A SMALL MODEL OF OUTPUT, EMPLOYMENT,
CAPITAL FORMATION AND INFLATION,
APPLIED TO
THE NEW ZEALAND ECONOMY

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No. 32

May 1979

DEPARTMENT OF ECONOMICS

UNIVERSITY OF SYDNEY
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National Library of Australia Card Number and ISBN 0 86837 006 1
R.W. Bailey and P.C.B. Phillips are at the University of Birmingham, England and V.B. Hall is at the University of Sydney. The authors wish to thank Peter Jonson, Mervyn King and Grant Spencer for their comments on a preliminary draft of the paper's first two sections, which the authors circulated in September 1977. We have also benefited from fruitful discussions with Peter Ledingham during the preliminary stages of this work.
A small model of output, employment, capital formation and inflation, applied to the New Zealand economy

1 Introduction

This paper reports the development of a small aggregative model of output, employment, capital formation and inflation. The model (BHP) is in the tradition of the prototype model developed for the United Kingdom by Bergstrom and Wymer [8] (BW). It is a medium term growth model that allows explicitly for market disequilibrium, it is formulated in continuous time and, after appropriate transformations, it is able to be estimated from discrete data by a full information technique. As in BW, the model is characterised by the role which economic theory plays in the specification of the equations, leading to important interdependencies in the system, including across equation parameter restrictions, and non-linearities in both the parameters and variables. The model is specified and its main features discussed in section 2. The model also corresponds with BW to the extent that many of its properties can be analysed mathematically and this provides a useful check on the model's realism, particularly with respect to the time paths the model is capable of generating for its endogenous variables and with respect to the steady state solution of the model. These aspects are outlined in section 3. However, although the framework of BHP has much in common with that of BW, there is no doubt that BHP incorporates a number of distinctive new features.

First, in several equations we have attempted to explicitly recognise the role of an effective supply constraint, and have specified adjustment coefficients as explicit functions of other variables in ways which allow us to test the significance of these effects in the empirical application. We argue that decision makers are planning to adjust (for instance, their rates of consumption or demand for labour) to certain desired levels at certain rates; but these plans can be disrupted by shortages in supply and by spillover effects from other markets (particularly, monetary
effects, labour shortages and so on), and some responses may be asymmetric in nature. Supply side elements and spillover effects in situations of disequilibrium have been emphasized in the work of Clower [10], Barro and Grossman [2,3], Malinvaud [25] and others. These authors stress the role that quantity rationing can play in market transactions when markets do not necessarily clear. Thus, if there is an excess supply of labour at the prevailing level of wages and the wage rate does not adjust fast enough to clear the market, the resulting unemployment reduces the effective demand for goods. In this way, the consumption function is quantity constrained and its formulation should depend quantitatively on the degree of "quantity rationing" that occurs in the labour market. The short side of the labour market, in this case the binding demand for labour, determines the level of employment; and the spillover effect of disequilibrium in this market on the goods market is characterised by the consumption function now being conditional on the employment level. This type of disequilibrium model has been receiving an increasing amount of attention in the theoretical literature. Most of this literature together with the research that has been done on the econometric estimation of single markets in disequilibrium has assumed the existence of a switching regime where transactions always take place on the short side of the market; and, hence, on either the supply curve or demand curve. This hypothesis is more realistic at the micro than at the macro level. In the latter case, we are essentially aggregating over a large number of different markets for different goods, occurring in different locations and, indeed, occurring at different times during the discrete time interval that corresponds with the interval of observation for our data. An interesting recent paper by Muellbauer [28] attempts to deal with some of these problems caused by aggregation. Muellbauer allows for a cross section of micro markets that may be in different regimes. These differences are smoothed out by aggregation over markets resulting in behavioural equations which are smooth functions of the systematic component of excess demand (individual market demand and supply functions are characterised by deviations from mean demand and supply functions over all markets and these latter functions lead to a systematic measure of excess demand). While this approach to aggregating micro markets in different regimes is very promising, it is not easy to see how to generalise it to deal with the problems of temporal aggregation where even the same market may be in different regimes at different times during the sampling interval and the systematic components of the demand and supply functions will, naturally enough, be time varying since the sampling interval does not correspond with the decision making intervals used by the economic agent at the micro level. As indicated at the beginning of this paragraph,
the approach taken in the present paper is rather different. We assume that quantity rationing constraints do occur at the macroeconomic level and that these constraints typically take the form whereby they influence the rate at which adjustments can be made towards the partial equilibrium values of the relevant variables. In other words, certain adjustment rates in the present model are endogenously determined.

Supply side constraints are not, however, directly treated in the BW model nor in the subsequent models of this genre that have so far been developed and with which we are familiar. Most of the equations in the BW model and its derivative models allow the actual levels of a variable to be determined by the adjustment towards a partial equilibrium (or desired) level of that variable at a constant rate. The following description of the main features of this type of specification is given by Jonson, Moses and Wymer [18, p.10] (JMW):

"Effective demands for commodities and assets are modelled in two steps. Equilibrium or long run demands are determined subject to the relevant constraints and relative prices. Effective demands and equilibrium demands are assumed to be linked by a first order adjustment process which is intended to capture the net effects of lags in the adjustment of expectations, uncertainties and other real world frictions."

If this type of specification is to be interpreted as a way of modelling market disequilibrium, then it is important to distinguish its features from the conceptual framework introduced by Clower [10]. In the first place the use of the term "effective demand" by Jonson et. al. above does not correspond to the usage by Clower since it does not explicitly allow for quantity rationing and quantity rationed functions in the same sense. Note that this is true even of those equations in Jonson et. al. [18] where the additional "effects of disequilibrium in real money balances" is taken into account.

To take the consumption function of Jonson et. al. [18, equation (1) page 28] as an example, we see that actual expenditure is assumed to adjust by a first order process towards a partial equilibrium or desired expenditure function (determined by disposable income and interest rates) and that, in addition, the adjustment of consumption is influenced by an additive term reflecting "the gap between actual and desired money balances where desired money balances are a function of income and interest rates" (Jonson et.al. [18, p.16]). This equation assumes that actual expenditure is completely determined by the level of actual household demand (as distinct from the desired expenditure function of households) which emerges from this (differential) equation. Thus, there is no mechanism in the equation to allow for the effect of disequilibrium in the market for goods on actual expenditure if the goods market does not
clear. The same point has recently been made by Muellbauer who argues for the use of excess demand indicators in all behavioural equations of macro-models. Thus:

"Conventional employment equations are a good example. Typically, desired labour demand is specified as a function of some variables such as output and the capital stock (obtained by inverting the production function) and a partial adjustment mechanism relates employment to desired labour demand. This either assumes that employment equals actual (as opposed to desired) labour demand, or else proxies non-clearing labour markets by an ad hoc adjustment mechanism which has nothing to do with the state of excess demand."

