A dynamic computable general equilibrium (CGE) model of the New Zealand economy

Kam Leong Szeto

New Zealand Treasury

Working Paper 02/07

June 2002

THE TREASURY
Kaitohutohu Kaupapa Rawa

NZ TREASURY WORKING PAPER 02/07

A dynamic computable general equilibrium (CGE) model of the New Zealand economy

MONTH/YEAR

June 2002

AUTHOR

Kam Leong Szeto
The Treasury, P.O Box 3724, Wellington, New Zealand

Email	Kam.Szeto@treasury.govt.nz
Telephone	64-4-471 5055
Fax	64-4-499 0922

ACKNOWLEDGEMENTS

I wish to thank Paul Gardiner and Nathan McLellan for their contribution to the development of this model through discussions and assistance with sections of this paper. This paper has been a long time in preparation. It benefited from comments on the early version of the paper from Bob Buckle, Viv Hall, Iris Claus, Bruce White and Roger Ridley. I would like to thank James Twaddle for his comments as discussant at the Australasian Macroeconomics Workshop, 4-5 April 2002.

NZ TREASURY

New Zealand Treasury
PO Box 3724
Wellington 6008
NEW ZEALAND

Email	information@treasury.govt.nz
Telephone	64-4-472 2733
Website	www.treasury.govt.nz

DISCLAIMER

Abstract

This paper documents the structure and key properties of a computable general equilibrium (CGE) model of the New Zealand economy. It is a three-good, small open economy model, which features a well-developed production block. This production block has been estimated as a system using Full Information Maximum Likelihood. Another key feature of the model is that it has a two–tiered structure: the steady-state version of the model and the dynamic version of the model. Using the steady-state version of the model, a macroeconomic balance measure of New Zealand's equilibrium exchange rate can be derived. Furthermore, the steady–state model provides estimates of potential output, which is used to measure the level of excess demand in the economy. The dynamic model is used to trace the dynamic response of a range of macroeconomic variables to various shocks such as changes to world prices for exports and changes to government policy.

JEL classification: C51, E23

Keywords: Computable general equilibrium model, Equilibrium exchange rate, potential output, Macroeconomic dynamics

Table of Contents

List of Tables

List of Figures

A dynamic CGE model of the New Zealand Economy

1 Introduction

Various economic models are used for forecasting the macro-economy at the New Zealand Treasury. One of the models, New Zealand Model (NZM) was a macroeconometric model of the NZ economy developed by Chris Murphy in 1995. In 1998, NZM was updated to allow for monetary policy operation under the Monetary Condition Index (MCI) regime. NZM was constructed in the style of the Murphy Model of Australia (see Powell and Murphy 1997), but modified to allow for differences in institutional structures, data availability and data properties between New Zealand and Australia.

The development of the macroeconometric model is an on-going process to incorporate latest policy changes, structural shifts in the data, and the development of economic theory and modelling. Over recent years, Treasury has re-developed the core macroeconometric NZM model. This has resulted in a new model reported in this paper. We refer to this new model as New Zealand Treasury Model (NZTM), to distinguish it from NZM.

The structure of the New Zealand Treasury Model (NZTM) differs from that the New Zealand Model (NZM) in three major areas. They are the relative price structure, the determination of the equilibrium exchange rate and the demand-pull framework that determines inflation. As a result of these developments, greater emphasis has been placed on using NZTM in aiding the Treasury forecast for the New Zealand economy.

One of the drawbacks of NZM was that the monetary policy reaction function was a contemporaneous price-level-targeting rule. Since the core theoretical structure was based on price levels, it was not possible to formulate the monetary rule as an inflation-targeting rule. Under a price-level target, following a shock to prices, the price level needs to return to the target level at some future point. Therefore, a price-level targeting rule tends to place a more demanding requirement on monetary policy than an inflation-targeting rule. In particular, price-level targeting means that the central bank needs to tighten or loosen harder and longer to achieve the target a price shock. This can be seen when comparing the dynamic response between two targeting rules. The variability of inflation and the variability of output are greater under price-level targeting than under inflation targeting because base level drift is not accepted under price-level targeting[1].

Since the core structure of NZM was based on price levels, the steady state model within NZM was simulated before running the dynamic version of the model in order to provide equilibrium values for forward-looking variables. Under a price-level targeting rule, all the price levels were well anchored in the long run. In this framework, the solution of the steady-state model on nominal exchange rates provided appropriate terminal conditions for the dynamic model.

In contrast, NZTM has a relative price structure that allows the monetary policy rule to be specified as an inflation target. Unlike NZM, NZTM does not have a fixed end point on the nominal exchange rate. Instead, the steady-state version of the model generates an equilibrium path for the real exchange rate that provides a key anchor for the dynamic structure of the model.

In NZM, production of the domestic good was demand-determined in the short run, with firms gradually adjusting the price of the domestic good to a medium-term target, which can be interpreted as the marginal cost of producing domestic goods. In this framework, the pass-through from wages and import prices into domestic inflation was strong. In NZTM, the pass-through from the labour market into domestic inflation has been reduced which might reflect both labour and product market reforms.

The production block of NZTM has been econometrically estimated (Szeto 2001). Hence, the steady-state version of the model provides an estimate of long-run potential output, which in turn provides the basis for a measure of the output gap used in the dynamic model. The output gap plays a major role in determining inflation in NZTM.

There is no single model that meets the requirements of both policy evaluation and forecasting. For policy simulation, more emphasis is placed on the theoretical structure of the model. For forecasting, more emphasis is placed on how well the specification of the model represents the data. It is also essential that a forecasting model is able to clarify how judgements about the key model assumptions affect the forecast. Furthermore, there is always a trade-off between complexity and simplicity. The main role of NZTM is to help the Treasury forecast the economy. With that role in mind, the theoretical structure of NZTM is parsimonious.

For example, estimates of the non-accelerating inflation rate of unemployment (NAIRU) are exogenously determined in NZTM. In theory, there are many factors determining the level of the NAIRU and those factors are not immutable. Therefore, for policy simulation, it is important to have a formal model of how the level of the NAIRU is determined. However, for forecasting, it is reasonable to assume that the level of the NAIRU is relatively constant over the short to medium-term forecast horizon.

In addition to providing the key anchor for the dynamic component of the model, the steady-state structure also strengthens the properties and analytic capabilities of the

[1] By contrast, Svensson (1999) found that price-level targeting results in lower short-run inflation variability than inflation targeting if output is at least moderately persistent.

dynamic component. After a considerable number of time periods has elapsed following a shock, the dynamic adjustment path converges to a growth path consistent with the steady state solution. Accordingly, the steady state structure is used to study the equilibrium effects of permanent shocks and provides a quality assurance on the long run properties of the dynamic model.

