AN INTRODUCTION TO THE TRYM MODEL
APPLICATIONS AND LIMITATIONS

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Abstract: This paper provides an introduction to the TRYM model of the Australian economy used for macro-economic analysis by the Australian Treasury. It provides a brief introduction to the design and overall structure of the model and the model's properties. The model works at a highly aggregated level and hence both demand and supply side responses need to be interpreted with care. The paper uses the control application as an example of the limitations of the model particularly in relation to exchange rate reactions on the demand side and the level of the NAIRU on the supply side. In contrast with the normal focus on the specification of the loss function and problems such as time inconsistency, these two areas are argued to be important sources of qualification to model based policy conclusions.

Keywords: Economics, Modelling, Forecasts, Control

1. INTRODUCTION

The TRYM model was developed in the Commonwealth Treasury between 1990 and 1993 and was designed to assist in macroeconomic policy analysis and forecasting at the macro economic level. The model gives greater weight to simplicity, transparency and internal consistency than previous Treasury models. The following section provides a brief qualitative introduction to the design of the model and the model's properties. A much more technical and detailed description is contained in Taplin et al (1993). This is followed by a brief discussion of the limitations of the model, with particular reference to the control results presented by Louis (1995). The conclusion is drawn that macro modelling work normally needs to be supplemented by detailed micro work to be a useful adjunct to policy analysis.

2. SUMMARY OF THE MODEL

The TRYM model has a core of key macroeconomic relationships that are estimated using historical data wherever possible. These are linked together by a larger number of accounting identities. In particular, there are 23 estimated equations, 3 financial market identities, 2 default response functions for monetary and fiscal policy and about 100 identities linking these key variables. Effort has been directed towards ensuring consistency between and within sectors in response to criticisms of ad hocery in macro models by Christopher Sims (1981) and others. This has lead to 16 of the model's 23 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 the explanation of policy effects or forcasts is much more tractable.

The following two sub sections attempt to describe the model from two different points of view. Section 2.1 attempts a description of the aggregates used in the model and their linkages in the model using flow charts. Section 2.2 looks at the model's main equations and identities set out in a theoretical framework.

2.1 Summary of Linkages

As with any model the desire to keep the model simple and internally consistent has driven many of the data choices and linkages. The model is not designed to provide fine sectoral detail. Nor is it designed for detailed taxation or industry policy analysis or to produce detailed short term forecasts of large numbers of measures. Rather it is designed for a specific purpose. That is to provide tractable 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.

To do so the model works at a high level of aggregation and makes a number of simplifying assumptions, but 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 - Figure 1.

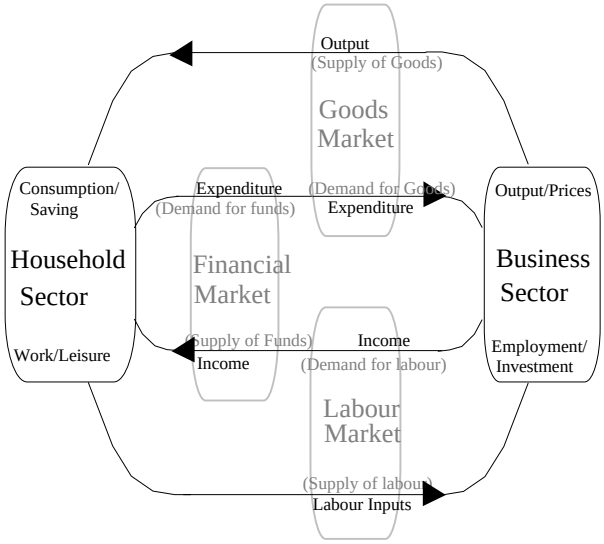

Figure 1: Simple Flow Diagram of a Closed Economy

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 (expenditure - output, output - income, and income - expenditure) is a market. The goods market balances the demand (expenditure) and supply of goods (output). The labour market balances the demand and supply of labour (balancing incomes with input). And financial markets balance the supply (saving) and demand (investment) for funds hence balancing income and expenditure.