In BHP we have allowed for variable rates of adjustment in the specification of a number of equations to take account of supply side effects, spillover influences from other markets, asymmetrical responses and the state of excess demand, where we believe these various effects are most likely to be relevant. These speed of adjustment coefficients are determined as explicit functions of other variables in the system and, in this way, are endogenously determined. The theoretical work by Treadway [36 and 37] lends some support to this type of specification. Treadway showed that, if a firm uses n quasi-fixed inputs measured by the vector x and \( \dot{x} \) denotes the rate of investment in these inputs, then a local solution to the optimal path which maximises the present value of profits is given by the multivariate adjustment process

\[
\dot{x} = M(x^*, r)[x - x^*]
\]

where \( x^* \) is a stationary equilibrium and \( M \) denotes a matrix of adjustment coefficients. These coefficients are seen to be functionally dependent on the target vector \( x^* \) and the rate of interest \( r \). It seems reasonable to suppose that local solutions to the optimal control problems faced by other representative economic agents such as consumers will display similar characteristics. Of course, these arguments apply strictly to the microeconomic problems only. But, to the extent that we can work on the assumption of representative agent behaviour in a macroeconomic model, it is useful to be guided by the implications microeconomic analysis may have for the form of local solutions such as the above adjustment mechanism. Unfortunately, economic theory does not yet provide any guidance concerning the functional dependence \( M = M(x^*, r) \) and this is at present a matter for the empirical investigator. Our present philosophy is, therefore, to allow for variable adjustment rates in certain equations and select functional forms which seem to correspond to plausible economic behaviour. This type of specification enables us to test
the significance of the supply and spillover effects that enter into the variable adjustment rates in our empirical application of the model to the New Zealand economy. Two supply side constraints are thought to be particularly important for the New Zealand economy: a supply of labour services constraint which is by nature asymmetric (i.e., the rate of adjustment in employment is more severely affected in periods of labour shortage); and an internal funds constraint affecting real imports and, hence, the overall supply of goods and services.

The second way in which our model differs from the BW framework is with respect to the (desired) factor demand functions for capital and labour services. These are jointly determined through a cost minimisation process so that relative prices figure prominently in these functions.

Third, we have moved to second order adjustment processes in a number of equations (BW use second order differential equations only for capital and money). We have specified, in addition, our wage and price equations as second order differential equations. Such a formulation seems necessary in view of the important changes in the rates of wage and price inflation in recent years which require explanation. The movement to a higher order adjustment process allows us to marry different theories of price determination consistently in the same equation.

In the context of other small models of the New Zealand economy, BHP is certainly a major development from the simple aggregate expenditure models of Bergstrom and Brownlie [6](BB) and Phillips and Yeabaley [32](PY). These two models have no behavioural equations for employment, capital formation and the price-wage sector. BHP also has features which are markedly different from those of the small models developed to date within the Reserve Bank of New Zealand (RBNZ). Their initial "small" model was presented by Morgan [27], but as this was essentially a condensation of the RBNZ's large model (involving about 80 endogenous variables) to about one-third its size, it did not exhibit particularly rigorous theoretical foundations and consistency. In Spencer, Smith and Joseph [34](SSJ), though, an attempt was made to develop a (24 behavioural equation) CORE model with rather more rigorous and consistent foundations. The first complete version of CORE was presented in Spencer [35]. It consisted of 22 behavioural equations and 17 identities and was estimated by Two Stage Principal Components. Each of these "small" RBNZ models has thus been specified in discrete time and been designed primarily for short-term forecasting and/or analysis of short-term dynamic behaviour. A smaller model of somewhat different nature has also been recently developed within the RBNZ. This is Gillian's [14] experimental small model (ESMO) of 21 equations which was specified with a view to capturing some
aspects of economic behaviour beyond the short term. Some degree of theoretical rigour and comprehensiveness was attempted, but although estimation was by a full information method, this model also was specified in discrete time. It necessitated the use of a linear approximation to ensure linearity in the logarithms of the variables, and the very preliminary empirical results were disappointing.

Consequently, because BHP has been specified in continuous time, has been designed primarily as a medium term econometric model which should be capable of producing plausible long run behaviour, and envisages simultaneous equation non-linear in variables estimation by a full information method, it is very much a differentiated product from small and medium-size models developed to date for New Zealand.

Finally, it should be pointed out that BHP is a subset of equations consistent with a larger model concurrently being developed by the authors, which additionally incorporates explicit monetary sector behaviour. Thus, BHP has an explicit goods market, factor demand relations and a wage price sector only, while the monetary activity influences (both domestic and foreign) are taken as exogenous.

2 Outline of the Model and its Main Features

2.1 Overview of the Model

The model presented below in deterministic form is for a small open economy whose single good is used for consumption or capital formation purposes, can be supplied either domestically or from foreign sources, and can be demanded either by the rest of the world or domestically by both the private and public sector. There is no explicit private income sector, the only explicit private sector financial asset is money, and there are therefore no significant private holdings of financial assets by the rest of the world.

The principal economic agents are households, firms, Central Bank and Central Government Authorities, and the rest of the world. As will become more apparent when each equation is more fully explained, the behaviour of these agents is assumed to be determined on the following basis. Households demand goods and services and real money balances and supply labour. The extent to which the demand for goods and services is achieved depends on the stocks of goods and services available and on each household's supply of real money balances. The supply of labour services is assumed to vary, in the short run, with the real wage and with trend demographic factors and, in the long run, with further demographic factors and the rate of technological progress. Firm behaviour is consistent with supplying goods
and services and demanding both capital and labour services. A major constraint on this domestic production process is provided by the form of the firm's production function; and the extent to which plans for the hire of labour services are achieved is dependent both on the nature and the degree of disequilibrium in the market for labour. Neither households (either alone or through their agents, the trade unions) nor firms are assumed to have complete control over prices and wages. Firms adjust prices in an attempt to cover their marginal (wage) costs, but the extent to which prices are changing may, in addition, be influenced by disequilibrium in the market for goods and services. Wage changes are assumed to be dependent on the extent of labour market disequilibrium; but the rate of change of wage inflation may also be influenced directly by the rate of change in prices. The Central Bank and Central Government Authorities are assumed responsible for interest rates, the level of real government expenditure and taxation rates, specific direct controls on the trading banks and imports, the exchange rate, and for allowing movements in the aggregate money supply to accommodate the aggregate demand for money. Exports are determined by the level of demand from the rest of the world and imports respond, subject to the direct controls of the authorities, to the domestic demand by households for imported goods and services and by firms for imported capital goods.