The main purpose of this paper is to describe the structure of both the steady state and dynamic versions of NZTM. Section 2 describes the formal theory that supports the steady-state model. Section 3 describes the calibration of the model and the numerical steady state it attains. In Section 4 we describe a number of permanent shocks to exogenous variables that help to illustrate the steady state properties. Section 5 outlines the dynamic structure of NZTM while Section 6 presents a series of shocks from the dynamic model. Concluding comments and discussion of potential applications of the model are contained in Section 7.

2 The Steady-state model

2.1 Introduction

The steady-state version of the NZTM is based on two blocks of estimated equations that are linked by a large number of identities. The first block relates to the supply side of model. There are two types of goods produced by the supply side of the model, which contains the domestic good (YD) and export good (TEXPS). Both goods are modelled in a nested production function format. The third type of goods is imports, which are intermediate inputs to production. This production block has been estimated as a system using Full Information Maximum Likelihood (FIML). For more details on the production block and the estimation methodology see Szeto (2001).

Within the production block, for simplicity, technical progress is assumed to be labour augmenting, that is technical progress is assumed to be Harrod-neutral[2]. When the production block was estimated, the data implied an estimate for labour augmented technical progress of around 2% per annum. This estimate is historically quite high for the NZ economy on a growth accounting basis[3]. Hence, the coefficient has been imposed at 1.5% per annum, which is closer to the historical average for the New Zealand economy.

The second block relates to the demand side of the model is composed of two equations. One equation is related to the long-run consumption equation. This is the key equation in the demand side of the model. It describes how household spending is determined in the

[2] Harrod defines an innovation as neutral if the relative input shares remain unchanged for a given capital/output ratio.

[3] There are three possible reasons why the estimate of productivity is higher than that derived from growth accounting. Firstly, the result of the estimation is based on private sector production. Secondly, gross output is used in the estimation and value added is usually used in the growth accounting approach. Imposing a restriction of no substitutability between value added and imports could bias labour productivity estimates downwards. Finally, two trend growth rates are included in the production block allowing for higher the import penetration and more open economy. These two growth rates can also be interpreted as changes in the quality brought about by higher productivity in the tradable sector. Without adjusting higher import penetration, the value added approach could lead to a lower estimate of productivity .

long run. The estimation method uses the cointegration approach to test for a long run relationship between consumption (CON), real income (RINCOME) and real wealth (RWEALTH). A cointegration approach is employed as non-stationary is observed in the relevant variables. This approach is similar to recent work on New Zealand consumption equations by Downing (2001).

The second estimated equation describes how consumers allocate total consumption between housing services (CONH) and other consumption (CONO). In the long run, consumption of housing services (CONH) and other consumption (CONO) are a function of the price of CONH relative to the price of CONO.

The model also contains four behavioural sectors. These are the private business sector, the household sector, the external sector and the government sector.

The private business sector determines the levels of inputs and outputs in the production sector. The business sector uses three inputs to produce its output: labour, business fixed capital and imports. It also produces two types of outputs: the domestic good (YD) and export good (TEXPS).

The household sector's consumption decision is based on household income and wealth. Households supply labour input for the production process and their savings for investment. Households are assumed to allocate their total consumption between housing services and other consumption by maximising their utility.

The external sector introduces international financial flows to the model, which determines the level of the real exchange rate, the level of underlying external capital flows and the level of net foreign debt.

The government sector is a simple entity in the model. Government buys some output and finances this expenditure through tax revenue or borrowing. All government spending decisions are set exogenously in the model, with the tax rate on labour income being endogenously adjusted to achieve a target public debt to GDP ratio.

The model contains 101 equations and therefore includes 101 endogenous variables. There are 49 exogenous variables. A full description of all the variables is included in Appendix 1. Appendix 2 lists all the equations and identities of the model. The following sections provide a brief overview and the relevant theory for each of the four sectors.

2.2 Private business sector

At the heart of NZTM is a theoretical micro-framework determining how firms decide how many goods are produced and what production input to use. Decisions about the quantities of inputs employed and the quantities of outputs produced are based on an optimising process in which firms maximise profits subject to a production function constraint.

The production block combines three inputs (capital KBF, labour N, imports IM[4]) to produce two outputs (domestic good (YD) and export supply (TEXPS)). It is composed of two constant elasticity of substitution (CES) functions and one constant elasticity of transformation (CET) function.

Those CES and CET functions[5] are expressed as follows:

$$\mathbf{Y_t} = ((\mathbf{A}_1 \mathbf{e}^{\lambda \mathbf{Trend}} \mathbf{N_t})^{\rho} + (\mathbf{A}_2 \mathbf{KBF_t})^{\rho})^{1/\rho} \tag{1}$$

$$\mathbf{T_t} = ((\mathbf{A}_3 \mathbf{e}^{\pi_1 \mathbf{Trend}} \mathbf{IM_t})^{\delta} + (\mathbf{A}_4 \mathbf{Y_t})^{\delta})^{1/\delta} \tag{2}$$

$$\mathbf{T_t} = ((\mathbf{A}_5 \mathbf{e}^{\pi_2 \mathbf{Trend}} \mathbf{TEXPS_t})^{\theta} + (\mathbf{A}_6 \mathbf{YD_t})^{\theta})^{1/\theta} \tag{3}$$

where Y denotes primary factors for production, T total gross output, Trend is a time trend, λ is the rate of labour augmenting technical progress, ρ, δ and θ are the substitution related parameters, π_1 and π_2 are the trend growth rates to capture changes in import penetration and a more open economy.

Equation (1) and (2) form a nested CES function. Equation (1) represents the value of production contributed by capital and labour. Hence, Y can be interpreted as value added. Value added (Y) is combined in equation (2) with imports in another CES function to yield gross output (T).

A common assumption made in macroeconomic models is that exports and the domestic good are perfectly transformable in production. As New Zealand's exports are based significantly on primary industries, the assumption of perfect transformation seems inappropriate. Thus, the domestic good (YD) and export supply (TEXPS) are combined in a transformation function described by equation (3).

In the short run, the domestic good (YD) is demand-determined, the cost of inputs (wages and import prices) is fixed, and the capital stock (KBF) is considered a fixed input. With the fixed unit price of exports, firms maximise profits by adjusting employment, the price of the domestic good (PYD), and the levels of both export supply (TEXPS) and imports (IM).

In the long run, employment becomes exogenous to the production block and is determined by labour supply. Wages become endogenous in the long run. The stock of business capital is no longer fixed in the long run and is determined by the rate of return on the business capital stock (AR) which in turn is a function of real interest rates, depreciation rates and the risk premium. Figure 1 shows a simple flow diagram of the production block in the steady-state version of the model.

