IMPACT OF DEMOGRAPHIC CHANGE ON INDUSTRY STRUCTURE IN AUSTRALIA

A joint study by the Australian Bureau of Statistics, the Department of Employment and Industrial Relations, the Department of Environment, Housing and Community Development, the Department of Industry and Commerce and the Industries Assistance Commission

CONFIDENTIAL : Not for quotation withour prior clearance from the authors; comments welcome

A MACRO MODULE FOR THE IMPACT MODEL

by

B. R. Bacon

and

H. N. Johnston

Australian Bureau of Statistics
Canberra

Preliminary Working Paper No. MP-01 Melbourne December 1976

Reprinted August 1977

The views expressed in this paper do not necessarily reflect the opinions of the participating agencies, nor of the Australian government.

IMPACT Project, Industries Assistance Commission, 606 St. Kilda Road, Melbourne, Victoria 3004 Australia
Area Code 03 Telephone 51 8611

CONTENTS

A MACRO MODULE FOR THE IMPACT MODEL

by

B. R. Bacon

and

H. N. Johnston*

Australian Bureau of Statistics
Canberra

1. INTRODUCTION

A general description of the modular structure of the IMPACT model has been given by Powell and Lawson [20] . There are three modules; MACRO is a medium term macro model of the Australian economy, ORANI is a general equilibrium model of industrial structure, and BACHUROO is a longer run model of population characteristics and the labour force. The theoretical specification of the ORANI module has been documented in [7] and [19] and the specification of the BACHUROO module is documented in [23]. This paper provides a preliminary report on the adaptation for the MACRO module, of a small medium term model of the Australian economy that has been developed by Jonson, Moses and Wymer [11], [12] at the Reserve Bank of Australia. This is referred to below as the RBA76 model.[1]

---

* The authors would like to acknowledge the considerable assistance that Peter Jonson and the staff at the Research Department of the Reserve Bank have given in our work with the RBA76. It must be unusual for a model to be as exhaustively evaluated by an independent party as to data concepts, replication of results and robustness. It is hoped that their own work has benefited as much by the interchange. Needless to say however, the results and opinions expressed herein are our own and need not be in agreement with their considered opinion.

1. The model discussed in this paper and listed in appendices A, B and C, refers to an earlier version of RBA76 made available at the RBA Conference in Applied Economics, Sydney, September, 1976. Attention will be drawn to significant differences as they arise in the course of the paper.

The function of the MACRO module is to provide the macroeconomic aggregates to drive the ORANI and BACHUROO modules. The interaction and feedback between the modules is discussed in more detail below, but it is clear that both the long run and the short run tracking ability of the IMPACT model depend critically on the MACRO module. While the principal concern of the IMPACT model is with medium to long term structural change in the economy, the sensitivity of policy change to short run adjustment costs means that the model must also be capable of evaluating the short run dynamic response to policy change. In many respects this is the most difficult modelling task facing the project. It can only be satisfied if the MACRO module successfully captures the short run business cycle and the ORANI and BACHUROO modules respond to short run disequilibrium. The development strategy for the IMPACT project [10], has identified these as separate objectives. The initial objective is to develop a model that provides a satisfactory medium to long term performance, with a later objective of improving the dynamic linkages between the modules to provide satisfactory short term solutions. In the case of the MACRO module, no advantage is gained by tackling the two issues separately and indeed, from an estimation point of view, more reliable results might be obtained from time series data if the specification reflects short run disequilibrium effects.

The RBA76 model appears to be well suited to the purpose of the MACRO module. It is referred to as a minimal model by its authors, by virtue of the fact that it limits its attention to the major economic aggregates. In all, it contains 22 endogenous variables, 17 exogenous variables, 18 behavioural equations and 4 identities. The economic theory embodied in the model is discussed in more detail below. An interesting feature of the model is its theoretical formulation as a set of non-linear differential equations in continuous time in the tradition of the models developed by Bergstrom and Wymer [1], Knight and Wymer [16], and Jonson [14] for the UK economy. The theoretical underpinnings of the specification and estimation of continuous time models is now well developed and Bergstrom [2] has recently edited a volume encompassing this literature. The RBA76 model is estimated using a FIML package developed by Wymer at the London School of Economics. The facility is part of a general estimation system designed specifically for implementing continuous time models. The estimation method consists of three basic steps. The first *linearises* the model around the long term growth path of the model to enable use of FIML system estimation methods. Non-linear FIML procedures, such as the Wymer package ASIMUL, are available but they are considered to be computationally impractical even for a minimal model of the size of RBA76. Similar restrictions apply to linear FIML procedures but are less severe, thus the advantages gained in using FIML system estimation have to be weighed against the cost incurred in the consequent practical limitation that the model be minimal and linear in variables. These costs are minimised by linearising the model about its long term growth path. The second step entails the transformation of the continuous time model into an "equivalent" discrete time model; a process referred to as *discretisation.* This step is required in order to express the theoretical model in terms of observable magnitudes. The third step is that of *estimation.* The theoretical specification of the model assumes that the continuous time equation residuals are white noise. The process of discretisation introduces serial correlation into the estimating equations, which must be recognised if satisfactory parameter estimates are to be obtained. The approach taken [1, pp. 36-39] is to filter all the variables in the equations using a fixed weight "continuous system moving average (COSMA) transformation." Under the maintained hypothesis that the underlying continuous time residuals are white noise, the effect of the transformation is to render the discrete time transformed residuals white. We discuss the COSMA transformation in more detail below.

In discretising a continuous time model, a choice of observation interval has to be made. In the case of the RBA76 model, the choice is for quarterly data over the interval 1958.3 to 1974.4, giving 62 observations with which to estimate the model. One advantage in working with a theoretical model specified in continuous time is that the parameter estimates relate to the continuous time specification. Suitable discretisation of the estimated model can then yield a discrete time model defined in terms of any chosen time interval. In the case of the IMPACT model, the ORANI and BACHUROO modules are estimated with annual data so MACRO has also to be specified in annual terms. The details of translating the quarterly model into an annual model are given below. It will be evident that the approximations are more severe, the wider the time interal and it is possible that some pragmatic adjustments will have to be made to the estimates to yield useful results.

The structure of the rest of the paper is as follows. Section 2 outlines in more details the steps of *linearisation*, *discretisation*, *estimation* and annualisation of the continuous time specification. Section 3 reviews the economic theory underlying the RBA76 model and discusses possible modifications to the specification to better suit the requirements of the IMPACT project.

2. METHODOLOGY

The theoretical specification of the RBA76 model is given in appendix A and the estimated parameters for the quarterly model are given in appendix B.

2.1 The Model

The general form of the equations in the model is typified by the consumption function :

$$D \log d = \alpha_1(\log \hat{d} - \log d) + \gamma_1(\log \hat{m} - \log M/P) \quad (2.1.1)$$

$$\log \hat{d} = d_0 + \log(y - T_1/P + c) + \beta_1 \log r \quad (2.1.2)$$

$$\log \hat{m} = m_0 + \log(y) + \beta_2 \log r \quad , \quad (2.1.3)$$

where

d = real consumption ;

M = nominal value of money ;

m = real value of money ;

y = real output net of depreciation ;

P = price of output ;

T_1 = nominal income taxes ;

c = real cash benefits ;

r = nominal interest rate ;

D is the first derivative operator; and ^ indicates desired level .

It is useful to distinguish between the stock and flow variables of the model. A continuous time system is specified in terms of the *rate of flow* of flow variables and the *stock* of stock variables at each point in time. In principle we can distinguish between a stock variable, which can be measured at any instant in time, and a flow variable, which can only be measured by reference to its behaviour over an interval of time (however small) in the neighbourhood of that point. The classification of most variables is quite clear. Thus, d and y are obvious examples of flow variables and M is an example of a stock variable. An illustration of the way in which the method of measurement of a variable can influence its classification is that of the interest rate. If it is measured by the ratio of the flow of interest receipts to the value of the stock of an interest earning asset, then r is a flow variable. If, however, r is measured as a quoted rate, relative to some given reference period (for example, a year) at a given point in time it is a stock variable.[1] Price deflators are defined as the ratio of the nominal flow of goods or services to the real flow of those goods or services and are accordingly stock variables; although they are conceptually average stock values measured at the *mid point* of the reference period. The point of measurement of stock variables is relevant to the discretisation process described below.

---

1. The reference period for the quoted rate must be known, but it is not relevant to the stock/flow distinction. Thus it is possible to have an annual rate appear in a quarterly model and alternatively a quarterly rate appear in an annual model. It would seem more suitable to use annual rates in both systems. The RBA76 model is specified in terms of an annual rate (see appendix A and Note 2).

2.2 Linearisation

The model is linearised around its long term growth path so that it is *linear in logarithms* of the variables. The long term growth path is considered to be that equilibrium growth path towards which the variable adjusts, if all exogenous variables grew at geometric rates in the absence of residual perturbation. Consider the variable R with the long term growth path $R^* e^{\lambda t}$. We employ the truncated Taylor series approximation to the exponential function :

$$e^x \doteq e^\alpha + (x - \alpha)\, e^\alpha \quad .$$

If we set

$$x = \log R \quad ,$$

and

$$\alpha = \log(R^* e^{\lambda t}) \quad ,$$

we have

$$e^x = R \quad ,$$

and

$$e^\alpha = R^* e^{\lambda t} \quad ;$$

so that with rearranging :

$$R \doteq R^* e^{\lambda t} (1 + \log R - \log R^* - \lambda t) \quad . \qquad (2.2.1)$$

Similarly, if we have two variables P and Q with long term growth paths $P^* e^{\lambda_1 t}$ and $Q^* e^{\lambda_2 t}$ respectively, we have that

$$PQ \doteq P^*Q^* e^{(\lambda_1 + \lambda_2)t}[1 + \log PQ - \log P^*Q^* - (\lambda_1 + \lambda_2)t] , \qquad (2.2.2)$$

and

$$P/Q \doteq (P^*/Q^*) e^{(\lambda_1 - \lambda_2)t}[1 + \log(P/Q) - \log(P^*/Q^*) - (\lambda_1 - \lambda_2)t] ; \qquad (2.2.3)$$

and if P + Q has the long term growth path $A^* e^{\lambda t}$:

$$\begin{aligned} \log(P + Q) \doteq\ & (P^*/A^*) e^{(\lambda_1 - \lambda)t}[\log P - \log P^* + 1 - \lambda_1 t] \\ & + (Q^*/A^*) e^{(\lambda_2 - \lambda)t}[\log Q - \log Q^* + 1 - \lambda_2 t] \\ & + \log A^* + \lambda t - 1 . \end{aligned} \qquad (2.2.4)$$