The TRYM model, while being much more complex, uses the same kind of scheme. 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, and 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. In theory, all of the equations in the model could be linked and jointly estimated.

However, to link the equations together in a tractable way requires aggregation. (Aggregation has other advantages in terms of simplicity of interpretation and making the model easier to maintain.) 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.

But aggregation comes at a price. In general, it means that all of the underlying cause of the behaviour of the aggregates is not identified (eg observational equivalence), and that possible effects from changes in composition, changes to expectational processes and structural changes at the micro level may be difficult to capture. (A number of equations contain unexplained time trends for this reason.)

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

However, aggregation does have 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 - ensuring consistency within the markets and sectors shown in Figure 1.

Figure 1, however, is not meant to be taken as an accurate depiction of the linkages in the model. It does not show the other decision units in the economy (the Government and the Reserve 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 Figure 2 and 3 below.

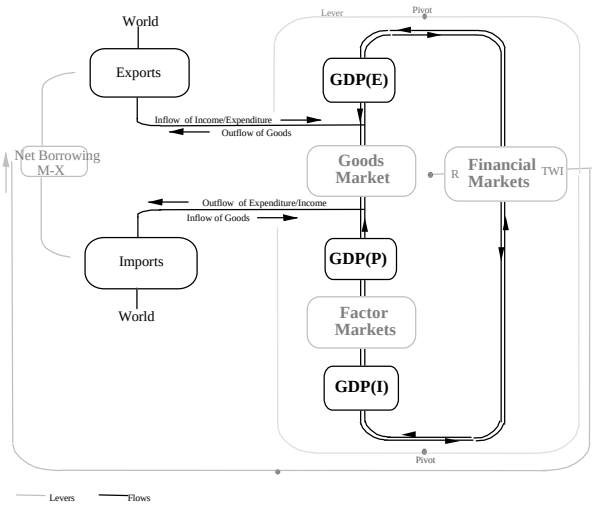

Figure 2: Simple Flow Diagram of an Open Economy

Figure 2 expands the closed economy case to include the external sector (imports and 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). [GDP(I)=GDP(P)=GDP(E)]. This is also the case in the open economy with the GDP(E) measure being derived by taking expenditure adding exports and subtracting imports. The order of the market linkage between the expenditure output and income aggregates is the same as in Figure 1 (but 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. In contrast to Figure 1, decision units are ignored and flows into and out of the system are introduced from overseas.

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 - 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 squeezes off the export outflow while opening up the import inflow. 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.

Similarly an injection of funds into the financial market (monetary expansion) will lead to lower interest rates and a lower exchange rate. The lower interest rates lead to a greater level of expenditure for a given level of income (lower saving, higher investment) but is also associated with a lower exchange rate. The falling exchange rate squeezes off the import inflow while at the same time releasing a larger export outflow. Thus, the increase in expenditure is maintained. 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 is 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 linkage between stocks and flows. Figure 3 may provide some idea of the linkages and classification of aggregates in the TRYM model.

The Figure introduces classifications and linkages for the Government sector and shows the linkage between exports and imports and the various components of demand and output (rather than the simple schemas in Figures 1 and 2.) However, the logic of the diagram is essentially the same as that of Figure 2. 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 is too difficult to attempt here and the reader should refer to the documentation (Taplin et al (1993)) for details. However, the diagram may be useful as an "at a glance" guide to where individual variables enter into the model.

