshadowing the demand stimulus to imports. As a result, GNE and GDP move together (Figure 6B). The short term interest rate does not taper towards its original level, but overshoots. This is due to the lagged adjustment processes on the demand side and inertia in business and dwelling investment. The initial stimulus to investment sets up a stock adjustment cycle in investment. As output is unaffected in the long run and the capital/output ratio must return to its long run level, any initial increase in investment must be unwound and most of this unwinding occurs in the first contractionary phase after the shock.

The shock is characterised by an expansionary phase, a contractionary phase and then a phase where GNE and GDP broadly taper towards equilibrium (involving dampened oscillations). The effects of the money shock over one year take up to ten years to work their way out of the system.

**Figure 6A: Temporary Monetary Stimulus**

\(^{19}\) It is unwound before the full price effects flow through (before the price level rises by 4 per cent) because demand is expanding. Interest rates react to movements in nominal GNE in TRYM. As both prices and quantities are increasing, the interest rate effects of the monetary expansion will be unwound before the price effects flow through fully.

**Fiscal Expansion**

In contrast to the monetary expansion, the fiscal expansion is accompanied by increasing interest rates and an increasing real exchange rate (Figure 7A). The increase in the exchange rate adds to the negative net export effects of the increase in demand. The exchange rate movement leads to net export reduction which works in the opposite direction to the initial stimulus to aggregate demand from the fiscal expansion: the opposite of the monetary policy case where a net exports stimulus supports the demand expansion. Instead of GDP moving in line with GNE as in Figure 5, more than half of the initial GNE response is crowded out by net exports.
Figure 6B: Temporary Monetary Stimulus

The expansion's effect on investment is much smaller than in the case of the monetary expansion. As a result, no significant stock adjustment cycle is set up. Consequently, GDP and GNE broadly move asymptotically back to their equilibrium levels. The effects of the shock on activity and prices are virtually completely unwound after three years.

Figure 7A: Permanent Fiscal Expansion

The fiscal policy simulation illustrates some important medium to long term features of the model. The GNE line in Figure 7B shows that the effects on GNE of the shock are reasonably persistent. This is because consumers are assumed to have adaptive rather than rational expectations. As a result, private saving does not adjust fully to the change in public net lending even in the medium to
Intuition Behind TRYM Results

long term (see Section 5.1 on Ricardian equivalence). Most of the crowding out of expenditure in the short to medium term occurs through net exports, consumption and investment. However, because of the absence of a fully offsetting savings response, some of the effects on GNE, the current account deficit (CAD) and nominal interest rates are persistent.\(^{20}\)

**Figure 7B: Permanent Fiscal Expansion**

In the short to medium term, the exchange rate and demand effects are working on the trade balance in the same direction, with both the appreciating exchange rate and demand expansion working to reduce net exports (see Section 5.6 for a discussion of the very short term exchange rate effect). As a result, the effect on the CAD is relatively rapid. A 1 percentage point increase in the PSBR as a percentage of GDP via higher government expenditure increases the CAD by about half a percentage point after the first year. The magnitude of the effect, however, depends on the form that the fiscal policy change takes (an equivalent tax change will have less effect). The speed of the response is also highly dependent on the short term reaction of the exchange rate (see Sections 5.2 and 6.1.1).

**Other Demand Shocks**

The fiscal and monetary policy shocks discussed above are both examples of demand side shocks. Although they differ in their effects (including in terms of persistence) on different demand components, overall, both lead to rising output and rising prices in the short term. This is also true of other demand side shocks (such as, for example, an increase in investment or consumption as a result of an exogenous increase in confidence). In general, shocks to the residuals of the private expenditure components of GNE have similar properties to those described for the fiscal policy shock above.

\(^{20}\) The slightly higher interest rate structure leads to a fall in investment and the capital stock. As the capital stock falls, the investment required to maintain the capital stock falls. Ultimately, in the long run, the fall in the capital stock offsets the increase in public debt and the associated lower level of private investment and helps to counterbalance the effects of the increase in public net lending on the CAD.
4.2.2 Supply Side and External Shocks

In contrast to demand side shocks, supply side shocks are usually characterised by prices and output moving in opposite directions. This can be seen by shifting the long run aggregate supply curve to the right in Figure 5. This outcome is also true of external shocks such as an increase in world output or the terms of trade. The exchange rate rises in response to increasing export prices and output, lowering import prices and acting to insulate the domestic economy from the price effects of the initial shock. In the case of both supply side and external shocks, the insulation of the economy from some of the price effects of the shock may reduce the requirement for discretionary monetary and fiscal policy responses to supply side or external shocks.

The TRYM User’s Guide (with TSP) contains examples (including TRYM simulation files to allow replication of the simulations) of both domestic supply side and external shocks and refers to relevant papers. Of these, the NAIRU shock is briefly described below. It provides a good example of how full model analysis can differ from partial analysis.

**NAIRU Shock**

A one per cent reduction in the NAIRU (or the equilibrium rate of unemployment) leads to a roughly proportional increase in labour supply in equilibrium (around 0.8 per cent). The availability of more employment encourages previously discouraged workers to enter the labour market, increasing equilibrium labour supply. As a result, employment rises by 2.0 per cent in the long run. The higher level of employment is associated with a similarly higher level of output.

While the long term effects are driven by the supply side, the short term effects are driven by the demand response to the reduction in inflationary pressures. Figures 8A and 8B, show that the initial effect is to lower the inflation rate (for any given level of unemployment). This leads to lower interest rates and a lower exchange rate. It is this interest rate and exchange rate response which initially stimulates investment (and, therefore, GNE) and output growth.

In response to the initial fall in real wages, employers also substitute labour for capital for a given level of output. However, this is a relatively small effect compared to the interest rate and exchange rate effects. Thus, the short term response of employment is much greater than would be thought from simply looking at the short term elasticity of the labour demand curve.

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21 The monetary policy default in the model is non-accommodating (that is, the growth in the nominal money supply is fixed).

22 In TRYM, the combination of an unemployment variable adjusted for search effectiveness (RNUSTAR) and two wage setting parameters (WS and WSo) determine the level of the NAIRU. Therefore, it is possible to examine the macroeconomic implications of changes in search effectiveness of the unemployed and wage setting factors separately. In this simulation, the one per cent reduction in the NAIRU is achieved by lowering the wage setting parameter, WS.

23 The equilibrium price level depends on the monetary policy assumption. In this simulation, monetary policy is assumed to be non-accommodating of the increase in real activity (see Section 3.2.3). Hence, the long run price level is lower. A monetary policy setting that accommodated the increase in real activity would lead to an unchanged price level. Inflation would then be the same on average over the period. The initial deflation would be offset by a future inflation.

24 As in the monetary policy shock, there is little external crowding out of the GNE stimulus and, in fact, there is a slightly positive contribution from net exports.
A similar, somewhat counter-intuitive result occurs in the long run. In the long run, the aggregate demand curve is relatively flat for an open economy like Australia. As a small economy, Australia can almost sell as much as it likes on the world market. Small changes in the real exchange rate would be expected to increase net exports in the long run by a significant amount. Thus, output is very elastic with respect to small changes in export prices relative to import prices (and hence output prices relative to consumer prices and changes in the consumer real wage). The elasticity of
employment for the economy as a whole in the long run is again much greater than would be apparent from the labour demand equation.\footnote{The intuition behind the result of the NAIRU shock is similar to that of an increase in labour supply. In the case of an increase in labour supply, the labour demand curve by itself would suggest that real producer wages needed to fall by 2.3 per cent to accommodate the additional employment achieved in the long run from the NAIRU shock. In comparison, the full model results indicate that real producer wages are virtually unchanged in the long run. Moreover, as the tax burden occasioned by unemployment benefit transfers has been reduced, the after-tax consumer real wage actually increases in the medium to long term (see Figure B8). In addition, as more people are in employment, living standards for the community as a whole are much higher. They rise by more than either after-tax consumer real wages or GDP. Stacey and Downes (1995) provide a fuller discussion of the interrelationships involved.}

The aggregate employment elasticity is determined by the sensitivity of net exports to real exchange rate changes rather than the elasticity of the labour demand curve. The labour demand curve by itself would suggest that real producer wages needed to fall by 2.3 per cent to accommodate the additional employment achieved in the long run from the NAIRU shock. In comparison, the full model results indicate that real producer wages are virtually unchanged in the long run. Moreover, as the tax burden occasioned by unemployment benefit transfers has been reduced, the after-tax consumer real wage actually increases in the medium to long term (see Figure B8). In addition, as more people are in employment, living standards for the community as a whole are much higher. They rise by more than either after-tax consumer real wages or GDP. Stacey and Downes (1995) provide a fuller discussion of the interrelationships involved.