Equations (2.2.1) to (2.2.4) provide all the basic approximations required to log-linearise the RBA76 model. It is clear that the approximations will be better, the closer the variable is to its growth path. Equations (2.2.1) to (2.2.4) are not log-linear themselves, because each log variable is prefixed by a corresponding exponential growth term. However, when the expressions for R, dR, etc. are substituted into the model the exponential growth and linear time trends cancel out if the growth paths of the model variables are *consistent* with each other. Equation (2.2.4) is used to log-linearise the linear identities in the model. If P and Q have the same long term growth rate of λ , then equation (2.2.4) becomes :

$$\begin{aligned} \log(P + Q) \doteq\ & \left(\frac{P^*}{P^* + Q^*}\right) \log P + \left(\frac{Q^*}{P^* + Q^*}\right) \log Q \\ & + [(P^* + Q^*) \log(P^* + Q^*) - P^* \log P^* \\ & - Q^* \log Q^*] \Big/ (P^* + Q^*) . \end{aligned} \qquad (2.2.6)$$

The major difficulty with log-linearisation is that the sample period history of the variables may not be consistent with the assumption of equal growth rates. Indeed, there may be good institutional reasons why all the variables in an identity do not have the same growth path. For example, in the consumption equation, a tendency over time for the public sector to increase in size relative to the private sector, would mean that T_1/P would have a different rate of growth to Y. Such a trend could not continue indefinitely, but the steady state of that structural change might be so far in the future as to be of no interest over the horizon for which the MACRO module is to be used. The RBA76 model imposes the P^* and Q^* values prior to the FIML estimation phase. To minimise the effect of the divergent growth rates the P^* and Q^* are now calculated at the mid point of the sample, which is equivalent to using the antilogs of the means of the logarithms of the variables. If the growth rates are too divergent, a time trend may have to be added to the equation. A residual constant is also estimated for each equation. Using superscript * to indicate values of the growth paths of the variables at the mid point of the sample, the linearisation of the consumption function gives :

$$D \log d = \alpha_1(\log \hat{d} - \log d) + \gamma_1(\log \hat{m} - \log M + \log P) \; ; \qquad (2.2.7)$$

$$\log \hat{d} = k + x_1^*.\log y - x_2^*.\log T_1 + x_2^*.\log P + x_3^*.\log c + \beta_1.\log r \; ; \qquad (2.2.8)$$

where

$$x_1^* = y^*/(y^* - T_1^*/P^* + c^*) \; ,$$

$$x_2^* = T_1^*/P^*(y^* - T_1^*/P^* + c^*) \; ,$$

$$x_3^* = c^*/(y^* - T_1^*/P^* + c^*) \; ,$$

and

$$\log \hat{m} = m_0 + \log y + \beta_2 \log r \; . \qquad (2.2.9)$$

It should be stressed that the linearisation phase is not essential to estimation of the model if one is satisfied with the use of single equation estimation methods. It is not the linearisation around the growth paths that ensures that the model exhibits realistic long run behaviour. The long run behaviour of the model is determined by the theoretical specification of the continuous time model. The advantage in using FIML is that it ensures consistency across equations. The alternative is to use selected single equation estimates to identify the across equation parameters and fix them to those values in the rest of the system. Our experience with the linearisation phase is that linearisation of the equations in the RBA76 model along the lines of equations (2.2.1) to (2.2.4) yields results very close to the non linear equations but those results can be quite sensitive to the deletion of the exponential and time trend adjustments. For this reason, we intend to compare the FIML and single equation estimates of the model to determine its sensitivity to the choice of estimator. It is possible that the trade-off is of minor importance, given the reasonableness of the results reported in Jonson *et al* [10].

2.3 Discretisation

The continuous time model is translated into its discrete time analogue by successive integration over an arbitrary interval of observation, δ . First we require the following notation :

f_t = rate of flow of a flow variable at time t ;

S_t = stock of a stock variable at time t ;

$$F_t = \int_0^{\delta} f_{t-v}\, dv \qquad (2.3.1)$$

= *observed* flow of a flow variable over the interval $(t - \delta , t)$;

$$\bar{X}_t = 0.5\ (X_t + X_{t-\delta})\ ; \qquad (2.3.2)$$

$$\bar{\bar{X}}_t = 0.25\ (X_t + 2X_{t-\delta} + X_{t-2\delta})\ , \qquad (2.3.3)$$

where X is the observed value of a flow or stock variable. We also employ the following approximations[1] :

$$\int_0^{\delta} S_{t-v}\, dv \doteq \delta.\bar{S}_t \qquad (2.3.4)$$

$$\int_0^{\delta} \log(S_{t-v})\, dv \doteq \delta.\overline{\log S_t} \qquad (2.3.5)$$

$$\int_0^{\delta} \log(f_{t-v})\, dv \doteq \delta.\log(F_t/\delta)\ . \qquad (2.3.6)$$

---

1. The last of these approximations follows on taking a linear approximation to the log function in the region in which it is evaluated :

$$\int_0^{\delta} \log(f_{t-v})\, dv \doteq \int_0^{\delta} [a + b.f_{t-v}]\, dv$$
$$= \delta a + b.F_t$$
$$= \delta[a + b.F_t/\delta]\ .$$

Since F_t/δ is of the same order of magnitude as f_t , we can apply the inverse approximation to obtain as required

$$\delta[a + b.F_t/\delta] = \delta \log (F_t/\delta)\ .$$

The discrete time model is then obtained by double integration of each variable over the period $(t - \delta, t)$. The typical double integrals are listed in Table 1.

Table 1

Continuous Time Variable	Single Integral	Double Integral or Measurable Analogue of Column 1
f_t	F_t	$\delta.\bar{F}_t$
S_t	$\delta.\bar{S}_t$	$\delta^2.\bar{\bar{S}}_t$
$d.f_t$	$\Delta(f_t)$	$\Delta(F_t)$
$d.S_t$	$\Delta(S_t)$	$\Delta(\delta.\bar{S}_t)$
$\log f_t$	$\delta.\log(F_t/\delta)$	$\delta^2.\overline{\log(F_t/\delta)}$
$\log S_t$	$\delta.\overline{\log S_t}$	$\delta^2.\overline{\overline{\log S_t}}$
$d \log f_t$	$\Delta(\log f_t)$	$\Delta[\delta.\log (F_t/\delta)]$
$d \log S_t$	$\Delta(\log S_t)$	$\Delta[\delta.\overline{\log S_t}]$

The quarterly model can be obtained by defining one quarter as the period of observation, setting δ equal to 1 and substituting the elements in the third column of Table 1 for the corresponding continuous time variable. The averaging of the variables can be viewed as a necessary timing adjustment to ensure that stock and flow variables are "measured" at a common point each period. As illustrated below in Figure 1, the first average of a stock variable translates the timing to the middle of the period and the double average places the timing at the beginning of the current period which corresponds to the timing of the dependent variables. It follows that a stock variable which is measured at the mid point of a period is already in the form of $\overline{\log S}$ and so need only be averaged once more to give $\overline{\overline{\log S}}$. Any stock variable that is not measured at the mid point of the period needs to have its timing adjusted accordingly.

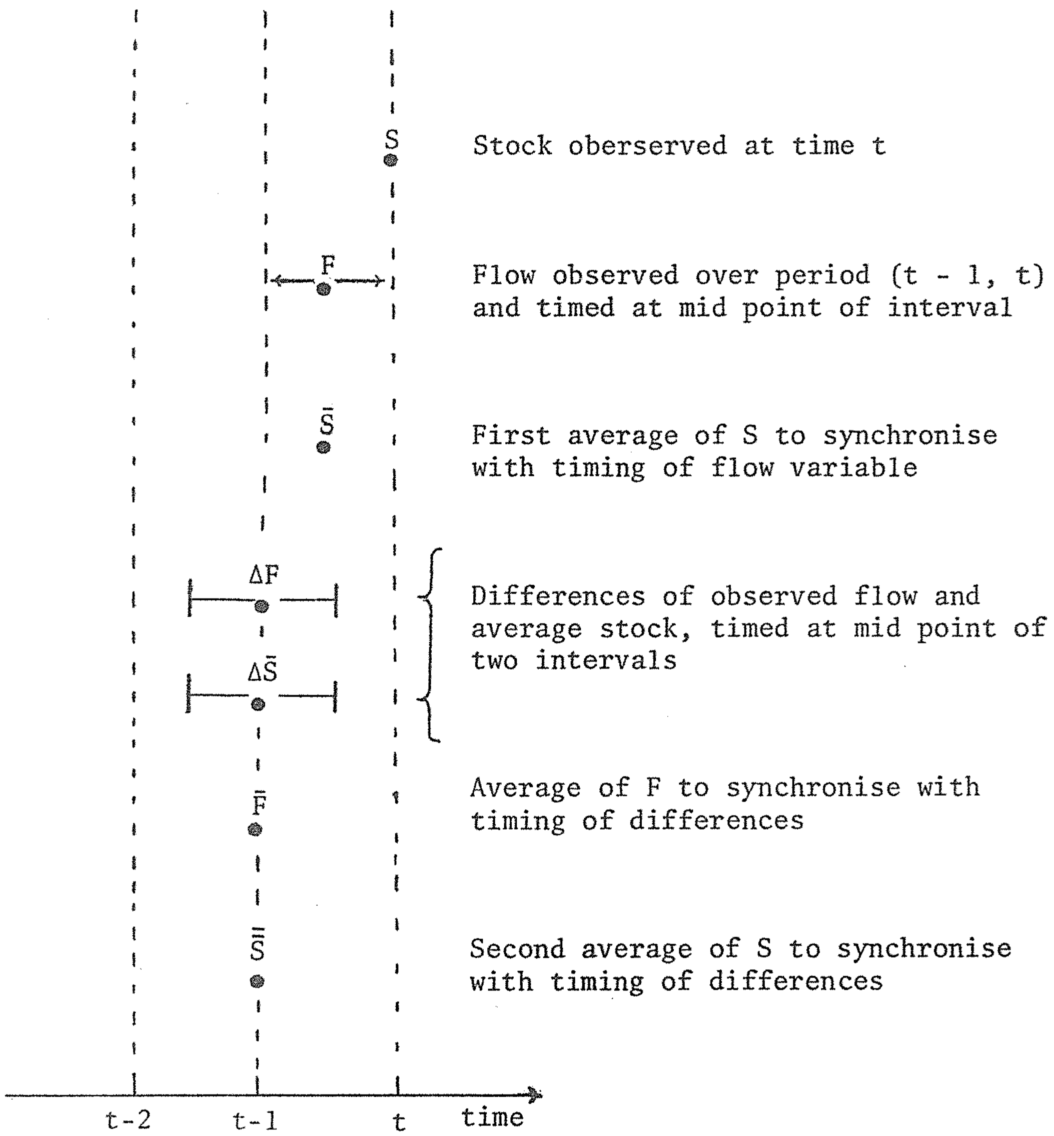

Figure 1

The discretised form of the consumption function, taken from equations (2.2.7) to (2.2.9) is :

$$\Delta \log d \doteq \alpha_1(\overline{\log \hat{d}} - \overline{\log d}) + \gamma_1(\overline{\overline{\log \hat{m}}} - \overline{\overline{\log M}} + \overline{\log P}) \; ; \qquad (2.3.7)$$

$$\log \hat{d} \doteq k_0 + x_1^{*}.\overline{\log y} - x_2^{*}.\overline{\log T_1} + x_2^{*}.\overline{\log P}$$

$$+ x_3^{*}.\overline{\log c} + \beta_1.\overline{\overline{\log r}} \; . \qquad (2.3.8)$$

$$\overline{\overline{\log \hat{m}}} \doteq m_0 + \overline{\log y} + \beta_2.\overline{\overline{\log r}} \; . \qquad (2.3.9)$$

Even though P is a stock variable, it is notionally measured at the mid point of the period and accordingly need only be averaged once to obtain the correct timing. In this derivation we have assumed that r is measured as a point estimate at the end of each period. The constant is also treated as a stock variable. Time does not appear in the consumption equation, but where it is included, it is classed as a stock variable. Applying the rules in Table 1 implies that time will appear in those equations as $\overline{\overline{t}} = (t - 1)$. It should be noted that Jonson *et al* estimate the equations using t rather than (t - 1). Accordingly, their constants differ from those implied by the above rules by the addition of the corresponding coefficients on time.

