DOCUMENTATION OF THE TREASURY
MACROECONOMIC (TRYM) MODEL
OF THE AUSTRALIAN ECONOMY

Modelling Section
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The views expressed here are those of the Modelling Section and should not be taken as implying similar views on the part of the Department of the Treasury or the Commonwealth Government.
Preface/Introduction

The Treasury macroeconomic (TRYM) model of the Australian economy has been developed and is used within the Commonwealth Treasury of Australia. For 25 years, Treasury has developed and maintained models of the Australian macroeconomy. Over this period, the modelling work has been a rich source of research, exposition, analysis and discussion and has led to the publication of large numbers of papers and articles.

The first Treasury macroeconomic model (known as the National Income Forecasting or NIF model) was developed between 1970 and 1973 and details of the model were published in the Journal of Econometrics in 1973. The early NIF modellers included such well known Australian economists as Chris Higgins, Ian Castles, Vince FitzGerald, Chris Caton and Ted Evans. Modification to the NIF model in the late 1970s reflected theoretical developments and changes in the structure of the economy (detailed in various published articles and conference papers). These culminated in the publication of the NIF6 Documentation in 1976, the NIF10 documentation in 1981 and the proceedings of a conference on the NIF10 Model in 1982. The model went through further substantial modification in the mid 1980s. This was partly in response to feedback from conference delegates, and partly as a result of changes in the structure of the economy occasioned by financial deregulation. The documentation of the revised model and a series of papers detailing the specification of individual sectors were presented at a conference titled ‘The Australian Macroeconomy and the NIF88 Model’ held in early 1988.

The research on the present TRYM model began in 1990, partly in response to feedback on the NIF88 model. However, it was also motivated by a desire for a smaller, more transparent model than NIF88 (one reason for the choice of the acronym TRYM) with a greater focus on internal consistency because of the advantages that has in conducting policy analysis and producing and interpreting model projections. Research on the new model was subject to an internal review in late 1992 by selected academics and outside modellers. This was followed by a conference held in June 1993 titled ‘The TRYM Model of the Australian Economy’. Documentation of the model was first released at the time of the conference.

The work on TRYM has been undertaken by the Modelling Section in Treasury. The personnel in the section have changed over the time since work began on the model in 1990. The personnel involved in the initial development work preceding the 1993 conference and release of the initial documentation included: Bruce Taplin, Mark Upcher, Brett Ryder, Andrew Johnson, Michael Kouparitsas, Melvino Mangolini, Paddy Jilek, Lawrence Antioch, Priya Parameswaran and Craig Louis. Those involved in the development of the model since 1993, the preparation of the revised documentation, this volume and the TRYM user’s guide for use with TSP software include: Peter Downes, Andrew Johnson, Robert Gardner, Gavin Stacey, Craig Louis, Rochelle Edge and Charlie Lay.

The model continues to be the focus of research and development.

The Documentation

This documentation provides the technical detail of the equations and identities TRYM model. It is divided into six parts, representing the different decision units and markets modelled in TRYM.
• **The private business sector** makes decisions about employment, prices, business investment and inventory investment (farm and non-farm). The equations for labour demand (hours worked), business investment and non-commodity output prices are jointly estimated.

• **The household sector** makes decisions about consumption (rental and non-rental), dwelling investment and labour supply. It also includes wage earners who participate in wage bargaining (make wage demands). The labour supply and wage equations are considered in the labour market section.

• **The public sector** is largely exogenous. It is split into the general government sector (comprising state, local and federal governments) and the government enterprise sector (comprising public trading and financial enterprises). The general government sector is assumed to have a target public debt to GDP ratio (set exogenously) and to adjust income tax rates so that this target will be met in the long run. Government expenditure items are set exogenously as are a variety of indirect tax rates and transfer rates. Government enterprises make decisions about public enterprise labour demand and quantity of output. Government enterprise investment is assumed to be exogenous.

• **The goods market** balances expenditure decisions made by households, business and the public sector with supply decisions made by businesses and the public sector. It consists of both domestic and international markets. The equations representing this market include those for relative expenditure prices, the quantity and price of imports of goods and services, the quantity and price of exports of commodities and the quantity of exports of non-commodities. The effects of aggregate demand/supply imbalances on aggregate prices are discussed in the private business sector section.

• **The labour market** balances household decisions about labour supply with business and public sector decisions about labour demand. It contains estimated equations for labour supply (hours worked), wages and unfilled vacancies. Labour demand is covered in the private business sector.

• **The financial market** balances savings and investment decisions made by householders, business and the public sector. It also balances the supply and demand for Australian dollars. It contains a money supply growth rule (in which the inflation target is set exogenously), a money demand equation (which is combined with the money supply rule and inverted to form an interest rate reaction function), an equation for the yield curve and an imposed exchange rate equation.

At the beginning of each section brief background to the relevant theory and data is presented. The specification of each equation is then examined, followed by tables showing the estimated parameters and a selected set of diagnostic statistics. Important results are interpreted. Some important identities are also presented.

Accompanying appendices provide a listing of the behavioural equations of the model and the identities used to close the model, as well as definitions of the mnemonics.
Other Manuals

The Macroeconomics of the TRYM Model of the Australian Economy explains the operation of the model using general macroeconomic relationships and linkages, as well as relationships that are subject to economic debate. The Macroeconomics of TRYM summarises the operation of the model from four different perspectives: through the use of flow charts linking the main aggregates in the model (Section 2.1); by linking the model’s main equations and identities (Section 2.2); by analysing the demand driven short run and the supply driven long run (Section 2.3); and by summarising the model’s relationships in the sectors and markets analysed in this documentation (Section 3). Section 2.2.3 of The Macroeconomics of TRYM outlines briefly the econometric principles and practices that have guided the estimation of the equations in the TRYM model.

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 the commercially-available 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 sections in The Macroeconomics of TRYM and the TRYM User’s Guide (with TSP).
1. The Private Business Sector

1.1 Background

The private business sector is defined in the TRYM model as private corporate and unincorporated enterprises. In the long run the optimal level of output produced by the private business sector is assumed to be consistent with profit maximising behaviour subject to a given technology. However, firms may be in disequilibrium in the short run as they adjust towards their desired position.

The production technology is not directly observable and must be inferred from the decisions concerning employment, investment and prices observed in the business sector. These decisions are captured in the TRYM model by behavioural equations for investment, the demand for labour and the price of non-commodities.

Care has been taken to ensure that these three equations are drawn together in a consistent and unified framework. In particular, the long run functional forms of the three equations are derived assuming a representative firm exists for the private business sector. This firm is assumed to produce output in the long run using a constant elasticity of substitution (CES) production function, exhibiting constant returns to scale, with capital (K) and labour (L) as the only inputs into production. Imports are treated as final goods when specifying the production technology. If output is denoted by \( Y \), and \( \alpha \) and \( \beta \) are the parameters on labour and capital respectively, the production function is defined as follows:

\[
Y = \left[ \alpha L^\rho + \beta K^\rho \right]^{\frac{1}{\rho}}
\]

where \( \rho = \frac{(\sigma - 1)}{\sigma} \), and \( \sigma \) is the elasticity of substitution between K and L.

The equations for labour demand, investment and the price of non-commodities are all specified in a way that provides for short term dynamic adjustment of these variables towards their equilibrium levels. Hence, the short run behaviour can be significantly influenced by adjustment costs, expectational lags and aggregate demand shocks. An aggregate demand shock, for example, will affect labour demand relatively quickly, prices with a longer lag and investment even more gradually.

Equations are also estimated for changes in both non-farm and farm stocks. Both incorporate adjustment to a desired level of stocks relative to sales.
1.2 Equation Specification, Results and Interpretation

The three core behavioural equations that make up the private business sector (labour demand, business investment and non-commodity prices) are estimated simultaneously. In this section, each equation is examined separately, followed by an interpretation of the parameters common to all three equations ($\sigma$, $\lambda_1$, $\lambda_2$, $\alpha$ and $\beta$). The final sections contain an outline of the stockbuilding sector (farm and non-farm stocks).

1.2.1 Labour Demand

The first order condition for profit maximisation requires that the marginal product of labour ($\partial Y/\partial L$) is equal to the real wage ($W/P$), and this is assumed to hold in the long run. Given the CES production function specified in TRYM, this implies that in the long run:

$$\frac{W}{P} = \alpha \left( \frac{L}{Y} \right)^{\sigma}$$

Rearranging to obtain the equilibrium level of labour demand as a function of output and real wages gives:

$$\ln(L) = \ln(Y) + \sigma \ln(\alpha) - \sigma \ln\left( \frac{W}{P} \right)$$

Firms can alter their labour input by either changing the number of people they employ or by altering the number of hours worked by existing employees. The labour demand equation is therefore specified using average hours worked (NH) in addition to the number of people demanded (NEBD). This approach helps to capture, for example, the effect of the trend decline in average hours worked over the 1970s and 1980s, related to the 35 hour week campaign in the mid seventies and the shift over time towards part-time work. Technical progress is assumed to be both labour and capital augmenting, however, post-sample capital productivity is assumed to equal zero in order to achieve a constant capital-output ratio and sensible steady state. The marginal product of labour is adjusted for the rate of Harrod neutral technical progress (or the underlying growth in private sector labour productivity, $\lambda_1$) to determine the equilibrium relationship for labour demand. Harrod neutral technical progress is consistent with the observed long-term constancy of the capital-output ratio.

To help to identify the labour demand curve, unfilled vacancies (NVA) are added to observed business employment (NEB) to form effective employment demand (NEBD). Unfilled vacancies are the difference between the labour demanded by firms and the people actually employed. Without this adjustment, the significant movements in vacancy levels over the business cycle and over time would tend to bias the estimate on the elasticity of substitution of labour for capital ($\sigma$). By adjusting for vacancies, the equation should capture more precisely the influence of various factors on the demand for labour. Put another way, the vacancy data helps to identify the labour demand relationship adjusting for the fact that some employment wage points would reflect or be influenced by the labour supply relationship.