4 All imports are intermediate materials.

5 Constant returns to scale is assumed in the production block.

2.3 Household sector

2.3.1 Private Final Consumption

The consumption decisions of households are assumed to approximate the life-cycle hypothesis developed by Ando and Modiglianli (1963). This approach implies that consumers will spread existing resource to achieve a smooth consumption profile. We therefore derive a consumption function of the form:

$$\mathbf{CON = f(REAL\ INCOME, REAL\ WEALTH)} \tag{4}$$

Equation (4) states that private consumption (CON) depends upon real income and real non-human wealth, which generates a stream of future income.

There are two major problems encountered in estimating equation (4). The first problem is to find adequate measures for both income and wealth. The second problem is that the sample period of all the available data is not long enough to support a stable long-run relationship.

As it is difficult to find a stable long-run relationship for consumption (see Downing 2001), the income and wealth measures are based on previous work by Murphy (1998). Household income is calculated as the sum of real after-tax labour income and transfers, while non-human wealth includes both financial and real assets. Labour income is preferred to household disposable income in estimating consumption equations because Rae (1996) explains that the use of household disposable income can lead to double-counting of property income. Rae further suggests that disposable income should not be used because it includes the highly volatile entrepreneurial income component. In this model, nominal household income is defined as:

$$\mathbf{Household\ \ Income = (1 - POL1) * W * NT + TRPUPR + TROSPR + MTRANSFER} \tag{5}$$

where POL1 is the rate of tax on labour income, W is the nominal wage, NT is total employment, TRPUPR is the nominal transfer from the public sector to the private sector, TROSPR is the nominal transfer from overseas to the private sector and MTRANSFER is the migrant transfer.

As households own all the business capital stock in the model, a theoretically preferred measure of net wealth includes business capital stock (KBF) and housing stock (KH) as real assets. Nominal net wealth is defined as follows:

$$\mathbf{Net\ Wealth = (B - ZPA - ZP / E) + PYD * (KBF + KH)} \tag{6}$$

where B denotes the private sector holdings of public sector bonds, E is the nominal exchange rate, ZPA and ZP are the private sector debt to foreigners contracted in New Zealand currency and in foreign currency respectively, and PYD is the price of the domestic good. The first three terms of equation (6) are classified as financial assets in the model.

Both nominal measures of income and net wealth are then deflated by PYD to derive the real measures of household income and net wealth. To ensure convergence to a balanced growth path, the consumption equation is linear homogenous in real income

(RINCOME) and real wealth (RWEALTH). The long-run equilibrium consumption function in real terms is expressed as follows:

$$\begin{aligned}&\mathbf{Log(CON)} = \mathbf{C}0101 + \mathbf{C}0102 * \mathbf{Log(RINCOME)}\\&+ (1 - \mathbf{C}0102) * \mathbf{Log(RWEALTH)} - \mathbf{Log(PCON / PYD)}\end{aligned} \tag{7}$$

PCON is the consumption price index. The last term in equation (7) implies that the higher the relative price of the consumption good, the lower is the level of consumption.

The level of household real income (RINCOME) and real wealth (RWEALTH) are graphed against the level of consumption expenditure in Figures 2 and 3. It appears that the consumption boom around 1995-1997 is associated with slower growth in real wealth during the following period. The rapid rise in private debt to foreigners allowed consumption to grow rapidly during this period. The data might suggest that consumption and real net wealth could be simultaneously determined in the medium run. It could explain why the coefficient on the wealth variable is inconsistent with life cycle theory.

The results of the unit root tests of all the relevant variables are reported in Appendix 3. The results suggest that all the variables are non-stationary and I(1). Using OLS, equation (7) is estimated over the period 1987q2 to 2001q4.

The coefficients from the estimation are presented in Appendix 3. The results suggest that the income elasticity is 0.98 when estimated over the full sample period.[6] This point estimate is higher than was expected. The results of the cointegration test suggest that there is some weak evidence of a long-run equilibrium consumption function. This finding is consistent with at in Downing (2001). The small sample size and the lack of the power of the unit root tests could explain the weak evidence of cointegration.

Another interesting finding is that the income elasticity in equation (7) is only 0.56 if the equation is estimated over a shorter period from 1987q2 to 1996q4. It is clear that the estimates are not very stable and are sensitive to the estimation period. As a result, equation (7) is calibrated in the model and a judgement was made to impose a coefficient of 0.66.

2.3.2 Demand for Housing Services

Households are assumed to maximize utility by choosing an allocation of consumption between housing services (CONH) and other consumption (CONO). The optimal split between consumption of housing services (CONH) and other consumption (CONO) is determined by the ratio of the equilibrium housing services price (PCONH) to the equilibrium price for other consumption. That is, the behavioural equation to be estimated is:

$$\begin{aligned}&\mathbf{Log(PCONH /(PYD} * (1 + \mathbf{POL}4))) = \mathbf{C}0200 + \mathbf{C}0201 * \mathbf{TREND} +\\&\qquad \mathbf{C}0202 * \mathbf{Log(CONH / CONO)}\end{aligned} \tag{8}$$

[6] The empirical literature often refers to the income elasticity as the marginal propensity to consume (MPC).

The time trend variable has been included in this long-run equation to capture changes in consumers' preference and changes in the demographic profile of the population. The elasticity of substitution (σ) between housing services (CONH) and other consumption (CONO) items can be derived from the following expression:

$$\sigma = -1 * \frac{1}{\mathbf{C}0202} \quad (9)$$

Figure 4 shows that the demand for housing services is inversely related to its own relative price. The large increase in the relative price of housing services in the second half of the 1990s coincided with a large decrease in the ratio of the demand for housing services to the demand for other consumption items.

The results of the unit root test suggest that both series are nonstationary. Estimation of (8) by OLS over the full sample period yields an estimate of the elasticity of substitution of 5.3, which is relatively high. Like the consumption equation, there is evidence of unstable coefficients. When we re-estimated the equation over the period of 1991q1 to 2001q4, the elasticity of substitution was 0.63. A judgement was made again to impose the elasticity of substitution at 0.83. The estimation results are presented in Appendix 4.

2.3.3 Labour Supply

In the steady-state, the labour market is in equilibrium. The unemployment rate is equal to the NAIRU when firms and workers expectation of the behaviour of wages and prices are realised. The NAIRU and the participation rate are set exogenously in the steady-state model.

2.4 External sector

Edwards (1987, 1989) developed an intertemporal framework to investigate how policy induced disturbances and other exogenous shocks affect the path of equilibrium relative prices in an economy. The equilibrium exchange rate is reached when the economy attains both internal and external equilibrium. Internal equilibrium means that the non-tradable goods market clears in all periods. External equilibrium means that current account balances are consistent with long-run sustainable capital flows.