2.4 Estimation

The discretisation of a continuous time specification with white noise residuals leaves serially correlated residuals in the discrete time model. Bergstrom and Wymer [1, p. 36] show that for "small" observation intervals, the residuals will have approximately the same auto covariance properties as the moving average process :

$$u_t = \varepsilon_t + 0.268\, \varepsilon_{t-1} \,, \qquad (2.4.1)$$

where ε_t is serially uncorrelated. It follows that u_t is also approximately equivalent to the auto regressive process :

$$u_t + (-\,0.268)\, u_{t-1} + (-\,0.268)^2\, u_{t-2} + (-\,0.268)^3\, u_{t-3} = \varepsilon_t \,. \qquad (2.4.2)$$

Accordingly, the discrete time model can be pre whitened by filtering all the variables by the "COSMA" transformation :

$$x_t - 0.268\, x_{t-1} + 0.072\, x_{t-2} - 0.019\, x_{t-3} \,. \qquad (2.4.3)$$

Most of the estimated equations in the RBA76 model still exhibit significant residual serial correlation[1]. It is possible that this reflects the use of an observation interval that is not "small" enough, but equally likely explanations are errors in variables and structural misspecification. The latter is not unexpected in a minimal model which by its nature must abstract from complexities that would be included in a larger model. The residual serial correlation is presently neglected in the FIML estimation of the system, but this need not be the case.

2.5 Annualisation

The annualisation of the quarterly model seeks to derive the parameter estimates that would otherwise have been obtained if the quarterly model were estimated as an annual model, using the same sequence of

---

1. The single equation Durbin-Watson statistic has been used for this purpose. This statistic is biased towards rejection of the hypothesis in the single and system equation context, so serial correlation may be even more significant than these tests have suggested.

linearisations, discrete approximations and COSMA transformations. Given the absence of experience in moving from estimation in one time frame to application in another, it would be instructive to also estimate the MACRO module using annual data. Butlin [3] is presently compiling an annual data base for the estimation of a minimal model for the post 1900 period. The RBA76 model limits its attention to the post 1958 period and accordingly has to use quarterly data to ensure an adequate sample size for FIML system estimation. Two approaches can be taken in deriving the implicit annual model for the same sample period. One might take the estimated quarterly model along with a hypothetical longer run path for the exogenous variables, simulate the model and use the output to derive annual observations with which to estimate the implied annual model. The other possibility, and the one explored here, is to utilise the relationship between the parameter estimates for quarterly and annual models derived from the same continuous time specification. It is the reverse of the traditional aggregation problem of identifying the underlying quarterly parameters from the annual parameters.

Using the results in Table 1 we can set δ equal to 4 and substitute the resulting composite variables into the linearised continuous time model to obtain the annual discrete time model. The parameters for the annualised version of the RBA76 model are listed in appendix C. In the case of the consumption function, using the result that $(x_1^* + x_2^* + x_3^*) = 1$, with rearrangement, we obtain the annual equivalent to the quarterly equations :

$$\Delta \log d \doteq 4\,\alpha_1(\overline{\log \hat{d}} - \overline{\log d}) + 4\,\gamma_1(\overline{\overline{\log \hat{m}}} - \overline{\overline{\log M}} + \overline{\log P}) \;; \qquad (2.5.1)$$

$$\overline{\log \hat{d}} \doteq k_0 + x_1^{*}.\overline{\log y} - x_2^{*}.\overline{\log T_1} + x_2^{*}\,\overline{\log P}$$

$$+ x_3^{*}.\overline{\log c} + \beta_1\,\overline{\overline{\log r}} \;. \qquad (2.5.2)$$

$$\overline{\overline{\log \hat{m}}} \doteq (m_0 - \log 4) + \overline{\log y} + \beta_2.\overline{\overline{\log r}} \;, \qquad (2.5.3)$$

where the previous notation for variables now refers to *annual* observations on those variables but the constants α_1, γ_1, β_1, β_2, k_0 and m_0 have the values estimated in the *quarterly* equations. The nature of the approximations made in obtaining these equations can be gauged by successive cumulation of the simplified quarterly consumption equation :

$$\Delta \log d_t \doteq \alpha_1(k_0 + \overline{\log y_t} - \overline{\log d_t}) + \gamma_1(m_0 + \overline{\log y_t} - \overline{\overline{\log m_t}}) \;;$$

that is :

$$\log d_t - \log d_{t-1} \doteq \alpha_1\left[k_0 + \left(\frac{\log y_t + \log y_{t-1}}{2}\right) - \left(\frac{\log d_t + \log d_{t-1}}{2}\right)\right]$$

$$\gamma_1\left[m_0 + \left(\frac{\log y_t + \log y_{t-1}}{2}\right) - \left(\frac{\log m_t + 2\log m_{t-1} + \log m_{t-2}}{4}\right)\right].$$

Taking a four quarter sum we have :

$$\log d_t - \log d_{t-4} \doteq \alpha_1 \left[4k_0 + \left(\frac{\log y_t + 2 \log y_{t-1} + \ldots + \log y_{t-4}}{2} \right) - \left(\frac{\log d_t + 2 \log d_{t-1} + \ldots + \log d_{t-4}}{2} \right) \right]$$

$$+ \gamma_1 \left[4m_0 + \left(\frac{\log y_t + 2 \log y_{t-1} + \ldots + \log y_{t-4}}{2} \right) - \left(\frac{\log m_t + 3 \log m_{t-1} + 4 \log m_{t-2} + \ldots + \log m_{t-5}}{4} \right) \right] .$$

Taking another four quarter sum :

$$\sum_{i=0}^{3} \log d_{t-i} - \sum_{i=0}^{3} \log d_{t-4-i} \doteq 4\, \alpha_1 \left[4k_0 + \left(\frac{\sum_{i=0}^{3} \log y_{t-i} + 2 \sum_{i=0}^{3} \log y_{t-1-i} + \ldots}{8} \right) - \left(\frac{\sum_{i=0}^{3} \log d_{t-i} + 2 \sum_{i=0}^{3} \log d_{t-1-i} + \ldots}{8} \right) \right]$$

$$+ 4\, \gamma_1 \left[4m_0 + \left(\frac{\sum_{i=0}^{3} \log y_{t-i} + 2 \sum_{i=0}^{3} \log y_{t-1-i} + \ldots}{8} \right) - \left(\frac{\sum_{i=0}^{3} \log m_{t-i} + 3 \sum_{i=0}^{3} \log m_{t-1-i} + \ldots}{16} \right) \right] .$$

We require two types of approximation to obtain the annualised equation. The first simplifies the average of the annual log sums. That approximation yields :

$$\sum_{i=0}^{3} \log d_{t-i} - \sum_{i=0}^{3} \log d_{t-4-i} \doteq 4\,\alpha_1 \left[4k_0 + \left(\frac{\sum_{i=0}^{3} \log y_{t-i} + \sum_{i=0}^{3} \log y_{t-4-i}}{2} \right) - \left(\frac{\sum_{i=0}^{3} \log d_{t-i} + \sum_{i=0}^{3} \log d_{t-4-i}}{2} \right) \right]$$

$$+ 4\,\gamma_1 \left[4m_0 + \left(\frac{\sum_{i=0}^{3} \log y_{t-i} + \sum_{i=0}^{3} \log y_{t-4-i}}{2} \right) - 4 \left(\frac{\log m_t + 2 \log m_{t-4} + \log m_{t-8}}{4} \right) \right]$$

The second approximation annualises the log sums of the flow variables :

$$\sum_{i=0}^{3} \log f_{t-i} \doteq 4 \log(f_T/4) \quad ,$$

where

$$f_T = \sum_{i=0}^{3} f_{t-i} \quad ,$$

$$T = t/4 \ , \qquad t = 4, 8, 12, \ldots \quad .$$

We then have :

$$\Delta[4 \log (\frac{d_T}{4})] \doteq 4\alpha_1[4k_0 + 4 \overline{\log (\frac{y_T}{4})} - 4 \overline{\log (\frac{d_T}{4})}]$$

$$+ 4\gamma_1[4m_0 + 4 \overline{\log (\frac{y_T}{4})} - 4 \overline{\overline{\log m_T}}] \quad .$$

That is, with rearranging :

$$\Delta \log d_T \doteq 4 \, . \, \alpha_1(\overline{\log \hat{d}_T} - \overline{\log d_T})$$

$$+ 4 \, . \, \gamma_1(\overline{\overline{\log \hat{m}_T}} - \overline{\overline{\log m_T}}) \quad ;$$

$$\overline{\log \hat{d}_T} \doteq k_0 + \overline{\log y_T} \quad .$$

$$\overline{\overline{\log \hat{m}_T}} \doteq (m_0 - \log 4) + \overline{\overline{\log y_T}} \quad ,$$

which is the same form as equations (2.5.1) to (2.5.3) .

The treatment of time is a little different from the other variables. It is a stock variable so the annual values will relate to the index over quarterly time. The index can be translated into annual time using the result that for the annual model :

$$\overline{\overline{t}} = 0.25 \, [t + 2 \, (t - 4) + (t - 8)]$$

$$= 0.25 \, [4T + 2 \, (4.(T - 1)) + 4(T - 2)]$$

$$= 4 \, \overline{\overline{T}} \quad . \qquad (2.5.4)$$

The quarterly model will also have to be synchronised with the annual model so that t = 0 in the quarterly model corresponds to T = 0 in the annual model. This only entails simple adjustments to the estimated constant terms in the quarterly model. Care has also to be taken with the interval of account of the flow variables. In most cases the flow variables will be observed over the reference period of the model; that is quarterly, annual intervals, etc.. A notable exception to this rule is that of interest rates, which are frequently quoted as annual rates, even in the context of a quarterly model. It happens that the interest rate in the RBA76 model is a stock measure, but if it were not, the coefficient of the variable would still be treated *as if* it were a stock variable so as to reflect the fact that the quarterly model has already "annualised" the parameter on that variable.