The real wage faced by producers is given by the hourly nominal wage (RWH) adjusted for payroll and fringe benefits taxes (RTPRB) and deflated by the price of business sector output (PGB). This gives the following long run relationship for labour demand by the private business sector (QTIME is a time trend):
\[
\ln(NEBD) = \ln(GBA) - \ln(NH) - \lambda_1 \times QTIME + \sigma \ln(\alpha) - \sigma \left[ \ln\left( \frac{RWH \times RTPRB}{PGB} \right) - \lambda_1 \times QTIME \right]
\]

The (producer) real wage, \(\ln(RWH \times RTPRB/PGB)\), adjusted for underlying labour productivity \((\lambda_1)\) can be interpreted as a measure of real hourly wages adjusted for efficiency. As labour efficiency improves, with unchanged real wages, the real wage per unit of production declines. The above equilibrium relationship defines the labour demand of profit maximising firms, given real wages and the level of private business output (GBA). The equation implies that if real wages grow in line with underlying labour productivity, employment, on an average hours worked basis, will grow in line with output less underlying labour productivity growth.

This relationship will not necessarily hold in the short run. An error correction specification has been used to incorporate both the dynamic and long-run responses (see Section 2.2.3 of *The Macroeconomics of TRYM*).

The estimated equation is adjusted for population growth to ensure that steady state bias is not introduced into the model. Average adult population (NPAD) growth over two years is used to smooth out short-term fluctuations in population growth.

\[
\Delta \ln(NEBD) = \frac{\Delta \ln(NPAD)}{8} - a_1 \times \sigma \left[ \Delta \ln\left( \frac{RWH \times RTPRB}{PGB} \right) - \frac{\lambda_1}{4} \right]
- (1 - a_2) \times \Delta \ln(NH)
+ a_3 \times \left[ \Delta \ln(GBA) - \frac{\Delta \ln(NPAD)}{4} - \frac{\lambda_1}{4} \right]
+ a_4 \times \left[ \Delta \ln(GBA(-1)) - \frac{\Delta \ln(NPAD(-1))}{4} - \frac{\lambda_1}{4} \right]
+ a_5 \times \left[ \Delta \ln(GBA(-2)) - \frac{\Delta \ln(NPAD(-2))}{4} - \frac{\lambda_1}{4} \right]
+ a_6 \times QPRIV
- a_0 \times \left[ \ln\left( \frac{NEBD(-1)}{GBA(-1)} \right) + \ln(NH(-1)) + \lambda_1 \times QTIME(-1) \right] - \sigma \ln(\alpha) + \sigma \left[ \ln\left( \frac{RWH(-1) \times RTPRB(-1)}{PGB(-1)} \right) - \lambda_1 \times QTIME(-1) \right]
\]
Results (from joint estimation of business employment, investment and price of non-commodities equations)

Sample: 1970(4) to 1999(2)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Interpretation</th>
<th>Estimate</th>
<th>t-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a_0$</td>
<td>error correction</td>
<td>0.198</td>
<td>6.42</td>
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<tr>
<td>$a_1$</td>
<td>real wages</td>
<td>0.150</td>
<td>3.16</td>
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<td>$a_2$</td>
<td>hours worked</td>
<td>0.713</td>
<td>6.48</td>
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<tr>
<td>$a_3$</td>
<td>output</td>
<td>0.240</td>
<td>5.37</td>
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<tr>
<td>$a_4$</td>
<td>output lagged 1 qtr</td>
<td>0.106</td>
<td>2.28</td>
</tr>
<tr>
<td>$a_5$</td>
<td>output lagged 2 qtrs</td>
<td>0.085</td>
<td>1.89*</td>
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<tr>
<td>$a_6$</td>
<td>privatisation dummy</td>
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<td>$\sigma$</td>
<td>elasticity of substitution</td>
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<td>14.88</td>
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<tr>
<td>$\lambda_1$</td>
<td>trend labour productivity</td>
<td>0.012</td>
<td>8.40</td>
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</table>

Diagnostic Statistics

- $R^2 = 0.55$
- $SE = 0.66\%$
- $DW = 1.67$
- Box-Pierce Q (1-8th order auto correlation) = 7.71
- Jarque-Bera Test for Normality = 0.90
- Chow Test for Parameter Stability = 1.00
- Ramsey's Reset Test = 0.08
- Breusch-Pagan Heteroscedasticity Tests:
  - Trend = 2.62
  - Y-Hat = 4.66*
  - Joint = 5.93

* Indicates the test has failed at the 5% confidence level.

Economic Interpretation

The adjustment toward equilibrium is fairly quick, with around 20 per cent of any difference between actual and desired labour demand eliminated each quarter. Other elasticities in this equation imply the following:

- A one per cent increase in private business output leads to an increase in the level of labour demanded of 0.24 per cent initially and 0.43 per cent after 3 quarters. However, this short-term direct response will be offset to some extent by the response of hours worked to the increase in activity (see the hours worked equation in Section 5). The response of employment to output builds to 1 per cent in the long run (in accordance with the constant returns to scale assumption). Employment here is defined in efficiency units.

- A one per cent increase in real wages would decrease the level of labour demanded by 0.15 per cent initially, building to 0.82 per cent in the long run. The direct effects on private employment and total employment are smaller (as discussed in Section 3.1).

- A one per cent increase in average hours worked would decrease the number of employees demanded (in terms of the number of people required) by about 0.71 per cent in the short run. That is, average hours worked play an important role in the adjustment of employment to any shock. Average hours worked, however, has no effect on unemployment in the long run since, in the model, the equilibrium unemployment level is
determined by wage adjustment in the labour market and, hence, the NAIRU (see Section 5). Wage adjustments lead back to changes in interest rates and output and, hence, in labour demand.

### 1.2.2 Non-Commodity Prices

The long run level of non-commodity prices is derived from the CES production function and the first order conditions for labour. Expressing equilibrium labour demand as a function of wages and output and substituting into the production function allows prices to be written as a function of nominal wages, capital stock and output.

\[
P = \left[ \frac{W}{\alpha} \right] \times \left[ 1 - \frac{\beta}{\alpha} \times \left( \frac{K \times e^{\lambda t}}{Y} \right) \left( \frac{\sigma - 1}{\sigma} \right) \right] \left( \frac{1}{\sigma - 1} \right)
\]

The price equation in the private business sector only relates to non-commodity prices. The price of commodities is determined by the price Australian exporters receive on world markets and is analysed in Section 6. This distinction is made because, in the TRYM model, non-commodity prices are sticky while commodity prices are assumed to be flexible and to clear the market for commodities.

Adjusting the above equation to take account of underlying productivity, and rewriting for the private business sector gives the following long run relationship:

\[
PNC = \left[ \frac{\text{RWH} \times \text{RTPRB}}{\alpha \times \exp(\lambda_1 \times \text{QTIME})} \right] \times \left[ 1 - \frac{\beta}{\alpha} \times \left( \frac{K \times e^{\lambda_1 \times \text{QTCAP}}}{Y} \right) \left( \frac{\sigma - 1}{\sigma} \right) \right] \left( \frac{1}{\sigma - 1} \right)
\]

The business sector is assumed to have little control over commodity prices. Therefore, the equilibrium relationship is defined for non-commodity output prices alone. This is done by removing the price effects of commodity exports (\(\text{XC} \)) and farm stocks (\(\text{SFM} \)) from the price of business sector output to form \(\text{PNC} \) (the price on non-commodity output). Using the suffix 'Z' to indicate nominal variables gives the long run relationship for the equilibrium price of non-commodities (\(\text{PSTAR} \)):

\[
\text{PSTAR} = \frac{\text{PNC} - \text{GB} \times \text{XCZ} - \text{SFMZ}}{\text{GB} - \text{XC} - \text{SFM}}
\]

The two essential elements of \(\text{PSTAR} \) are the nominal wage adjusted for trend productivity and the output to capital ratio, which moves closely with capacity utilisation. \(\text{PSTAR} \) could loosely be defined as desired output prices given wages, productivity and the utilisation of capital. It is closely related to \(\text{GSTWK} \) (hypothetical output given current wages, prices, productivity and capital) - see Sections 3.1.1 and 5.8 of *The Macroeconomics of TRYM*. When non-commodity prices (\(\text{PNC} \)) reach their equilibrium level (\(\text{PSTAR} \)) derived from the first order conditions for profit maximisation, prices will have fully adjusted to any wage movement and \(\text{GBA} \) will equal \(\text{GSTWK} \). However, the labour market and the financial market will not necessarily be in
equilibrium at this point. Figure 1 shows that movements in PSTAR relative to PNC are closely related to movements in real wages and short run capacity utilisation, GBA/GSTAR.

As can be seen, PNC does not equal PSTAR in the short run. Non-commodity prices are assumed to adjust slowly toward their equilibrium level. In the short run, PNC is assumed to be driven by:

- a weighted average of current and past growth in PSTAR, with contemporaneous and lagged changes from one through to four quarters;
- short run movements in import prices PMGS (note that any effects are assumed to be unwound in the next quarter); and
- any disequilibrium between actual PNC and the desired level PSTAR, with a lag of five quarters, to ensure that prices are in equilibrium in the long run.

In order to ensure that the equation exhibits homogeneity with respect to inflation, the sum of the changes in the equilibrium growth of non-commodity prices is constrained to one.

**Figure 1: PSTAR/PNC, Producer Real Wages and Capacity Utilisation (GBA/GSTAR)**
The price of non-commodities equation is specified in error correction form as follows:

\[
\Delta \ln(PNC) = a_1 \times \{\Delta \ln(PSTAR)\} + \{1 - a_1 - a_2 - a_3 - a_4\} \times \{\Delta \ln(PSTAR(-1))\} \\
+ a_2 \times \{\Delta \ln(PSTAR(-2))\} \\
+ a_3 \times \{\Delta \ln(PSTAR(-3))\} \\
+ a_4 \times \{\Delta \ln(PSTAR(-4))\} \\
- a_5 \times \{\Delta \ln(PMGS)\} \\
+ a_5 \times \{\Delta \ln(PMGS(-1))\} \\
+ a_0 \times \{\ln(PSTAR(-5)) - \ln(PNC(-5))\}
\]

where PSTAR is defined as above.