The external structure of NZTM developed in this paper is similar to the general equilibrium intertemporal model described by Edwards (1989). The key difference is that in NZTM imports are included as an intermediate input. When there is significant variability in the terms of trade, it is not appropriate to treat tradables as a single composite good. In this context, there are two relevant real exchange rates. One is the relative price of importables to non-tradables (RPM). The other is the relative price of exportables to non-tradables (RPTEX). For more discussion on the theoretical framework for the real exchange rates used in this model, refer to Szeto and Gardiner (2001).

The key structure of the external sector can be represented by the following equations:

$$\mathbf{FRWEALTH} = \mathbf{PAGDPR} * \mathbf{RGDP} \quad (10)$$

$$\mathbf{RFDEBT} = \mathbf{RPFDEBT} + \mathbf{RGFDEBT} \quad (11)$$

Equation (10) simply states that the level of the net real household financial wealth (FRWEALTH) is determined by a ratio of net household financial wealth to real GDP (PAGDPR). The private financial wealth variable is composed of domestic bonds and foreign assets (RPFDEBT). The steady state solution for government foreign debt (RGFDEBT) is set exogenously in the model. Equation (11) states that net foreign debt is a sum of household foreign debt and government foreign debt.

$$\mathbf{RDOS} - \mathbf{RMTRANSFER} = \mathbf{RFDEBT} * (\mathbf{GR} - 1) \tag{12}$$

At the steady state, the level of underlying capital inflows (RDOS) is equivalent to a proportion of net foreign debt (RFDEBT) as specified by Equation (12) after adjusting for migrant transfers (RMTRANSFER). The proportion is determined by the natural growth rate of the economy (GR-1).

The following equation is the balance of payments equation:

$$\begin{aligned} &\mathbf{RDOS} = -1 * (\mathbf{RPTEX} * \mathbf{TEXP} - (\mathbf{RPM} / (1 + \mathbf{POL5})) * \mathbf{IM} \\ &+ \mathbf{RTROSPR} - \mathbf{RTRPUOS} + \mathbf{RYOSPR} + \mathbf{RYOSPU}) \end{aligned} \tag{13}$$

where RTROSPR denotes real transfers from overseas to the private sector, RTRPUOS real transfers from the public sector to overseas, RYOSPR net real investment income from overseas to the private sector and RYOSPU net real investment income from overseas to the public sector.

Equation (13) states that the underling capital inflow is equal to the current account and the equilibrium real exchange rates (RPM or RPTEX) are defined as the rate at which equation (13) holds.

2.5 Government sector

The government sector is composed of a set of accounting identities. The role of the government is to provide public services such as health and education and provide a safety net for those who are in need. The government's activity consists of purchasing goods and services and making transfer payments and financing these expenses and transfers. Government spending can be financed in two ways: taxing and borrowing from the private sector.

In NZTM, five tax flows are modelled. They include income tax, consumption tax on non-housing, consumption tax on housing, import tax and lump sum tax related to capture a combination of taxes on company income and interest income.

A range of transfer payments, including superannuation, unemployment benefits, and other benefits are included

The steady-state level for real public liability to RGDP ratio and government expenditure are set exogenously. The tax rate on labour income is then endogenously adjusted to ensure that public debt is restored to its target.

3 The steady state

The steady-state version of the model comprises 49 exogenous variables. In order to remove the short-term volatility of the data representing these variables, a Hodrick-Prescott (1997) filter (HP) is used to decompose the exogenous variables into trend and cyclical components. The trend variables are then used to solve for the steady state solution over the historical period. The HP filter calculates a trend component of a variable by minimising the following expression:

$$A = \sum_{t}^{T}(y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1}[(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2 \tag{14}$$

where y_t is the log of the actual series and τ_t is its trend. The parameter λ is a smoothness constraint that determines how closely trend output follows the actual series.

In Section 3.1, we discuss the historical properties of the key exogenous variables. In Section 3.2 we compare the steady state solution of the model with actual values for two key endogenous variables, namely private sector production and real exchange rates.

3.1 The exogenous variables

3.1.1 NAIRU

Figure 5 shows the actual unemployment rate and its trend value estimated using the HP filter. The historical trend value of the unemployment rate is used as a proxy for the Non-Accelerating Inflation Rate of Unemployment (NAIRU). As can be seen from Figure 5, while the estimated NAIRU rose in the late 1980s and early 1990s, since around 1993 it has fallen continuously to around 5.5% in 2001. This fall in the NAIRU may reflect the impact of labour market reform in the early 1990s. The 1991 Employment Contracts Act (ECA) removed compulsory unionism and promoted wage bargaining on the basis of individual employment contracts

In NZTM's forecast environment, the steady-state assumption for the NAIRU is set at 5.5%.

3.1.2 Labour Force Participation Rate

Figure 6 shows actual and trend labour force participation rates. The participation rate is defined as the ratio of the labour force to the population aged 15 years and over. In NZTM's forecast environment, the steady-state assumption for the participation rate is 65.8%. This assumption is based partly on a long-term historical average of around 65% and partly on recent higher rates of participation.

3.1.3 Net Real Household Financial Asset to Real GDP ratio

The steady-state assumption for the net real household financial assets to GDP ratio is a key determinant of the steady-state solution for the net foreign debt to GDP ratio. As can be seen from Figure 7, there is a decreasing trend in the net real household financial assets to GDP ratio between 1987 and 2001. The consequence of the trend decline in this ratio is that the net foreign debt to GDP ratio increased between 1987 and 2001 (see Figure 8), reflecting the fact that the New Zealand economy has run current account deficits over this period. Haugh (2001) has argued that the increase in the current account deficit from 1997-2000 and hence the increase in the net foreign debt to GDP ratio after 1997 was due to households undertaking residential investment. In other words, the household sector as a whole was not saving enough to fund its investment in housing and had to borrow the shortfall. Banks went offshore to meet this shortfall in funding

In NZTM's forecast environment, the steady-state assumption for the net real household financial assets to GDP ratio is set at –0.9. This assumption leads to a level of current account deficits as a proportion of New Zealand GDP of 4.3%. This is consistent with the average current account ratios and underlying net capital inflows over the 1990s.

3.1.4 Real Public Liability to GDP ratio

The model-based estimate of the real public liability to GDP ratio is shown in Figure 9. While the public liability to GDP ratio rose during the late 1980s and early 1990s, this ratio declined between 1993 and 2001. This trend decline between 1993 and 2001 reflects fiscal consolidation over the 1990s.

The steady-state assumption for the public liability to GDP ratio in the forecast environment is set at 30% to reflect the current public gross debt target.

3.1.5 Export and Import Prices

As shown in Figures 10 and 11, export and import prices in foreign currency did not exhibit a marked long-term trend over the data period chosen. Over the same period, the price of the domestic good has been trending upwards. The difference in productivity between the traded and non-traded sector might explain the divergent price movement between traded and non-traded goods.