We have so far neglected the residuals in the annual equations. We would expect those residuals to be auto correlated for the same reasons that were discussed for the quarterly model. To the extent that this is due solely to the discretisation of the continuous time model, and to the extent that the observation interval can still be said to be "small," the annual residuals can also be considered to be approximately generated by a moving average process of the form of equation (2.4.1). This component of the residuals can be removed by application of the same COSMA transformation to the annual equations. It would not be too surprising if there were still significant residual serial correlation in the residuals and it may be necessary to estimate the serial correlation properties of the annual residuals directly, in order to improve the short run simulation properties of the model.

3. SPECIFICATION

3.1 General Description

The theoretical specification of the RBA76 model is described in detail in [11]. As stated above it takes its approach from the work of Bergstrom and Wymer [1], Knight and Wymer [16] and Jonson [14] and the more recent studies being undertaken in the International Monetary Research Program at the London School of Economics. The model is best characterised as a one good, two sector (private and government) growth model for a small trading country with two financial assets, money and bonds. The underlying production function is assumed to be of Cobb-Douglas form. The model is closed off by the modelling of official sector reaction functions for the interest rate and the exchange rate.

Most of the model equations assume a delayed Koyck type adjustment towards desired levels based on the long run general equilibrium solution. This type of response has the advantage that it is readily translated from continuous time into an empirically validated discrete time model. More complicated lagged adjustment can be captured by the use of the same Koyck type adjustment with a higher order differential equation. The investment equation uses this device. Combination of equations (2) and (22) in appendix A will yield a second order differential equation for the capital stock.

The theoretical specification also assumes that disequilibria in the different markets will interact with each other. Thus disequilibrium in the goods market which is evidenced by unintended stock decumulation or accumulation interacts with imports, output and prices. Disequilibrium in the labour market interacts with wages and the government's policy response functions. Disequilibrium in international prices influences imports, exports, the price of exports, demand for bonds, net capital inflow and the government's policy response function for the exchange rate. The model also allows for the impact of disequilibrium in the money market on consumption, prices and wages. Jonson discusses this aspect of the model in some detail in [13]. He stresses "the role of money as a *buffer stock* in an uncertain world (a role) not unrelated to the traditional concept of the precautionary motive for holding money" [13, p. 6]. He also argues that "prices and quantities are influenced importantly in the short run by their past history through expectation generating mechanisms. Accumulation and decumulation of money balances will *signal* (our emphasis) the need to adjust expectations, and therefore the prices and quantities controlled by the relevant economic agent, a point developed at some length by Laidler [17]," [13, p. 7]. Needless to say, the role of money in the economy remains a controversial issue. The model builder cannot avoid taking a stand on the issue and we see considerable merit in retaining this feature of the RBA76 model. However some care needs to be taken in the interpretation of those results and we return to this issue below.

3.2 The Data

The definitions of the Jonson *et al* data are given in Appendix D. Our data differ from these in several important respects. Firstly our data are seasonally adjusted using the US Bureau of the Census package X11-Q. The RBA76 model uses data that are adjusted using fixed additive factors applied to the logarithm of each series. This seems to have left significant residual seasonality in some of the series, particularly those for prices, wages and income taxes. The evidence of residual seasonality is not in itself unacceptable, and indeed there is considerable debate in the literature on the optimal method of seasonal adjustment. What is unsatisfactory is that this residual seasonality is apparently not explained by the equation specifications. We expect the use of X11-Q to alleviate this problem.

We have also modified the definition of some of the data items. The most notable of these is that for the stock of money which we have expanded from M3 to include the deposits, shareholders funds and unsecured borrowings of Permanent Building Societies. The advantage in using this definition is that the velocity of circulation defined in terms of the ratio of the expanded stock of money to NDP at market prices has a stable long term trend. This is not the case for velocity defined in terms of M3 and we believe it is this change in trend which yields the puzzling result reported in Jonson [12, p. 16] for the money disequilibrium effect. His results imply that money was tighter in 1972, as measured by disequilibrium in the money market, than at the time of the 1961-62 credit squeeze and that money was as tight in 1972 as it was, in reverse, easy in 1975.

Another significant difference in the data arises in the measurement of the capital stock and depreciation. Jonson *et al* use taxation depreciation data to depreciate the capital stock and obtain a measure of net domestic product. The weaknesses of this approach are that depreciation for taxation purposes is at historical cost and no allowance is made for depreciation of other building and construction capital. We have used the private sector capital stock and depreciation rates from the NIF model [21] as adjusted by Higgins *et al* [9] in combination with Clark's [5] estimates of the public sector capital stock to construct the required series. In principle the modified series take both of these factors into account, but the conceptual problems and the quality of the source data leave a lot to be desired in deriving capital stock estimates for Australia. We will return to this issue again in the discussion of the net investment equation.

The only other significant change in the data is to expand the coverage of the expenditure taxes series to include excise taxes, state and local government indirect taxes (excluding payroll taxes) and federal government other indirect taxes as defined in the National Accounts. These are in addition to the value of customs duties, payroll and sales taxes that already appear in the series. The present specifications of the equations for expenditure and income taxes are limited in their specification of their respective tax bases by virtue of the model's concentration on a restricted number of macro aggregates. Consequently the equations cannot be expected to yield reliable estimates of the revenue response to specific tax rate changes. From the point of view of the medium term, the most important policy considerations are the *choice* between income and expenditure taxes and the different influences they exert on wages, prices, consumption and investment. Accordingly we intend replacing these behavioural equations with identities defined in terms of *implicit* average tax rates applied to their respective macro tax bases. In the case of income taxes this is taken to be nominal net domestic product (income) and in the case of expenditure taxes it is taken to be nominal sales. The implicit average tax rates are found by dividing the respective revenue series by their corresponding tax bases.

3.3 The Equations

The results reported by Jonson *et al* seem to be quite satisfactory on the whole but we have in mind a number of changes to the specification that we believe will both improve the performance of the model and make it more compatible with the ORANI and BACHUROO modules. We are presently re-estimating the model using our own data base and these results will be the subject of a further report.

3.3.1 Consumption. Turning to the consideration of specific behavioural equations we see firstly that the desired level of consumption is given as a function of disposable income and the interest rate. The income elasticity is specified to be one in the long run. A freely estimated elasticity is insignificantly different from unity. The introduction of demographic effects would strengthen the linkages between MACRO and BACHUROO. In principle it should be possible to include such demographic variables as the size and age distribution of the population, both of which might be expected to influence the level of *aggregate* consumption. The *composition* of consumption is likely to be more sensitive to demographic factors and this aspect is being examined by Williams [24] for the IMPACT project. Denton and Spencer [6, p. 94] review some of the evidence for the influence of demographic factors on aggregate consumption. Their own study of Canadian time series and OECD across country data finds no significant impact whereas the study by Leff [18] finds a significant impact across developed and underdeveloped countries. The difficulty in evaluating these influences using time series data is one of obtaining a sample period of sufficient length to encompass significant changes in the demographic variables in the aggregate. We would not expect to find significant results over the sample period of this model.

3.3.2 Money. Disequilibrium in the money market also appears in the consumption function. The stock of money is generated by the formation identity in equation (18) and the demand for real money balances is specified as a function of real income and the nominal interest rate. In principle, this approach enables the identification of a genuine demand for money equation and is to be contrasted to the usual approach of estimating a single reduced form behavioural equation for the stock of money (variously referred to as demand and supply functions). The income elasticity is again assumed to be unity in the long run and the interest elasticity is fixed at - 0.3 . Necessity for the latter is a disappointing feature of the Jonson *et al* results.[1] The money disequilibrium effect is of considerable importance to the dynamics of the model and one would have hoped for a stable interest rate effect. It is possible that the change in the definition of money will improve this result, but it may also indicate that the 10 year bond rate is not representative enough of market rates or that too broad a definition of money is being used with the consequence that it includes a significant proportion of interest bearing near money. Preliminary single equation estimates of the consumption, output price and wage equations suggest that the money disequilibrium effect is only well determined in the wage equation. This suggests that the variability in the interest rate coefficient may also be due to structural misspecification of some of these equations. These matters remain the subject of further investigation.

3.3.3 Net Investment. The net investment equation is based on the Cobb-Douglas production function where β_3 is the profit share :

$$\beta_3 = (P.y - WL)/(P.y) = (r_k.K)/(P.y) ,$$

so that

$$\beta_3.(y/K) = (r_k/P) = \textit{marginal product of capital} .$$

Thus we have the *rate* of net investment adjusting to equate the marginal product of capital with the real rate of return on bonds. As stated in Bergstrom and Wymer [1, p. 9], λ is the partial equilibrium rate of capital formation associated with equality between the two rates of return. If there is perfect competition and no risk it would equal the rate at which entrepreneurs expect output to grow. This specification differs from that in Bergstrom and Wymer

1. The equation for money demand has been modified in the most recent RBA76 model by the inclusion of the world interest rate together with exchange rate and inflationary expectations variables. When so modified, a freely estimated interest rate elasticity has the value of - 0.301. However, that value is apparently not robust to the choice of sample period ([11], Appendix A, page 6) and the implied money balances still have the puzzling features discussed above.

in two respects. They specify their production function to be of CES form although they are unable to find a stable estimate for the elasticity of substitution for the UK economy and so fix it at unity. Estimation of a CES production function is difficult at any time but the problem is compounded in FIML estimation by the requisite linearisation of the function. There is little to discriminate between the *linearised* Cobb-Douglas and CES production functions so little is gained empirically from the additional refinement (Kmenta [15], Griliches and Ringstadt [8], and Tsang and Persky [22]). However, from the point of view of consistency between the investment functions in the MACRO and ORANI modules, it may be of value at a later stage, to fix the elasticity at some "average" of the industry specific elasticities.

The net investment equation also differs from that used by Bergstrom and Wymer by the incorporation of the deviation in exports from their long term growth path.[1] One of the puzzling features of the capital goods market in the post-war period is the apparent steady rise in the capital-output ratio for both plant and equipment and other building and construction capital. This might reflect the growth in the mining sector over the same period and it is this growth which the export term is intended to capture, since the (y/K) term can only measure the realised rate of return as against the expected marginal rate of return that is required for a dynamic model of investment. Unfortunately, an equally likely and plausible explanation of the trend in the capital-output ratio is error in the measurement of the capital stock series. Higgins *et al* [9, appendix 2] demonstrate that minor changes to the assumed depreciation rates and not unreasonable changes to the base stock estimates can yield a trend-free capital-output ratio. They also observe that the revised capital stock series is then also consistent with the value of the capital stock imputed by means of National Accounts and stock market data. The

---

1. This term has been dropped from the latest version of the RBA76 model but the problems raised here still remain.

latter explanation seems the more reasonable and it is intended to test the exports term using the revised capital stock series.