**Results (from joint estimation of business employment, investment and price of non-commodities equations)**

Sample: 1970(4) to 1999(2)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Interpretation</th>
<th>Estimate</th>
<th>t-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a_1)</td>
<td>equilibrium prices</td>
<td>0.486</td>
<td>7.87</td>
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<tr>
<td>(a_2)</td>
<td>lagged equilibrium prices</td>
<td>0.041</td>
<td>0.67*</td>
</tr>
<tr>
<td>(a_3)</td>
<td>lagged equilibrium prices</td>
<td>0.297</td>
<td>5.01</td>
</tr>
<tr>
<td>(a_4)</td>
<td>lagged equilibrium prices</td>
<td>0.009</td>
<td>0.15*</td>
</tr>
<tr>
<td>(a_5)</td>
<td>change in import prices</td>
<td>0.071</td>
<td>1.67*</td>
</tr>
<tr>
<td>(a_0)</td>
<td>error correction</td>
<td>0.040</td>
<td>1.96</td>
</tr>
<tr>
<td>(\beta)</td>
<td>CES parameter on K</td>
<td>0.392</td>
<td>7.83</td>
</tr>
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</table>

**Diagnostic Statistics**

- \(R^2 = 0.36\)
- \(SE = 1.8\%\)
- \(DW = 2.46\)
- Box-Pierce Q (1-8th order auto correlation) 16.45*
- Jarque-Bera Test for Normality 46.28*
- Chow Test for Parameter Stability 1.66
- Ramsey's Reset Test 0.005

Breusch-Pagan Heteroscedasticity Tests:
- Trend 2.95
- Y-Hat 0.67
- Joint 5.41

* Indicates the test has failed at the 5% confidence level.
Interpretation

The lag distribution reflecting the effect of changes in PSTAR on the growth of PNC is well determined, except for the coefficient on the second and fourth lags ($a_2$ and $a_4$), which are insignificant but have been included to maintain continuity in the dynamics of PNC. Any disequilibrium between actual and desired PNC is eliminated very slowly, by around 4 per cent each quarter.

Imports are not included as a factor of production in TRYM. However, it seems likely that fluctuations in import prices will have some effect on short term movements in non-commodity output prices. Hence, the equation contains changes in import prices in the short term dynamics, but with the restriction that there is no effect after two quarters. The results indicate that import prices have a positive effect on non-commodity output prices after one quarter. This could reflect:

- changes in the price of imported inputs affecting the timing of non-commodity output price changes even though non-commodity output is net of imports;

- changes in the exchange rate leading to fluctuations in exporters’ margins and, hence, in the relationship between the domestic price and the Australian dollar non-commodity export price (non-commodity export prices are assumed to be supply determined in TRYM with the Australian dollar price assumed to be a simple ratio of the domestic price); or

- the ABS practice of constructing some expenditure deflators (such as the one used for plant and equipment) with lagged import prices resulting in contamination of the data.

The main avenue by which import prices affect domestic prices in the model is via the price of total supply (both domestically produced and imported) to the domestic market (PT) and, in turn, via the block of equations for relative expenditure prices - see Section 4. The above equation for PNC deals with the price of domestically produced non-commodities only.

1.2.3 Investment

In equilibrium, business investment (IB) ensures that the capital stock (KB) grows in line with the adult population (averaged over a two year period), business sector labour productivity growth ($\lambda_1$) and business sector capital productivity growth ($\lambda_2$), taking into account depreciation of the capital stock at the rate RKDB:

$$\frac{IB}{KB(-1)} = \left[ \frac{\lambda_1}{4} + \frac{\Delta_s NPAD}{8} - \frac{\lambda_2 \times QTCAP}{8} \right] + RKDB$$

The sum of the growth rate of the adult population and the underlying rate of productivity growth gives the underlying growth rate of the economy (GR), so that we can write:

$$\frac{IB}{KB(-1)} = GR + RKDB$$

In TRYM, it is actually underlying business investment (IBU) which is modelled. This is defined as business investment less second-hand asset sales. Such asset sales are simply at the will of the government of the day and therefore follow no particular economic theory. Many of these asset sales are quite large (e.g. Dampier to Bunbury gas pipeline sold in March 1998) and as such
distort business investment in the quarter that they occur. It is for this reason that they have been removed.

In the short run, investment also depends on the business sector Q-ratio (QB), capacity utilisation and past investment decisions.

**Business Sector Q-ratio**

The business sector Q-ratio is calculated as the ratio of the real expected rate of return from an extra unit of investment to the real required rate of return of that investment were it at the profit maximising margin. If the extra investment is at the profit maximising margin, the real expected and real required rate of return are equal and the Q-ratio is unity. The higher the Q-ratio is above unity, the more attractive the expected returns from investing and the higher investment is likely to be.

The real expected rate of return (ERR), given the current real wage, can be derived from the first order condition for capital from the CES production function. The dollar return from investing in one extra unit of capital is given by the value of the marginal product of capital (P.\(\frac{\partial Y}{\partial K}\)). The price of one additional unit of capital investment is given by the price index for investment. If the price index for output is denoted by P, and the price index for investment by PI, the expected rate of return is given by:

\[
ERR = \frac{P}{PI} \times \beta \left( \frac{K \times e^{\lambda t}}{Y} \right)^{(\rho-1)}
\]

The CES production function and the first order conditions for labour demand can be used to substitute out \((K/Y)\), giving:

\[
ERR = \frac{P}{PI} \times \beta \left( \frac{\alpha}{\rho-1} \right) \left[ 1 - \alpha \sigma \left( \frac{W}{P} \right)^{(1-\sigma)} \right]^{\frac{1}{1-\sigma}}
\]

The real required rate of return (RR) - which at the profit maximising margin equals the real user cost of capital - comprises real interest costs, depreciation and an adjustment for risk. On the assumption of a constant rate of physical deterioration of the business capital stock (RKDB), RR is calculated as the 10 year government bond rate (RIGL), expressed in real terms, plus RKDB adjusted for the interaction of physical depreciation and expected inflation (FIE).¹ A risk premium (RISK) is also added. RISK is an imposed parameter (given a value of 1) in the investment equation, and the derivation of FIE is explained in Section 6 - Financial Markets.

\[
RR = RKDB \times (1 + \frac{FIE}{400}) + \frac{RIGL-FIE}{4\pi(100+FIE)} + \frac{RISK}{400}
\]

Therefore, the Q-ratio can be written as:

---

¹ With a nominal interest rate, \(r\), and a marginal asset that is deteriorating at the constant rate \(s\) (corresponding to a constant proportional reduction in expected net receipts with no inflation), the required rate of return - and the user cost of capital - is \(r+s\). With expected inflation at the rate \(\pi\), real net receipts - and real economic value - change by the proportion \((1-s)(1+\pi)-1\). The real required rate of return (abstracting from risk) is therefore given by \((r-\pi)/(1+\pi)+s(1+\pi))\).
The private business sector Q-ratio, QB, is derived from the above equation by adjusting real wages for underlying productivity growth (as in the specification of labour demand above):

\[
QB = \frac{P_{GBB} \times \beta \left( \frac{\sigma}{\sigma-1} \right) \times \left[ 1 - \alpha \left( \frac{W}{P} \right)^{(1-\sigma)} \right]^{\frac{1}{1-\sigma}}}{RKDB \times \left( 1 + \frac{FIE}{400} \right) + \frac{RIGL-FIE}{4 \times (100+FIE)} + \frac{RISK}{400}}
\]

**Capacity Utilisation**

The ratio of demand to supply, which can be interpreted as capacity utilisation, also influences investment decisions in the short run. In particular, investments that may be profitable over the medium to long term may be delayed as a result of a lack of demand or the presence of spare capacity in the short run. The capacity utilisation term in the investment equation relates current private business sector output (GBA) to a theoretical construct, GSTAR. Conceptually, GSTAR is the maximum output consistent with firms' current levels of employment and capital stock. It is calculated by substituting current levels of employment - on an hours-worked (NHB) basis - and capital stock (KB) into the assumed CES production function as follows:

\[
GSTAR = \left( \alpha \times (NHB \times \exp(\lambda_1 \times QTIME)) \left( \frac{\sigma-1}{\sigma} \right) + \beta \times KB(-1) \times e^{\lambda_2 \times QTCAP(-1)} \left( \frac{\sigma-1}{\sigma} \right) \right)^{\frac{\sigma}{\sigma-1}}
\]

**Past investment**

Past investment decisions are another determinant of investment in the short run, and this is reflected in the persistence of, and serial correlation in, investment behaviour. It is captured in the equation for investment by including a series of lagged dependent variables.