While there are a large number of caveats to the model results, the results serve to illustrate how analysis done in the context of a fully articulated model can provide a very different view from that of a partial analysis that focuses only on selected interrelationships.

### 4.3 EXAMPLE OF DYNAMIC ADJUSTMENT TO A STEADY STATE PATH

Another way of illustrating the dynamic (short run) and long run properties of the model is to perform a dynamic simulation of the model over a projection period (starting in the quarter immediately after the historical data ends) and to compare the results of that simulation with the steady state path\footnote{Another way of illustrating the dynamic (short run) and long run properties of the model is to perform a dynamic simulation of the model over a projection period (starting in the quarter immediately after the historical data ends) and to compare the results of that simulation with the steady state path. The steady state path is derived from the long run version of the model (that is, excluding the short run components of the TRYM behavioural equations). The steady state path is a representation of the economy when product, labour and financial markets (the equilibrating markets in Figures 1 and 2 of Section 2.1) are in equilibrium. A dynamic simulation draws on both the short run and long run components of the estimated behavioural equations of TRYM. Typically, the most recent point in history will be a disequilibrium situation due to the fact that the economy is continually undergoing shocks of one sort or another. With exogenous variables in the future moving the same in both the dynamic and steady state simulations - and in the absence of further shocks that affect the short run dynamics relative to the steady state - the path of the dynamic simulation can be expected to eventually settle on the economy’s steady state growth path. More detailed discussion and explanation of dynamic and steady state simulations and extrapolation of exogenous variables is given in Section 2 of the TRYM User’s Guide (with TSP).}. The steady state path is derived from the long run version of the model (that is, excluding the short run components of the TRYM behavioural equations). The steady state path is a representation of the economy when product, labour and financial markets (the equilibrating markets in Figures 1 and 2 of Section 2.1) are in equilibrium. A dynamic simulation draws on both the short run and long run components of the estimated behavioural equations of TRYM. Typically, the most recent point in history will be a disequilibrium situation due to the fact that the economy is continually undergoing shocks of one sort or another. With exogenous variables in the future moving the same in both the dynamic and steady state simulations - and in the absence of further shocks that affect the short run dynamics relative to the steady state - the path of the dynamic simulation can be expected to eventually settle on the economy’s steady state growth path. More detailed discussion and explanation of dynamic and steady state simulations and extrapolation of exogenous variables is given in Section 2 of the TRYM User’s Guide (with TSP).}

26 Section 2.1.2 of the TRYM User’s Guide (with TSP) explains these modelling terms simply.
The following comparison of a dynamic and a steady state simulation is designed to give some impression of how quickly the convergence occurs and how long dynamic fluctuations persist in the absence of further shocks. All exogenous variables are therefore assumed to grow along their steady state path and any residuals in the behavioural equations are assumed to jump to zero immediately at the start of the projection period. The simulation shown is thus purely illustrative and should not be interpreted as a Treasury forecast or projection. The assumptions for the paths of exogenous variables are not forecasts or projections. The recent performance of behavioural equations in terms of tracking actual outcomes has not been closely examined. There has also not been any consideration of partial or anecdotal information as would be the case with a considered forecast. More detail on undertaking projection simulations with TRYM, including making residual adjustments to variables into the projection period, is given in Section 3 of the TRYM User’s Guide (with TSP).

Figures 9, 10 and 11 compare the steady state path and the dynamic adjustment towards that path for GDP (Figure 9), for the unemployment rate (Figure 10) and for business fixed investment (Figure 11).

Figure 9 shows that the product and financial markets are close to equilibrium at the start of the projection (there is a relatively small GDP gap between the dynamic and steady state path, initially). Most of the additional growth towards the steady state path is coming from the initial starting point disequilibrium in the labour market (unemployment higher than the NAIRU): Figure 10 shows a large initial gap between the dynamic and steady state unemployment level. Fuller utilisation of labour resources (the unemployment rate equal to the NAIRU) enables greater output and higher living standards.

The dynamic adjustment towards this steady state path takes some time. The dynamic tendencies evident in the simulation mainly come from inertia in the private investment components in the goods market (and the stock cycle), as discussed in Section 3.1. These, in turn, tend to be driven by backward looking or adaptive expectations in the household and business sectors, modelled through distributed lag structures in TRYM. The resultant over-shooting, stock adjustment behaviour is
Intuition Behind TRYM Results

more clearly evident in relation to business fixed investment and the unemployment rate in Figures 10 and 11.

**Figure 10: Dynamic Adjustment towards Steady State - Unemployment**

GDP growth in the dynamic simulation tends to remain stronger on average than the steady state rate until slack in the labour and product markets is unwound and the GDP level approaches the steady state path. Eventually (and in the absence of further shocks), the equilibrating tendencies in the model coming from the three markets identified in Figures 1 and 2 overcome the dynamics due to investment components and the stock cycle.
Intuition Behind TRYM Results

There is considerable uncertainty over the level of the steady state path. For example, equilibrium in the labour market (the level of the NAIRU) is not well determined and it may well be that the NAIRU is lower or higher than that estimated from the model's wage equation (see Section 6.2.1). Similarly, equilibrium in the financial market occurs when the risk-adjusted domestic real long bond rate equals the world real long bond rate. There are a number of measurement difficulties in determining real bond rates and appropriate risk adjustments; the equilibrium could conceivably be lower or higher than that estimated. The lower the equilibrium real long bond rate, the greater the equilibrium capital stock and, consequently, the higher the equilibrium level of output.

There is also uncertainty associated with the steady state growth rate. The steady state growth rate is determined in the model by the growth rate of labour input and the rate of underlying productivity growth and both these rates of growth are particularly uncertain in the future.
5. Selected Macroeconomic Issues and TRYM

This section is designed to answer a number of questions often asked of the model in relation to various macroeconomic propositions. It is not meant to provide a comprehensive coverage of the issues discussed but rather to briefly point out TRYM’s treatment of the issue.

There are a large range of theoretical and applied economic issues which the model may shed light on or can be used to investigate. The following by no means provides a comprehensive list but, rather, covers a number of such issues that are topical. Explaining how TRYM deals with the issues helps extend and reinforce the understanding of TRYM interrelationships and limitations.

5.1 RICARDIAN EQUIVALENCE / FISCAL POLICY

The Ricardian equivalence proposition states that an increase in government expenditure funded via an increase in borrowing will have equivalent effects on household consumption and capital formation as an increase in expenditure funded via a lump sum tax. This follows if economic agents take account of the fact that the increase in Government borrowing implies a future tax liability. An implication of this proposition is that any fiscal expansion or contraction or change in public saving will be offset by an opposite change in private saving.

The proposition assumes a relatively high degree of rationality and foresight on the part of households. At the extreme, Ricardian equivalence would result in fiscal policy having no effect on activity or inflation. For example, householders would not increase consumption in response to an increase in household income following a tax cut (reduction in public saving). Rather, household saving would rise by an equivalent amount to the tax cut. Consumption would be unchanged because householders as rational, permanent units would see that the government would need to raise taxes in the future to stabilise public debt. Their expected permanent income would be unchanged. Hence, the tax cut would have no aggregate effect on demand or activity. The proposition also requires that householders do not count private sector holdings of government issued bonds as part of their net wealth - see Barro (1974).

TRYM provides little support for this proposition in the short to medium run. This is consistent with the finding in other Australian models such as MSG, Murphy, NIF88 and AMPS - see Pagan (1990). Fiscal policy appears to be only moderately offset by changes in consumption in the short term. Rather, crowding out of the effect of fiscal policy on activity occurs via investment and the external sector which is consistent with Mundell Fleming-type results - see the fiscal policy simulation results in Sections 4.1 and 4.2.1, as well as Appendix B of the TRYM User’s Guide (with TSP).

The lack of support for the Ricardian equivalence proposition partly rests on the assumptions in TRYM concerning the behaviour of consumers and investors. TRYM attributes some forward looking behaviour to both consumers and investors (see TRYM Documentation): investors respond

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27 The logic of the proposition was first put forward by David Ricardo in his Principles (1821). However, it seems unlikely that he would have agreed with some of the modern variants of the proposition.

28 TRYM does include government securities as part of private sector wealth - see Commonwealth Treasury (1995). As a result, Ricardian equivalence does not hold even in the very long run in TRYM.
Macroeconomics and the Model

5.2 TWIN DEFICITS

The 'twin deficits' proposition is roughly the reverse of the above Ricardian equivalence proposition and was first put forward in the US in the early 1980s. In its crudest form, the twin deficits proposition states that any reduction in the budget deficit (fiscal tightening) will lead to an equivalent reduction in the current account deficit, and vice versa for an increase in the budget deficit.