The trend growth rates of π_1 and π_2 are estimated to be negative in the production block, reflecting the increasing openness of the New Zealand economy. In the forecasting horizon, π_1 and π_2 are set at –0.01 allowing for higher import penetration and more open economy. In order words, the growth rate of the tradable sector is higher than that of the non-tradable sector by 1.0 % per annum. In order to maintain a constant expenditure share of traded goods, the trend growth rates for both export and import prices are set equal to 0.5% per annum if the domestic inflation rate is set at 1.5% per annum

3.2 The steady-state solution

Like the fit of a regression model, the steady-state solution gives us an indication of how well the data fits the model. In practice, the steady-state solution should not be too far away from the actual data; otherwise convergence problems may arise when using the dynamic version of the model for forecasting. The difference between the actual values and the steady-state values can be interpreted as measures of disequilibrium. In this section, we focus on explaining the steady state solution of two key endogenous variables, namely output and the real exchange rate.

3.2.1 Potential Output

In recent years, many central banks have favoured a demand-pull framework for modelling inflation. Usually, some measure of the output gap is used to measure future inflationary pressures. The output gap is the difference between actual output and potential output. The production block of the model provides a measure of potential output of the private business sector.

Although private sector production (PNA10) accounts for about 68% of total production, almost all the variability in total production can be attributed to PNA10. Figure 12 shows the output gaps for total GDP (NA10) and private sector production (PNA10). Both measures of potential output are estimated using the HP filter with λ=1600.

The other components of total GDP (NA10) besides PNA10 are housing consumption (CONH), government employment (C5000*NGG) and consumption tax (C5001*CONO). The following identity defines NA10 as:

$$\mathbf{NA}10 = \mathbf{PNA}10 + \mathbf{C}5000 * \mathbf{NGG} + \mathbf{CONH} + \mathbf{C}5001 * \mathbf{CONO} \qquad (15)$$

where PNA10 =YD+TEXPS-IM.

In NZTM, the output gap measure is based on the private business sector production rather than total production. The main reason for using the private business sector production is that the output gap is used to determine the inflation rate of the domestic good but not the general inflation rate in the dynamic model. Therefore, it is more appropriate to use the private sector output gap.

Figure 13 compares the output gap derived from the model with the output gap estimated from the HP filter. The steady-state solution is very similar to the potential output estimated from the HP filter over the estimation period. The main advantage of using the production function approach is that one can analyse the impact of changes in the economic structure on potential output.

3.2.2 Real Exchange Rate

Like potential output, the level of the long-run equilibrium real exchange rate is unobservable and various techniques have been developed to estimate it. In this model, the steady-state solution of the real exchange rate is the level at which both internal and external balance is simultaneously attained. External equilibrium is attained when the current account balances are compatible with the underlying capital inflows. Internal equilibrium means that the market for the domestic good and the factors of production are in equilibrium. The resultant estimates of the real exchange rate from the steady-state model are, therefore, consistent with the definition of the long-run equilibrium exchange rate developed by Williamson (1985).

The real exchange rate is defined as the relative price of importables to non-tradables (RPM) or exportables to non-tradables (RPTEX). An appreciation of the real exchange rate is represented by a decrease of RPM or RPTEX. Figure 14 charts the inverse of the steady-state solution of RPM with that of the actual RPM. The extent of real exchange rate misalignment is plotted in Figure 15, which plots the difference between the actual real exchange rate and its long-run equilibrium. The results suggest that the real exchange rate overshot its long-run equilibrium level over the period 1996 to 2000.

Although the nominal exchange rate has dropped sharply since 1997, the real exchange rate remained overvalued for a long period of time after the initial fall in the nominal exchange rate started in 1997. Our results suggest that the fall in the nominal exchange rate has been offset by a sharp fall in the world prices during the Asian crisis. As a result, the real exchange rate remained overvalued substantially at the beginning of 1999.

By the beginning of 2001, the real exchange rate had fallen to the point where the model estimates that it was undervalued by about 6%. Assuming all else being equal, the equilibrium nominal value for the NZD at that time was around 53 on a Trade Weighted Index (TWI) basis.

4 Steady-state model simulation

In this section, we examine some of the properties of the model by simulation analysis. The illustrative simulations presented here identify the new steady-state solution of the model following a shock. These shock experiments are designed to illustrate the properties of the model and the impact of particular calibration decisions on the steady state assumption of the model. The results of the simulation are presented in Table 1.

4.1 A permanent increase in the world price of NZ exports by 1%

In this experiment, we consider a permanent improvement in the terms of trade by raising the world price of New Zealand exports. This permanent shock raises the purchasing power of New Zealand exports and consequently a higher level of imports can be achieved while still maintaining external equilibrium. Consumers benefit from the increase in purchasing power and a larger share of domestic production becomes available for consumers. Higher domestic demand leads to an appreciation of the real exchange rate. Overall, the long-run impact on production of the improvement terms of trade is to raise the desired capital to output ratio as firms benefits from higher export prices. As a result, the domestic productive capacity is increased slightly, by 0.09% at the first quarter and 0.05% by the end of 10 years after the shock.

4.2 A permanent 1% increase in the level of productivity

This shock has no impact on the relative prices of the model and the only long-term consequence is an upward shift in the productive capacity by 1%. As there are no relative price changes, all components of demand for domestic output and the demand for imports rise by 1 %.

Third, there is a negligible change in the income tax rate because government expenditure is set exogenously and grows at the same rate as the private productive sector.

4.3 Lowering the real household financial assets to GDP ratio

In this experiment, the long-run real household financial asset to GDP ratio is decreased from –0.9 to –1.2 (a decline of 0.3). As a result, the foreign debt to GDP ratio is increased by 0.3 from 2.94 to 3.24, reflecting the switch from domestic to foreign savings to finance domestic investment and imports. The increase in foreign liabilities means a higher debt-servicing burden. Hence, the real exchange rate is required to depreciate, leading to an increase in exports and a fall in imports. In the long run, the shock has a negligible impact on the private sector output but the consumption's share of output is lower in the new equilibrium.

4.4 Reducing the public liability to GDP ratio

In this experiment, the government reduces the public liability to GDP ratio from 30% to 28%. As government spending remains unchanged, a lower debt to GDP ratio implies a lower level of government debt and a lower debt-servicing burden, which in turn leads to a lower income tax rate in the new equilibrium.

Since consumers must hold a lower level of government bonds, households raise their desired level of real assets to compensate for the decrease in their level of holdings of government bonds and therefore financial wealth. The impact of a lower income tax rate raises higher household disposable income which leads to higher consumption. The other adjustment comes through the consumption deflator. In the new equilibrium, the consumption deflator is lower.