Finally, a dummy variable (QMIN) is included to capture the mining booms of the late 1970s, early 1980s and late 1990s, and an additional variable (XRITC) is used to adjust for investment tax credits.
The underlying business investment equation is therefore given by:

\[
\frac{IBU}{KB(-1)} = (GR + RKDB) \times (1 - a_1 - a_2 - a_3)
\]

\[+ a_1 \times \left\{ \frac{IBU(-1)}{KB(-2)} \right\}
\]

\[+ a_2 \times \left\{ \frac{IBU(-2)}{KB(-3)} \right\}
\]

\[+ a_3 \times \left\{ \frac{IBU(-3)}{KB(-4)} \right\}
\]

\[+ a_4 \times \ln \left( \frac{GBA}{GSTAR} \right)
\]

\[+ a_5 \times \{QB(-2) + XRITC(-2) - 1\}
\]

\[+ a_6 \times QMIN
\]

**Results (from joint estimation of business employment, investment and price of non-commodities equations)**

Sample: 1970(4) to 1999(2)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Interpretation</th>
<th>Estimate</th>
<th>t-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>a1</td>
<td>lagged investment</td>
<td>0.708</td>
<td>7.52</td>
</tr>
<tr>
<td>a2</td>
<td>lagged investment</td>
<td>0.141</td>
<td>1.19*</td>
</tr>
<tr>
<td>a3</td>
<td>lagged investment</td>
<td>-0.124</td>
<td>-1.41*</td>
</tr>
<tr>
<td>a4</td>
<td>capacity utilisation</td>
<td>0.028</td>
<td>4.82</td>
</tr>
<tr>
<td>a5</td>
<td>Q-ratio</td>
<td>0.003</td>
<td>4.73</td>
</tr>
<tr>
<td>a6</td>
<td>mining boom dummy</td>
<td>0.001</td>
<td>2.46</td>
</tr>
<tr>
<td>RISK</td>
<td>risk component</td>
<td>1.000</td>
<td>Imposed</td>
</tr>
<tr>
<td>(\alpha)</td>
<td>CES parameter on L</td>
<td>0.404</td>
<td>4.65</td>
</tr>
<tr>
<td>(\lambda_2)</td>
<td>capital productivity</td>
<td>-0.0035</td>
<td>Imposed</td>
</tr>
</tbody>
</table>

**Diagnostic Statistics**

- \(R^2 = 0.89\)
- \(SE = 0.12\%\)
- \(DW = 1.86\)
- Box-Pierce Q (1-8th order auto correlation) 6.20
- Jarque-Bera Test for Normality 1.93
- Chow Test for Parameter Stability 0.30
- Ramsey’s Reset Test 0.03
- Breusch-Pagan Heteroscedasticity Tests:
  - Trend 0.17
  - Y-Hat 4.10*
  - Joint 4.14

* Indicates the test has failed at the 5% confidence level.
Interpretation

Since the dependent variable measures the flow of investment relative to the stock of capital, it is rather small in numerical terms. Over the sample period the dependent variable ranges from 2.5 to 4.5 per cent. Hence, the estimated coefficients also tend to be small numbers. The coefficients of this equation cannot be interpreted in the usual manner as respective elasticities.

The estimated parameters show that:

- the Q-ratio has a significant influence on investment even though the coefficient on the Q-ratio seems small due to the presence of lagged dependent variables in the equation;
- the capacity utilisation rate is highly significant;
- the risk component is imposed at 1 per cent per annum. This implies that, in equilibrium, business capital has to yield a real rate of return that is around 1 per cent greater than that on government bonds in order to compensate investors for its relatively higher risk;

1.2.4 Interpretation of common parameters

The following table draws together estimates of the common parameters in the supply side of the economy.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Interpretation</th>
<th>Estimate</th>
<th>t-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda_1$</td>
<td>labour productivity</td>
<td>0.012</td>
<td>8.40</td>
</tr>
<tr>
<td>$\lambda_2$</td>
<td>capital productivity</td>
<td>-0.0035</td>
<td>Imposed</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>elasticity of substitution</td>
<td>0.817</td>
<td>14.88</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>CES parameter on L</td>
<td>0.404</td>
<td>4.65</td>
</tr>
<tr>
<td>$\beta$</td>
<td>CES parameter on K</td>
<td>0.392</td>
<td>7.83</td>
</tr>
</tbody>
</table>

The growth rate of labour efficiency, $\lambda_1$, for the private business sector (that is, underlying labour productivity growth) is estimated to have been about 1.2 per cent per annum on average since 1970, whilst the growth rate of underlying capital productivity, $\lambda_2$, is estimated to have been about –0.35 per cent per annum.\(^2\)

The elasticity of substitution between labour and capital, $\sigma$, is another key model parameter. It is estimated to be about 0.817. The importance of this estimate is that it implies that a real wage increase will lead to a rise in labour's share of income, consistent with events of the 1970s and 1980s. More precisely, a one per cent increase in the real wage will raise labour's share by about 0.817 per cent (or, for example, from 60 per cent of nominal business output to 60.5 per cent).

The table below compares the TRYM estimates of growth in labour productivity and the elasticity of substitution of K for L with those of some other models. The TRYM estimate of the elasticity of substitution is somewhat higher than that in the AEM or AMPS models, reflecting the inclusion of hours worked and vacancy data in the labour demand equation in TRYM. Failing to adjust for vacancies should, in theory, bias the estimated elasticity of substitution downwards, with the bias increased with higher vacancy rates. Thus, the bias would be expected

\(^2\) In the post-sample period, capital productivity is assumed to be zero. This is necessary to ensure the model settles down on a steady state (Harrod Neutral) growth path.
to be significant using Australian data if the sample period extends back into the late sixties and early seventies when the vacancy rate was high. This is possibly the reason for the lowest estimate being from AMPS which was estimated for the period 1966 to 1986. The labour demand equation in TRYM is estimated from 1970(4).

**Comparison of Growth in Labour Productivity and Factor Substitution**

<table>
<thead>
<tr>
<th></th>
<th>TRYM</th>
<th>AEM(a)</th>
<th>AMPS(b)</th>
<th>NIF88(c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Growth in Labour Productivity (%)</td>
<td>1.2</td>
<td>0.9</td>
<td>1.4</td>
<td>1.5</td>
</tr>
<tr>
<td>Capital/Labour Substitution</td>
<td>0.817</td>
<td>0.75</td>
<td>0.32</td>
<td>1.00 (d)</td>
</tr>
</tbody>
</table>

(a) Access Economics macroeconomic model, see Access Economics (1998).
(b) Australian Medium-term Policy Simulation Model, see Murphy et al (1986).
(c) Treasury National Income Forecasting Model, see Simes et al (1988).
(d) From the imposed Cobb-Douglas functional form.

Another feature of the comparison is the difference in the estimated growth in labour productivity in the different models. This reflects differences in measurement, assumed functional forms, estimation techniques and sample periods. TRYM and NIF88 measure labour input on an hours worked basis while the other models measure this on a heads basis. TRYM estimates its production function using private business sector measures of output, output prices and labour and capital while the other models use economy-wide measures. TRYM, AEM and AMPS assume a CES functional form for the production function while NIF88 assumes a Cobb-Douglas functional form. TRYM, AMPS and NIF88 assume that imports are final goods while AEM assumes they are an input into production in a nested production function. TRYM’s estimate of the growth in labour productivity is for the period 1970(4) to 1999(1) while that for AEM is for 1976(1) to 1997(1), AMPS for 1966 to 1986 and NIF88 for 1969(4) to 1986(4). The fact that NIF88 and AMPS have higher estimated rates of labour productivity is probably partly explained by the fact that their estimation periods have a greater proportion of observations in the higher productivity growth period of the late sixties, early seventies.

### 1.2.5 Non-Farm Stockbuilding

The sales variable (DDSNN) used in determining the non-farm stocks to sales ratio is defined as the sum of private non-rent consumption (CNR), business investment (IB), dwelling investment (IDW), government market demand (DGM) and the statistical discrepancy (DISA).

\[
DDSNN = CNR + IB + IDW + DGM + DISA
\]

A large number of factors appear to have reduced the non-farm stock to sales ratio over the estimation period. These include: the introduction of computer technology and better stock management techniques, the increase in import penetration, the growth of services and the increased consumption of services relative to manufactured goods. This combination of compositional and behavioural changes is captured by a logistical growth function (variable rate trend). The specification of a logistic growth trend is superior to the alternatives of a linear downward sloping time trend or a one off shift dummy and a kinked time trend.

The equilibrium non-farm stocks to sales ratio (KSN/DDSNN) is, thus, expressed as follows:
The actual stocks to sales ratio can temporarily deviate from the desired level in response to unanticipated changes in the level of imports (MGS). This approach is consistent with that taken in modelling imports where it is assumed that import supply drives stock levels rather than vice versa. An error correction equation has been specified with changes in the level of non-farm stocks being driven in the short run by a lagged dependent variable and changes in the quantity of imports. Attempts to include a short run interest rate variable effect proved to be unsuccessful.

The equation is adjusted by GR+ADJ to remove steady state bias, where GR is the steady state growth rate of the economy and ADJ is an adjustment for changes in the logistical growth function (ADJ = -Δlogistical growth function).

\[
\Delta \ln(KSN) = (GR + ADJ) \\
+ a_1 \times \left\{ \Delta \ln\left[ \frac{KSN}{DDSNN} \right] - (GR(-1) + ADJ(-1)) \right\} \\
+ a_2 \times \left\{ \ln\left[ \frac{MGS}{MGS(-1)} \right] - GR \right\} \\
- a_0 \times \left\{ \ln\left[ \frac{KSN(-1)}{DDSNN(-1)} \right] - c_0 - \frac{c_1}{1 + c_2 \times \exp\left\{ -c_3 \times QTIME(-1) \right\}} \right\}
\]

**Results**

Sample 1974(3) to 1995(3)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Interpretation</th>
<th>Estimate</th>
<th>t-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a_1)</td>
<td>lagged dependent</td>
<td>0.443</td>
<td>5.97</td>
</tr>
<tr>
<td>(a_2)</td>
<td>imports</td>
<td>0.068</td>
<td>3.13</td>
</tr>
<tr>
<td>(a_0)</td>
<td>error correction</td>
<td>0.226</td>
<td>5.96</td>
</tr>
<tr>
<td>(c_0)</td>
<td>long run constant</td>
<td>-0.282</td>
<td>-9.22</td>
</tr>
<tr>
<td>(c_1)</td>
<td>logistical growth parameter</td>
<td>0.359</td>
<td>7.54</td>
</tr>
<tr>
<td>(c_2)</td>
<td>logistical growth parameter</td>
<td>2.474</td>
<td>3.20</td>
</tr>
<tr>
<td>(c_3)</td>
<td>logistical growth parameter</td>
<td>-0.268</td>
<td>-4.50</td>
</tr>
</tbody>
</table>
Diagnostic Statistics

R² = 0.61  
SE = 0.84%  
DW = 2.07  
Box-Pierce Q (1-8th order auto correlation) 13.30  
Jarque-Bera Test for Normality 0.62  
Chow Test for Parameter Stability 4.87*  
Ramsey's Reset Test 0.05  
Breusch-Pagan Heteroscedasticity Tests:  
  Trend 0.001  
  Y-Hat 0.43  
  Joint 0.43  

* Indicates the test has failed at the 5% confidence level.

Interpretation

Figure 2 shows the estimated logistical growth function, depicting the equilibrium level of the stocks to sales ratio, against the actual level of the stock to sales ratio. The estimated long run adjustment coefficient suggests that the model corrects any deviation between actual and desired stocks at a rate of approximately 23 per cent every quarter.