This proposition ignores the fact that both public and private saving and investment decisions determine the current account deficit outcome. By definition, the current account deficit (CAD) must equal the sum of public borrowing (the net PSBR) and private net lending - private investment.
less private saving. Thus, the impact on the CAD of increased public saving (reduced net PSBR) may be offset - or more than offset - in a particular year by unrelated falls in private saving or increases in private investment.

In practice, therefore, it is difficult to draw conclusions from simple comparisons (regressions) of movements in the PSBR against the CAD because of the diverse forces that affect private saving and investment. Cyclical movements are particularly relevant in this regard. For example, in an economic upturn, demand will spill over into imports increasing the CAD at the same time as the PSBR is moving towards surplus because of the effects of higher activity on tax revenue and unemployment benefits. Hence, cyclical fluctuations will tend to lead to an apparent inverse relationship between budget deficits and the current account.

One way of isolating the various influences on the CAD and obtaining estimates of the possible marginal effect of discretionary changes in the budget on the current account (other things unchanged) is to use a structural model such as TRYM. In TRYM, a discretionary reduction in the budget deficit will lead to roughly half that reduction in the CAD (in the absence of other shocks). That is, a $1 billion discretionary tightening will lead to a reduction in the current account deficit of about $0.5 billion. This is roughly the same relationship found by NIF88 and the AEM and MSG models - see Pagan (1990). 'The precise effect will, however, depend on what fiscal component is being 'shocked'. For example, a reduction in the budget deficit will have less effect if it is achieved through increased taxation or reduced transfers (concomitant with their smaller impact on activity and expenditure) rather than reduced expenditure.

A stylised version of the effects of a fiscal policy contraction on the CAD and the real exchange rate in TRYM is given in Figure 12. TRYM simulations of changes over time in the exchange rate and the CAD following changes in fiscal policy (and monetary policy) are shown in Section 4.2 and in Appendix B of the TRYM User’s Guide (with TSP).

In the short term, a fiscal contraction in TRYM leads to both a direct reduction in import demand and a fall in the real exchange rate. In the longer term, the contraction in demand is offset completely by increasing net exports (and a decreasing CAD) primarily as a result of the falling real exchange rate in the context of the highly mobile international capital market in TRYM.

With a floating exchange rate, a capital account surplus must equal the current account deficit, by definition. The exchange rate ensures that the two are balanced. Any current account deficit adds to the supply of Australian dollars (demand for foreign dollars) which must be matched by a capital account inflow or demand for Australian dollars (supply of foreign dollars) with the exchange rate adjusting, if necessary, to ensure that. Following a fiscal contraction, the size of the change in the CAD over time depends on the elasticity of net exports with respect to the exchange rate. In TRYM, in the short term, the trade balance is relatively insensitive to exchange rate changes. The early improvement in the CAD is mainly due to the expenditure effects on imports (see Figure 12). However, in the long run the trade balance is much more elastic with respect to the exchange rate and the lower CAD is largely a result of the effects of the lower exchange rate (as in Figure 12). Some of the initial expenditure effects are unwound (not shown in Figure 12); however, as Ricardian equivalence does not fully hold in the model, the improvement in the CAD is maintained into the medium term.
Figure 12: Stylised Representation of the Effect of a Fiscal Tightening on the CAD and the Real Exchange Rate in TRYM

The diagram consists of two curves: the net supply of $A (M-X)$; and the net demand for $A (I-S)$. The net supply of Australian dollars is determined by the excess of imports over exports ($M-X$ or the CAD). The net demand for Australian dollars is equal to the excess of investment over domestic saving ($I-S$, the capital account inflow). The $I-S$ curve is relatively steep because in TRYM the real exchange rate does not have significant direct effects on domestic $I$ or $S$.

Short run: The reduction in government expenditure ($G$) (increase in $S$) leads directly to a fall in $M$. The absolute change in $M$ is less than the change in expenditure because the import penetration ratio is much less than one. $I$ and $X$ are little changed despite reduced demand and reduced domestic interest rates. The $M-X$ curve, which is also quite steep in the short term, therefore shifts to the left by a lesser amount than the $I-S$ curve and $e$ immediately falls (jumps) to $B$ in the context of high capital mobility. Private business output and prices respond to the reduction in $G$ in the short term. Hence, private income and saving fall in the short term, partly offsetting the increase in public saving. Thus, $I$ and $S$, and therefore the CAD, do not fall by as much as the initial change in government expenditure. Overall, national expenditure ($C+I+G$) falls, but national income ($C+I+G+X-M$) falls less.

Long run: In the long term, net exports are much more responsive ($M-X$ is relatively flat) to the fall in the real exchange rate. Lower $M$ and higher $X$ reverse the initial fall in output and local interest rates return to their original level. National expenditure remains down because of the permanent reduction in $G$, but national income is restored by the increase in net exports. Thus, the CAD decrease is widened. The path of $e$ moves the rest of the way from $B$ to $E$. The crowding out of the output effects of a permanent change in fiscal policy takes about 2 years in TRYM - see Section 4.2.1.

The path of the real exchange rate (ABCDE) also reflects the expectational influences in TRYM. The uncovered interest parity (UIP) condition in TRYM (again reflecting high capital mobility) has any change in the real risk-adjusted interest return between here and overseas matched by an expected appreciation or depreciation of the exchange rate. The expected future equilibrium exchange rate is derived by first simulating the steady state version of the model. This gives $e^*$ at the intersection of $I-S'$ and the long run $M-X$ curve in Figure 12. With UIP, the short term reduction in domestic interest rates relative to world interest rates after the fiscal contraction must be matched by an expected exchange appreciation. Thus, the exchange rate falls below the new equilibrium for the period where activity and interest rates are lower than the initial position. There is a perfectly elastic supply of foreign currency at this exchange rate level.

The real exchange rate will normally fall with a fiscal tightening in TRYM (other things unchanged). The size of the initial fall is determined by: (a) the fall in the equilibrium real exchange rate; and (b) the size of the short term fall in interest rates. It may be the case, however, that the nominal exchange rate appreciates with a fiscal tightening. This would happen if the fiscal tightening were accompanied by an 'accommodating' monetary tightening leading to a lower equilibrium price level. See Section 5.4 on the nominal exchange reaction to a monetary tightening. While Figure 12 shows a fall in $e^*$ as a result of a permanent fiscal tightening, the result in TRYM is actually a small appreciation in $e^*$. This follows from the effect on the net income deficit of the lower level of public debt in the long run. The reduction in the net income deficit due to the lower long run level of public debt is slightly greater than the reduction in the saving investment balance. As a result, the trade balance has to deteriorate slightly in the long run and the equilibrium exchange rate rises slightly to achieve this. Figure 12 also shows that the extent of the movement in $e^*$ depends on the extent of Ricardian equivalence in the model which determines the extent to which the $I-S$ curve shifts in the long run (there would be no shift in the $I-S$ curve if Ricardian equivalence held in the long run).
In the case of a monetary contraction in TRYM, the real exchange rate rises. In the short to medium term, the contractionary effects from the rising exchange rate (reducing net exports) add impetus to the demand contraction. The short term effects on the CAD are very small and could go either way depending on the net export response to the exchange rate rise.

5.3 REAL BUSINESS CYCLES

The real business cycle (RBC) school of economic modelling developed in response to the Lucas critique of traditional economic models (see Section 6.1.2). The main aim of the school was to build macroeconomic models incorporating deep parameters which were properly identified and based on maximising behaviour in competitive markets. The early versions of these models were calibrated (coefficients were imposed on the basis of theoretical analysis and then adjusted to obtain desirable simulation properties). More recent models have made greater use of estimation.

The early versions of the RBC models - see, for example, Kydland and Prescott (1982) - contained little role for demand side factors and attempted to explain the salient features of the business cycle by recourse to technology shocks or other supply side fluctuations. If business cycle fluctuations could be explained by productivity or other supply side shocks in the context of a competitive equilibrium, the cycle itself might be Pareto optimal. If this were the case, there would be little reason for government intervention in the form of counter-cyclical demand management and stabilisation policy.

TRYM, while being a traditional macroeconomic model, does have some similarities with RBC models in that maximising behaviour is assumed in the long run and supply side shocks will produce cycles in activity. Moreover, TRYM can be used to demonstrate circumstances in which there may be less need for government intervention in the case of a supply side shock where activity and prices are moving in opposite directions (see Section 4.2) than in the case of a demand side shock where prices and activity are moving in the same direction.