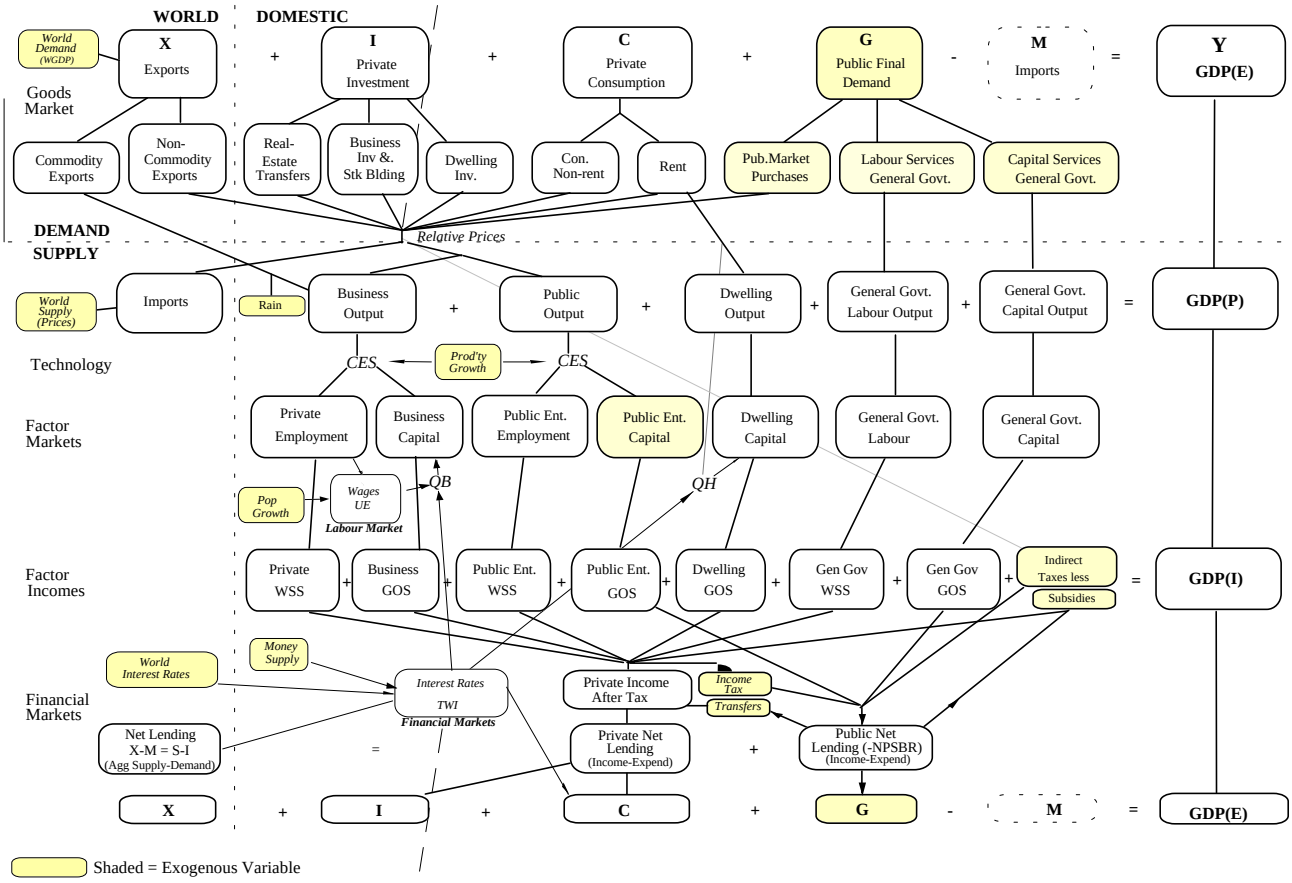

Figure 3: Classification and Linkage of Income, Expenditure and Ouptut in the TRYM Model

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

2.2 Summary of Equations and Relationships

Another way of representing the model is to list the equations. Behavioural modelling (reflecting the current state of economic theory) concentrates mainly on the goods market expenditure components of GDP(E). Of the models 23 behavioural equations, 16 deal with quantities and relative prices of the expenditure components. Another four determine wages employment 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 then linked to the other items shown 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 the Table 1 below. As with normal comparative static theoretical models many of the behavioural equations relate to the goods market expenditure aggregates of Figure 3, the prices of these aggregates (supply), behaviour in the labour market (labour supply, demand and the wage equation), and behaviour in financial markets. (Full details of the equations and identities are provided in the documentation.)