2.2 Equations of the Model

The model BHP consists of 11 equations. Seven equations are behavioural and four equations are identities. There are ten exogenous variables. The total number of parameters is 32, consisting of 19 behavioural parameters (such as elasticities, propensities, efficiency and share parameters), 11 adjustment parameters and 2 growth rates.

Our notations for the variables are as follows:

**Endogenous**

\[
\begin{align*}
C &= \text{real private consumption expenditure} \\
Y &= \text{real net output or income} \\
S &= \text{real stock of inventories} \\
k &= \text{proportional rate of change of real net fixed capital} \\
K &= \text{stock of real net fixed capital} \\
W &= \text{wage rate} \\
P &= \text{price of output} \\
L &= \text{employment} \\
I &= \text{real imports of goods and services} \\
\phi &= \text{proportional rate of change of price}
\end{align*}
\]
\[ W = \text{proportional rate of change of wages} \]
\[ L_s = \text{labour supply} \]
\[ MC = \text{short-run marginal (wage) costs} \]

**Exogenous**

\[ GB = \text{real government expenditure on monetary (social security) benefits} \]
\[ TP = \text{real personal income tax payments} \]
\[ MBD = \text{bank demand deposits, \$m} \]
\[ J = \text{interest rate} \]
\[ t = \text{time} \]
\[ E = \text{real exports of goods and services} \]
\[ G = \text{real government expenditure} \]
\[ P_i = \text{imports price level} \]
\[ ZQI = \text{dummy variable representing the relative strength of quantitative imports restrictions} \]
\[ ZAT = \text{dummy variable representing official monetary policy with respect to trading banks' advances} \]

Writing the differential operator as \( D = d/dt \), the equations of the model are:

\[(1) \quad \frac{DC}{C} = \gamma_1 \ln \left[ \frac{\hat{C}}{C} \right] \]

\[ \hat{C} = \beta_1 (Y + GB - TP) \]

\[ \gamma_1 = \beta_2 + \beta_3 \left( \frac{D(MBD)}{MBD} - \frac{DP}{P} \right) + \beta_4 \exp \left( - \frac{DS}{S} \right) \]

\((\beta_4 < 0)\)
(2) \( D_k = \gamma_2 \left[ \gamma_3 \ln \left( \frac{\hat{K}}{K} \right) - k \right] \)
\[ \hat{K} = \beta_5 \left\{ \frac{1}{1+\beta_7} - \frac{\left( \beta_7 \lambda_1 \right)}{1+\beta_7} e^{\frac{1}{1+\beta_7}} \right\} \]
\[ H = \frac{W}{F(\beta_8 + \beta_9 (J-DP/P))} \]

(3) \[ \frac{DL}{L} = \gamma_4 \ln \left( \frac{\hat{L}}{L} \right) \]
\[ \hat{L} = \beta_5 \beta_6 \left\{ \frac{1}{1+\beta_7} e^{-\lambda_1 t} \right\} \]
\[ \gamma_4 = \beta_{10} \ln \left( \frac{L_s}{L} \right) \]
\[ L_s = \beta_{11} e^{\frac{\lambda_2 t}{1+e^{\lambda_1 t}}} \]

(4) \[ DS = Y + I - C - DK - E - G \]

(5) \[ \frac{DY}{Y} = \gamma_5 \ln \left( \frac{\hat{Y}}{Y} \right) + \gamma_6 \ln \left( \frac{\hat{S}}{S} \right) \]
\[ \hat{Y} = (1 - \beta_{13})(C + DK + E + G) \]
\[ \hat{S} = \beta_{14}(C + DK + E + G) \]
\[ \beta_{13} = \beta_{15} \left( \frac{P}{P} \right)^{\beta_{16}} (ZQI)^{\beta_{17}} \]
\[
\frac{\Delta I}{I} = \gamma_7 \ln \left[ \frac{\hat{I}}{I} \right] + \gamma_8 \ln \left[ \frac{\hat{S}}{S} \right]
\]

\[
\hat{I} = \beta_{13}(C + DK + E + G)
\]

\[
\gamma_7 = \beta_{18} + \beta_{19}ZAT
\]

\[
Dp = \gamma_9 \left[ \gamma_{10} \ln \left( \frac{(1 + \beta_{20})MC}{p} \right) - p \right] + \gamma_{11} \ln \left[ \frac{\hat{Y}}{Y} \right]
\]

\[
MC = \omega_{\beta_5}^{-\beta_7} \beta_6^{-1} e^{\beta_7 \lambda_1 t} (L/Y)^{1+\theta_7}
\]

\[
Dw = \gamma_{12} \left[ \gamma_{13} \ln \left( \frac{\hat{L}}{L} \right) - w \right] + \gamma_{14} \frac{DP}{p}
\]

\[
k = \frac{DK}{K}
\]

\[
p = \frac{DP}{p}
\]

\[
w = \frac{DW}{w}
\]

2.3 Equation (1):

The Consumption Function

Equation (1) shows private consumer expenditure as being primarily demand determined but subject to important additional supply side influences including both monetary and goods market effects. It is assumed that the rate (of flow) of real private consumer expenditure adjusts to a desired or partial equilibrium rate \( \hat{C} \) in such a way that the greater the excess of \( \hat{C} \) over \( C \) the greater the proportional rate of change of \( C \). \( \hat{C} \) is assumed to be dependent on the level of real private disposable income and the parameter \( \beta_1 \) is the relevant long run marginal propensity to consume. Clearly, many alternative
specifications of \( \hat{C} \) are possible but it is interesting to note that not all of these are necessarily consistent with plausible long run steady state growth paths of the real variables in the system. For instance, an alternative specification is

\[
\hat{C} = \mu_1 (Y + GB - TP)^{\mu_2} \left( \frac{M}{P} \right)^{\mu_3}
\]

which incorporates the additional real liquid assets variable \( M/P \), where \( M \) is the aggregate volume of money. Such a specification is consistent with that of many aggregate consumption functions which have been used elsewhere (c.f. Mayer [26]). However, if (12) is to be used in the context of our complete system of equations, then the parameter constraint

\[
\mu_2 + \mu_3 = 1
\]

is required if the real variables \( C \) and \( Y \) are to grow at the same constant proportional rate in the steady state (assuming an exponential growth path for \( M \) and the other exogenous variables in the system).