TRYM provides little support, however, for one of the central ideas of the RBC models, that technology shocks play a dominant role in generating cycles in activity and cyclical movements in labour productivity. Rather, TRYM assumes that technology change follows a smooth process that proceeds at a constant rate (see TRYM Documentation, Section 1.2.4) and that cyclical movements in labour productivity are explained by lagged adjustment and labour hoarding effects in the face of demand side and other shocks. The observed cyclical movements in labour productivity have been quite large. Comparing actual movements in labour productivity with those predicted by TRYM (based on labour hoarding and lagged adjustment) may provide some indication of whether changes in underlying productivity have been a significant cause of business cycle fluctuations. If labour hoarding and lagged adjustment provide an adequate explanation of the movements in labour productivity it seems less likely that the movements could be attributable to technology shocks. Figure 13 shows actual movements in labour productivity against predicted values from TRYM for the period since March 1971.

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29 TRYM is estimated rather than calibrated, allows for sluggish adjustment of prices and quantities and gives demand side factors a significant role in the short run.
Figure 13 suggests that lags and labour hoarding effects, as specified in TRYM, explained most of the fluctuations in labour productivity over this time. There appears to be no large or systematic pattern to the residuals.\textsuperscript{30} Hence, the model appears to provide little support for exogenous productivity shocks being an important source of cyclical fluctuation over the period studied. The results point to short run changes in productivity being caused by cyclical effects, rather than shocks to underlying productivity causing the cycles in activity.

Another possible form of evidence on the relative importance of productivity shocks in explaining the Australian business cycle might be gained by comparing the co-movements in productivity and employment generated by a productivity shock in TRYM with those observed in history. The initial reaction of TRYM to a productivity increase is for employment to fall (unless the change is fully anticipated) - see results in Appendix B of the \textit{TRYM User’s Guide (with TSP)}. While employment does eventually increase in response to a productivity increase (and output does rise before employment as in the real business cycle models), it is with a lag of up to two years in TRYM simulations.\textsuperscript{31} Such a long lag between productivity changes and employment changes is different from the relationship between employment and productivity observed in history. The long lags in TRYM may arise partly because the model’s labour supply equation gives little support to the sort of real wage effects on labour supply that would be required in the short term in the real business cycle models - as in Kydland and Prescott (1982). The fact that TRYM simulations of productivity shocks do not appear to be consistent with the relationship between productivity and employment growth in history therefore argues against real business cycles being an important explanation of the Australian business cycle.\textsuperscript{32}

\textsuperscript{30} Kydland and Prescott (1982) were, nevertheless, able to generate systematic fluctuations with serially independent productivity shocks.

\textsuperscript{31} This is despite the fact that TRYM (particularly its steady state representation) has many of the features of the calibrated real business cycle models - for example, volatility of investment - see King, Plosser and Rebelo (1988).

\textsuperscript{32} Model results aside, it is difficult to imagine that changes in productivity have been of sufficient magnitude to explain the size of the cycles in the Australian economy over the period. There is, nevertheless, a potential simultaneity problem in estimating the TRYM employment equation. It may be that, in practice, exogenous fluctuations in productivity are leading to fluctuations in output and causing the positive correlation between output, productivity and employment (with employment possibly responding positively to lower unit labour costs). Large employment fluctuations would, however, require a rapid response to productivity changes.
That is not to say that they play no role. The productivity growth shown in Figure 13 for the early 1970s followed a period of much higher productivity growth. The significant slow-down in productivity growth in the early 1970s may have played a role in producing the dislocations of that period. Moreover, the assumption of constant underlying productivity growth from 1971 onwards is unlikely to be true. There is no reason to believe that technical change is an absolutely smooth process. The key issue is how large a distortion the assumption imposes. Figure 13 suggests that it may be small for the period in question.

Cyclical fluctuations are likely to be caused by a large number of factors. TRYM helps appreciate the fact that there are a wide variety of exogenous, behavioural and policy influences that impinge on economic activity at any one time. This is in contrast to the simple uni-causal theories of the business cycle often found in the theoretical literature.\(^\text{33}\)

While the model provides little support for the real business cycle proposition, the effects of productivity shocks can be examined using the model. TRYM has been used, for example, to examine the effects of possible productivity improvements stemming from microeconomic reform - see Taplin and Louis (1993) and Johnson and Louis (1994). The results have some similarities with those of calibrated real business cycle models such as those of Kydland and Prescott (1982) and King, Plosser and Rebelo (1988).

### 5.4 EXCHANGE RATE OVERSHOOTING

The proposition concerning ‘overshooting’ of the exchange rate was originally put forward by Dornbusch (1976). The proposition relates to the nominal exchange rate and states that it will overshoot its equilibrium level following a monetary shock. The overshooting occurs because financial market variables such as the exchange rate jump (the market clears instantaneously) whereas prices in the goods market are slower to adjust.

Dornbusch’s 1976 model can be represented as four simple equations and is similar to the simple models set out by Krugman (1993). These four equations are: a reduced form IS curve; a reduced form LM curve; a Phillip’s curve or ‘surprise’ supply equation; and an uncovered interest parity condition. The solution of the system yields dynamic paths for the exchange rate which are illustrated in Figure 14. The model normally implies overshooting but undershooting is also possible in certain circumstances (for example see Dornbusch’s appendix to his 1976 article).

The intuition behind Dornbusch overshooting follows from the result inherent in Dornbusch’s original model that the equilibrium price level will ultimately fall in direct proportion to the size of the monetary contraction, leaving the real money supply unchanged. This result means that ‘monetary neutrality’ holds whereby a change in the money supply has no long run effect on activity because the real exchange rate, the real money supply and interest rates are unchanged in the long run. If agents in the financial market are forward looking they immediately build the expected fall in the future price level in the current exchange rate. This leads to an appreciation in the nominal exchange rate so that the current exchange rate maintains a fixed relationship with the expected future equilibrium exchange rate (with the difference between the current and expected future rate being given by the uncovered interest parity condition). That is, a 1 per cent decrease in the nominal money supply causes a 1 per cent decrease in the expected future price level and, hence, an immediate 1 per cent appreciation (jump) in the nominal exchange rate.

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\(^{33}\) See Fair (1988) for a number of examples.
In practice, to what extent the exchange rate overshoots this 1 per cent appreciation depends, in part, on the degree to which the monetary contraction leads to a rise in domestic interest rates relative to those overseas. It is possible to theorise about extreme situations in a small open economy in which domestic interest rates would fall rather than rise (for example, if import and export volumes respond very quickly to the exchange rate appreciation leading to a rapid decline in real output and, hence, money demand). This situation would be accompanied by undershooting of the exchange rate as illustrated in Figure 14.

The interest rate reaction and the degree of overshooting also depend on price flexibility in the goods market. If the price level (in the goods market) fell instantaneously to its new long run equilibrium level, the nominal exchange rate would simply jump by the same proportion. The real money supply would be unaffected by the shock and the domestic interest rate $R$ would not rise above the world interest rate $R^*$. The nominal exchange rate would not overshoot its equilibrium position and there would be no short run effects on real activity. Overshooting occurs in the Dornbusch model, however, if price rigidities and adjustment lags in the goods market result in ‘the’ domestic nominal interest rate increasing initially above ‘the’ world nominal interest rate following a monetary contraction. The resulting temporary increase in the nominal exchange rate above the equilibrium level is proportional to the difference between the domestic and world interest rates ($R-R^*$ in Figure 14).

TRYM has all of the central elements of the simple Dornbusch model but one crucial difference: the uncovered interest parity condition in TRYM uses the real long term bond yield, as opposed to short term interest rates. The exchange rate movement in TRYM therefore depends directly on the relationship in TRYM between the short term interest rate change caused by the monetary policy change and the consequent change in long bond yields. The nominal long rate can be thought of as comprising a real component and an inflationary expectations component. The real long rate will rise with a monetary tightening as real short rates rise. However, inflationary expectations might fall. As a result, in TRYM, the effects of a monetary policy change on the real long bond rate and on inflationary expectations are roughly offsetting. Even though the shock will change the short term interest rate, the long bond yield will usually be little affected.
Because TRYM's uncovered interest parity condition uses the long bond rate, there will usually be no overshooting in the exchange rate driven by an increase in the Australian bond yield relative to the world yield. The change in the nominal exchange rate is roughly proportional to the change in the money supply for any given shock. For example, a 10 per cent reduction in the money supply in TRYM leads to an initial increase in the 90 day bill rate (RI90) of around 4 percentage points and an appreciation in the exchange rate of around 10 per cent (see Figure 15). The exchange rate then moves in the short run from this equilibrium level depending on movements in the economy - particularly, changes in expenditure relative to output. The exchange rate balances demand and supply for Australian dollars and, hence, will move in the short term in response, for example, to short term changes in import demand.