Table 1: TRYM - Summary of Main Relationships

Variable	Influenced by:	
. *Demand - Goods Market (IS)*		
Consumption	After-tax labour income, transfers (pensions, benefits), market value of private wealth (confidence, interest rates)	*..1*
Business Investment	Capacity utilisation, inertia, expected return given real wages, real interest rates	*..2*
Dwelling Investment	Cyclical dynamics, rental prices relative to construction prices, real interest rates	*..3*
Non-Farm Stocks	Sales growth, and adjustment to desired stock levels from trend stocks to sales ratio	*..4*
Farm Stocks	Commodity exports, rain, time trend	*..5*
Commodity Exports	(Supply driven) Bus potential output, rain, A$ export prices / domestic prices.	*..6*
Non-Comm Exports	(Demand driven) world demand, F$ non-comm export prices / world prices	*..7*
Imports	Domestic demand and import prices / domestic prices	*..8*
. *Demand - Government Balance*		
Government Demand	Exogenous	
Income Taxation	Reaction function - responds to target public debt to GDP ratio	...I
Indirect Taxation	Rates are exogenous	...I
Transfers	Benefit rates are exogenous	...I
. *Demand - Money Market (LM)*		
90 Day Bank Bills	React to nominal GNE growth over underlying supply growth plus inflation target	*..9*
10 Year Bonds	90 day bill rates, quasi rational inflation expectations, world bonds, risk	...I
. *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)	...I
. *Supply - Output*		
Bus Potential Output	Current business capital and labour, substituted into estimated CES production function	...I
Public Ent Output	Public enterprise capital and labour given CES production function, private output	*.10*
Government Output	Transformation of government capital and labour	...I
Dwelling Output	Constant ratio to dwelling stock	...I
. *Supply - Labour Market*		
Labour Supply	Encouraged worker effect (employment ratio), adult pop growth, after-tax real wage	*.11*
Private Employment	Demand for business output, real labour costs (adj for on-costs, trend productivity)	*.12*
Public Ent Employees	Public capital (which is exogenous)	*.13*
Gov Employees	Exogenous	...I
Wages	Adaptive inflation expectations, unemployment less NAIRU, change in UE, productivity	*.14*
. *Prices*		
Desired Output Prices	Nominal labour costs (adj for on-costs, trend productivity) demand/supply imbalances	*.15*
Import Prices	World industrial prices / TWI, with lagged pass through	*.16*
Dom Final Good Prices	Lags of desired output prices and import prices	*17-21*
Commodity Prices	World prices, world activity and the exchange rate	*.22*
Dwelling Rental Prices	Non rent consumption prices, and dwelling demand / dwelling supply imbalances	*.23*
. *Wealth, Capital Stock, Foreign Debt Identities*		
Capital Stocks	Cumulated investment less depreciation (PIM methodology)	...I
Private Wealth	Cumulated private saving, valuation from real interest rates, expected rates of return	...I
Public Debt	Cumulated net PSBRs, valuation effects on public foreign debt and reserve assets	...I
Net Foreign Liabilities	Cumulated CADs with valuation effects from exchange rate and interest rate movements.	...I

Notes: Numbers *1-23* 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.

In broad terms the first four equations of Table 1 (consumption, dwelling investment, business investment, and non-farm stock building) drive the dynamics of the model via the investment accelerator and the inventory cycle. In particular, the presence of significant lagged dependants (inertia) in both the dwelling investment and business investment equations is an important part of the reason why the model tends to overshoot the return to equilibrium following a shock. (The timing of adjustments on the supply side also play a role - eg 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 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, the domestic money market, and the exchange rate to any change in the economy. Together these determine movements in aggregate demand.