The estimation results also indicate that a 1 per cent increase in imports causes the level of stocks to increase by about 0.07 per cent after one quarter. This outcome is consistent with the reaction of domestic producers to an unanticipated increase in supply resulting from an unanticipated increase in import growth. Two quarters after an unanticipated change in import volumes, the stocks to sales ratio adjusts back to equilibrium.

1.2.6 Farm and Public Authority Stockbuilding

As opposed to non-farm stocks that appear to be dominated by movements in sales in the short run and rapidly converge to their desired level, farm stocks are affected by production (buffering the effects of volatile production) and converge on a long run desired stocks to sales ratio more slowly. The stocks to sales ratio is measured as the ratio of agricultural stockpiles (KSFM) to
commodity exports or sales (XC). In the case of farm stockbuilding, the desired stocks to sales ratio is captured by a downward time trend in the long run better than a logistical growth trend:

\[
\ln \left[ \frac{KSFM(-1)}{XC} \right] = c_0 + c_1 \times QTIME
\]

The stocks term (KSFM) is lagged once, so that the contemporaneous desired stocks to sales ratio is the level of stocks at the end of the last quarter compared to output in the present quarter. Due to the uncertain nature of agricultural supply, this appeared to be a more realistic way of looking at the options facing a stockpiling agent at any one point in time.

Short run deviations from this level are modelled by contemporaneous changes in exportable commodity production (XC plus farm stockbuilding, SFM), which capture fluctuations in stock levels due to fluctuations in commodity output, a rain index (QRAIN) and a lagged dependent variable. As with the equation for non-farm stockbuilding, the steady state bias is removed from the equation by adjusting for the steady state growth rate of the economy (GR).

This gives the following error correction model:

\[
\Delta \ln(KSFM) = \left\{ GR + \frac{c_1}{4} \right\} + a_1 \times \left\{ \Delta \ln(KSFM(-1)) - \left( GR(-1) + \frac{c_1}{4} \right) \right\} \\
+ a_2 \times \left\{ \Delta \ln(XC + SFM) - GR(-1) \right\} \\
+ a_3 \times QRAIN(-2) \\
- a_0 \times \left\{ \ln \left[ \frac{KSFM(-1)}{XC(-1)} \right] - c_0 - c_1 \times QTIME(-1) \right\}
\]

Results

Sample 1974(3) to 1995(3)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Interpretation</th>
<th>Estimate</th>
<th>t-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a_1)</td>
<td>lagged dependent</td>
<td>0.689</td>
<td>8.06</td>
</tr>
<tr>
<td>(a_2)</td>
<td>commodity production</td>
<td>0.211</td>
<td>8.30</td>
</tr>
<tr>
<td>(a_3)</td>
<td>rainfall</td>
<td>-0.006</td>
<td>-3.54</td>
</tr>
<tr>
<td>(a_0)</td>
<td>error correction</td>
<td>0.061</td>
<td>2.72</td>
</tr>
<tr>
<td>(c_0)</td>
<td>long run constant</td>
<td>0.741</td>
<td>25.31</td>
</tr>
<tr>
<td>(c_1)</td>
<td>time trend</td>
<td>-0.028</td>
<td>-6.92</td>
</tr>
</tbody>
</table>
Diagnostic Statistics

R² = 0.63  
SE = 1.35%  
DW = 2.27  
Box-Pierce Q (1-8th order auto correlation) 6.94  
Jarque-Bera Test for Normality 0.62  
Chow Test for Parameter Stability 0.91  
Ramsey's Reset Test 0.15  
Breusch-Pagan Heteroscedasticity Tests:  
  Trend 0.12  
  Y-Hat 2.16  
  Joint 2.54  

* Indicates the test has failed at the 5% confidence level.

Interpretation

All the estimated coefficients are significant. The error correction coefficient suggests that the level of stocks adjusts to any discrepancies between the desired and actual level of stocks at a rate of 6 per cent per quarter. This is roughly a quarter of the rate of adjustment of non-farm stocks and possibly reflects the larger buffering role of farm stocks.

It is difficult to interpret the negative coefficient on the QRAIN variable, given that a high level of rainfall would normally be expected to increase output and therefore the level of stocks. The equation has particular trouble capturing the behaviour of farm stockbuilding in the late eighties. In conjunction with commodity exports and the external sector generally, the farm stockbuilding equation is currently under review.
2. The Household Sector

2.1 Background

Households make decisions about consumption, saving, labour supply, dwelling investment and rental versus non-rental consumption. Households include wage earners who make wage demands. Decisions relating to wage behaviour and labour supply are discussed in Section 5, The Labour Market. The other decisions are captured by behavioural equations for private final consumption, dwelling investment and the price of rents.

Households are assumed to smooth their consumption spending over their life time in accordance with the life-cycle hypothesis - see Ando and Modigliani (1963). Therefore, total private consumption depends upon real household disposable income and real non-human private wealth, which reflects the future income potential of the associated assets. Private sector wealth is derived using the market value of dwellings (62 per cent), business assets (25 per cent) public securities (6 per cent), Australian equity investment abroad (6 per cent) and Reserve Bank liabilities (1 per cent). Household disposable income is calculated as the sum of after-tax wages, salaries and supplements and various personal benefit payments by governments.

Households are assumed to first choose their total level of consumption, and then the utility maximising proportion of total consumption devoted to rental services, using a constant elasticity of substitution (CES) utility function defined over the consumption of rental services and 'other' consumption items. The share of rental consumption depends upon the price of rental services relative to the price of non-rental consumption. However, the supply of rental services (dwelling investment) is fixed in the short run implying that the relative price of rental services is primarily driven by the relative quantity of rental to non-rental consumption.

The price of rental services is used to determine the rate of return on dwelling investment. Following the deregulation of housing finance for new loans in 1986, the financial markets determine the cost of funds for dwelling investment. This enables a Q-ratio for dwellings to be calculated as the difference between the expected rate of return on dwellings and the required rate of return based on the cost of funds. The Q-ratio is used as the primary determinant of investment in dwellings.

Once the level of total consumption and consumption of rental services is estimated, non-rental consumption can be calculated as a residual.
2.2 Equation Specification, Results and Interpretation

2.2.1 Private Final Consumption

The equilibrium level of private final consumption (CON) depends on after-tax labour income (YNZ) and the income from private non-human wealth (VMZ), both deflated by the consumption price deflator (PCON). In the long run, the marginal and the average propensities to consume out of real labour income are constrained to be equal, consistent with the life cycle and permanent income hypotheses.

This gives the following equilibrium relationship for consumption:

\[
\ln(CON) = \ln(c_0) + \ln \left( \frac{YNZ}{PCON} + c_1 \times \frac{VMZ(-1)}{PCON} \right)
\]

In the short run, households adjust their actual consumption only sluggishly towards the desired or equilibrium level. This may be due to habits or some uncertainty about whether changes are persistent. It may also reflect short term credit constraints or some buffer stock saving behaviour. To capture the short term dynamics, private consumption is modelled using a first order partial adjustment specification. Changes in the unemployment rate (RNU) are included to capture the additional effects of consumer confidence and distributional effects of changes in employment status; for example, as the employed move from secure to less secure status.

\[
\ln(CON) = \left( 1 - a_0 \right) \times \ln\left( CON(-1) \right) + a_0 \times \left[ \ln\left( c_0 \right) + \ln \left( \frac{YNZ}{PCON} + c_1 \times \frac{VMZ(-1)}{PCON} \right) \right] - a_1 \times \left[ RNU - RNU(-1) \right]
\]

Results

Sample 1980(1) to 1995(3)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Interpretation</th>
<th>Estimate</th>
<th>t-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>a0</td>
<td>partial adjustment</td>
<td>0.257</td>
<td>5.02</td>
</tr>
<tr>
<td>a1</td>
<td>change in unemployment</td>
<td>0.004</td>
<td>2.07</td>
</tr>
<tr>
<td>c0</td>
<td>long run constant</td>
<td>0.737</td>
<td>21.41</td>
</tr>
<tr>
<td>c1</td>
<td>wealth</td>
<td>0.019</td>
<td>6.35</td>
</tr>
</tbody>
</table>
Diagnostic Statistics

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>0.998</td>
</tr>
<tr>
<td>SE</td>
<td>0.65%</td>
</tr>
<tr>
<td>DW</td>
<td>2.36</td>
</tr>
<tr>
<td>Box-Pierce Q (1-8th order auto correlation)</td>
<td>10.45</td>
</tr>
<tr>
<td>Jarque-Bera Test for Normality</td>
<td>4.92</td>
</tr>
<tr>
<td>Chow Test for Parameter Stability</td>
<td>0.13</td>
</tr>
<tr>
<td>Ramsey's Reset Test</td>
<td>0.03</td>
</tr>
<tr>
<td>Breusch-Pagan Heteroscedasticity Tests:</td>
<td></td>
</tr>
<tr>
<td>Trend</td>
<td>0.45</td>
</tr>
<tr>
<td>Y-Hat</td>
<td>0.29</td>
</tr>
<tr>
<td>Joint</td>
<td>2.19</td>
</tr>
</tbody>
</table>

* Indicates the test has failed at the 5% confidence level.

Interpretation

There is considerable inertia in consumption, with the lagged dependent variable determining a significant proportion (74 per cent) of the current quarter's consumption. The long run coefficient on wealth ($c_1$) gives the quarterly expected after-tax real rate of return on wealth. This estimate implies that the annual expected after-tax real rate of return from wealth is around 8 per cent. In terms of income flows, the estimates imply that expected income from private sector wealth is roughly equivalent to 48 per cent of after-tax labour income, which is much higher than measured property income in history. After-tax real property income only accounts for around 20 per cent of household disposable income in the National Accounts.

The estimated average propensity to consume out of labour income and expected income from wealth is 0.74, which implies a high average saving ratio. This adds weight to the suggestion that income from wealth is overestimated, since overstating income (including expected income from asset holdings) will result in the average propensity to consume being understated.