![Figure 15: Exchange Rate Reaction to a Permanent Monetary Shock in TRYM](image)

The discussion above relates to changes in nominal interest rates and the nominal exchange rate consequent on a monetary policy change in TRYM. However, monetary policy in TRYM influences the real economy via its effect on real interest rates and the real exchange rate rather than nominal rates. The interesting thing about the jump in the nominal exchange rate, as described above, is that it leads to an initial appreciation in the real exchange rate as the domestic price level is sticky in the short term. The appreciation reflects an expected future change in the price level rather than a current change. In real terms, the exchange rate rises immediately. Thus, in TRYM the real exchange rate will appreciate by around two and a half per cent for a monetary shock that produces a 1 percentage point change in the real 90 day bill rate, and the real bond rate will increase immediately by roughly a quarter of a percentage point.

In summary, consistent with the Dornbusch model, real interest rates and exchange rates are unaffected in TRYM by monetary policy in the long run. Price rigidities result in short term effects on activity in TRYM following a monetary contraction - even though there is no general Dornbusch-type overshooting of the nominal exchange rate accompanied by increases in the Australian bond yield relative to the world yield. The profile of the effects on real GDP of changes in monetary policy is discussed in Section 5.5.
TRYM estimates the lag between a temporary change in interest rates and the peak effect on inflation to be around 2 years (although there is a substantial effect after one year). This can be seen in Figure 16 which shows the effect of a temporary increase in interest rates on GDP and inflation. The main initial impact on inflation in TRYM comes via the effect of interest rate changes on the exchange rate and, hence, import prices (the exchange rate rises and import prices fall). These import price effects are unwound as real interest rates fall back to equilibrium levels. After the first year, the main dampening effect on inflation comes from the lagged effects of interest rates on activity and capacity utilisation and on unemployment and wage demands. As can be seen, the peak effect on activity comes after 6 quarters. The peak effect on inflation necessarily lags the activity effects.

The TRYM results are based on historical relationships and raise the question whether the lags may have increased or decreased in recent years. A number of influences are relevant to this question, including the more transparent operation of monetary policy (including explicit announcement of interest rate changes), the increasing penetration of imports into the domestic economy and the time taken to complete wage negotiations.

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**Figure 16: Response in the level of Real GDP and Consumer Price Inflation**

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35 TRYM may overestimate the initial effects of a monetary tightening by feeding the import price effects too quickly into wages. The overall magnitude of monetary policy effects may also have changed in recent years for a number of reasons: for example, the higher indebtedness of the household sector, on the one hand; and lower indebtedness of the corporate sector and increased prevalence of fixed (and capped) loans, on the other. Moreover, TRYM uses the National Accounts measure of consumer price inflation (PCON) to measure inflation in the wage equation. This measure is much more akin to the underlying rate than the headline CPI (it does not include mortgage interest charges). In so far as the inflation expectations of wage earners are affected by the headline CPI, the effect of a given change in monetary policy on nominal wage demands may not be fully captured by the model. All of these are examples of possible structural changes not captured at the aggregate level and highlight the need for caution in interpreting model results.

36 The rise in interest rates is progressively unwound as money demand declines in line with the lagged response of the real economy and prices to higher interest rates.
5.6 MARSHALL LERNER CONDITION (J CURVE)

The Marshall Lerner condition states that the sum of the price elasticities of demand for exports and imports has to be greater than one for an exchange rate depreciation to improve the balance of trade. In a small open economy like Australia, the price elasticity of demand for exports is relatively high even in the short term.37 As a result, the Marshall Lerner condition is satisfied even in the short term (first quarter).

A related concept is the J curve effect stemming from a larger proportion of import contracts being written in foreign prices than export contracts. The pass through of an exchange rate change to $A import prices is, therefore, faster than in the case of export prices. This reflects the relative importance of manufactured goods and services in Australia’s export trade - somewhat more than 40 per cent of total export trade in 1994-95 - and the fact that the export contracts in those items are invariably written in $A terms. Prices of these items are more related to domestic cost developments rather than, in the case of most commodities, being determined by world market conditions. As a result, $A export prices of manufactures and services may be less responsive - at least in the short term - to exchange rate movements than either commodity exports or imports. Hence, following a depreciation in the exchange rate, there is a temporary endogenous fall in the terms of trade, tending to worsen the trade balance.

TRYM has the terms of trade falling initially by around 2 per cent for every 10 per cent fall in the exchange rate. This means that even though the Marshall Lerner condition holds the trade balance worsens in the first quarter following a depreciation. However, as time goes on the endogenous terms of trade effect unwinds and the import and export volume responses become larger. After two quarters the trade balance begins to improve (other things being equal). In practice, the exact size of the J curve effect will also depend on whether the US dollar is moving against other currencies. This is because it is the TWI which is the most relevant exchange rate for the determination of Australia’s import price index, whereas it is the US dollar which is more important for export price determination. Therefore, if the $A is depreciating against the $US, which is itself depreciating against other major currencies, then the depreciation of the $A in TWI terms will be more pronounced than that against the $US. In these circumstances, the initial terms of trade decline would be more significant than if the $A depreciation were similar in TWI terms and against the $US.

5.7 LIQUIDITY TRAP

The liquidity trap proposition holds that money demand will become highly elastic at low rates of interest. As a result, a given injection of liquidity (monetary expansion) into the financial market will primarily increase the amount of money held by people, rather than reduce interest rates, and therefore will have limited effect on the economy.

By speculating on a limited response by interest rates to a change in the money supply in circumstances of low interest rates, the liquidity trap proposition implies non-linearities in the money demand curve (and, in turn, in the LM curve of Section 4.1). The proposition is not concerned with the response of investment, consumption or output to interest rate changes (the slope of the IS curve of Section 4.1). It implies differences in the relative effectiveness of monetary and fiscal policies in influencing the level of economic activity at very low levels of interest rates.

37 In fact, for commodity exports demand is assumed to be perfectly elastic. Lags in pass through and the supply response determine the response of exports to an exchange rate change.
Macroeconomics and the Model

(fiscal policy changes being less subject to ‘crowding out’ if the interest rate response to those changes is limited).

The relative effectiveness of monetary and fiscal policies does not change significantly in TRYM under different economic circumstances over the business cycle. TRYM's money demand function is assumed to be linear and there is no difference in the interest elasticity of money demand at low levels of interest rates. The equation diagnostics of the money demand function do not indicate a problem with the functional form. This argues against the liquidity trap proposition being important over the range of outcomes in past business cycles even under different monetary circumstances. Nevertheless, the estimation period of the equation is 1975(3) to 1995(3), a period of generally high nominal interest rates. It may be that, because the level of interest rates was high over the estimation period, any non-linearity will only be apparent when a significant period of very low interest rates is included in the estimation period.

5.8 OUTPUT GAP

‘The’ output gap is usually defined as the difference between the potential output of an economy and current actual output. It is sometimes used as a measure of the spare capacity in the economy. In the long run, however, it goes beyond being the ‘mirror image’ of aggregate capital utilisation: it reflects the potential output achievable with the capital base expanded sufficiently to absorb available labour resources.

The model provides a number of measures of potential output of the private business sector. A difficulty in deriving measures of potential output or capacity utilisation is that they require a knowledge of the production technology used. However, production function parameters cannot be estimated directly unless utilisation rates are known. This dilemma is handled in TRYM by jointly estimating the employment, investment and price equations and deriving the production function parameters indirectly. This is done by assuming that the first order conditions associated with the production function hold in the long run (real wages, adjusted for productivity, equal the marginal product of labour and the expected rate of return of investment equals the user cost of capital). This assumption enables the linking of the long run relationships of the employment, investment and price equations. Evidence from the price equation on whether demand is greater than desired supply is, thus, used to improve the estimates derived from the investment and employment equations. Section 3.1.1 above and Section 1.2 of the TRYM Documentation provide more discussion of these issues.