The supply side assumes 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 a expectations augmented Phillip's curve and hence the aggregate supply curve is vertical in the long term at a level of employment and production consistent with the NAIRU. (Or more precisely the economy grows along a steady state growth path consistent with the NAIRU.) However, 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 below.

Expectation Formation

Another important aspect in the specification of the demand side is the behaviour of expectations.

Expectations are modelled in TRYM in two distinct fashions. Wage earners and consumers are assumed to have adaptive 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.[1]

Financial market agents are assumed to form their expectations for nominal variables in a forward looking manner by assessing the effect of a shock on equilibrium values of the price level and the exchange rate. These price and exchange rate expectation variables are derived from the steady state model[2]. Hence the nominal exchange rate jumps in a fashion similar to that of the simple model set out by Dornbusch (1976).[3]

However, 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 the model takes after a shock. However it is assumed that they anticipate the long run effects of monetary and other shocks to nominal variables.

Policy Reaction Functions

Policy reaction functions also play a role in shaping the simulation properties of the model although these are not estimated. The reaction functions are introduced in the TRYM model as *default* mechanisms for monetary and fiscal policy and to ensure that the model converges on a unique long run equilibrium. By their nature, these reaction functions are arbitrary. They are a highly simplified representation of the policy formation process. They do not represent how policy makers would or should act. The reaction functions provide a mechanism for introducing fiscal and monetary responses to disturbances arising elsewhere in the economy. They allow comparisons to be more easily made between different simulations. (That is they ensure that the long run equilibrium is comparable between model runs, ie not changing due to unintended changes in long run policy settings.)

- The default fiscal policy rule allows fiscal drag to occur but gradually adjusts income tax rates in the

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[1] This is a description of the expectational set up in the standard version of TRYM. It is possible when necessary, however, to implement solution procedures which make the financial market fully rational.

[2] As the model should be returning to the steady state ten years after a shock, the expectations of the nominal variables will be almost model consistent.

[3] However, the nominal exchange rate does not display 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.

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 is that the money supply grows at the same rate as underlying supply (population growth plus trend labour productivity growth) plus an exogenous inflation target.

2.3 Equation Specification and Linkage

The following section briefly outlines the econometric principles and practices that have guided the estimation of the equations in the TRYM model.

Specification and Estimation

Most equations have been specified in an Error Correction Model (ECM) format. Where an ECM is not specified, a partial adjustment model is used. Special care has been taken to avoid Salmon steady state bias.

The extensive use of ECMs means that clear distinctions are made between an equation's short and long run properties. All equations are specified so 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.

Since economic theory is usually less precise about the determination of variables in the short run, parameters are usually freely determined in the short run, while theory is often used to guide the long run.

The non-linear least squares estimation technique has been extensively used to estimate equations. Equations have also been estimated jointly wherever possible to either jointly estimate demand and supply equations or to jointly estimate common parameters.

- For example, private business firms make decisions concerning employment, investment and prices based on common production function parameters. Therefore, these three equations are estimated jointly.

- The quantity and price of imports is determined by demand and supply curves respectively. The demand and supply curves are estimated jointly for each sector.

Equations are specified so that the growth accounting and orders of integration of economic variables are respected. Most equations are specified as ECMs and estimated using non-linear estimation techniques. On this basis, the significance or otherwise of an error correction parameter has generally been used as a guide to whether a co-integrating relationship exists.

Table 2 below shows that of the 23 equation estimated in the TRYM model, 16 have been jointly estimated and the remaining 7 individually estimated.

Table 2: Individual and Joint Estimation

Jointly Estimated Equations		
Business employment, investment and prices	(3)	
Import quantities and prices	(2)	
Commodity export quantities* and prices	(2)	
Dwelling investment and the price of rents		(2)
Relative Prices of Expenditure Components		(5)
Public Enterprise Employment and Output		(2)
Sub-Total		(16)
Separately Estimated Equations		
Labour Supply		(1)
Wages		(1)
Money Demand		(1)
Private Consumption		(1)
Non-commodity export prices		(1)
Farm Stockbuilding		(1)
Non-Farm Stockbuilding		(1)
Sub Total		(7)

* The long run component of the commodity export equation was estimated individually first.