3.3.4 Exports. The exports equation is best regarded as a reduced form equation for exports reflecting the composite influence of demand and supply factors. Basically, exports are assumed to be expanding along a long term growth path proxied by t. Jonson *et al* have experimented with replacing t by world exports and net domestic product and these results are included in the latest version of the RBA76 model. In the earlier specification, the ratio of export and world prices tends to have an unstable coefficient, but single equation and FIML estimates suggest that it lies in the vicinity of the fixed value of - 0.5 . The small country assumption would normally imply an infinite or at least a high price elasticity of demand.

Alternatively, if Australian exporters supply a fixed proportion of the world market in the goods they export, and for which they are price takers, then $P_x/(E.P_W)$ can be viewed as the *world* relative price for that basket of goods and goods in general. Given the composition of Australia's exports it is not unreasonable to expect the price elasticity of demand to be low and of the estimated order. On the supply side, the profitability of producing and exporting at the given world price might be captured by the price relative, $P/(E.P_W)$; and the relative attractiveness of producing for the domestic as against the export market might be captured by the price relative, P_x/P . $P_x/(E.P_W)$ will obviously reflect a combination of these supply and demand influences. These are separately identified in the latest version of the equation. A complicating factor is that the specification takes no account of the influences of discoveries of new mineral deposits, etc.. The significance of these over the sample period leads us to be sceptical of the likely reliability of a behavioural equation for exports of the type estimated here. The choice seems to be to make exports an exogenous variable when this model is used in isolation, and of making this a linkage point with ORANI when operated in the context of the IMPACT model. The ORANI module takes export prices to be given and each export industry then sets output so as to maximise profits subject to the period's predetermined constraints of capital, land, etc.. The module identifies approximately 12 export industries (those Input-Output industries that export at least 20% of their output) and the exports of other industries are set exogenously.

3.3.5 Allocation of Sales Between Imports and Domestic Output. Equations (5) and (6) determine the allocation of sales between imports and domestic output in response to the relative price of imports and domestic output, and in response to speculation against currency movements, proxied by the variable QE. Sales is defined as the total of public and private consumption, public and private investment expenditure and exports. Imports and output also respond to the unintended accumulation and decumulation of inventories in a similar manner to that modelled by Caton and Higgins [4]. The present specification assumes that the desired level of inventories is proportional to the level of sales. The trend in the inventories/sales ratio has shown a steady decline over our sample period from a level of around 0.94 in 1960 to a level of around 0.68 by 1974. Consequently it would seem advisable to modify the theoretical specification of the desired inventories equation to :

$$\hat{v} = v_0 + v_1 S \quad .$$

This makes no difference to the estimated equation however as a general constant term appears in all the linearised equations.

3.3.6 Prices. In the long run, the price of output is assumed to be a markup on unit labour costs. As with the stock of inventories, the constant markup is subsumed within the general constant term. One weakness of the present specification is that it makes no allowance for the direct effect of expenditure taxes on price formation. This can be accommodated by having prices adjust towards an after tax markup on unit labour costs. This would yield a modified price equation of the form :

$$D \log P = \alpha_7(\log[(W.L/y)(1 + T_2/(S.P))] - \log P) + \beta_{11}(\log \hat{v} - \log v) + \gamma_2(\log \hat{m} - \log (M/P)) .$$

In the short term, prices are also assumed to be sensitive to the pressure of demand, as evidenced by unintended inventory movements, and to disequilibrium in the money market. Disequilibrium in the money market might represent an availability of finance effect, and hence indirectly, another aspect of pressure of demand. Alternatively it might provide a signal for the formation of price expectations that breeds on itself as firms try to protect their own profits from expected price movements in their inputs. The availability of finance effect could work in reverse, if firms were able to increase prices to improve their internal cash flow performance and provide their own source of finance. One would expect this to be a marginal factor however, and the estimated value for γ_2 in the RBA76 model is negative, and at - 0.14, is significantly different from zero, giving a positive correlation of prices with money supply.

The price of government goods and services is assumed to adjust towards private sector prices, with the modification that an allowance for productivity increases has to be added back in to reflect the National Accounting methodology which records little or no change in the productivity of the general government sector. Productivity in the private sector is measured by the marginal product of labour, which, given the underlying Cobb-Douglas production function, becomes $(1 - \beta_3).y/L$. Hence the specification of equation (7). The RBA76 model also includes an equation for export prices. We have already observed that the ORANI model takes export prices to be exogenously determined and we would see this as the preferable approach at this stage. The estimated equation for export prices sees them adjusting towards the exogenously determined import prices (or possibly world prices in general) with short run deviations away from that pattern in response to exchange rate speculation and divergence in the general cost structure of the domestic as opposed to the overseas market. Viewed in this manner the equation might be better specified as :

$$D \log P_x = \alpha_9(\log E.P_W - \log P_x) + \beta_{12}(\log E.P_W - \log P) + \beta_{13}\, QE .$$

It is clear that each of these elements will have an influence on export prices, and certainly in the long run, export prices must reflect the general trend in world prices. In the short and medium term however, the composition of exports and, for Australia, the variability in prices for primary products can result in significant divergence from these trends.

3.3.7 Wages. The basic determinant of wages is seen as a demand by wage and salary earners that in the long run their real wage equal the marginal product of their labour. The wage deflator is formulated as a weighted average of domestic and world prices and it yields the result that β_{16} is estimated to be 0.16 ; not an unreasonable number given the import content of sales. Wages are also assumed to respond to labour market pressures as they vary over the business cycle, pressures generated by the process of award wage determination under the auspices of the Conciliation and Arbitration Commission and a money balance effect. Some care will have to be used in forecasting with this equation to ensure that λ_3 is set to reflect the underlying trend in award wages over the forecast period as against the assumed movement in the exogenous series for award wages themselves. The money balance effect may once again be reflecting the availability of finance and the consequent willingness of firms to agree to wage demands. Alternatively it may be a signal used by wage and salary earners to formulate their price expectations. Jonson *et al* are currently experimenting with a specific measure of price expectations to clarify the role money is playing in this equation. As it stands, the equation is well determined in both systems and single equation estimation. A more detailed discussion of the wage and price of output equations is found in Jonson [12].

3.3.8 The Labour Market. The labour demand equation adjusts to equate the real wage with the marginal product of labour. That is :

$$\log \hat{L} - \log L$$

$$= \log [(1 - \beta_3).y.P./W] - \log L ,$$

$$= \log [(1 - \beta_3).y/L] - \log (W/P) .$$

Labour supply adjusts towards a desired supply which is expressed as a function of employment and the real after tax wage share of product. As specified, the estimated equation implies a backward bending supply curve. Further experiments with the equation reveal that the tax correction makes almost no difference to the estimated parameters and that removal of the delayed adjustment in the specification reverses the sign on the wage share. The wage share has a strong cyclical component which rises over the slumps and falls in the booms. It would appear that in the delayed adjustment specification, its cyclical swings are being used to *smooth* out some of the cyclical movement in employment in order to better explain the damped cyclical swings in the labour force. The timing of the cycle in the wage share may also be a factor. Evidence for this is the fact that replacing the wage share by the deviation in product from its long term trend (a capacity utilisation related variable) yields the expected sign in the delayed adjustment formulation. That is, in the specification :

$$\log \hat{N} = N_0 + \beta_{17} \log[y/(y^* e^{\lambda t})] + \log L \quad ,$$

β_{17} has a negative coefficient. It would appear that the present specification is dominated by the short run sensitivity of the supply of labour to conditions in the labour market, rather than considerations of the real wage etc., that is, that the implicit backward bending supply curve is illusory. It may be more satisfactory to introduce population into the MACRO module and model the labour supply around variation in the participation rate.

3.3.9 Finance. The equations for non bank demand for government bonds and net foreign capital investment in the domestic economy both assume a desired demand that is proportional to the level of product and to the differential between the domestic and overseas interest rates. They also respond to speculation against movements in the exchange rate and the differential between domestic and overseas prices. Jonson *et al* [11, p. 9] consider the latter to represent longer term expectations of movements in the exchange rate required to maintain purchasing power parity. Purchasing power parity can also be restored by price adjustments so this term can also be taken to be a measure of the expected differential in domestic as against overseas rates of inflation.

That is, the price term can be seen to adjust the interest rate differential to yield a real interest rate differential. The net capital inflow equation has the additional feature of a specific dummy variable to capture the effect of the variable deposit requirement introduced in December 1972 and dropped in November 1974. The result of this requirement was to raise the effective cost of funds raised overseas, or equivalently, to lower the effective rate of return on funds invested in Australia. If overseas investors were an important source of demand for government bonds then QF should also appear in that equation; however, that is not the case since government overseas borrowing is included in the net capital inflow series. One obvious shortcoming of the equation for net capital inflow is the assumption that in the long run net overseas capital investment is proportional to *domestic* product. Rapid development of Australia's mineral resources would for example, seem to require a rise in that proportion that would not be captured by the present equation.

The equation for bank advances is formulated as a portfolio decision given the level of "bank" liabilities, M. Hence in the long run the supply of advances is assumed to be proportional to M with short term deviation from that allocation in response to movements in domestic and overseas interest rates, capital controls and specific lending instructions issued by the Reserve Bank. Jonson *et al* [11, p. 12] see the primary portfolio decision as one between advances and government bonds. For this purpose they take r_W to be a proxy for the rate on advances and r to be the rate on government bonds. However over this sample period the average rate on advances has moved quite closely with r and we would conclude that the interest rate terms are playing a similar role to that in the equation for government bonds; they measure the pressure of demand for domestic as against overseas finance. Evidence in favour of this interpretation are the sign and close absolute values for the interest rate coefficients and the significance and sign of the coefficient on the dummy for capital controls. The equation also includes a specific proxy for domestic demand pressures, expressed as the differential between product and its long term trend. This variable will be highly correlated with such measures as capacity utilisation and overdraft utilisation and so should serve the purpose well.

3.3.10 Policy Response Functions. The bond rate and exchange rate equations are formulated as policy response functions with the instruments reacting to divergence in the *target* variables from their desired levels. The primary target variables are taken to be the level of foreign reserves, the employment/ unemployment rate and the money supply. It is assumed that the desired level for reserves is some fixed proportion of the money supply, that the desired level for employment is some fixed proportion of the labour supply and that the target level for the money supply is some fixed proportion of the trend in nominal product. These fixed target constants and proportions are subsumed within a single constant in each equation. Thus for the bond rate equation we have :

$$D \log r = \alpha(\log \hat{r} - \log r) \quad ,$$

where the desired level for the bond rate is given by :

$$\log \hat{r} = \log r^* + \beta_0 \log(R/(\alpha_0 M)) + \beta_1 \log(L/(\alpha_1 N)) + \beta_2 \log(M/(\alpha_2 P^* y^* e^{(\lambda_1+\lambda_2)t})) + \beta_3 QS \quad .$$

Log r^* denotes the desired level for the bond rate in the absence of disequilibrium in the target variables. It is assumed to be constant. α_0, α_1 and α_2 are the constant target proportions. Combining the two equations we have the form of equation (20) in Appendix A, where :

$$\log r_0 = \log r^* - \beta_0 \log \alpha_0 - \beta_1 \log \alpha_1 \quad ,$$

and

$$M^* = \alpha_2 P^* y^* \quad .$$

The absence of the rate of inflation from this set of target variables might at first seem surprising, but that target is subsumed within the target for the money supply. It is necessary in both equations to include dummy variables to capture the precise timing of changes in the policy variables. Jonson *et al* [11, p. 15] suggest that these "represent an irreducible amount of exogeneity in policy reaction functions." The exchange rate is defined in terms of the $US so a dummy variable is also included to reflect the decision not to follow the devaluation of the $US in February 1973. As of September 1974, Australia severed its link with the $US with the introduction of the trade weighted exchange rate. This event is at the tail end of the estimation period but it would complicate the use of the model in making projections. For the latter purpose the QUS dummy variable could be used to reflect movements in the $US against the currencies of our other major trading partners.