Given the estimated production function parameters and related variables, three summary measures of potential output can be derived (spanning the very short term to the long term). These are: GSTAR (short term potential output given current levels of the capital stock and the number of employed people); GSTWK (hypothetical output given employment consistent with current real wages and the current capital stock); and equilibrium output derived from the steady state version of the model. Each has its own uses and applications. However, neither of the first two measures should be regarded as a measure of equilibrium output or considered as a suitable basis on which to measure ‘the’ output gap. Ultimately, where long term potential output (or long run equilibrium) lies for the economy as a whole depends on where the overall equilibrium in Figures 1 and 2 (Section 2.1) lies in the goods market, the labour market and the financial market. Equilibrium in the labour market and the financial markets influences equilibrium in the goods market (equilibrium supply for the economy as a whole). Equilibrium in the goods market is determined on the supply side in TRYM. It depends on the model's estimated production technology (in turn reflecting existing market structures, work practices and trends in productivity). It is also influenced by commodity prices, the NAIRU and world real interests rates (the last two reflecting the labour and financial market equilibriums). The third of the above measures reflects the estimation of this

5.12
equilibrium position in TRYM. Even this third measure should, nevertheless, be interpreted with caution given the uncertainty that surrounds the long run equilibrium in the model (see Section 5.2).

Despite the shortcomings of each as a measure of ‘the’ output gap, the following description of past movements in the three TRYM measures may give some insight into the workings of TRYM.

Figures 17, 18 and 19 show how the three measures have moved over time. As mentioned, GSTAR is designed to measure short term potential output given the utilisation in production of current business capital and employment. Short term capacity utilisation (GBA/GSTAR, where GBA is current private sector output) is a significant short term influence on business investment. A change in GBA/GSTAR has roughly 10 times the effect on business investment in the short term than an equivalent change in the Q-ratio. Figure 17 shows that movements in GBA/GSTAR are similar to those of the business output to capital ratio. Short term capacity utilisation rose rapidly following the 1982-83 recession. The fall in investment during the recession and the lagged slow-down in the growth of capital stock acted to hold down the short term measure of potential output relative to actual output. Output then rose rapidly with the cyclical increase in labour productivity. In contrast, the TRYM measure of short term capacity utilisation actually fell during the late 1980s ‘boom’ (a period when private output was growing at over 7 per cent per year). This was a result of short term potential output increasing very rapidly because of rapid growth of the private capital stock through rapidly rising investment and very rapid growth of private employment (hours worked basis).

Figure 17: Private Business Output to Capital Ratio (GBA/KB) and GBA/GSTAR

![Figure 17: Private Business Output to Capital Ratio (GBA/KB) and GBA/GSTAR](image)

Note: The GBA/KB measure shown is detrended to take account of substitution of labour for capital in the private business sector during the 1970s and 1980s. The trend may also be picking up compositional factors.

In contrast to short term potential output, GSTAR, GSTWK measures hypothetical output given current real wages and the current capital stock. It is estimated by assuming that the level of employment adjusts to the point where marginal productivity equals the current real wage (the capital stock being unchanged). This is not used directly anywhere in the model but is closely related to PSTAR\(^{38}\) (desired prices given wages, the capital stock and capacity utilisation) which is used in the price equation. While GBA/GSTWK provides some indication of how far the business

\(^{38}\) PSTAR is the desired supply price given current wages and the capital stock (see Section 3.1.1). GSTWK is hypothetical output given current wages and the capital stock. PNC/PSTAR is a constant times GBA/GSTWK, where PNC is actual output price. If PNC adjusted to the desired supply level (PSTAR) then real wages would be at their equilibrium and GSTWK would equal GBA.
sector might be away from equilibrium, GSTWK does not reflect long run equilibrium output. It is based on a hypothetical adjustment in employment (to the point where the marginal product equals the real wage) and assumes the price level and the capital stock remain unchanged. In practice, employment will not adjust fully and prices and the capital stock will change. The GSTWK measure of output is, therefore, not necessarily consistent with equilibrium in the various macroeconomic markets, including the labour market. Take, for example, the situation where GSTWK falls because of a rise in real wages. As GBA begins to fall towards GSTWK, unemployment begins to rise. Rising unemployment leads to downward pressure on real wages. Real wages fall and GSTWK falls. GBA can never reach the original GSTWK because that level of output would be inconsistent with equilibrium in the labour market.

Figure 18 compares movements in GBA/GSTWK with movements in real wages and movements in the short term capacity utilisation measure. Given that it is closely related to PNC/PSTAR, GBA/GSTWK can perhaps best be thought of as composite indicator of wage and capacity utilisation pressures on prices. If GBA/GSTWK is above 1, wage and demand pressures are adding to inflation in the model. If it is below 1, they are subtracting from inflation.

**Figure 18: Real Wages Faced by Private Business and GBA / GSTWK**

Note: The real wage measure used is deflated by business output prices, and adjusted for trend labour productivity (hours worked basis) and payroll taxes.

As mentioned, long run potential output in TRYM is ultimately determined when demand and supply in the three aggregate markets (goods, financial and labour) are in equilibrium. This is the steady state equilibrium discussed in Section 2.3.4 where model projections grow in line with underlying supply. This equilibrium is influenced by technology, commodity prices, world real interest rates, the NAIRU (via their effects on the goods, financial, and labour markets) and by a range of other exogenous factors.

Conceptually, long run potential output in the past can be estimated from TRYM by running the steady state over history. However, this involves the difficulty of distinguishing between temporary and permanent changes in world interest rates, commodity prices and other exogenous variables in history. Equilibrium output in the steady state should only change if the associated changes in
exogenous variables are expected to be permanent. For example, equilibrium consumption should only respond to perceived changes in permanent income. A practical approach is to use trend levels for these variables in history and adjust labour supply for trend changes in hours worked and the participation rate. This approach is used to calculate the ratio of output to potential output in Figure 19.39

There are a great number of uncertainties surrounding the level of equilibrium output in TRYM and some of these are outlined in Section 6.2. These difficulties are compounded when looking into the future. Equilibrium output will change, for example, with changes in the NAIRU, changes in market structures and work practices and changes in the real cost of funds from overseas. The factors that influence these variables and how they change are not easily captured in any model.40

Thus, practical difficulties make the estimation of ‘the’ past (or present) output gap problematic. This is compounded by measurement difficulties. In TRYM, for example, equilibrium output is measured for the business sector rather than the economy as a whole. At best, the measure may give some broad indication of how far the economy fell away from equilibrium levels in past periods, such as in the early 1980s and early 1990s as a result of cyclical fluctuations and wage dislocations.

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39 The measure is therefore similar to output relative to an estimated trend, although the trend here is derived from first principles rather than fitted using a Hodrick Prescott filter or ordinary least squares.

40 EPAC (1994) and Industry Commission (1995), for example, outline a range of reforms over recent years which might lift potential output for the economy as a whole.
6. Limitations of TRYM

A small aggregate model such as TRYM will necessarily have a number of limitations, often imposed by data constraints or the desire for transparency. This section explores some of the more important limitations of the TRYM model. Section 6.1 covers the demand side. It discusses the Lucas critique and expectations determination and uncertainty about the workings of the bond and foreign exchange markets. Section 6.2 looks at the supply side of the model, noting that there is considerable uncertainty surrounding the estimate of the NAIRU, the differential between Australian and world long bond rates and the treatment of productivity growth.

When using the model or interpreting model results, the limitations of the model need to be kept in mind. The main limitations follow from the simplifying assumptions required for working at the aggregate level and other assumptions imposed by data constraints or the desire for transparency. There are important qualifications to be made to both the short run (Keynesian) demand side and long run (neo-classical) supply side responses.

The responses in TRYM on the demand side are subject to the Lucas and time inconsistency critiques. The responses of consumers and investors may (and indeed should) be changing over time in ways not identified by the model. More importantly, the lack of knowledge about how bond and exchange rate markets will react to a given policy change in the short term adds a major component of uncertainty to policy analysis.

On the supply side, there is uncertainty around each of the three equilibrating markets identified in Figures 1 and 2 (Section 2.1). In the labour market there is a wide confidence interval surrounding the estimate of the NAIRU. In the financial market there is a differential imposed between the domestic real bond rate and the world real long bond rate. This differential is assumed to continue into the future. However, if the differential narrows in the future, the equilibrium capital stock will be higher, as will the equilibrium level of output.

Similarly, equilibrium in the goods market is determined by current technology. The model's estimate of the steady state goods market equilibrium (or potential output) is based on historical estimation. That is, it reflects past and existing technology, market structures and work practices. No attempt is made to explain what causes the underlying growth in productivity. Moreover, a number of simplifying assumptions are made in estimating the production technology used by the private business sector. For example, imports are treated as a final good rather than input into production. Similarly, government output does not enter as an input into private production.

Such limitations suggest that results from the model need to be analysed carefully and perhaps supplemented by judgements made on the basis of more detailed work at the microeconomic level. Ideally, the user should be aware of the assumptions underlying the model.