4.5 An increase in government consumption and investment by 10%

This simulation illustrates the effects in NZTM of a 10% increase in government consumption and investment. In this simulation the government debt to GDP ratio is held constant. Hence, the increase in government spending is financed by an increase in income tax. As the output of the domestic good remains almost unchanged, fiscal expansion crowds out private consumption of the domestic good and housing services.

The reduction in private demand for consumption goods is induced through two channels. The first channel is through higher taxes lowering disposable income, and hence consumption. The second adjustment comes through lower real assets. With lower consumption of housing services, the housing stock must be lower in the new equilibrium. Therefore, household wealth is also reduced.

Although private sector output remains unchanged, the shock affects total GDP through its impact on the consumption of housing services. As a result, there is a small appreciation of the real exchange rate in response to a lower equilibrium level of foreign debt.

5 Dynamic structure

The dynamic structure of the model evolves or fluctuates around the steady state structure and attempts to replicate the actual cycles in macroeconomic data. While the steady-state version of the model is particularly important in determining the steady-state values for the key endogenous variables, the dynamic model also has an important role in shaping the path of the economy following a shock as it adjusts over the medium term to the long run equilibrium steady-state path. The specification of the dynamic model is therefore critical in determining short- to medium- term economic forecasts. Dynamic equations are specified to capture both short to medium-term data movements and partial adjustment to equilibrium steady-state values.

While parts of the model have been estimated, for example the production block, the dynamic component of the model has been calibrated[7]. A noted example of a calibrated New Zealand macroeconomic model is the FPS model developed by the Reserve Bank of New Zealand (See Black et al, 1997). The results from previous estimation work to develop the earlier NZM model (Murphy, 1998) have been used to inform the calibration of this new model.

The dynamic structure of the model has been kept as parsimonious as possible while still replicating the dynamic properties of the data. One of the motivations for this parsimonious specification is the ability to trace back and understand what is driving a model forecast. Applying over-specified dynamic models to actual data, which in New Zealand's case is normally quite volatile, can lead to model forecasts that are difficult to understand.

This section will focus on the components of GDP and discuss the inflation process and the monetary and fiscal rules. The equations comprising the dynamic model are listed in Appendix 5.

5.1 Private consumption

Many models of consumption are based on individual optimisation of utility, where an individual makes consumption decisions over some period, based upon their earnings and wealth, and preferences for present and future consumption. The long-run structure of the private consumption sector has been detailed in the previous section. The dynamic specification of private consumption is intended to capture the idea that private consumption is modelled in a partial adjustment process.

The dynamic consumption equation is shown by equation (16). It specifies current consumption (CON) as a function of the equilibrium level of consumption (COND), the

---

[7] This is an area of ongoing development as the model is "fine tuned."

yield curve (YCURVE) and the relative price of imports (RPM). The equilibrium level of consumption is determined by labour income and wealth. The yield curve reflects the fact that households will decrease (increase) consumption when interest rates rise (fall) and the return on savings increases (decreases).

As mentioned before, all imports are intermediate goods in the production function. The last two terms in the equation capture the impact of import prices on consumption goods. If the relative price of imports (RPM) is above its long-run equilibrium (ERPM), real consumption is reduced.

LOG(CON) = C0401*LOG(COND) + (1-C0401)*LOG(CON(-1)*GR)
+C0402*(YCURVE(-2)) +C0403*(RPM(-1)-ERPM(-1))+C0404*(RPM(-2)-
ERPM(-2))+Z_CON (16)

GR-1 is the sustainable growth rate of real output. We assume that the rate of potential growth of the economy (GR-1) is 2.75% per annum. This growth rate is composed of population growth of 1.25% per annum, labour productivity growth of 1.5% per annum and other technological change parameters of the production block.

If our view changes around any of these determinants of growth then the assumptions can be changed to reflect that revised view. Section 6.5 for example examines the consequences of changing our view on the labour productivity growth assumption on the properties of the model.

5.2 Residential Investment

A Tobin-q style (Tobin, 1969) model of housing investment is used in which the rate of investment is above or below a benchmark rate, according to whether the actual rate of return on housing investment is above or below a required rate of return. This requires measures of the benchmark rate of housing investment and of the actual and required rates of return on housing investment.

In the long run, the stock of housing will increase in line with the natural rate of growth of the economy, GR-1. Thus the benchmark rate of housing investment (IH) needs to cover both natural growth in the stock of housing and depreciation which is set at 1% per quarter, as shown by equation (17).

IH = (GR - 1 + DRRB_EQ)*KH (17)

The required rate of return on housing (RRH) is defined by equation (18). It includes depreciation, the equilibrium real interest rate, RI_EQ, and a risk premium, RP, where each of these is expressed as a proportionate rate per quarter.

RRH=DRRB_EQ + RI_EQ + RP (18)

The rate of housing investment adjusts partially to the benchmark rate, and is influenced by the Tobin q-effect (the difference between the actual and required rates of return) lagged one quarter. The slope of the yield curve, YCURVE, also appears as a second interest rate effect on housing investment. The adjustment process is captured by equation (19).

$$IH/KH=C0501*(IH(-1)/KH(-1))+(1-C0501)*(GR(-4)+DRRB\_EQ-1)+C0502*(KSRATIO*(RPCONH(-1)-POL7\_EQ(-1))-(DRRB\_EQ+RI\_EQ+RP)) +C0503*YCURVE(-2) + C0504*YCURVE(-3) +Z\_IH, \tag{19}$$

The housing stock is calculated through a perpetual inventories approach where housing investment, net of depreciation, adds to the housing stock, which is carried over to the next quarter. These are captured by equations (20) and (21).

$$KH1 = (1 – DRRB\_EQ).KH + IH \tag{20}$$

$$KH = KH1(-1) \tag{21}$$

5.3 Business investment

A Tobin-q style model is used for private business investment, the same approach that was used for housing investment. Thus the rate of investment is above or below a benchmark rate, according to whether the actual rate of return on business investment is above or below a required rate of return. This approach incorporates the main factors commonly believed to influence business investment. In this approach, higher real wages reduce business investment by reducing the actual rate of return, while higher real interest rates reduce business investment by increasing the required rate of return.