The possible overstatement of income may be due to the fact that the wealth term and the household income term have a degree of collinearity. The equation is also estimated over a relatively short sample period. If the expected after-tax real rate of return from wealth were constrained to be lower, the estimated average propensity to consume out of labour income would probably be higher. The consumption equation is currently under review (in conjunction with the other household sector equations).

Other points include:

- In the short run, changes in labour income or income from wealth are initially reflected in savings. A fall in the level of income will result in a fall in savings while consumption adjusts to a new long run level.

- The wealth term introduces a mechanism by which interest rates affect consumption. An increase in interest rates reduces the market value of wealth via their effect on the business and dwelling investment Q-ratios. Other things being equal, a one percentage

---

3 Estimated by multiplying $c_1$ by the current estimate for private sector wealth (VMZ) and dividing by the current estimate of quarterly after-tax labour income (YNZ).
The point rise in the interest rate on 90 day bills directly reduce consumption by around a fifth of a percentage point in TRYM simulations.

- A change in the unemployment rate has a relatively small but significant effect on consumption behaviour beyond the direct effect on income. An increase in the unemployment rate of 1 percentage point leads to a short run fall in the level of consumption of around 0.4 of a percentage point. It is unclear why an increase in the unemployment rate has this temporary effect. It may be the case that the change in unemployment term is picking up an uncertainty effect and a buffer stock motive for saving. However, confidence effects should mainly be picked up by changes in the market value of private wealth (which is affected by valuation ratios).

2.2.2 The Demand for Rental Services

In the long run, the consumption of rental services (CRE) relative to the consumption of non-rental goods (CNR) is assumed to be a function of the price of non-rental consumption (PCNR) relative to the price of rental services (PCRE). Thus, if the price of rental services increases relative to non-rental consumption items, the desired long run amount of consumption of rental services would fall relative to that of ‘other’ consumption items. The coefficient on the relative price term ($\sigma_{dw}$) can therefore be interpreted as the elasticity of substitution between rental services and ‘other’ consumption items. It indicates the extent of substitution between rental services and other consumption items.

$$\ln \left( \frac{CRE}{CNR} \right) = \gamma_0 - \sigma_{dw} \times \ln \left( \frac{PCRE}{PCNR} \right)$$

where: $\gamma_0 = -\sigma_{dw} \times c_0$

Two time trends - (QTIME+20.875) and Q901xQTIME - have also been included in the long run specification to capture the effects of demographic changes and financial market deregulation over the whole sample period and over the 1990s, respectively.

$$\ln \left( \frac{PCRE}{PCNR} \right) = c_0 + c_1 \times (QTIME + 20.875)$$
$$- c_1 \times Q901 \times QTIME$$
$$- \frac{1}{\sigma_{dw}} \times \ln \left( \frac{CRE}{CNR} \right)$$

In the short run, the supply of rental services is effectively fixed because new dwelling investment is such a small proportion of the total dwelling stock. Therefore, in response to any excess or deficiency in demand for rental services, it is PCRE/PCNR that adjusts in the short run and not CRE/CNR to balance consumption and supply of rental services in the short run.

To illustrate, should the economy experience a positive demand shock, consumers would desire higher levels of both rental and non-rental consumption. Given that the level of rental consumption is fixed in the short run, the ratio CRE/CNR would fall and the price of rental services relative to the price of non-rental consumption would be expected to rise. The
increased price of rental services would improve the return from investment in dwellings. In
time, the resulting increase in dwelling investment would expand the dwelling capital stock and
therefore the supply of rental services.

The short term relationship between CRE/CNR and PCRE/PCNR in this illustration is broadly
consistent with that in the above long term relationship. Consequently, the relative share of
rental services to non-rental consumption, Δln(CNR/CRE), is included as a short run explanator
in the following rental price equation.

Because of contractual arrangements, actual rental prices are likely to lag equilibrium rental
prices. Accordingly, the rental price equation is estimated in error correction form, with short
run movements in rental prices explained by lagged changes, as well as the relative share of
rental services to non-rental consumption.

The equation and estimation results are shown below.

\[
\Delta \ln(\text{PCRE}) = (1 - a_1 - a_2) \times \Delta \ln(\text{PCRE}(-1)) \\
+ a_1 \times \Delta \ln(\text{PCRE}(-2)) \\
+ a_2 \times \Delta \ln(\text{PCRE}(-3)) \\
+ a_3 \times \Delta \ln\left(\frac{\text{CNR}(-3)}{\text{CRE}(-3)}\right) \\
- a_0 \times \left\{ \ln\left(\frac{\text{PCRE}(-1)}{\text{PCNR}(-1)}\right) \\
+ c_0 - c_1 \times (\text{QTIME}(-1) + 20.875) \\
+ c_2 \times Q901 \times \text{QTIME}(-1) \\
- \frac{1}{\sigma_{dw}} \times \ln\left(\frac{\text{CNR}(-1)}{\text{CRE}(-1)}\right) \right\}
\]

**Results**

Sample: 1983(1) to 1995(3)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Interpretation</th>
<th>Estimate</th>
<th>t-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a_0)</td>
<td>error correction</td>
<td>0.196</td>
<td>4.47</td>
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<tr>
<td>(a_1)</td>
<td>price of rental services</td>
<td>0.267</td>
<td>2.62</td>
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<tr>
<td>(a_2)</td>
<td>price of non-rental consumption</td>
<td>0.347</td>
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<td>(a_3)</td>
<td>non-rental to rental consumption</td>
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<td>(c_0)</td>
<td>constant</td>
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<td>(c_2)</td>
<td>time trend</td>
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<td>(\sigma_{dw})</td>
<td>non-rental to rental consumption</td>
<td>4.464</td>
<td>1.98</td>
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The Household Sector

Diagnostic Statistics

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>$R^2$</td>
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</tr>
<tr>
<td>SE</td>
<td>0.32%</td>
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<tr>
<td>DW</td>
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<td>Box-Pierce Q (1-8th order auto correlation)</td>
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<td>Jarque-Bera Test for Normality</td>
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<td>Chow Test for Parameter Stability</td>
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<td>Ramsey's Reset Test</td>
<td>0.00</td>
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<tr>
<td>Breusch-Pagan Heteroscedasticity Tests:</td>
<td></td>
</tr>
<tr>
<td>Trend</td>
<td>2.50</td>
</tr>
<tr>
<td>Y-Hat</td>
<td>2.60</td>
</tr>
<tr>
<td>Joint</td>
<td>2.87</td>
</tr>
</tbody>
</table>

* Indicates the test has failed at the 5% confidence level.

Interpretation

The results suggest that a gap between the actual and desired equilibrium price of rents is eroded by 20 per cent per quarter. The equation also implies that:

- the elasticity of substitution between rental services and non-rent consumption is about 4.5; and
- an increase of one per cent in the relative share of non-rental to rental consumption increases the relative level of rents by 0.19 per cent after one quarter.

As indicated above, the demand for rental services is currently being re-examined in conjunction with other equations in the household sector.

2.2.3 Dwelling Investment

The Q-ratio for dwellings (QDW) is the primary determinant of dwelling investment. It is defined as the ratio of the expected rate of return from an extra unit of dwelling capital to the required rate of return of that investment were it at the profit maximising margin (when the required rate of return equals the user cost of capital) - in line with the business sector Q-ratio discussed in Section 1.2.3. Conceptually, when QDW is greater than one, households would be expected to invest in dwellings, when QDW is less than one, households will face an incentive to reduce their investment, and when QDW is equal to one dwelling investment should be sufficient to maintain the desired growth in the stock of dwellings (KDW).

Conceptually, dwelling services are expanded until the expected rate of return from the marginal dwelling investment equals the user cost of capital (interest cost plus depreciation). The expected rate of return on the marginal dwelling investment is calculated as the ratio of the price of rental services (PCRE) to the implicit price deflator for dwelling investment (PIDW), adjusted for the rate of tax on the consumption of rental services (RTCRE), times the amount of rental services produced each quarter by a unit of dwelling investment. The historical average ratio of production of dwelling rents to the dwelling capital stock is 0.023134. The expected rate of return on dwelling investment is therefore given by:
**Expected rate of return on dwelling investment**

\[
\text{Expected rate of return on dwelling investment} = \frac{(1 - RTCRE) \times PCRE \times 0.023134}{PIDW}
\]

In the long run, the user cost of capital for dwellings will be equal to the 10 year bond rate (RIGL) less long run inflationary expectations plus the physical depreciation rate on dwellings (RKDDW) adjusted for the interaction of physical depreciation and expected inflation (see discussion on the business sector Q-ratio). In the short run, however, the cost of funds for dwelling investment is also influenced by short term interest rates. The short run cost of funds for investment in dwellings is therefore calculated as a weighted average of long bond rates (RIGL) and the 90 day bank bill rate (RI90). The method used to measure inflationary expectations is examined in Section 6 (Financial Markets). The required rate of return on the marginal dwelling investment (equal to the user cost of capital) is therefore given by:

\[
\text{Required rate of return} = RKDDW \times \left( 1 + \frac{FIE}{400} \right) + \frac{\left( a_6 \times RIGL + \left( 1 - a_6 \right) \times RI90 - FIE \right)}{(400 + 4 \times FIE)}
\]

QDW is therefore defined as:

\[
QDW = \frac{(1 - RTCRE) \times PCRE \times (0.023134)}{PIDW \times \left( RKDDW \times \left( 1 + \frac{FIE}{400} \right) + \frac{\left( a_6 \times RIGL + \left( 1 - a_6 \right) \times RI90 - FIE \right)}{(400 + 4 \times FIE)} \right)}
\]

In the long run, when QDW is at unity, investment in dwellings (IDW) as a ratio of the dwelling capital stock (KDW) is assumed to grow at the equilibrium growth rate of the economy (GR) plus the rate of depreciation on the dwelling capital stock (RKDDW). As explained in Section 1.2.3 in relation to business investment, GR is the sum of the growth of underlying productivity growth in the economy and growth in the adult population.