Some of the important qualifications to TRYM on the demand side and on the supply side are discussed in the following sub-sections.
6.1 DEMAND SIDE

The demand side reactions are highly dependent on a number of simplifying assumptions required for aggregation. Nevertheless, many of the demand side reactions, such as consumer or investor responses to changes in income or relative prices, appear to be reasonably stable over time and much better determined than some of the supply side reactions discussed later. However, two important areas on the demand side stand out as being particularly uncertain. These are exchange rate determination and expectations formation.

6.1.1 Exchange Rate

One of the most difficult areas to model is the exchange rate. As Paul Krugman (1993) noted in a recent survey article:

‘The theory of exchange rate determination has never recovered from the empirical debacle of the early 1980s. ... Quantitative policy analysts must have something to determine exchange rates in their empirical models, so they either have an exchange rate equation that more or less fits the data, or simply impose some mechanism, but they make little pretence that they have solved the riddle of exchange rates’.

The exchange rate equation in TRYM is based on an imposed uncovered interest parity condition using ten year bonds (see Section 3.2.3). The difference between the expected exchange rate in ten years time and the current exchange rate is a function of the difference in the current interest rates, adjusted for risk, of domestic and world ten year bonds.

While this condition is imposed, both the bond yield equation and the exchange rate equation have been calibrated so that they are broadly consistent with observed relationships in history. The equilibrium exchange rate in TRYM moves with changes in the terms of trade and changes in the equilibrium saving and investment position. Real ten year bond rates are calibrated to increase by about 15 basis points initially - and by about 20 basis points in the long run - for every percentage point increase in the real 90 day bill rate. As a result, both the nominal and real exchange rates increase more than proportionally in response to a given increase in the 90 day bill rate due to monetary tightening (see also Section 5.4 on exchange rate overshooting).

While there is little doubt that the exchange rate responds to fundamental influences such as commodity prices and the domestic interest rate structure, there is great uncertainty over short term movements. This uncertainty is sometimes attributed to the existence of ‘noise traders’ and chartists in the financial markets and, hence, to the lack of ‘speculative efficiency’ in the short term. If speculative efficiency held, the short term change in the exchange rate would, on average, be equal to the market's expectation derived from short term interest differentials. However, there appears to be mounting evidence against speculative efficiency in the short term. As Krugman notes:

‘Most people would view the assumption of speculative efficiency [as] something that must be maintained in the face of seemingly unfavourable evidence. In my view, the situation is even worse: there is no plausible way to reconcile the assumption of speculative efficiency with the data’.

It is not possible here to review the burgeoning literature on speculative efficiency and exchange rate determination. It is sufficient to note that the reasons for short term movements in the exchange
rate are not well understood. Yet these movements play an important role in determining the short term effects of both monetary and fiscal policy. Uncertainty about short term movements in the exchange rate, thus, adds considerable uncertainty to results of policy analyses using the model. This uncertainty includes the reaction of the exchange rate to the policy changes themselves. As a result, model-based analysis of a policy change normally needs to be supplemented with analysis of, or some judgement concerning, how financial markets may react in the short term to the change.

6.1.2 Lucas Critique / Expectations Formation / Time Consistency

The other major uncertainty on the demand side relates to the microeconomic causes of the behaviour observed at the aggregate level. In his critique of economic policy evaluation, Lucas (1973) pointed out that most econometric relationships did not truly establish the microeconomic causes of the observed behaviour. One of his examples of this was the estimated short run Phillip's curve trade-off between unemployment and inflation. If the apparently stable relationship in history was due to inflation surprises experienced by employees, any attempt by governments to continue to exploit the trade-off would merely lead to accelerating inflation. This, in turn, would lead to 'parameter drift' in the estimated unemployment/inflation trade-off as behaviour changed and inflation expectations were revised up. If the underlying causes of the relationship were not recognised by governments, the ultimate result could be repeated attempts by them to exploit the revised trade-off leading to ever higher inflation without any improvement in the rate of unemployment. Lucas suggested that the only way to avoid this problem of misinterpretation was to identify ‘deep parameters’; that is, the parameters that determine how people form their expectations.

Parameter drift in the wage equation is less likely in TRYM given that the wage equation specifically includes a term for inflationary expectations (albeit adaptive expectations). However, the more substantive point remains that modelling at the aggregate level usually involves parameters that do not truely identify the underlying structure of behaviour (that is, ‘mongrel’ parameters which reflect a mixture of behavioural reactions) rather than ‘deep’ parameters. For example, Goodhart (1989) notes that the reaction to any policy instrument chosen by the authorities tends to change over time. In Australia the use of changes in SRDs and LGS ratios and moral suasion as monetary instruments in the 1970s led to the growth of borrowing from the less regulated non-bank financial sector. Large fluctuations in short term interest rates in the 1980s may similarly have changed borrowing and lending behaviour in the 1990s; such as, in relation to the intensity of use of fixed interest mortgages as a vehicle for borrowing. Exploitation by governments of a reduced form relationship where the structure of behaviour is not identified may lead to changes in that relationship.

A related idea is that first discussed by Kydland and Prescott (1977) concerning the time inconsistency of optimal plans. This has been characterised as a dynamic form of the Lucas critique. Put simply, if agents can understand the government's incentive structure, they will react in anticipation of planned policy changes. Behaviour will not only change in reaction to, but also in anticipation of, changes in government policy. Borrowers and lenders, for example, could be expected to change decisions both in response to, and in anticipation of, changes in the central bank’s/government’s approach to the setting of monetary policy. ‘Optimal’ plans based on past (estimated) relationships would therefore have sub-optimal outcomes (as in Lucas) even in the short term. It is difficult to believe that agents have the extreme form of rationality and foresight that Kydland and Prescott ascribe to them (eg see Currie (1985). There are, nevertheless, financial incentives for people to seek to understand the workings of government and government agencies
and to seek to ‘second guess’ future changes in the approach to policy. Hence, responses to policy changes are likely to change over time.

Related issues arise with the lag structures of economic variables observed in history. For example, there appear to be well established cycles in the building construction industry due to time-to-build factors. If agents were rational they should learn from past cycles and, hence, change their behaviour in the current cycle.

Apart from changing expectational effects there are a number of other reasons for expecting behaviour in a time-dependent system to change over time. The structure of different markets, for example, should be expected to evolve over time rather than stay the same, leading to changing responses as the composition of agents in the markets change. The recent growth of small business relative to large business might, thus, affect employment and investment responses. Similar considerations apply in relation to lag structures in variables such as employment and stockbuilding. The pattern of a lag structure applicable to particular variables in some models may change over time (for example, if lags are due to discrete adjustment costs, the lag structure may depend on the rate of growth or the position in the cycle) which may affect the composition of firms at different stages of adjustment. Again there may be sufficient adjustment in behaviour to influence estimated relationships. An example of such a changing lag structure is the ‘S,s model’ for inventory investment discussed by Blinder (1981).41 A time-to-build model may have a more stable lag structure.

These are some of the reasons why the short run demand side responses in TRYM need to be treated with caution and the possibility of changes in the underlying relationships needs to be appreciated. Usually this can only be done by detailed examination of the sector or market involved.

### 6.2 SUPPLY SIDE

As mentioned, the main uncertainties on the supply side relate to: the level of the NAIRU in the labour market; the level of the equilibrium real interest rate in the financial market; and, the level and rate of productivity growth in the goods market. These variables are treated as exogenous in TRYM, but all may be partly endogenous to the system. The level of the NAIRU has significant implications for any short to medium term analysis. The level of productivity growth and the equilibrium real interest rate are important determinants of the medium to long term equilibrium growth path.

#### 6.2.1 Labour Market - NAIRU

Figure 20 shows estimates of the NAIRU obtained from a rolling regression of the TRYM wage equation42 (specified in Section 5.2.4 of the TRYM Documentation) from 1974 to 1994. A 13 year estimation period is rolled through the data from 1974(2) to 1987(2) through to 1981(2) to 1994(2) and the NAIRU estimated for each period. The ninety five and ninety nine per cent confidence intervals are then added to the resulting NAIRU estimates.

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41 Similar models can be used to explain lags in price adjustment (eg via menu costs discussed in Akerlof and Yellen (1985)), employment and other aggregates.

42 A version of the TRYM wage equation excluding the centralisation dummy was used (see TRYM Documentation).
Limitations of TRYM

As can be seen the NAIRU estimates derived from the wage equation tend to be unstable and have a very wide confidence interval, particularly towards the end of the period. Not shown is the period in the early seventies when the NAIRU estimate increased from somewhere around 2 per cent to around 6 per cent.