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. This is simulated before running the dynamic version of the model to provide future equilibrium values for forward looking variables in the financial markets (inflationary expectations and the exchange rate).

3. MODEL PROPERTIES

Dynamic versus Stabilising Forces

In broad terms, the first four equations in Table 1 can be thought of as determining the short run dynamics. They contain:

- the dwelling cycle (driven by time to build factors and coordination failure);
- 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 stock building with sales growth);

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

- 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 *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 accentuates the inflow into imports and reduces exports.
- the *labour market* response - real wages rise as unemployment falls below the NAIRU lowering employment demand and increasing labour supply (slightly); and
- the *goods market* response - aggregate prices rise as demand outstrips desired supply.

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 correspond to the three markets balancing the flows in Figures 1 and 2.

However, the reaction of demand is slow in all three markets. (Investment and net exports respond to interest rates 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 damps with time.

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. However, it is important to note that the model is estimated at the aggregate level and does not identify the market structures or decision processes that underlie behaviour on either 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 prices 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 is not identified in the financial market but 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 exchange reaction for policy effectiveness) is a major source of uncertainty for policy analysis on the demand side.

- Similarly, on the supply side, the model does not identify the market structure or the sources of innovation that underlies 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. Nor does it 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 implicitly perfect - and in fact must have imperfections in the short term to explain the lag structures and inertia observed.)

Thus, as noted above, 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 are also the reason that modelling work needs to be backed up by more detailed empirical work at the disaggregated level to form the basis of the judgements required for forecasting and policy analysis.

4. SIMULATION EXAMPLES

The simulations below are designed to show how the model compares to the comparative static results derived from the standard IS/LM aggregate demand aggregate supply framework, particularly the Mundell Fleming results for a small open economy with free capital flows.

The first simulation is a one off expansion in the money supply of 3.8 per cent phased in over the course of a year. This leads to a fall in interest rates and an expansion of demand.

The second is a fiscal policy expansion increasing the net PSBR by 1 percentage point as a percentage of GDP by increasing government market demand. This also leads to an expansion of demand but with rising interest rates and a rising exchange rate.

Monetary Expansion

As can be seen the expansion of the money supply leads to a fall in interest rates in the first year. However this interest rate increase is unwound as the price level rises and the real money supply falls back towards its original level. The interest rate increase is completely unwound after the second year.[4]

The fall in interest rates stimulates GNE (via investment and consumption). However, the lower real exchange rate offsets any net export crowding out. As a result GNE and GDP move together.

The interest rate however does not asymptote to 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 the capital output ratio must return to normal. Any initial increase must be unwound and most of this unwinding is done in the second downward phase after the shock.

Thus the shock is characterised by an upward phase, a downward phase, and then a phase where it asymptotes back towards equilibrium. All in all the effects of the money shock over one year take up to ten years to work their way out of the system.

Fig 5A: Temporary Monetary Stimulus

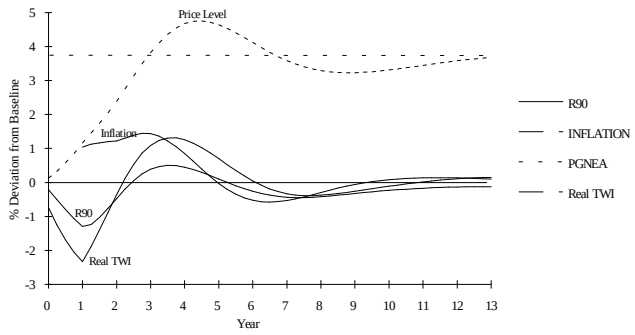
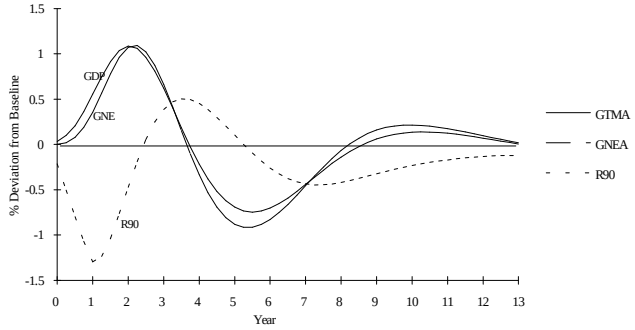