In the long run, the stock of business capital (KBF) will increase in line with the natural rate of growth of the economy, GR-1. Thus the benchmark rate of business investment (IBF) needs to cover both natural growth in the stock of business capital and depreciation (DR_EQ), as shown by equation (22).

$$IBF = (GR - 1 + (DR\_EQ)).KBF \tag{22}$$

In the business investment equation the ratio of business investment to capital is driven by its own lag, prospective profitability and the tightness of monetary policy. Profitability is measured through the gap between actual and required rates of return. The required rate of return on investment includes the depreciation rate, the real interest rate and a risk premium (RP1), as shown in equation (23).

$$DR\_EQ + RI\_EQ + RP1 \tag{23}$$

The actual rates of return on capital is increased through higher prices for outputs and lowered through higher prices for inputs. Although the dynamic structure is calibrated, the parameter values for the equation are close to those of their estimated values. The dynamic specification of the business investment equation is represented by equation (24).

$$IBF/KBF=C1301*(IBF(-1)/KBF(-1))+(1-C1301)*(GR(-4)+DR\_EQ-1)+C1302*(AR(-1)-(DR\_EQ+RI\_EQ+RP1))+C1303*YCURVE(-2)+))+C1304*YCURVE(-3)+Z\_IBF, \tag{24}$$

Net business investment adds to the business capital stock carried over to the next quarter.

$$KBF1 = (1 – DR\_EQ).KBF + IBF \tag{25}$$

$$KBF = KBF1(-1) \tag{26}$$

5.4 Inventories

There are two types of inventories in the model: those for domestic consumption (IINR) and those for export (IIE). Domestic inventories are modelled as a function of YD and a deviation of the level of inventories from their equilibrium value.

$$IINR=EXP(LOG(YD*SSRATIO\_EQ)+C0701*LOG(KINR(-1)/EKINR(-1)))+Z\_IINR, \tag{27}$$

Export inventories are simply a residual and represent the difference between the domestic supply of commodity exports (CEXPS) and the foreign demand for commodity exports (CEXP).

5.5 Exports

In a small country like New Zealand, it is reasonable to assume that New Zealand is a price-taker in the markets for our exports. Export volumes respond to a change the relative price of exports. Therefore, a change in world growth affect exports through its impact on the foreign price for exports. The other prices that affect the supply of exports are the prices of production inputs, wages and import prices. Export supply increases in response to lower wages and import prices.

From the production block the model generates a path of medium-run equilibrium solution for export supply (EXRSR). These medium-run solutions represent the optimising or neoclassical solution from the production block. Total export supply (TEXRS) adjusts to equilibrium supply (EXRSR) in a partial adjustment model.

$$LOG(TEXPS)=C1101*LOG(GR*EXP(-1*\pi_2/4)*EXRSR(-1))+(1-C1101)*LOG(GR*EXP(-1*\pi_2/4)*TEXPS(-1))+Z\_TEXPS, \tag{28}$$

where GR-1 is the natural rate of growth of the economy. π_2 is a trend growth rate that captures changes in import penetration and a more open economy. The production of total exports is then disaggregated into commodities (CEXPS) and other exports (NCEXPS) where commodities are at constant share of total export supplies

5.6 Imports

The dynamic structure of the import equation is also formulated as a partial adjustment model. The production block also determines equilibrium imports in the dynamic model. Since imports are considered to be an intermediate input, higher wages leads to an increase in imports as firms substitute imports for labour.

Actual imports (IM) adjust to equilibrium imports (IMSR) according to the following partial adjustment model.

$$LOG(IM)= C0901*LOG(GR*EXP(-1*\pi_1/4)*IMSR(-1)) +(1-C0901)*LOG(GR*EXP(-1*\pi_1/4)*IM(-1))+Z\_IM, \tag{29}$$

5.7 Labour market

5.7.1 Employment

Actual business sector employment (NT-NGG) is the difference between total employment (NT) and government sector employment (NGG), and adjusts to equilibrium employment (NSR), which is derived from the production block in a partial adjustment model. The coefficient of C1001, which can be interpreted as the speed of adjustment to equilibrium, is imposed at 0.15. This is marginally slower than recent empirical estimates; see for example Gardiner (2001).

$$LOG\ (NT\text{-}NGG) = (C1001*LOG)\ (NSR(-1))*EXP(POPGR\_EQ)) + (1-C1001)*LOG((NT(-1) - NGG(-1))*EXP(POPGR\_EQ))) + Z\_NT, \qquad (30)$$

Having modelled business employment (NT-NGG), total employment is obtained by adding general government employment (NGG), which is treated as an exogenous policy variable.

5.7.2 Labour Force

The labour force participation rate is the ratio of the labour force to the population aged 15 years and over.

$$PARTT= C2001*PARTT(-1)+C2002*(PARTT\_EQ)+C2003*(NAIRU(-1)-URT(-1)), \qquad (31)$$

For the purposes of the participation rate equation, the population aged 15 years and over is measured using demographic data sources. This is to ensure consistency with the age-specific population effects appearing in the rest of the model. However, official data for the participation rate (PARTT) uses a different measure of the population aged 15 years and over. To match this official definition, an equation for PARTT is included in which the appropriate scaling factor (RPOP3) is applied to correct the demographic sources estimate of the population aged 15 years and over.

$$PARTT = 100.NTS/(RPOP3.(POP3 + POP4)) \qquad (32)$$

A further equation appears for the trend growth rate of the working age population, POPGR_EQ. In the long run, the participation rate is assumed to stabilise, and growth in the working age population determines growth in the labour force which in turn is part of the sustainable growth rate of real output, GR-1.

$$POPGR\_EQ = \Delta LOG(POP3\_EQ + POP4\_EQ) \qquad (33)$$

Using total employment (NT), and the labour force (NTS), which is derived form the above specification of the participation rate (PARTT), unemployment (NUN) and the unemployment rate (URT) and can be calculated.

$$NUN = NTS – NT \qquad (34)$$

$$URT = 100.(1 - NT/NTS) \qquad (35)$$

5.7.3 Wages

The wage equation is an inflation expectations augmented Phillips Curve.

$$(1+INF\_WA)=EXP(INFE(-1))*(C0301*A1(-3)/A1(-4)+C0302*A1(-4)/A1(-5)+C0303*A1(-5)/A1(-6)+C0304*A1(-6)/A1(-7))+C0305*(URT(-2)-NAIRU)+C0306*LOG(ERWA(-2)/RWA(-2))+C0307*LOG(RPYDMR(-1))+Z\_W, \quad (36)$$

Wage inflation is determined by backward-looking expectations of inflation, lagged productivity growth and excess demand pressures in the labour market as measured through deviations of the actual unemployment rate from its equilibrium value. The equation also includes the medium-run variable, RPYDMR, which proxies the profitability of firms. Finally, the equilibrium real wage (ERWA) derived from the production block provides a long-run anchor for the equation.

5.8 Inflation

Inflation can diverge from the target rate of 1.5% per annum as a result of three influences. The first concerns the degree of excess demand. This is measured by the output gap, which has become a popular way to model inflationary pressures. In this framework, inflation will deviate from the monetary authority's target rate when demand pressures deviate from the economy's potential to supply. Potential output is unobservable and therefore needs to be calculated. As mentioned before in the steady state model, the estimate of potential is based on the estimated production function.