There are number of competing theories about why the NAIRU has increased over time. The theories can be divided into two broad types:

- Wage setting explanations; such as, the efficiency wage theory (and variants thereof), the ‘insider’ or membership theory - where ‘insiders’ are those employed with significant wage bargaining power - and wage bargaining models tied to increases in union power or the reservation wage. These theories suggest reasons why the labour market equilibrium may not be the market clearing equilibrium (the point where unfilled vacancies equal unemployment).

- Search effectiveness theories. There are a number of factors that might lead to reductions in the effectiveness of the unemployed in filling available jobs and, hence, explain the rise in structural unemployment. Increases in long term unemployment may lead to deterioration of skill levels or morale problems which reduce search intensity. Structural change (particularly in the face of relative wage rigidities) can increase the mismatch between the skills of the unemployed and available jobs. Increases in welfare benefits can reduce the incentive to seek employment. In all cases, unfilled vacancies should rise for a given unemployment rate. The unemployed would be less search effective and the unemployment rate would be higher at the point where the market clears.

Figure 20: Rolling NAIRU Estimates

Limitations of TRYM

Given the need for parsimony in modelling the labour market in TRYM, it is not possible to introduce the detailed disaggregated data required to distinguish between the different theories (although the inclusion of a change in unemployment term in the TRYM wage equation that is significant is suggestive of insider-outsider effects being present in the data to some extent). However, it does appear to be possible to distinguish between search effectiveness and wage setting explanations of the increase in unemployment at a very broad level by the use of unfilled vacancy data. Hence, the model includes an estimated Beveridge curve (showing the relationship between unemployment and unfilled vacancies) and attributes part of the increase in the NAIRU in the mid-1970s to a reduction in search effectiveness as evidenced by an outward shift in this relationship (see Section 5.2.4 of the TRYM Documentation).

The model's wage equation can be viewed as a relatively simple expectations augmented Phillip's curve. In common with other Australian wage equations, it finds it difficult to capture the various institutional influences on wage-setting behaviour and therefore only explains a moderate amount of the quarterly variation of wages. Analysis of the equation's results therefore normally needs to be supplemented by more detailed microeconomic analysis to form some judgement about whether the assumed path of the NAIRU is realistic. This is particularly the case in the face of recent changes to product markets and changes to the industrial relations system.

6.2.2 Goods Market - Productivity Levels and Growth

Long run equilibrium in the goods market is determined mainly from the long run parameters on the supply side in the model (see Section 1.2.4 of the TRYM Documentation). These parameters have been estimated for the period from 1971 to 1995 - a period of significant change in product markets due to microeconomic reform and the opening up of the economy. The equilibrium estimated by the model may therefore not reflect current circumstances. A number of recent studies - such as EPAC (1994) and Industry Commission (1995) - have pointed to a range of reforms since the early 1980s that could lead to higher output and productivity growth. The model attempts no detailed attribution of the sources of growth over history but simply assumes that output growth is due to a combination of increases in labour and capital and a trend rate of increase in labour productivity due to technical progress. The model employs a CES production function and assumes constant returns to scale and Harrod neutral technical progress (Section 1.2 of the TRYM Documentation).

Figure 21 compares the trend rate of growth of output per unit of labour input from TRYM due to technical change with measured labour productivity for the private business sector from the TRYM model data base. The figure shows that the contribution from trend labour productivity growth in TRYM accounts for around half the increase in labour productivity since 1971. The other half is attributable to increases in the capital/labour ratio over time. The fact that half of the growth in labour productivity (and hence improvements in real incomes) is attributable to an unexplained trend indicates that there are limitations on the ability of simple neoclassical growth models to explain economic growth over time. This leads to such questions as: how and why are these productivity changes occurring? The dissatisfaction with the large contribution from trend productivity growth in neoclassical growth models led to attempts at ‘growth accounting’ (the attribution of growth to different sources) in the 1970s by Dennison (1985) and others and, more recently, to endogenous growth theories.
A review of the endogenous growth literature is not possible here. However, it seems likely that any feed back effects from higher demand and investment to higher rates of innovation would be greater for a large closed economy than for a small open economy such as Australia. Australian research and development (R&D) represents only a small proportion of world R&D and a slow down in Australian growth is unlikely to have a noticeable impact on world R&D.

In using TRYM results, some judgement must be made as to whether the assumption of exogenous trend growth is realistic. Relevant to this may be the question whether there is some endogenous component or dynamic trade effects impacting on productivity. Some judgement needs to be made about the absolute level of productivity and whether recent and proposed reforms will lead to a shift in the level of productivity compared to that predicted by the model. Such judgements cannot be made within the context of the model but, rather, need to backed up by detailed empirical work at the microeconomic level. The estimate for trend labour productivity growth, nevertheless, appears to be much more tightly determined than for the NAIRU, with a standard error of a little over 0.1 of a percentage point on an estimate of trend growth of around 0.8 per cent a year.

6.2.3 Financial Markets - Interest Differential

Financial market equilibrium is attained in the long run in TRYM when the ‘risk-adjusted’ domestic real long bond rate equals the world real long bond rate. For TRYM, Australian real 10 year bonds are calculated as the nominal rate less 10 year inflation expectations (derived from indexed bonds). The world real rate is calculated as the world nominal rate (a weighted average of 10 year bond rates in the US, Japan, and the UK) less an artificial measure of world inflation expectations. Figure 22 shows that there has been a significant wedge between the model's measures of the domestic and world real long bond rates over the last ten years.
Limitations of TRYM

No attempt is made in the model to explain the wedge. There are a number of measurement difficulties involved in estimating both the domestic and world real rates. In the absence of a more detailed study examination as to why the wedge occurs, the measurement difficulties mean that the differential in rates should not be interpreted as a measure of a risk premium. The same differential is assumed to remain at the same level in the model over simulation periods and in the long run.

In using TRYM results, judgements may need to be made as to the appropriate level of this differential.
7. Conclusions

Macroeconomic models such as TRYM, working at the aggregate level, are subject to a number of criticisms in relation to the lack of detailed identification of the underlying causes of behaviour and the structure of markets. Nevertheless, there are few alternative means of coherently interpreting movements in the economy and systematically understanding the transmission mechanisms of policy changes. Moreover, the models are very useful at sorting out what is reliably known and what is not known on the basis of available data. They highlight the limitations of our understanding of economic behaviour and point to where major uncertainties lie.

To be useful for policy analysis or forecasting the model needs to be backed up by judgement based on detailed analysis at the microeconomic level. As Ted Evans noted in his introduction to the NIF-10 Conference volume in 1983, anyone who has been involved in model building for long enough develops an informed scepticism regarding its efficacy.

‘Much of the knowledge that is gained from econometric research will not be represented in the equation or model that emerges as a result of the research. ... Many of the more important aspects of economic behaviour are not amenable to measurement and hence cannot be adequately represented in econometric results. ... Econometric investigation, nevertheless, provides the researcher with a feel for the quantitative importance of such factors. The benefit of that will be found in the development of views and of abilities to interpret the results of the lesser number of relationships that can be formally quantified.’

What TRYM attempts to do is to quantify those relationships that are quantifiable and to do so in a consistent and transparent fashion so that judgement based on more detailed analysis can be added and the implications understood. By itself the model does not reduce the world to what Lord Keynes (1937) referred to as a state of certainty by the application of the calculus of probability - ‘reducing uncertainty to the same calculable status as certainty itself’. There are a number of parts of TRYM where uncertainties are particularly significant. However, there are other areas which appear to be more certain - where behaviour appears to be reasonably consistent over time. The skill in using a model therefore lies in knowing where the major uncertainties lie, backing these up with judgements (ideally based on more detailed analysis) and recalling the judgements and uncertainties when interpreting results.

Forecasting applications provide a good example. The accuracy of model projections to be used as a basis for forecasting is limited by a range of factors. The projections depend on how accurately the model reflects the operation of the economy. They require projections for exogenous variables, some of which are difficult, if not impossible, to forecast with any accuracy (such as commodity prices and rainfall). The model’s data underlying the projections must, in part, be based on survey data which are incomplete, contain substantial survey errors and are subject to revision. Simple measurement error can be expected to add, on average, around half a percentage point to the error of any model-based projection of GDP growth. Preparation of model-based projections, thus, requires judgements on a wide range of factors. Their use as an input into a forecasting process should recognise these limitations.

Policy analysis is subject to even greater caveats because it involves making judgements about how responses of people to the use of policy instruments may change over time, including in anticipation of policy changes. This is in addition to the judgements required for the projection baseline to
Conclusions

which the policy analysis is applied. Raw model results should, therefore, be treated with caution and the user will usually need to back up model analyses with detailed analysis of his or her own.
8. References


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