Fig 5B: Temporary Monetary Stimulus



Fiscal Expansion

In contrast to the monetary expansion, the fiscal expansion is accompanied by increasing interest rates and an increasing exchange rate. The increase in the exchange rate adds to the negative net export effects of the increase in demand. (The exchange rate movement is leading to net export crowding out rather than crowding in, the opposite of the monetary policy case.). Instead of GDP moving in line with GNE, as in the monetary policy case, more than half of the GNE response is crowded out by net exports.

The expansions effects on investment are relatively small and as a result no stock adjustment cycle is set up. Consequently, GDP and GNE more or less asymptote back to their equilibrium. The effects of the shock on activity and prices are virtually completely unwound after three years.

[4]It is unwound before the full price effects flow through because demand is expanding.

Figure 6: Fiscal Policy Expansion

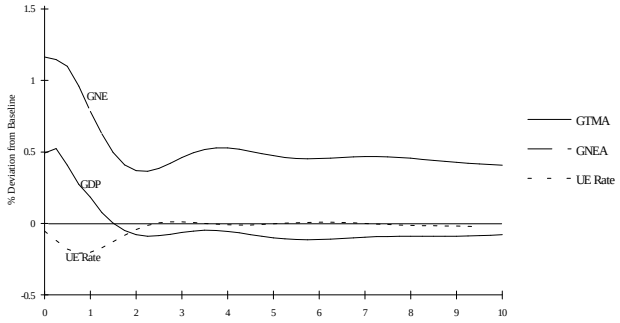
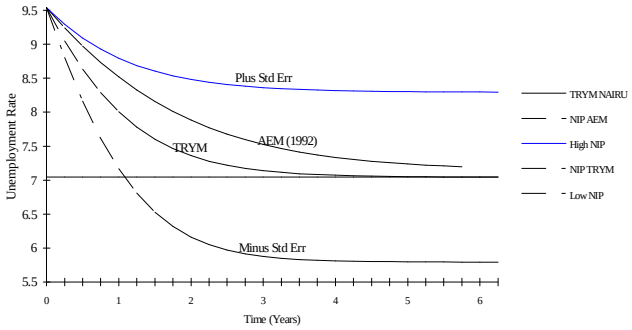


Figure 7: NAIRUs and Non Inflationary Paths (NIPs) for Unemployment



5 INTERPRETATION AND QUALIFICATION OF MODEL RESULTS

The interpretation of model results is fraught with difficulty because of the limitation of working at the aggregate level.

- On the demand side the responses are subject to the Lucas and time inconsistency critiques. The response 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 uncertainty over the level of the NAIRU and whether some portion of productivity growth is endogenous rather than exogenous are major uncertainties.

The NAIRU problem is particularly important for control applications. Rolling estimates from the TRYM wage equation indicate that the 95 per cent confidence interval gives a range of plus or minus 2.5 percentage points for the NAIRU estimated for the 13 years to 1994.

Figure 7 below gives some impression of the implications of this uncertainty for the speed limits to growth by deriving non-inflationary paths for unemployment from TRYM's wage equation. (The TRYM wage equation has the change in unemployment as well as a level of unemployment as an explanator. The point at which the wage pressure coming from falling unemployment equals the wage deflation from unemployment being high is used to derive the non inflationary path. Note this is a partial solution rather than a full model solution.)