3.4 Linkages. The primary role of the MACRO module is to provide projections of aggregate consumption and investment for input into the ORANI module. While MACRO is being estimated as a self-contained macro model it would seem advisable to utilise the available reverse linkages when it is felt that the detailed structures of ORANI and BACHUROO are going to yield more reliable projections than the corresponding macro equations. In some instances it will be preferable to retain the macro equations as a check against the micro projections. The potential reverse linkage points are :

1. Imports
2. Exports
3. Labour supply
4. Labour demand .

Our present assessment of the MACRO equations would suggest that the macro exports and labour supply equations should be over-ridden by exports, as generated by ORANI, and by labour supply, as generated by BACHUROO. We would have more confidence in the imports and labour demand equations and these should provide a useful check against the ORANI output. Our previous comments would also suggest that it will be preferable to leave export prices and the exchange rate exogenous to the system in most applications of the model.

Appendix A : The RBA76 Model (Early version)

The specification of the model is as follows:

1. Consumption expenditure

$$D \log d = \alpha_1(\log \hat{d} - \log d) + \gamma_1(\log \hat{m} - \log {}^{M}/_{P})$$

$$\log \hat{d} = d_0 + \log(y - {}^{T_1}/_{P} + c) + \beta_1 \log r$$

$$\log \hat{m} = m_0 + \log y + \beta_2 \log r$$

2. Net private investment

$$Dk = \alpha_2[\alpha_3(\beta_3 \, {}^{y}/_{K} - {}^{r}/_{4} + D \log P) - \lambda + \beta_4 \log({}^{x}/_{x^* e^{\lambda_1 t}}) - k]$$

3. Exports

$$D \log x = \alpha_4(\log \hat{x} - \log x)$$

$$\log \hat{x} = x_0 + \lambda_1 t + \beta_5 \log ({}^{P_x}/_{EP_w}) + \beta_6 \, QE$$

4. Imports

$$D \log i = \alpha_5(\log \hat{i} - \log i) + \beta_7(\log \hat{v} - \log v) \, ,$$

5. Output

$$D \log y = \alpha_6(\log \hat{y} - \log y) + \beta_8(\log \hat{v} - \log v)$$

$$\hat{i} = \left[i_0 \left(\frac{EP_i(1 + t_3)}{P} \right)^{\beta_9} e^{\beta_{10}QE} \right] S$$

$$\hat{y} = \left[1 - i_0 \left(\frac{EP_i(1 + t_3)}{P} \right)^{\beta_9} e^{\beta_{10}QE} \right] S$$

$$\hat{v} = v_0 \, S$$

$$S = d + DK + DK_g + x + g$$

6. Price of output

$$D \log P = \alpha_7 \left(\log \frac{13WL}{y} - \log P \right) + \beta_{11} (\log \hat{v} - \log v) + \gamma_2 (\log \hat{m} - \log {}^{M}/_{P})$$

7. Price of government goods and services

$$D \log P_g = \alpha_8(\log P + \log(1 - \beta_3)\ {}^{y}/_{L} \quad \log(1 - \beta_3)\ {}^{y_0}/_{L_0} - \log P_g)$$

8. Price of exports

$$D \log P_x = \alpha_9(\log EP_i - \log P_x) + \beta_{12} \log({}^{P}/_{P^*e}\ \lambda_2 t) + \beta_{13}QE$$

9. Average weekly earnings

$$D \log W = \alpha_{10}[\log(1 - \beta_3)\ {}^{y}/_{L} - \log {}^{13W}/_{P'}] + \beta_{14} \log {}^{L}/_{N}$$

$$+ \beta_{15} \log({}^{W_A}/_{W_A^*} e^{\lambda_3 t}) + \gamma_3(\log \hat{m} - \log {}^{M}/_{P})$$

$$\log P' = P_0 + \beta_{16} \log EP_w + (1 - \beta_{16}) \log P$$

10. Labour supply

$$D \log N = \alpha_{11}(\log \hat{N} - \log N)$$

$$\log \hat{N} = N_0 + \beta_{17} \log \left(\frac{(1 - t_1)\ 13WL}{Py} \right) + \log L$$

11. Labour demand

$$D \log L = \alpha_{12}[\log(1 - \beta_3)\ {}^{y}/_{L} - \log {}^{13W}/_{P}]$$

12. Non-bank demand for government bonds

$$D \log B = \alpha_{13}(\log \hat{b} - \log {}^{B}/_{P})$$

$$\log \hat{b} = b_0 + \log y + \beta_{18} \log r - \beta_{18} \log r_w + \beta_{19} QE + \beta_{20} \log {}^{EP_w}/_{P}$$

13. Net capital inflow

$$D \log F = \alpha_{14}(\log \hat{f} - \log {}^{F}/_{P})$$

$$\log \hat{f} = f_0 + \log y + \beta_{21} \log r - \beta_{21} \log r_w - \beta_{22}QF + \beta_{23}QE + \beta_{24} \log {}^{EP_w}/_{P}$$

14. Bank advances

$$D \log A = \alpha_{15}(\log \hat{A} - \log A) + \beta_{25} \log ({}^{Py}/_{(Py)^{*}e^{(\lambda_1 + \lambda_2)t}})$$

$$\log \hat{A} = A_0 + \log M + \beta_{26} \log r + \beta_{27} \log r_w + \beta_{28}QA + \beta_{29}QF$$

15. Income taxes

$$D \log T_1 = \alpha_{16}(\log \hat{T}_1 - \log T_1)$$

$$\log \hat{T}_1 = T_{01} + \log t_1 Py$$

16. Expenditure taxes

$$D \log T_2 = \alpha_{17}(\log \hat{T}_2 - \log T_2)$$

$$\log \hat{T}_2 = T_{02} + \log t_2 Pd$$

17. Balance of payments

$$DR = P_x X - EP_i i + DF$$

18. Supply of money

$$DM = DR + D(PK_g) + P_g g + P_g c - T_1 - T_2 - DB + DA + f(rB)$$

19. Change in inventories

$$Dv = y + i - d - DK - DK_g - x - g$$

20. Bond rate

$$D \log r = \alpha_{18} \log {}^{r_o}/_{r} + \beta_{30} \log {}^{R}/_{M} + \beta_{31} \log {}^{L}/_{N}$$

$$+ \beta_{32} \log ({}^{M}/_{M^* e} (\lambda_1 + \lambda_2)t) + \beta_{33} QS$$

21. Exchange rate

$$D \log E = \alpha_{19} (\log {}^{E_0}/_{E}) + \beta_{34} \log {}^{R}/_{M} + \beta_{35} \log {}^{L}/_{N}$$

$$+ \beta_{36} \log ({}^{M}/_{M^* e} (\lambda_1 + \lambda_2)t) + \beta_{37} QUS + \beta_{38} QER$$

22. Capital stock

$$\frac{DK}{K} = k$$

Notes :

(1) A subscript of zero indicates a constant.

(2) The form of equations 2, 6, 7, 9, 10 and 11 is slightly modified from that given in RBA76 to clarify the adjustment processes in the model. The modifications ensure that related variables are measured in the same units. The modifications only affect the constants in the estimated equations (which are not reported in appendix B).

The endogenous variables are :

d	real household demand
D	net private investment
x	real exports of goods and services
i	real imports of goods and services
y	real output (net of depreciation)
P	price of output
P_g	price of government goods and services
P_x	price of exports
W	money wages (average weekly earnings)
N	labour supply
L	labour demand
B	bonds held by private (non-bank) sector
F	net Australian capital owned by overseas residents
A	bank advances to private sector
T_1	direct tax receipts
T_2	indirect tax receipts
R	foreign exchange reserves
M	stock of money (M3)
v	stock of inventories
r	bond rate
E	exchange rate ($^{\$A}/_{\$US}$)
K	stock of real capital

The variables assumed to be exogenous are :

P_w	world prices ($US)
P_i	Australian import prices ($US)
r_w	world interest rate
g	Australian government current spending
DK_g	Australian government capital spending
c	cash benefits to persons
t_1	income tax rate
t_2	expenditure tax rate
t_3	tariff rate
W_A	award wages
t	time
QA	dummy variable for requests to limit advances in 1961
QE	dummy variable for exchange rate expectations 1972-4
QER	dummy variable for timing of exchange rate changes
QF	dummy variable for capital controls 1973-4
QS	dummy variable for credit squeeze 1961, 1967, 1973
QUS	dummy variable for devaluation of $US 1973

Appendix B : Parameter Estimates for the Quarterly Model - Jonson *et al*

	Estimate	Standard Error	t-ratio		Estimate	Standard Error	t-ratio
α_1	.5770	.0853	6.76	β_{11}	.0745	.0123	6.07
α_2	.5710	.1462	3.91	β_{12}	.1349	.0307	4.39
α_3	.1	(value imposed)		β_{13}	-.0718	.0318	2.26
α_4	1.0	(value imposed)		β_{14}	.8022	.2766	2.90
α_5	.4618	.0936	4.94	β_{15}	.4033	.0738	5.46
α_6	.5	(value imposed)		β_{16}	.1598		
α_7	.4325	.0843	5.13	β_{17}	-.3563	.1131	3.15
α_8	.4114	.0783	5.26	β_{18}	.6506	.1028	6.33
α_9	.3231	.0724	4.46	β_{19}	-.3883	.1074	3.62
α_{10}	.4017	.0930	4.32	β_{20}	1.7030	.1128	15.10
α_{11}	.1364	.0273	4.99	β_{21}	.6166	.1058	5.83
α_{12}	.1320	.0171	7.72	β_{22}	.0233	.0088	2.66
α_{13}	.1272	.0147	8.66	β_{23}	-.6220	.1055	5.90
α_{14}	.1272	.0147	8.66	β_{24}	1.7756	.1899	9.35
α_{15}	.26	(value imposed)		β_{25}	.1696	.0269	6.30
α_{16}	2.4082	.4313	5.58	β_{26}	-.2236	.0689	3.25
α_{17}	.2311	.0914	2.53	β_{27}	.2690	.0509	5.28
α_{18}	.1788	.0330	5.42	β_{28}	-.0134	.0063	2.11
α_{19}	.0822	.0306	2.68	β_{29}	.0416	.0060	6.94
β_1	-.1033	.0137	7.55	β_{30}	-.0511	.0125	4.10
β_2	-.3	(value imposed)		β_{31}	1.1348	.5022	2.26
β_3	.3	(value imposed)		β_{32}	.4024	.0623	6.46
β_4	.0362	.0121	3.00	β_{33}	.1037	.0096	10.83
β_5	-.5	(value imposed)		β_{34}	-.0155	.0043	3.59
β_6	-.2332	.0965	2.42	β_{35}	-.1911	.1949	.98
β_7	.05	(value imposed)		β_{36}	-.0396	.0230	1.72
β_8	.0182	.0242	.75	β_{37}	.1024	.0081	12.71
β_9	-.3356	.1504	2.23	β_{38}	.0686	.0047	14.54
β_{10}	.2016	.1243	1.62				
γ_1	-.1440	.0394	3.66	λ_1	.0158	.0006	26.72
γ_2	-.1426	.0435	3.28	$\lambda_1+\lambda_2$	.0161	.0005	34.02
γ_3	-.1874	.0474	3.96	λ_3	.0019	.0003	6.67

Appendix C : Annualisation of the RBA76 Model

The annual model is obtained from the quarterly model by making the following changes to the specification and parameter values. The changes are considered in the order of the equations in Appendix A. Unless otherwise indicated, each parameter value is that estimated for the quarterly model and each variable is now measured in annual terms. It should be noted that linearisation of the annual model requires that the sample mid point values of the long term growth paths also be evaluated in annual terms.