In the short run, dwelling investment is a function of QDW. In particular, contemporaneous and lagged QDW is found to impact on investment in dwellings. This is consistent with the influence of lags in households' response to changes in economic conditions due, for example, to the time taken in planning housing investment and in gaining approval to start construction. Because of the serial correlation in QDW, freely estimated coefficients tended to vary in size and significance in an erratic fashion. To smooth the reaction of dwelling investment to QDW, and to consistently obtain significant coefficients, the estimated parameters on QDW have been constrained to be the same.

Past dwelling investment is also used to explain contemporaneous dwelling investment. This effectively captures the discrete nature of dwelling investment and the associated inertia or serial correlation in dwelling investment behaviour.

The preferred dwelling investment equation is therefore as follows:
The Household Sector

\[
\frac{IDW}{KDW(-1)} = (GR + RKDW) \times \left(1 - a_1 - a_2 - a_3 - a_4\right) \\
+ a_1 \times \frac{IDW(-1)}{KDW(-2)} + a_2 \times \frac{IDW(-2)}{KDW(-3)} \\
+ a_3 \times \frac{IDW(-3)}{KDW(-4)} + a_4 \times \frac{IDW(-4)}{KDW(-5)} \\
+ a_5 \times \left[\left(QDW(-1) + (QDW(-1) - 1) + (QDW(-2) - 1)\right) + \left(QDW(-3) - 1\right) + \left(QDW(-4) - 1\right)\right]
\]

Results

Sample: 1986(1) to 1995(3)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Interpretation</th>
<th>Estimate</th>
<th>t-Statistic</th>
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<td>(a_2)</td>
<td>past investment</td>
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<td>(a_3)</td>
<td>past investment</td>
<td>0.058</td>
<td>0.35*</td>
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<tr>
<td>(a_4)</td>
<td>past investment</td>
<td>-0.210</td>
<td>-1.86*</td>
</tr>
<tr>
<td>(a_5)</td>
<td>Q-ratio</td>
<td>0.0004</td>
<td>5.59</td>
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<tr>
<td>(a_6)</td>
<td>interest rate split</td>
<td>0.664</td>
<td>12.12</td>
</tr>
</tbody>
</table>

Diagnostic Statistics (based on single equation estimates)

- \(R^2 = 0.94\)
- \(SE = 0.03\%\)
- \(DW = 1.84\)
- Box-Pierce Q (1-8th order auto correlation) = 5.97
- Jarque-Bera Test for Normality = 0.84
- Chow Test for Parameter Stability = 1.35
- Ramsey's Reset Test = 0.22
- Breusch-Pagan Heteroscedasticity Tests:
  - Trend = 1.00
  - Y-Hat = 1.00
  - Joint = 1.68

* Indicates the test has failed at the 5% confidence level.

Interpretation

The coefficients on the second, third and fourth lags of past dwelling investment are insignificant. These have been included to maintain continuity in the lag structure.

The equation implies that if the rate of return from investing in dwellings is 10 per cent greater than the user costs associated with the investment, dwelling investment as a ratio of the capital stock will increase by 0.04 per cent after 5 quarters. Other features of the results are:

- The lag structure implies that there will be significant short run cycles in dwelling investment. An increase in investment in dwellings today will persist for three quarters after which it will begin to be reversed. This is consistent with a dwelling cycle of around
four years, possibly due to time-to-build lags and coordination failure (eg a persistent cobweb cycle). The dwelling construction sector is characterised by low entry costs and, hence, large numbers of small businesses.

- The elasticity on the Q-ratio implies that a one percentage point rise in the 90 day bill rate will directly reduce dwelling investment by 2.7 per cent after 5 quarters (other things being equal).

- The estimates imply that in measuring the cost of funds to obtain the QDW, about two thirds of the weight should go on long term interest rates and one third on short rates.
3. **Public Sector**

3.1 **Background**

This section examines the treatment of the government business enterprise sector and the general government sector in the TRYM model. The TRYM model abstracts from detailed information on the various levels of government and all estimation is carried out on data that have been aggregated across all tiers of government.

3.1.1 **Government Enterprises**

Government enterprises are treated separately from private sector firms because investment behaviour by government enterprises is very different from that of private business enterprises. In addition, a number of enterprises (including, for example, Telstra) have moved between the general government sector and government enterprise sectors over the last two decades. Furthermore, historically at least, government enterprises have not sought to maximise profits. Despite these differences, government enterprises are assumed to have the same underlying production technology as private sector firms.

Equations are estimated for labour demand and quantity of output by government enterprises, and an identity is used to define output prices. Labour demand is largely determined by the available capital stock, while the output equation is in reduced form and is demand determined in the short run, but supply determined in the longer run. Prices charged by government enterprises are assumed to move in line with prices charged by the private business sector.

Very limited data are published by the ABS for government enterprise employment, output or prices and therefore limited data are available on a consistent basis. However, data have been constructed for the government enterprise sector specifically for use in the TRYM model. These data are constructed using a combination of unpublished information from the ABS and a variety of assumptions. The quality of the data has had an adverse impact on the fit of the estimated equations described below.

3.1.2 **General Government**

The general government sector is represented in the model by three equations dealing with expenditure, revenue and the public sector borrowing requirement (PSBR). The former two are modelled explicitly, with the PSBR being determined as a residual. The stock of public debt is determined, in turn, by the PSBR. Expenditure is applied to public final demand and transfers.

Net expenditure on public final demand consists of purchases of capital services, payment for labour services in general government employment and purchases of goods and services from elsewhere, defined as government market demand. Purchases of capital services and government market demand are exogenously determined, while purchases of general government labour services have an endogenous wage component.
Net expenditure on transfers includes unemployment benefits, other personal benefit payments (which include spending on pensions, amongst other things), transfers to non-profit institutions for consumption purposes (which are exogenously determined as a proportion of GDP) and transfers overseas, which are also exogenously determined as a proportion of GDP.

The model also contains a default fiscal policy response mechanism, which is designed to restrict the amount of public debt that is allowed to accumulate. It operates through general government revenue collections and automatically ensures shifts in fiscal policy setting in response to changes in the economic environment. By its very nature, the reaction function is a highly simplified representation of the policy formation process. It does not represent how governments would or should act, but rather one plausible way that they could act. While the reaction function is imposed and not estimated, it has important effects on the simulation properties of the model and alternative specifications are currently under consideration.

The response mechanism is set so that the fiscal target — an exogenously predetermined public debt to GDP ratio — is achieved in the medium to long run. Government deficits are assumed to be debt financed in the short run (although the TRYM model also has the capacity to allow deficits to be financed by ‘printing money’). Debt is issued both in the domestic and foreign bond markets, with the relative composition based on historical averages.

In moving toward the target debt to GDP ratio, all the adjustment is assumed to take place by changes in the rate at which government revenue is collected. In particular, in the medium to long run, direct tax rates on labour and business incomes change to restore the public debt to GDP ratio to the exogenously specified level.

Indirect tax rates are fixed, so that this source of revenue only fluctuates with changes in the tax base. Indirect taxes levied on payrolls and fringe benefits apply as an exogenous tax rate on wages, which is normally held constant. Indirect taxes on other items apply as an exogenous implicit tax rate on items of expenditure. The incidence of the indirect taxes is consistent with information from Treasury's microeconomic model, PRISMOD (1992).

Once the expenditure and revenue decisions have been determined, the PSBR is derived. It is split into debt issued domestically, overseas in Australian dollars, overseas in foreign currencies and revenue from overseas reserve assets.

### 3.2 Equation Specification, Results and Interpretation

#### 3.2.1 Government Enterprise Labour Demand

Labour demand by government enterprises is formulated in terms of hours worked, with NEGE representing the total number of persons employed in the sector and NH representing an economy-wide measure of average hours worked per person. This parallels the treatment of employment in the private business sector.

In the long run, government enterprise labour demand is expressed as a function of the government enterprise capital stock (KGE) and the underlying efficiency of labour. As in the private business sector, a time trend is used to capture the increase in Harrod neutral efficiency. Allowance is made for the different underlying productivity growth in the government enterprise sector relative to that experienced in the private sector ($\lambda$) by incorporating an additional time
trend and coefficient. With this exception, the production technology in the government enterprise sector is assumed to be the same as in the private business sector.

In contrast to the specification for labour demand in the private business sector, labour costs were found to be an insignificant determinant of government enterprise labour demand in the long run. This may reflect non-profit maximising behaviour and inflexible employment patterns over the 1970s and 1980s, rather than Leontief production technology.

Long run labour demand is expressed as follows:

\[
\ln(NEGE \times NH) = \ln(KGE) + c_0 - c_1 \times QTIME - \lambda \times QTIME
\]

Government enterprises take time to increase their labour demand in response to new investment projects. To capture these lags, an error correction specification was chosen, with a lagged dependent variable providing additional dynamics.

\[
\Delta \ln\left(\frac{NEGE \times NH}{KGE(-1)}\right) = -c_1 \times (\Delta QTIME) - \frac{\lambda}{4} + a_1 \times \Delta \ln\left(\frac{NEGE(-1) \times NH(-1)}{KGE(-2)}\right) + c_1 \times (\Delta QTIME) + \frac{\lambda}{4} + a_0 \times \left[c_0 - c_1 \times QTIME(-1) - \lambda \times QTIME(-1) - \ln\left(\frac{NEGE(-1) \times NH(-1)}{KGE(-2)}\right)\right]
\]

Results (from joint estimation of public enterprise employment and output equations)

Sample: 1970(1) to 1995(3)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Interpretation</th>
<th>Estimate</th>
<th>t-Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>a_1</td>
<td>lagged dependent</td>
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<td>1.11*</td>
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<tr>
<td>a_0</td>
<td>error correction</td>
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<td>1.74*</td>
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<tr>
<td>c_0</td>
<td>long run constant</td>
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<td>-319.96</td>
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<tr>
<td>c_1</td>
<td>difference in productivity</td>
<td>0.036</td>
<td>14.92</td>
</tr>
</tbody>
</table>

Diagnostic Statistics (based on single equation estimates)

\[ R^2 = 0.999 \]
\[ SE = 1.16\% \]
\[ DW = 2.01 \]

Box-Pierce Q (1-8th order auto correlation) 8.38
Jarque-Bera Test for Normality 5.12
Chow Test for Parameter Stability 4.57*
Ramsey's Reset Test 2.83
Breusch-Pagan Heteroscedasticity Tests:
  Trend 4.09*
  Y-Hat 4.17*
  Joint 4.19

* Indicates the test has failed at the 5% confidence level.
# The equation is transformed and estimated with the level of NEGE as the dependent variable.
**Interpretation**

The equation implies that, over the long run, labour productivity growth has been 3.6 per cent per annum higher in the government enterprise sector than in the private business sector. Overall, therefore, labour productivity growth in government enterprises is estimated to have been 4.4 per cent per annum over the period. This estimate should be interpreted with caution given changes in industry composition and problems measuring the capital stock for the sector.