The channel we have selected for a liquidity influence to work in equation (1) enters through the speed of adjustment parameter \( \gamma_1 \). In the specification of \( \gamma_1 \) it is assumed that if, for example, real aggregate demand deposits, \( MBD/P \), are falling then the speed of adjustment of \( C \) to \( \hat{C} \) will be curtailed. In this way monetary behaviour can have a direct spillover effect on consumer expenditure. The importance of this effect is measured by the parameter \( \beta_3 \), and the effect is symmetric for positive and negative values of \( D(\ln(MBD)/P) \) -- that is, the magnitude of the effect on \( \gamma_1 \) will be the same regardless of the sign of the change in \( (MBD)/P \). This channel of influence for liquidity was chosen in preference to the "disequilibrium money balances" approach of Knight and Wymer [21] and Jonson, Moses and Wymer [18]. As will be apparent from the explicit monetary sector of the large version of BHP being developed, the variable \( MBD \) is the residual in the private sector wealth constraint. If money is to take the role of a buffer stock and signalling device as argued by Jonson, Moses and Wymer [18, p.11], then it is our view that \( MBD \) will be more appropriate in measuring the effect of such a role than the aggregate volume of money. Note that the form of our specification suggests that if the real purchasing power of the residual in the private sector wealth constraint is being run down then the rate at which the rate of consumption expenditure is being adjusted to its desired level \( \hat{C} \) will be curtailed. This type of specification preserves the recursive nature of the model, because although \( D\ln C \) is a first derivative
C is a flow and DlnC measures the proportional rate of change of the rate of consumption expenditure at a point in time. It is, therefore, perfectly consistent with the recursive nature of the model to have the adjustment coefficient \( \gamma_1 \) dependent on the proportional rate of change Dln(\((MBD)/P\)).

The importance of the recursive structure in continuous time modelling in order to ensure meaningful solutions was stressed in the fundamental paper by A.W. Phillips [31].

An additional supply side influence involving the real supply of goods and services is incorporated in \( \gamma_1 \) through the term \( \beta_4 \exp(-DS/S) \).

At the microeconomic level, supply side bottlenecks often mean that observations refer to the (short) supply side of the market; and, when there are no supply constraints, observations refer to the demand side of the market so that the method of switching regression regimes is appropriate for analysing this situation (c.f. Fair and Jaffee [11]). At the macroeconomic level where we are aggregating across markets that may be expected to be in different regimes, the strict switching regressions technique seems less appropriate. Nevertheless, it seems reasonable to consider, even in aggregate, market behaviour where supply side constraints may be a dominating (if temporary) influence.  

Our specification of \( \gamma_1 \) allows for this possibility, so that if stocks are being run down in aggregate (\( DS < 0 \)) the speed of adjustment with which C can effectively adjust to \( \hat{C} \) is curtailed (\( \beta_4 < 0 \)). The form of the function \( \exp(-DS/S) \) has been selected so that the supply constraint is binding in the right direction and, thus, when stocks are being built up the effect of this term will be small. The importance of this supply side effect is measured through the parameter \( \beta_4 \), which we would expect to have a negative sign as already indicated. In addition to these goods market and monetary supply influences on \( \gamma_1 \) there is assumed to be a constant component in the speed of adjustment measured by the parameter \( \beta_2 \).

2.4 Equations (2) and (3):

The Investment and Employment Relations

The fundamental ideas underlying equations (2) and (3) can conveniently be explained together. The expressions \( \hat{K} \) and \( \hat{L} \) represent the desired demand for capital and labour services respectively and result from a conventional cost minimisation process under the assumption of a CES production function of the form

\[
Y = \beta_5^{-1} \left\{ \frac{\beta_7}{K} + \beta_6 \left[ \frac{\lambda_1}{L} \right]^{-\beta_7} \right\}^{-1/\beta_7}
\]

Thus, the representative firm is assumed to know its relative factor prices
and its production function and to jointly determine its desired demands for factor services on the basis of cost minimisation. One innovation in equations (2) and (3) is our representation of the cost of capital as a linear function of the real rate of interest (J - DP/P) multiplied by the general price level P. The use of the price variable P is consistent with the strict interpretation of the entire model as a single good model and if we were to distinguish consumption and capital goods in the theoretical structure of the model we would, of course, use the appropriate capital goods price variable instead. Our cost of capital variable \( P(\beta_8 + \beta_9 (J - DP/P)) \) then has the same form as that normally used in models of investment behaviour except that the rate of depreciation and tax variables do not appear explicitly in the expression. Since these latter variables can vary in practice considerably across firms it seems to us worthwhile to attempt to estimate an empirical measure of the cost of capital that is applicable to our "representative" firm by the introduction of the parameters \( \beta_8 \) and \( \beta_9 \). Note that this allows the representative firm to introduce a proportional markup (through \( \beta_9 \)) on the real rate of interest in its decision on the profitability of investment. This form also enables us to handle empirically observations for which the real rate of interest is negative and yet the cost of capital still positive (since \( \beta_8 > 0 \)).

Since \( k = \Delta K/K \) (equation (9)), (2) is a second order differential equation in \( K \) and describes the way in which the rate of capital formation is adjusted over time according to the extent to which the capital stock deviates from the desired level of capital \( \hat{K} \), which in turn depends on the level of output, the prevailing wage rate and the cost of capital as well as the rate of technical progress. As in BW (but with a rather different functional form, due to the presence of \( \hat{K} \)), equation (2) assumes that there is a partial equilibrium proportional rate of increase in the stock of capital (measured by \( \gamma_3 \ln(K/K) \)). It is further assumed that for a variety of reasons (including the costs associated with varying the rate of capital formation, delivery lags in the supply of capital goods and the availability of internally generated funds to finance investment) the rate of capital formation is not necessarily equal to this partial equilibrium rate. Instead the rate of change of the rate of capital formation is taken to depend on the excess of the partial equilibrium rate over the actual rate. Some consideration was given to the idea of specifying the adjustment rate \( \gamma_2 \) explicitly in terms of a costs of adjustment variable (Brechling [9]) or a measure of the flow of internally generated funds (Nickell [29, pp. 262-263]); but this idea was rejected, at least for our present study of BHP, since (2) is already a heavily complicated equation.
The employment equation (3) differs considerably from that of BW in that it seeks not only to capture the major (and somewhat unique) features associated with New Zealand's market for labour services but also to tackle certain deficiencies of the BW and Knight and Wymer (KW) formulations.

A traditional labour services formulation requires that the supply of labour services be infinitely elastic or be able to react through the appropriate adjustment procedures to fully satisfy the desired factor demand, because the supply of labour services is always at least that demanded. In New Zealand until very recently, however, the usual situation has been a significant shortage of labour (alleviated to some extent in the shorter run by the working of extra hours of overtime, and in the longer run, by net immigration) with the supply of labour services consistently failing to satisfy demand (in the notation of the model \( \hat{L} \geq L = L_s \)). Since \( L \) and \( L_s \) are smooth functions of other variables, this situation typically leads to an employment function for \( L \) with a discontinuity in the first derivative, which is difficult to model directly. Our own approach in equation (3) is based on the hypothesis that employment, \( L \), adjusts towards the desired level \( \hat{L} \) but that the rate of adjustment explicitly depends on the supply of labour services, \( L_s \), the extent of the gap between \( L_s \) and \( \hat{L} \) and, indeed the direction of the inequalities \( \hat{L} \leq L_s \) or \( \hat{L} > L_s \) (the latter being the more usual situation in New Zealand). More specifically, we take into account two separate factors in the formulation of \( \gamma_4 \):

(i) The speed of adjustment parameter \( \gamma_4 \) depends on the extent of labour market disequilibrium and does so in a non-linear way. The use of the logarithmic specification enables us to capture the asymmetry of a more powerful (negative) effect on the adjustment speed of employment when \( L_s < \hat{L} \) than the (positive) effect on the adjustment speed when \( L_s > \hat{L} \). Thus, although we cannot capture the full force of the inequality \( L \leq L_s \), it is hoped that this specification will go some way towards modelling the labour supply constraint on movements in employment.