1. Consumption Expenditure

   Multiply α_1 and γ_1 by 4 .

   Subtract log 4 from the equation for $\hat{m}$.

2. Net Private Investment

   The annual equation becomes :

$$Dk = 4\,\alpha_2[4\,\alpha_3((\beta_3\,y)/(4K - r/4 + (D\log P)/4)$$

$$- 4\lambda + 4\,\beta_4 \log\left({}^{x}/_{x^{*}e}\ 4\,\lambda_1 t\right) - k] \quad .$$

3. Exports

   Multiply α_4 and λ_1 by 4 and add log 4 to the equation for $\hat{x}$.

4. Imports

   Multiply α_5 and β_7 by 4 .

5. Output

Multiply α_6 and β_8 by 4 .

6. Price of Output

The annual equation becomes :

$$D \log P = 4\,\alpha_7(\log 52\ {}^{WL}/_{y} - \log P) + 4\,\beta_{11}(\log \hat{v} - \log v) + 4\,\gamma_2(\log \hat{m} - \log {}^{M}/_{p}) \ .$$

7. Price of Government Goods and Services

Multiply α_8 by 4 .

8. Price of Exports

Multiply α_9, β_{12}, β_{13} and λ_2 by 4 .

9. Average Weekly Earnings

The annual equation becomes :

$$D \log W = 4\,\alpha_{10}(\log(1 - \beta_3)\ {}^{y}/_{L} - \log 52\ {}^{W}/_{p}) + 4\,\beta_{14} \log{}^{L}/_{N} + 4\,\beta_{15} \log(W_A/W_A^* e^{4\lambda_3 t}) + 4\,\gamma_3(\log \hat{m} - \log {}^{M}/_{p}) \ .$$

10. Labour Supply

α_{11} is multiplied by 4 and the equation for $\log \hat{N}$ becomes :

$$\log \hat{N} = N_0 + \beta_{17} \log[(1 - t_1)\ 52\ {}^{WL}/_{(Py)}] + \log L \ .$$

11. Labour Demand

The annual equation becomes :

$$D \log L = 4\,\alpha_{12}(\log(1 - \beta_3)^{Y}/_{L} - \log 52\ ^{W}/_{P}) .$$

12. Non-bank Demand for Government Bonds

Multiply α_{13} by 4 and subtract log 4 from the equation for $\log \hat{b}$.

13. Net Capital Inflow

Multiply α_{14} by 4 and subtract log 4 from the equation for $\log \hat{f}$.

14. Bank Advances

Multiply α_{15}, β_{25}, λ_1 and λ_2 by 4 .

15. Income Taxes

Multiply α_{16} by 4 .

16. Expenditure Taxes

Multiply α_{17} by 4 .

20. Bond Rate

Multiply α_{18}, β_{30}, β_{31}, β_{32}, β_{33}, λ_1 and λ_2 by 4 .

21. Exchange Rate

Multiply α_{19}, β_{34}, β_{35}, β_{36}, β_{37}, β_{38}, λ_1 and λ_2 by 4 .

Appendix D : Definitions and Sources for the Data in the RBA76 Model

In this section, the sources from which raw data are obtained are set out; the construction of variables used to estimate the Model is described and a listing of the data is provided. References cited [ ] refer to the data sources listed on page 56.

1. RAW DATA

ADVSB loans, advances and bills discounted by All Savings Banks, average of weekly figures for third month in quarter, $m. [12]; "All Savings Banks, Selected Assets."

ADVTB loans, advances and bills discounted by All Trading Banks, average of weekly figures for third month in quarter, $m. [12]; "All Trading Banks, Selected Assets."

C personal consumption expenditure on goods and services, $m. at 1966/67 prices. [6], [4]; "Table 2 - Expenditure on Gross Domestic Product at Average 1966/67 Prices."

DEPN$ depreciation allowances, private capital stock, $m. [1]; "Table 18 - Depreciation Allowances, by Industry and Form of Organization." Items : Companies and Unincorporated Enterprises.

The series is interpolated from annual figures using the method described in part 4 of this appendix.

DEPNG$ depreciation of public capital stock, $m. [1]; Table 18 - Depreciation Allowances, by Industry and Form of Organization." Item : Public Enterprises.

The series is interpolated as for DEPN$.

ER exchange rate, $US/$A, Market value of $1A on the last day of the quarter. Note : In September 1974 Australia adopted a trade weighted exchange rate. International Department, Reserve Bank of Australia.

FR official holdings of gold and foreign reserves, end of quarter, $m. [12]; "International Liquidity."

FRV adjustment for the effects of the exchange rate changes on official holdings of gold and foreign reserves. Research Department, Reserve Bank of Australia.

GDP gross domestic product (at market prices), $m. at 1966/67 prices.
[6], [4]; "Table 2 - Expenditure on Gross Domestic Product at Average 1966/67 Prices."

GDP$ gross domestic product (at market prices),$m.
[6], [4]; from "Table 1 - Domestic Production Account."

GEC government final consumption expenditure, $m. at 1966/67 prices.
[6], [4]; "Table 2 - Expenditure on Gross Domestic Product at Average 1966/67 Prices."

GEC$ government final consumption expenditure, $m.
[6], [4]; "Table 1 - Domestic Production Account."

GEK government (public) gross fixed capital expenditure, $m. at 1966/67 prices.
[6], [4]; "Table 2 - Expenditure on Gross Domestic Product at Average 1966/67 Prices."

GNO face value of non-official holdings of Australian Government securities and Treasury notes, end of quarter, $m.
[12]; from Table - "Government Securities Classified by Holder." "Total Holdings" less the sum of 'Reserve Bank' and 'Public Authorities (excl. Finance)'.

GSS face value of the holdings of Australian Government securities by Savings Banks, average of weekly figures in third month of quarter, $m.
[12]; "Savings Banks, Selected Assets."

GST face value of the holdings of Australian Government securities by All Trading Banks, average of weekly figures in third month of quarter, $m.
[12]; "All Trading Banks, Selected Assets."

IC construction investment; gross private fixed capital expenditure on other building and construction, $m. at 1966/67 prices.
[6], [4]; "Table 7 - Gross Fixed Capital Expenditure and Increase in Stocks at Average 1966/67 Prices."

ID dwelling investment; gross private fixed capital expenditure on dwellings, $m. at 1966/67 prices.
[6], [4]; as for IC.

IE equipment investment; the 'all other' component of gross private fixed capital expenditure, $m. at 1966/67 prices.
[6], [4]; as for IC.

M3 volume of money, average of weekly figures in third month of quarter, $m.
[12]; "Volume of Money."

MM imports of goods and services, $m. at 1966/67 prices. [6], [4]; "Table 2 - Expenditure on Gross Domestic Product at Average 1966/67 Prices."

MM$ imports of goods and services, $m. [6], [4]; "Table 1 - Domestic Production Account."

NDEF defence employment, permanent defence forces in Australia and overseas, last month of quarter figures, thousands; [2] "Table 1 - Civilian Employees and Defence Forces : Australia." (Category : Defence Forces).

NE employment, non-farm civilian employees, last month of quarter figures, thousands. [5], [2]; "Table 2 - Civilian Employees : States and Territories." (Category : Persons).

Note: This series is only published from 1966(3). The series from 1958(3) to 1966(2) is obtained from Commonwealth Treasury. There is a minor break in the series after 1971(2); trainee teachers are excluded from the definition.

NF farm employment, thousands; [3]; "Table 2 - Civilian Population 15 years of age and over by Employment Status."

Note: This series is only available from 1964(1). Earlier figures are obtained from the regression (1958(3) - 1974(4)):

$$NF = 435 - .04S1 - 10.01S2 - 4.98S3 - 2.37t + 0.22NE$$

NU unemployment; persons registered for employment with the Commonwealth Employment Service, last month of quarter figures, thousands. [5], [2]; from "Table 11 - Registered Unemployed," (Item : total unemployed, persons, original; Australia). Revised definition of Unemployed series from 1973(3). A revision in the definition of school leavers involved a decrease of approximately 1,000. (Old series still used.)

PW(US) world price series, index, 1963 = 1.0. U.S. implicit price deflator. [11]

QA dummy variable for requests by the Reserve Bank to All Trading Banks about advances outstanding, assuming a lag of one quarter in response of advances to a request.

QA = 1 in 1961(1) - 1961(2); 0 otherwise.

QE dummy variable for expectations of a change in the exchange rate.

$QE = -(0.5)^i$ $i = 1$ in 1972(4) and 1973(3) ;
$= (0.5)^i$ $i = 1$ in 1974(3); and $i = 2$, 3, 4 in the preceding three quarters in each case.

QER dummy variable for the timing of exchange rate changes.

QER = - 1 in 1972(4) and 1973(3) ;
= 1 in 1974(3); = 0 otherwise.

QF dummy variable for the imposition of direct controls on capital inflow.

QF = 1 in 1973(1) - 1974(3); = 0 otherwise.

QS dummy variable for credit squeeze.

QS = 1 in 1961(1); = .25 in 1967(4) and = 2 in 1973(3); = 0 otherwise.

QUS dummy variable for devaluation of the $US in 1973(1).

QUS = 1 in 1973(1); = 0 otherwise.

RCHD rate of sales tax on household durables, percentage. Series supplied by Australian Treasury.