The chart shows the non inflationary paths for an unemployment rate starting at 9.5 per cent derived from both TRYM and the AEM Model (AEM(1992)). The difference between the two paths gives an impression of the uncertainty that arises from different specifications even with wage equations with similar NAIRUs. In the AEM case the Phillip's curve is somewhat flatter than in TRYM and the coefficient on the unemployment change term a little higher. Hence the non inflationary path is flatter.

Above and below the TRYM and AEM NIPs are the NIPs that result when one standard error is added to or subtracted from the TRYM NAIRU estimate.

Most discussions of optimal control usually centre around the specification of the loss function and solution procedures and whether problems such as time inconsistency have been avoided. However most loss functions and solution procedures, so long as they contain inflation and unemployment targets will yield result somewhere near the non inflationary path back to equilibrium.

Figure 7 indicates how uncertain these paths can be. If the NAIRU is a little under 6 per cent unemployment can fall by almost 2.5 percentage points in the first year without generating wage inflation (implying GDP growth rate about 5 percentage points above trend). On the other hand if the NAIRU is a little over 8 per cent then unemployment can only fall by around 0.7 of a percentage point in the first year (implying GDP growth of about 1.5 per cent above trend).

This suggests that rather than the limitations of the control applications being determined by the choice of loss function or the solution procedure, they are mainly determined by the uncertainty surrounding the trade offs and policy responses in the model itself.

Moreover, to be useful control ultimately has to be applied to a forecasting baseline. The accuracy of the forecast baseline not only depends on knowledge of the true parameters of the economy (such as the NAIRU above) but also require projections for exogenous variables which are difficult to forecast such as commodity prices and rainfall, and must be based on survey data which is incomplete, contains substantial survey errors and is subject to revision. As a result the accuracy of forecasts for most target variables even for the first year out is relatively low. This limits the degree to which policy can reasonably respond even if the exchange rate, bond market and demand reactions to changes in policy were known with certainty. (See Debelle and Stevens (1995) for an example of the implications of forecasting error for policy rules.)

Therefore, to be useful the model results ultimately have to be supplemented by detailed analysis at the micro level to answer questions such as: How is behaviour by investors and consumers changing? or, What factors are agents in the financial markets reacting to? In particular, the results above highlight the need for detailed work on the effects of various institutional changes in the labour and product markets and their likely effect on wage setting behaviour and the NAIRU.

6. CONCLUSION

Winston Churchill once said 'Democracy is the worst form of government other than all those other forms that have been tried from time to time'. The same is true for structural macro economic models such as TRYM. Working at the aggregate level they are subject to a number of criticism in relation to the lack of identification of the underlying causes of behaviour and the structure of markets. However there is no other way of sensibly interpreting movements in the macro economy or providing tractable explanations of policy linkages. Moreover the models are very useful (as in the control example above) at pointing out where major uncertainties lie. In applied situations in a small open economy like Australia these uncertainties are not mainly in the choice of weights in the loss function or choice of solution techniques but rather in the likely behaviour in financial and labour markets and their likely reaction in a given set of circumstances to policy changes.

REFERENCES

Debelle G. and Stevens G., (1995) "Monetary Policy Goals for Inflation in Australia" *RBA Research Discussion Paper No 9503*

Dornbusch R., (1976), "Expectations and Exchange Rate Dynamics" in Dornbusch R., (1988) *Exchanges Rates and Inflation* MIT Press.

Louis C., (1995), "Control Applications of the TRYM Model", in *Symposium on Modelling and Control of National and Regional Economies,* International Federation of Automatic Control, July 1995.

Murphy, C.W. (1992), "Access Economics Murphy Model - The Model in Detail (version 2.1)", *Access Economics Murphy Model - User's Guide.*

Sims C.A.(1980), "Macroeconomics and Reality", Econometrica, 48, 1-47.

Taplin et al (1993), *Documentation of the Treasury Macroeconomic (TRYM) Model of the Australian Economy*, TRYM Paper No 2, Commonwealth Treasury.