(ii) The labour supply function, \( L_s \), extends the earlier formulations used by BW, KW and JMW. In BW there seems to be no allowance for direct short run adjustment of the labour supply (or \( \hat{L} \)) to any change in the real wage rate. KW introduce a real wage rate influence on the labour supply but need, in addition, to remove this influence for their model to have a steady state solution. Our own formulation of \( L_s \) in the model above is intended to tackle both these difficulties. It is a simplification of the
following functional form:

\[
L_s = \mu_6 e^{\frac{\lambda_2 t}{\frac{W/P}{\lambda_1 t}}} e^{\frac{\mu_8}{\mu_7 e^{\frac{\lambda_2 t}{\frac{W/P}{\lambda_1 t}}}}}
\]

where \( \lambda_2 \) = rate of growth of the labour force due to population growth and immigration and \( \lambda_1 \) = rate of technical progress.\(^{16}\)

In equation (14) it is assumed that the labour force is growing at the constant proportional rate \( \lambda_1 \) and in later work we hope to include separate influences for population growth and immigration (which has been subject to some fluctuation in recent years). We distinguish from the labour force, the labour supply which measures the number of persons available for employment at the ruling level of wages and prices. Although the parameters \( \mu_6 \) and \( \mu_7 \) in equation (14) are not separately identifiable (and, hence, become the composite parameter \( \beta_{11} \) in equation (3) of the model, \( \mu_7 \) has an important economic interpretation. It is assumed that at each point in time there will be a level of the real wage (here \( \mu_7 e^{\frac{\lambda_1 t}{\frac{W/P}{\lambda_1 t}}} \)) for which the labour supply would be equal to the labour force. That is, at this level of the real wage the entire labour force would be available for employment; and, if wages are not at this level, then \( L_s < \mu_6 e^{\frac{\lambda_2 t}{\frac{W/P}{\lambda_1 t}}} \). We also allow for the level of real wages for which the whole labour force would seek employment to change over time in accordance with the increasing efficiency of labour resulting from technical progress taking place at the rate \( \lambda_1 \).

In the steady state, \( W/P = (W/P)_e^{\frac{\lambda_1 t}{\frac{W/P}{\lambda_1 t}}} \). \((W/P)_e \) is the equilibrium growth path constant given in section 3, so that we have

\[
L_s = \mu_6 \left( \frac{(W/P)_e}{\mu_7} \right)^{\mu_8} e^{\frac{\lambda_2 t}{\frac{W/P}{\lambda_1 t}}}
\]

which allows for some proportion of the labour force to be unemployed in the steady state; but this is not necessarily so, as \( \mu_7 \) is an unknown parameter and could equal \((W/P)_e^{\frac{\lambda_1 t}{\frac{W/P}{\lambda_1 t}}} \).\(^{17}\) Thus, the model encompasses the case where, even in the steady state, there may be some fraction of the labour force who are not willing to work at the prevailing real wage rate.
2.5 Equations (4), (5) and (6): Inventories, Output and Imports

The definitional equation (4) takes actual inventory investment (which of course incorporates unanticipated inventory investment) as residually determined.

Equations (5) and (6) are similar in concept to the real output and real imports supply equations of BW, but have important additional supply constraints introduced through functional forms for the parameters $\beta_{13}$ and $\gamma_7$. Both the rate of increase of home production and of imports depend on excess demand for inventories through the term $\ln(\hat{S}/S)$; the former depends also on excess demand for home production, $\ln(\hat{Y}/Y)$, and the latter depends also on excess demand for imports, $\ln(I/I)$. The adjustment of actual real output, $Y$, to the partial equilibrium rate of home production $\hat{Y}$ is assumed to take place at a constant rate $\gamma_5$. A more sophisticated and realistic specification of $\gamma_5$ would allow this rate of adjustment to vary according to effective constraints on employment arising from the labour market. We have left the study of this more complicated adjustment hypothesis to a later version of BHP.

The adjustment rate $\gamma_7$, of actual real imports, $I$, to the desired rate of real imports, $\hat{I}$, is assumed to be influenced by monetary conditions as reflected by the availability of trading bank credit through the dummy variable ZAT. The parameter $\beta_{13}$ represents the proportion of total sales that is desired as imports; it varies not only with the relative prices of home produced and imported goods but also with the degree of severity of import quotas as measured by the dummy variable ZQI. Postulating this latter influence on $\beta_{13}$ implies that importers are aware of current and impending policy decisions on import quotas and do, in fact, incorporate this information in their decisions about the desired level of imports (and, hence, about the desired rate of home production).

2.6 Equations (7) and (8): The Price and Wage Sector

Equations (7) and (8) both feature higher order adjustment processes of the second order to assist in modelling the important empirical phenomena of recent years of fluctuations in the rate of change of prices and wages. Each equation also captures certain of the more traditional hypotheses about the inflationary mechanism.

The price equation (7) incorporates both cost and goods market excess demand influences within its second order dynamic specification. It
is assumed that firms attempt to set prices on the basis of some markup (dependent on the degree of imperfection in the market for goods, here measured by the parameter $\beta_{20}$) on the marginal cost of labour. $^{20}$ More specifically, in the first part of the equation (noting from equation (10) that $p$ is the proportional rate of change of prices, $DP/P$) it is assumed that firms would like prices to adjust according to the excess of $(1+\beta_{20})MC$ over the present level of prices, where $MC$ is the marginal cost of labour obtained from the production function. However, if prices are not increasing at the desired proportional rate as given by the expression

$$\gamma_{10} \ln \left\{ (1 + \beta_{20})MC/P \right\}$$

then inflationary pressure builds up and this pressure causes the rate of inflation, $p$, to change: the rate of change of $p$ is then assumed to be greater, the greater the excess of (15) over the current rate of inflation $p$. The final term on the right side of (7) measures the extent to which excess demand in the market for goods and services, $\dot{Y}/Y$, contributes directly to the inflationary process. If $\gamma_{11} > 0$, then excess demand in the goods market will cause prices to change at a rate which is faster than it would otherwise have been. Some of the reasons we have given for using an explicit second order differential equation for prices can be seen as an alternative to incorporating price expectations directly in the equation. It could be argued, for instance, that firms are expecting to adjust prices in an attempt to cover their marginal wage costs and that, in addition, this behaviour on the part of firms is expected by other economic agents in the system. Such a view would certainly play an important role in the general formation of price expectations. Our equation then assumes that these expectations are not necessarily realised and that, as a result, the actual rate of inflation will differ from the partial equilibrium rate (which would prevail if these expectations were realised) and that, moreover, this difference directly influences the acceleration of price changes.