The coefficient on the error correction term implies that labour demand adjusts to changes in investment with a mean lag of around 3½ years. The demand for labour substantially lags changes in investment demand. This long lag time may reflect the time taken in undertaking an investment or sluggish response of government enterprises due to public sector employment conditions.

The equation specification was made difficult by uncertainty over the extent to which government enterprises have sought to maximise profits, have pursued alternative strategies and/or were constrained by government-imposed community service obligations. The difficulty in detecting a significant effect of labour costs on labour demand might suggest that commercial principles have not heavily influenced government enterprise decision making over the entire estimation period. Indeed, this was one of the reasons for distinguishing between the private business sector and government enterprises in constructing the model. As further investigation reveals a more satisfactory theoretical basis for the equation specification, or as the data begin to reflect greater commercial orientation government enterprises following the reforms of recent years, there will be scope to improve the government enterprise labour demand equation.

**3.2.2 Government Enterprise Output**

In the long run, government enterprise output (GGE) is assumed to be driven by supply capacity, which is a function of the underlying production technology in the government enterprise sector. Given that government enterprises have not always exhibited profit maximising behaviour, it is difficult to estimate a production function. It has therefore been assumed that government enterprises have the same basic production technology as the private business sector. In particular, it has been assumed that the elasticity of substitution between capital and labour (\(\sigma\)) and the underlying productivity growth (\(\lambda\)) for government enterprises is the same as for private sector firms. Additional productivity has been allowed for by including scaling factors to account for the different levels and growth of productivity experienced by the government enterprise sector in the past relative to the private business sector.

The production function outlined for the private business sector in Section 1 may be rewritten as follows for the government enterprise sector, expressing government enterprise output as a function of government enterprise employment, average hours worked and government enterprise capital stock. The inclusion of parameters (\(c_0\), \(c_1\) and \(c_2\)) allows for different productivity levels and growth rates in the government enterprise sector. Productivity growth rates for government enterprises exhibited a structural break in the early 1990s, and this is captured by an additional time trend (\(c_2^*Q901\)).

\[
\ln(GGE) = \ln\left(c_0 + (c_1 + c_2 \times Q901) \times QTIME\right) + \frac{\sigma}{\sigma - 1} \times \ln \left\{ \alpha \times [NEGE \times NH \times \exp(\lambda \times QTIME)]^{(1-\sigma)} + \beta \times [KGE]^{(1-\sigma)} \right\}
\]
Government enterprise output represents quantities actually demanded as well as supplied. Short run fluctuations in output are thought to be largely demand determined, as with the private business sector. Therefore, in the short run, government enterprise output is also determined by growth in private and public output (GB+GGE). Following is the error correction specification.

\[
\Delta \ln(GGE) = GR + \left( c_1 + c_2 \times Q901 \right) \times \left( QTIMF - QTIMF(-1) \right) \\
+ a_1 \times \left[ \ln \left( \frac{GB + GGE}{GB(-1) + GGE(-1) \times \exp\left( c_1 + c_2 \times Q901 \times (QTIMF - QTIMF(-1)) \right)} \right) - GR \right] \\
+ a_2 \times \left[ \ln \left( \frac{GB(-1) + GGE(-1)}{GB(-2) + GGE(-2) \times \exp\left( c_1 + c_2 \times Q901 \times (QTIMF - QTIMF(-1)) \right)} \right) - GR(-1) \right] \\
+ a_0 \times \left[ \ln \left( c_0 + c_1 \times QTIMF + c_2 \times Q901 \times (QTIMF + 0.125) + \left( \frac{\sigma}{\sigma - 1} \right) \times \right) \right] \\
\ln \left[ \alpha \times \left[ NEGE(-1) \times NH(-1) \right]^{(1-\sigma)} \times \exp\left( \lambda \times QTIMF(-1) \right) \right] + \beta \times \left[ KGE(-2) \right]^{(1-\sigma)} - \ln(GGE(-1)) \\
\]

Results (from joint estimation of public enterprise employment and output equations)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Interpretation</th>
<th>Estimate</th>
<th>t-Statistic</th>
</tr>
</thead>
<tbody>
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<td>error correction</td>
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<td>(c_0)</td>
<td>long run constant</td>
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<tr>
<td>(c_1)</td>
<td>trend productivity</td>
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<td>(c_2)</td>
<td>90s trend productivity</td>
<td>0.048</td>
<td>9.07</td>
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Diagnostic Statistics

<table>
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<th>Parameter</th>
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<td>(R^2) = 0.999 #</td>
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<td>SE = 1.1%</td>
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<td>DW = 1.85</td>
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<td>Box-Pierce Q (1-8th order auto correlation)</td>
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<td>Jarque-Bera Test for Normality</td>
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<td>Chow Test for Parameter Stability</td>
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<td>Breusch-Pagan Heteroscedasticity Tests:</td>
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<td>Trend</td>
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<td>Y-Hat</td>
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<tr>
<td>Joint</td>
<td>0.97</td>
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</tbody>
</table>

* Indicates the test has failed at the 5% confidence level.

# The equation is transformed and estimated with the level of GGE as the dependent variable.
Interpretation

The estimated coefficients suggest that government enterprise output responds to increased demand in the short run. A one per cent increase in aggregate demand leads to an increase in output by government enterprises of about 0.74 per cent. However, supply constraints will determine government enterprise output in the long run. The mean lag on the adjustment to equilibrium is about 1½ years.

The estimated coefficients imply that productivity growth in the government enterprise sector was 2.3 per cent per annum higher than for the private business sector over the 1970s and 1980s, and an additional 4.8 per cent per annum higher in the 1990s. These coefficients need to be viewed with caution as the quality of the data for the public sector is likely to have had an impact on all estimates for this sector.

3.2.3 Government Enterprise Prices

An attempt was made to estimate an equation for the price of government enterprise output (PGGE) as a function of consumer choices between public and private enterprises. This proved unsuccessful owing to the relatively poor quality of the data (the ABS does not publish price data on the split between public and private enterprises). PGGE is therefore determined by an exogenously determined ratio (XRPGGE) and the price of business output, according to the following simple identity:

\[ \text{PGGE} = \text{XRPGGE} \times \text{PGB} \]

3.2.4 The Default Fiscal Policy Response Mechanism

TRYM has a default fiscal policy reaction function, but it is just one possible way of dealing with fiscal policy in the model. Whether the default reaction function is used depends on the purpose for which the model is being used. As outlined in the *Macroeconomics of TRYM*, 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 rather than the default functions.\(^4\)

The default fiscal policy response function is relevant where the fiscal policy variables are not specified by assumption and the optimal control algorithm is not being used. A series of identities governs the issuing of bonds that finance budget deficits in the short run. These are shown in Appendix C. The default fiscal policy response mechanism governs the stance of fiscal policy in the medium to long run and is based on the following framework.

A target level of government debt to GDP (XRVDGT) is exogenously specified and the rate of tax on labour income (RTN) and capital income (RTK) changes to move the actual debt to GDP ratio toward the target level over the long run.

\[^4\] Refer to Louis (1995) for a more detailed discussion of the optimal control algorithm.
The stock of government debt is defined as the sum of government ($A) debt held by the overseas sector (VDGOAZ), government foreign currency held by the overseas sector (VDGOFZ) and government debt held by the private sector (VDGPZ), less official reserve assets (VDOGFZ). Therefore, the actual ratio of government debt to GDP (nominal average GDP, GDPAZ) is defined as:

\[
\text{Debt to GDP ratio} = \frac{VDGOAZ + VDGOFZ + VDGPZ - VDOGFZ}{GDPAZ}
\]

Under the default fiscal reaction function, tax rates respond to the difference between the current debt to GDP ratio and the long term debt to GDP target. For example, if the current debt to GDP ratio is above the target then taxes will rise.

In addition, tax rates also respond to the direction of movement of the debt to GDP ratio relative to the target. This means that if the current debt to GDP ratio is moving further away from the target, taxes will change more rapidly than otherwise. With a policy simulation using TRYM, in the absence of specific exogenous changes to the budget deficit in the short run, the default fiscal policy reaction function will determine the year-by-year changes to the budget deficit.

The default fiscal policy reaction function for RTN is defined as follows:

\[
\Delta RTN = A1RTN \times \left( \frac{VDGOAZ + VDGOFZ + VDGPZ - VDOGFZ}{GDPAZ} - XRVDGT \right) \\
+ A2RTN \times \left( \left( \frac{VDGOAZ + VDGOFZ + VDGPZ - VDOGFZ}{GDPAZ} - XRVDGT \right) \right)
\]

\[
+ A2RTN \times \left( \left( \frac{VDGOAZ(-1) + VDGOFZ(-1) + VDGPZ(-1) - VDOGFZ(-1)}{GDPAZ(-1)} - XRVDGT(-1) \right) \right)
\]

The parameters A1RTN and A2RTN were chosen to ensure that the full model produced reasonable simulation properties while ensuring that the actual debt to GDP ratio returns to the target level within a reasonable time frame.

The (imposed) parameter values are:

\[
A1RTN = 0.007 \\
A2RTN = 0.12
\]

As noted, the rate of tax on capital income (RTK) also adjusts to bring the government debt to GDP ratio back toward the targeted level. Movements in RTK are governed by changes in RTN via an exogenously determined ratio (XRRRTK) according to the following identity:

\[
RTK = RTN \times XRRRTK
\]