RCMV rate of sales tax on purchase of motor vehicles, percentage.
[4]; there are six sales tax schedules.

$$RCMV = \sum_j u_j R_j \qquad j = 2, 3, 4$$

$$u_2 = .1787 \qquad u_3 = .5293 \qquad u_4 = .2920$$

where
R_j is the rate for the j^{th} schedule
u_j is the average proportion of the total sales value of household durables taxed under each of the relevant schedules.

$$RCMV = R_4$$

When a rate changes, that quarter's observation is derived by weighting the two rates depending on the number of days each had its effect in that quarter. For further details, see [10].

RCND rate of sales tax on non-durables, percentage. [4];

$$RCND = \sum_j u_j R_j \qquad j = 2, \text{ general rate}$$

$$u_2 = .0496 \qquad u_{GR} = .9504$$

For an explanation of the above treatment of rate changes and references, see RCMV.

RCS statutory tax rate on taxable company profits, ratio. [8], [9].

REA effective average tax rate. Research Department, Reserve Bank of Australia.

RGM theoretical yield on Australian Government securities with ten year term to maturity, (non-rebatable bonds), percentage. [12]; "Interest Rates and Security Yields."

RW(US) world interest rate, percentage. U.S. Government security yield on long dated bonds (ten years or more), monthly average. [12].

TXC indirect taxes : customs duty, $m. [4]; "Table 20 - Taxes, Fees, Fines, etc."

TXP indirect taxes : payroll tax (net), $m. [4]; "Table 20 - Taxes, Fees, Fines, etc."

TXS indirect taxes : sales tax, $m. [4]; "Table 20 - Taxes, Fees, Fines, etc."

TYCP company income tax payments, $m. [4]; "Table 20 - Taxes, Fees, Fines, etc." An adjustment is made to the series for 1974 to account for temporary changes in the seasonal pattern of payments.

TYHPNP personal income tax payments by non-PAYE taxpayers, $m. [4]; "Table 20 - Taxes, Fees, Fines, etc.". The item is "Income Taxes - Persons - Other."

TYHPP personal income tax payments by PAYE taxpayers, $m. [4]; "Table 20 - Taxes, Fees, Fines, etc.". The item is "Income Taxes - Persons - Net Tax Instalments."

W_A minimum weekly wage rates (adult males), $. [Data obtained from ABS by Activity Section, Research Department, RBA.] Monthly figures available. Quarterly observations are weighted averages of monthly figures. Example : a second quarter observation has a weight for each month as shown in column (1) below. March and June have lower weights because each only applies for one half of a month in the quarter. A wage decision in the first half of April means that the March observation has no relevance to the second quarter. Weights are therefore as in column (2) (this weighting pattern in 1961(3), 1965(3) 1967(3) and 1971(1)).

	(1)	(2)
March	1/6	0
April	2/6	3/6
May	2/6	2/6
June	1/6	1/6

WE average weekly earnings per employed male unit, index. [5], [7]; "Table 16 - Average Weekly Earnings for Employed Male Unit." The figure in this table is given in dollars. To convert to an index based on 1966/67 = 1.00, divide by 61.90 (the average figure for the four quarters of the fiscal year 1966/67). This series is only published after 1961(3). Data from 1958(3) to 1961(2) are estimated using data from an earlier definition of WE. There is a break in the series after 1971(2). Trainee teachers were excluded from the result (the series is roughly 30 cents higher).

X exports of goods and services, $m. at 1966/67 prices. [6], [4]; "Table 2 - Expenditure on Gross Domestic Product at Average 1966/67 Prices."

X$ exports of goods and services, $m. [6], [4]; "Table 1 - Domestic Production Account."

YCB cash benefits to persons from general government, $m. [4]; from "Table 14 - Households (including Unincorporated Enterprises) Income and Outlay Account."

<u>Sources of Data</u> :

[1] Australian Bureau of Statistics, <u>Australian National Accounts</u>, Canberra, annually.

[2] Australian Bureau of Statistics, <u>Employment and Unemployment</u>, Canberra, monthly.

[3] Australian Bureau of Statistics, <u>Labour Force</u>, Canberra, monthly.

[4] Australian Bureau of Statistics, <u>Quarterly Estimates of National Income and Expenditure</u>, Canberra, quarterly.

[5] Australian Bureau of Statistics, <u>Seasonally Adjusted Indicators</u>, Canberra, annually.

[6] Australian Bureau of Statistics, <u>Supplement to Quarterly Estimates of National Income and Expenditure</u>, Canberra, annually.

[7] Australian Bureau of Statistics, <u>Wage Rates and Earnings</u>, Canberra, monthly.

[8] Australian Taxation Office, <u>Annual Report of the Commissioner of Taxation</u>, Canberra, annually.

[9] Australian Taxation Office, <u>Taxation Statistics</u>, Canberra, annually.

[10] Mackrell, N.C., <u>Sales Tax Rates for 'Other Durables,' 'Non-Durables' and 'Motor Vehicles,'</u> mimeographed, Reserve Bank of Australia, December 1971.

[11] O.E.C.D., <u>Main Economic Indicators</u>, Paris, monthly.

[12] Reserve Bank of Australia, <u>Statistical Bulletin</u>, Sydney, monthly.

Construction of Variables :

$d = C + ID$

$k = DlnK$

$x = X$

$i = MM$

$y = (GDP\$ - DEPN\$ - DEPNG\$)/P$

$P = GDP\$/GDP$

$P_g = GEC\$/GEC$

$P_x = X\$/X$

$W = WE$

$N = L + NU$

$L = NE + NF + NDEF$

$B = GNO - GSS - GST$

$DF = DR - P_x.x + P_i.i$

F is cumulated from a base stock 2945.0 in 1958(2)

$A = ADVSB + ADVTB$

$T_1 = TYHPP + TYHPNP + TYCP$

$T_2 = TXP + TXC + TXS$

$R = FR - FRV$

$M = M3$

Dv = $y + i - DK - d - x - g - DKg + DEPNG\$/P$

v is cumulated from a base stock 3957.0 in 1958(2)

r = $RGM/100$

E = $^{1}/_{ER}$

DK = $IC + IE - DEPN\$/P$

K is cumulated from a base stock 11095.0 in 1958(2)

P_w = $PW(US)/1.0795$

1.0795 is the average 1966/67 value of PW(US)

P_i = $(MM\$/MM)/E$

r_w = $RW(US)/100$

g = GEC

DKg = $GEK - DEPNG\$/P$

Kg is cumulated from Kg from a base stock 23977.0 in 1958(2)

c = YCB/P_g

t_1 = $0.5\ [REA + RCS]$

t_2 = $.334\ (RCHD + RCMV + RCND)$

t_3 = $TXC/MM\$$

W_A = $(WA/43.24)/P$

43.24 is the average 1966/67 value of WA

t = time

Bibliography :

[1] Bergstrom, A. R. and Wymer, C. R., "A Model of Disequilibrium Neoclassical Growth and its Application to the United Kingdom," *European Econometrics Conference*, Grenoble, September 1974.

[2] Bergstrom, A. R. (ed.), *Statistical Inference in Continuous Time Economic Models*, North-Holland, Amsterdam 1976.

[3] Butlin, M. W., *Research Discussion Paper*, forthcoming, Reserve Bank of Australia, Sydney 1977.

[4] Caton, C. N. and Higgins, C. I., "Demand-Supply Imbalance, Unexpected Imports and Unintended Inventory Accumulation," *International Economic Review*, Vol. 15, No. 1, February 1974.

[5] Clark, C., "Net Capital STock," *Economic Record*, December 1970.

[6] Denton, F. T. and Spencer, B. G., "Household and Population Effects on Aggregate Consumption," *Review of Economics and Statistics*, Vol. 58, No. 1, February 1976.

[7] Dixon, P. B., "The Theoretical Structure of the ORANI Module," Impact of Demographic Change on Industry Structure in Australia, *Working Paper* No. 0-01, Industries Assistance Commission, Melbourne, October 1975.

[8] Griliches, Z. and Ringstad, V., *Economies of Scale and the Form of the Production Function : An Econometric Study of Norwegian Manufacturing Establishment Data*, North-Holland Publishing Company, Amsterdam 1971.

[9] Higgins, C.I., Johnston, H. N. and Coghlan, P. L., "Business Investment : The Recent Experience," *Conference in Applied Economic Research*, Reserve Bank of Australia, Sydney, September 1976.

[10] Industries Assistance Commission : "The Purpose of IMPACT," mimeo, May 1976.

[11] Jonson, P. D., Moses, E. R. and Wymer, C.R., "A Minimal Model of the Australian Economy," *Research Discussion Paper* 7601, Reserve Bank of Australia, Sydney, November 1976.

[12] Jonson, P. D., "Some Aspects of Recent Inflation," *Conference in Applied Economic Research*, Reserve Bank of Australia, Sydney, September 1976.

[13] Jonson, P. D., "Money, Prices and Output : An Integrative Essay," *Kredit und Kapital*, forthcoming, 1976.

[14] Jonson, P. D., "Money and Economic Activity in the Open Economy, the U.K. 1880-1970," *Journal of Political Economy*, forthcoming, 1976.

[15] Kmenta, J., "On Estimation of the CES Production Function," *International Economic Review*, June 1967, pp. 180-9.

[16] Knight, M. D. and Wymer, C. R., "A Monetary Model of an Open Economy and its Application to the United Kingdom," *Proceedings of AUTE Conference*, 1975.

[17] Laidler, D. E. W., "Information, Money and Macroeconomics of Inflation," *Swedish Journal of Economics*, Vol. 76, No. 1, March 1974.

[18] Leff, N. H., "Dependency Rates and Savings Rates," *American Economic Review*, Vol. 61, No. 3, June 1971.

[19] Parmenter, B. R., "Input-Output Accounting and the ORANI Module," Impact of Demographic Change on Industry Structure in Australia, *Preliminary Working Paper* No. OP-05, Industries Assistance Commission, Melbourne, August 1976.

[20] Powell, A. A. and Lawson, T., "IMPACT : An Economic-Demographic Model of Australian Industry Structure, Preliminary Outline," Impact of Demographic Change on Industry Structure in Australia, *Working Paper* No. I-01, Industries Assistance Commission, Melbourne, September 1975.

[21] Treasury - Australian Bureau of Statistics, "An Econometric Model of the Australian Economy (NIF-6)" mimeo, August 1976.

[22] Tsang, H. H. and Persky, J. J., "On the Empirical Content of CES Production Functions," *The Economic Record*, December 1975, pp. 539-548.

[23] Tulpulé, A. H. and McIntosh, M. K., "BACHUROO : An Economic-Demographic Module for Australia," Impact of Demographic Change on Industry Structure in Australia, *Working Paper* No. B-02, Industries Assistance Commission, Melbourne, April 1976.

[24] Williams, R., "Household Consumption in Australia : An Examination of Patterns Across Socio-Economic Classes," Impact of Demographic Change on Industry Structure in Australia, *Preliminary Working Paper* No. SP-04, Industries Assistance Commission, Melbourne, May 1976.