Our specification of equation (7) can also be seen as an alternative to the procedure adopted in JM&W of using a disequilibrium real money balances variable to proxy expectations in the price equation (note that our hypothesis does not assume that price expectations are formed solely on the basis of past observations of prices). It also avoids the problem of having to obtain a measure of the price expectations variable if it were to be included directly.

The wage equation (8), with the wage rate $W$ referring to the nominal wage rate, is also specified as a second order differential equation. The primary idea underlying the equation is that the wage rate adjusts
(i.e. \( w = \frac{DW}{W} \)) according to the excess of desired demand for labour, \( \hat{L} \), over the present level of employment, \( L \). However, if wages are not adjusting at the desired rate, which is measured in the equation by \( \gamma_{13} \ln(\hat{L}/L) \), then there is a change in the rate at which wages are changing. Thus, the rate of change of wage inflation is sensitive to deviations of the actual rate of adjustment in wages from the desired rate. \(^{21}\) The final term of equation (8) is intended to measure the direct influence of the rate of price inflation on the rate of change of wage inflation. The specification implies that the rate of change of wages is dependent with a distributed time lag on present and past rates of inflation. More directly, if \( \gamma_{11} > 0 \), the rate of change of wage inflation is greater the greater the current rate of price inflation. The presence of this last term in equation (8) can also be seen as an alternative to including price expectations directly into the equation.

The remaining equations (9), (10) and (11) are definitions necessary to express the whole model as a system of first order differential equations.

3 The Steady State Solution of the Model

The structural equations (1) - (11) of BHP form a system of non-linear differential equations. This system involves nine exogenous variables (other than time) and the time paths generated for the system's endogenous variables from certain initial conditions will clearly depend on the paths taken by these exogenous variables. Under the explicit assumptions that the exogenous variables grow at constant proportional rates and that these growth rates are consistent for real variables and prices, we find a particular solution of the system in which each endogenous variable also grows at a constant proportional rate. As in BW, this particular solution displays the usual characteristics of a steady state (Solow \([33]\)) and for the real variables appearing as components of output the growth rate is the same as the equilibrium growth rate of output and capital in the simple neoclassical growth model.

Specifically, we assume that the following explicit paths for the exogenous variables:

\[
\begin{align*}
(16) & \quad GB = GB^0 e^{(\lambda_1+\lambda_2)t} \\
(17) & \quad TP = TP^0 e^{(\lambda_1+\lambda_2)t} \\
(18) & \quad MBD = MBD^0 e^{mt} \\
(19) & \quad J = J^0
\end{align*}
\]
(20) \[ E = E_0^e (\lambda_1 + \lambda_2) t \]
(21) \[ G = G_0^e (\lambda_1 + \lambda_2) t \]
(22) \[ P = P_1^e \{ m - (\lambda_1 + \lambda_2) \} t \]
(23) \[ ZQI = ZQI^o \]
(24) \[ ZAT = ZAT^o \]

The steady state solution of (1) to (11) is then

(25) \[ C = C^e \{ \lambda_1 + \lambda_2 \} t \]
(26) \[ Y = Y^e \{ \lambda_1 + \lambda_2 \} t \]
(27) \[ K = K^e \lambda_2 t \]
(28) \[ L = L^e \{ \lambda_1 + \lambda_2 \} t \]
(29) \[ S = S^e \{ \lambda_1 + \lambda_2 \} t \]
(30) \[ I = I^e \{ m - (\lambda_1 + \lambda_2) \} t \]
(31) \[ P = P^e \{ m - \lambda_2 \} t \]
(32) \[ W = W^e \]
(33) \[ p = m - (\lambda_1 + \lambda_2) \]
(34) \[ w = m - \lambda_2 \]
(35) \[ k = \lambda_1 + \lambda_2 \]

The steady state growth rates for \( P \) and \( W \) are not uniquely determined in this particular solution as a function of the model's parameters. In fact, any growth rate for \( P \) and \( W \) for which the growth rate of \( W/P \) is \( \lambda_1 \) constitutes a particular solution. This is because the model does not fully describe the relationship between money, income and prices. In fact, we would expect the steady state growth rate of prices to depend on the growth rate of the money supply relative to that of real output; and the indeterminancy results from the fact that the monetary sector is not endogenous in BHP. In the larger version of BHP under construction, the monetary sector is more fully developed and our specifications imply that, if \( M \) is the volume of money, then \( M/P \) and \( Y \) grow at the same rate in the steady state. We now suppose that \( M = M^e \) in the steady state (this gives a growth rate of \( m \), consistent with that assumed for the exogenous variable \( MBD \) which is a component of \( M \)) and then the growth rate of \( P \) becomes \( m - \lambda_1 + \lambda_2 \) as shown in (31).

The constant coefficients (or levels of the steady state growth
paths that appear in the steady state solutions (25) to (35) satisfy the equations

\[
\lambda_1 + \lambda_2 = \gamma_1 \ln \left[ \frac{\beta_1 (Y^* + CB^O - TP^O)}{C^*} \right]
\]

\[
\gamma_1 = \beta_2 + \beta_3 (\lambda_1 + \lambda_2) + \beta_4 e^{-(\lambda_1 + \lambda_2)}
\]

\[
O = \gamma_2 \gamma_3 \ln \left[ \frac{\beta_5 Y^* \left\{ \frac{1}{1 + \beta_7} \right\}}{1 + \beta_6} \frac{1}{h} \frac{1}{k^*} \right] - \gamma_2 (\lambda_1 + \lambda_2)
\]

\[
h = \frac{W^*}{p^* \{\beta_6 + \beta_9 (J^O - m + \lambda_1 + \lambda_2)\}}
\]

\[
\lambda_2 = \gamma_4 \ln \left[ \frac{\beta_5 \beta_6 Y^* \left\{ \frac{1}{1 + \beta_7} \right\}}{1 + \beta_6} \frac{1}{h} \frac{1}{l^*} \right]
\]

\[
\gamma_4 = \beta_{10} \ln \left[ \frac{\beta_{11} (W^*/p^*) \beta_{12}}{\beta_7} \right]
\]

\[
\left(\lambda_1 + \lambda_2\right)S^* = Y^* + I^* - C^* - \left(\lambda_1 + \lambda_2\right)K^* - E^O - G^O
\]
\[\lambda_1 + \lambda_2 = \gamma_5 \ln \left[ \frac{(1-\beta_{13})(C^* + (\lambda_1 + \lambda_2)K^* + E^O + G^O)}{Y^*} \right] + \gamma_6 \ln \left[ \frac{\beta_{14}(C^* + (\lambda_1 + \lambda_2)K^* + E^O + G^O)}{S^*} \right] + \gamma_{10} \ln \left[ \frac{\beta_{20} W^* \gamma_1 \beta_6 \beta_5^{-1}(L^*/Y^*)^{1+\beta_7}}{P^*} \right] - \gamma_9 (m - (\lambda_1 + \lambda_2)) + \gamma_{11} \ln \left[ \frac{(1-\beta_{13})(C^* + (\lambda_1 + \lambda_2)K^* + E^O + G^O)}{Y^*} \right] + \gamma_{12} \ln \left[ \frac{\beta_5 \beta_6 Y^* (1+\beta_6)}{L^*} \right]
\]

\[\beta_{13} = \beta_{15} (P^*/P^*)^\beta_{16} (2Q_1^O)^\beta_{17}\]

\[\lambda_1 + \lambda_2 = \gamma_7 \ln \left[ \frac{\beta_{13}(C^* + (\lambda_1 + \lambda_2)K^* + E^O + G^O)}{I^*} \right] + \gamma_8 \ln \left[ \frac{\beta_{14}(C^* + (\lambda_1 + \lambda_2)K^* + E^O + G^O)}{S^*} \right] + \gamma_{18} + \gamma_{19} ZAT^O\]

\[\gamma_7 = \beta_{18} + \beta_{19} ZAT^O\]
These equations can be solved to find the values of the steady state levels of the endogenous variables for given values of the model's parameters and given coefficients of the exogenous variable time paths in (16) to (24). After some manipulations, we obtain explicitly

\begin{align*}
(36) \quad C^* &= \beta_1 \mu_3 h^{12} \left\{ \frac{\beta_7}{1 + \beta_6 h} \right\} + \frac{1}{\beta_7} \ln \left( \frac{1}{1 + \beta_7 h} \right) e^{-(\lambda_1 + \lambda_2)/\mu_1} \\
(37) \quad \ln L^* &= \mu_2 + \ln \left\{ \frac{1}{\beta_7} \right\} + \beta_{12} \ln h \\
&\quad + \frac{2}{\beta_7} \ln \left\{ \frac{1}{1 + \beta_6 h} \right\} \\
(38) \quad Y^* &= \mu_3 h^{12} \left\{ \frac{1}{1 + \beta_7 h} \right\} \\
(39) \quad K^* &= \beta_5^{\mu_3} \frac{1}{\gamma_3} h^{12} \beta_{12} \left\{ \frac{1}{1 + \beta_6 h} \right\} \\
(40) \quad I^* &= d + \beta_{14} (\lambda_1 + \lambda_2)(1-g) \gamma_5/\gamma_6 \delta (\gamma_5 + \gamma_6)/\gamma_6 Y^* \gamma_5/\gamma_6 e^{-(\lambda_1 + \lambda_2)/\gamma_6} Y^* \\
(41) \quad S^* &= (\lambda_1 + \lambda_2)^{-1} (Y^* + I^* - d) \\
(42) \quad P^* &= P^0 \left( \frac{\beta_1}{\beta_5} \right)^{1/15} \left( ZQI^0 \right)^{-\beta_{17}/\beta_{16}} \\
(43) \quad W^* &= h F^* \left\{ \beta_8 + \beta_9 (J - m + \lambda_1 + \lambda_2) \right\} \\
(44) \quad d &= C^* + (\lambda_1 + \lambda_2) K^* + E^0 + G^0
\end{align*}
and \( g \) and \( h \) satisfy the following two non-linear simultaneous equations

\[
O = \mu_4 + \gamma_9 \gamma_{10} \ln h + \gamma_9 \gamma_{10} \left( \frac{1+\beta_7}{\beta_7} \right) \ln \left( 1 + \beta_6 \frac{1}{1+\beta_7} h \right) \left\{ -\frac{1}{1+\beta_7} - \frac{\beta_7}{1+\beta_7} \right\} \\
+ \gamma_{11} \ln \left[ \left( \frac{1-g}{\mu_3} \right) d h \right]^{-\beta_{12}} \left\{ -\frac{1}{1+\beta_7} - \frac{\beta_7}{1+\beta_7} \right\}^{-1/\beta_7} \\

\]

(46) \[
\mu_5 = \gamma_5 \gamma_8 \ln \left[ \left( \frac{1-g}{\mu_3} \right) d h \right]^{-\beta_{12}} \left\{ -\frac{1}{1+\beta_7} - \frac{\beta_7}{1+\beta_7} \right\}^{-1/\beta_7} \\
- \gamma_6 \gamma_7 \ln \left[ g d / \left\{ d + \beta_{14} (1+\lambda_2)(1-g) \gamma_5 / \gamma_6 \gamma_5 / \gamma_6 \gamma_6 e^{-\beta_{13} \gamma_{10} (1+\lambda_2)} - \gamma_5 / \gamma_6 \right\} \right] \\

\]

where the additional parameter functions are defined by

\[
\mu_1 = \beta_2 + \beta_3 (\lambda_1 + \lambda_2) + \beta_4 e^{-\beta_{13} \gamma_{10} \gamma_{13}} \\
\mu_2 = -\frac{m-\lambda_2}{\gamma_{13}} + \frac{\gamma_{14}}{\gamma_{12} \gamma_{13}} \left\{ m-(\lambda_1 + \lambda_2) \right\} \\
\ln \mu_3 = \ln \left[ \beta_{11} \beta_5^{-1/\beta_7} \left\{ \beta_8 + \beta_9 (S^m - m + \lambda_1 + \lambda_2) \right\} \beta_{12} \right] - \frac{\lambda_2}{\beta_{10} \mu_2} \\

\mu_4 = \gamma_9 \gamma_{10} \ln \left[ (1+\beta_{20}) \beta_5^{-1/\beta_7} \left\{ \beta_8 + \beta_9 (S^m + m + \lambda_1 + \lambda_2) \right\} \right] \\
+ \gamma_9 \gamma_{10} (1+\beta_7) \ln (\beta_5 \beta_6^{1/\beta_7}) + \mu_2 \gamma_9 \gamma_{10} (1+\beta_7) \\
- \gamma_9 \left\{ m - (\lambda_1 + \lambda_2) \right\} \\
\mu_5 = \gamma_8 (\lambda_1 + \lambda_2) - \gamma_6 (\lambda_1 + \lambda_2).
In order to solve (45) and (46) for g and h we substitute in these equations the expressions for d and \( Y^* \) in terms of h as given in the earlier equations (44), (36), (39) and (38). The resulting equations can then be solved by numerical methods to obtain the values of h and g corresponding to given values of the parameters. To determine the impact on the steady state levels (37) to (43) of changes in the parameters we differentiate these expressions and write the derivatives in terms of the corresponding derivatives of h and g with respect to the same parameters. The values of the latter can be found by the implicit differentiation of equations (45) and (46). Some exercises of this type will be reported at a later date using estimated values of the parameters.

4 Conclusion

BHP is essentially a model of output, capital formation, employment, and the inflationary process. It incorporates, as specified above, some explicit features of the New Zealand economy to which our application refers, but it is hoped that it embodies certain new features and innovations in specification which will be found useful in other macroeconometric models.

Its equations concentrate on explaining aggregate behaviour in the markets for goods and for labour and influences from the monetary sector have been kept exogenous and are more limited than they would normally be even in a slightly larger model. For instance, feedbacks associated with the effect of the balance of payments on the money supply do not appear explicitly in BHP. But they have been taken into account in the construction of the data and are consistent with the larger version of the model which is being developed. It is also clear that BHP has not been designed primarily for economic policy making, as the fiscal, monetary and external policy variables included (or implicit) are very limited in number and appropriateness for this purpose. However, the accent in the present paper is to provide a framework of tightly specified equations designed to explain goods and labour market behaviour in aggregate and capable of extension to a larger and more complete national economic model. Further and more relevant economic policy variables could be incorporated into the latter model, should our smaller model prove useful in explaining observed data.
FOOTNOTES

1 It therefore covers only model development aspects of a much more comprehensive project. Subsequent papers will feature important theoretical econometric estimation problems posed by the model, and present numerical estimates of the model's parameters. The quarterly database has been kindly supplied to us by the Research Department of the Reserve Bank of New Zealand.

An initial report on some of the econometric and computation problems tackled is available in sections 4 and 5 of Bailey, Hall and Phillips [1].

2 The reader is referred to Bergstrom [4] and Bergstrom and Wymer [8] for a more detailed background discussion of these particular model characteristics.

3 Innovative features in the area of econometric estimation and interpretation will be reported in a subsequent paper.

Suffice to say at this stage that our treatment of variable non-linearity directly by a discrete (but not an additional linear) approximation goes some way towards meeting the important criticisms of Fisher [12] about the number and type of linear approximations used in previous empirical work with continuous time models.

4 For example, Fair and Jaffee [11], Maddala and Nelson [24], Goldfeld and Quandt [15] and Laffont and Garcia [23].

5 In the case of a multi-market model, these curves may be quantity constrained by other markets (and vice versa) and this leads naturally to the question under what conditions will there be a consistent set of transactions in both markets. This question has recently been tackled by Gourieroux, Laffont and Monfort [16].

6 See, for example, Knight and Wymer [21] and Jonson, Moses and Wymer [18].

7 The 21 equations included 6 identities and 4 endogenous reaction functions, but the supply of labour was assumed exogenous.

8 Some arguments in favour of using models specified in continuous time are set out in Turnovsky [38, p.2] and Wymer [39, section 2].

9 In the larger version of this model that is being developed, both money and bonds are explicitly available as financial assets. Net private capital inflow has not been significant for New Zealand and, therefore, remains an exogenous variable within the overall level of foreign reserves.

10 As in BW we refer to the particular solution of the differential equation system (1) - (11) that has the conventional properties of a steady state growth path (c.f. Solow [33]) as the steady state solution. We will detail this particular solution (on the basis of assumed paths for the exogenous variables) in the next section.

11 Thus, at any point in time it seems reasonable to suppose that some proportion of all micro goods markets will be in excess demand. Weighting this proportion by the relative size of the markets, we might then be prepared to argue that supply constraints
would be a dominating influence if the resulting weighted proportion exceeded one half.

See, for instance, Nickell [29, p.10].

Compare Jorgenson [19], Brechling [9] and Nickell [29, particularly ch. 9].

This is of some importance because some common algebraic specifications exclude this possibility.

The initial formulation took the form

\[ \gamma_4 = \mu_4 + \mu_5 \ln(\hat{L}_s / \hat{L}) \]

so that the significance of the labour supply effect could separately be measured through the parameter \( \mu_5 \); but the specification of constant parameters in \( L_s \) and \( L \) mean that for empirical work the separate effects are not identifiable.

No specific allowance is made for the influence of changing effective income tax rates as these are probably important only at the margin.

The cases can be expressed as:

\[
\begin{align*}
\text{if } W/P &= \mu_7 e^t \\
L_s &= \mu_6 e^t \\
\text{if } W/P &< \mu_7 e^t \\
L_s &= \mu_6 e^t \\
\text{if } W/P &> \mu_7 e^t \\
L_s &= \mu_6 e^t
\end{align*}
\]

The third case is unlikely for New Zealand, in light of the historical experience mentioned above.

The form chosen for \( \beta_{13} \) as a function of \( P/P_I \) gives a price elasticity imports of \( \beta_{16} \). To see this we write \( V_I \) for the volume of imports so that \( V_I = PI/P_I \) (since the price deflator for \( I \) is \( P \)) and then the elasticity of the desired volume of imports with respect to relative prices \( P/P_I \) is \( \beta_{16} \).

These equations were specified before we became aware of the arguments recently put forward by Flemming [13] for higher order adjustment mechanisms in price equations.

As in BW we assume a fixed capital stock for the purpose of price setting, not only for simplicity but also because labour costs will be by far the more dominant variable of the two.

Incomes policy may well affect what is considered to be a realistic rate of adjustment in wages and we could specify \( \gamma_{13} \) as a function of an incomes policy dummy. Incomes policy may also lead to a build up of inflationary pressure measured by the
deviation of the actual rate of changes of wages, \( w \), from the desired rate; and this pressure will, according to our specification, be released through a change in the rate of change of wages, i.e. through the second derivative. To be accurate in our timing of these effects according to what was legally permissible during incomes policy periods we would need an additional (multiplicative) dummy variable to switch the effect on and off or perhaps control its magnitude. For simplicity, we have decided to see how well the present specification performs without introducing extra dummy variables. However, it is worth noting that incomes policy dummy variables are already available for the New Zealand economy, such as those tested in Hall and King [17].

We followed the now well-known procedure of constructing our data base so as to ensure overall consistency of variables and exact adding up of numerical data within the balance of payments identity and the balance sheets of the authorities (i.e. Central Bank and Central Government), the banking system, and the non-banking private sector. See Knight and Wymer [21] equations (22) to (24) for an illustration of the procedure in theory.
REFERENCES


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