Inflation can also deviate from its target rate through inflation expectations. Inflation expectations are formed as a mixture of both forward and contemporaneous inflation.

Changes in mark-ups will also influence inflation. The coefficient of RPYDMR is relatively small so that less weight is placed on this channel in the model.

The following autoregressive specification recognises the persistence of inflation.

$$(INF\_PYD-INF\_TAR)=C1201*(C1202*(INFE(-1)-INF\_TAR)+(1-C1202)*(INF\_PYD(-1)-INF\_TAR))+(1-C1201)*(C1203*LGAP(-1)+C1204*LGAP(-2)+C1205*LGAP(-3)+C1206*LOG(RPYDMR(-1))), \quad (37)$$

The measure of inflation targeted by the monetary authority is the growth rate of the Consumer Price Index (CPI), which is represented by the following equation:

$$INF=((1-(SHARE/(1+SHARE)))*(INF\_PYD)+(SHARE/(1+SHARE))*(INF\_PCONH)) \quad (38)$$

where INF_PCONH is the inflation of housing services and share is the ratio of housing services expenditure to other consumption. Therefore, both the price deflator for YD and the price deflator for housing services are the main ingredient determining the CPI index.

5.9 Monetary policy

In the model, the central bank adjusts short-term interest rates to achieve an inflation target of 1.5% per annum. The reaction function is forward looking with the monetary authority targeting deviations of annual inflation from the target rate over a 5 to 7 quarter horizon. Equal weight is placed on these target quarters.

RCS=(C6001*(INF_CPIX(5)-CPI_TAR)+C6002*(INF_CPIX(6)-CPI_TAR)+C6003*(INF_CPIX(7)-CPI_TAR)+C6004*(RCS-RCS(-1))+RL), (39)

5.10 Fiscal policy

The fiscal authority rule is set so that the authority targets both the level of public debt to GDP and the rate of change. The fiscal authority has a target for public debt relative to GDP, which is pursued through adjustments in the rate of labour income tax. The fiscal policy rule like the monetary policy rule is forward looking.

POL1=POL1(-1)+C8001*(PUBDER(8)/ERGDP(8)-PUBDE_EQ(8))+C8002*((PUBDER(9)/ERGDP(9)-RPUBDE_EQ(9))-(PUBDER(8)/ERGDP(8)-RPUBDE_EQ(8))) +C8003*(RPUBDE_EQ-RPUBDE_EQ(-1)), (40)

5.11 Financial Markets

5.11.1 Exchange Rate

The determination of the equilibrium real exchange rate has been discussed in section 2.3 on the steady state structure. A common specification of the exchange rate dynamics focuses on using some form of uncovered interest rate parity (UIP) to explain exchange rate deviations from the equilibrium value. However, recent experience with applying such a model to the exchange rate have proved unsuccessful in explaining recent developments in the value of the New Zealand Dollar (King 1998).

The steady state model generates an equilibrium path for the real exchange rate index (ERE) for a given set of real variables such as world prices and technology. The medium-run equilibrium real exchange rate index (RE) is driven by the future deviation between the target and actual foreign debt to GDP ratio and can deviate from its steady value in the medium term.

RE = (((0.25*ERE+0.25*ERE(-1)*EXP(INF_TAR) +0.25*ERE(-2)*EXP(INF_TAR*2)+0.25*ERE(-3)*EXP(INF_TAR*3)) - 1.2*LDGDPR(4)-1.2*LDGDPR(5))), (41)

The following equation shows the adjustment process of the actual real exchange rate index (RER) towards its equilibrium. The assumption of uncovered interest parity continues to hold if the partial adjustment coefficient (C1600) is set to 1.

RER=(1-C1600)*RER(-1)*EXP(INF_TAR)+C1600*RE*(1+RCS/400-INF)/(1+(RCSFB+RPRCS)/400-INFW) (42)

RCS is the 90-day bill rate and RCSFB is the foreign bill rate. Equation (42) implies that after adjusting for both domestic (INF) and foreign inflation (INFW) and risk premium (RP), the expected return from domestic and foreign 90-day bills are equal. However, the assumption of uncovered interest parity is not imposed in the model.

5.11.2 Bond Market

The bond market is modelled using the expectations theory of the term structure of interest rates. This sets the yield on a 10-year bond equal to the expected yield from holding a continuous sequence of 3-month bank bills over the same 10-year period. This would involve a sequence of 40 bank bills, which would add 39 expected future bank bill rates to the model. To avoid this complexity, it is assumed that the 10-year bond rate equals a geometrically declining weighted average of expected future bank bill rates, rather than a simple five-year average. This approximation allows a transformation to be applied which results in the 10-year bond rate, RL, equalling a weighted average of the one quarter-ahead forecast for the 10-year bond rate, RL(1), and the current 3-month bill rate.

$$RL = (1 - 0.95).RCS + 0.95.RL(1) \tag{43}$$

Rational expectations are assumed. Thus new information changes the model forecast for RL(1), causing RL to jump to a new level. The objections and counter-arguments to this approach are the same as for uncovered interest parity. In the forecasting environment, rational expectations are not assumed. Thus a 10-year expected inflation rate, INFE, is needed to convert RL to a real rate. For consistency, the relationship of INFE to the annualised quarterly inflation rate, INF, is the same as the relationship of RL to RCS.

$$INFE = (1 - 0.95).INF + 0.95.INFE(1) \tag{44}$$

6 The dynamic properties of the model

In this section, we describe the dynamic properties of the model by presenting the results of seven shocks. The first three shocks describe the mechanism through which changes in world prices affect the economy. These experiments demonstrate that the dynamic path of the external export price shock is quite different from that of the import price shock, a result first demonstrated empirically for New Zealand by Wells and Evans (1985). This illustrates that in a three-sector economy, it is important to determine how the terms of trade shocks are formed. The fourth shock is intended to illustrate how the economy responds to higher nominal wage inflation. We consider a temporary reduction in aggregate demand in the fifth experiment. The final two shocks, which lead to a permanent change in the economy, involve raising the level of productivity and lowering the government liability to GDP ratio.

The results of the simulation experiments are presented in Figures 16 to 22. The responses are expressed either as per cent or percentage point deviations from the steady-state levels. The units on the horizontal axis are years.

6.1 A Temporary World Export Price Shock

The decrease in the world price of New Zealand exports shock is introduced as a 3 percentage point decrease in the world export price. The shock lasts for 3 quarters. The responses to this shock are shown in Figure 16.

This shock results in an immediate deterioration in the current account, which leads to an increase in foreign debt. The real exchange rate depreciates instantly, responding to the future deviation between the target and actual foreign debt to GDP ratio.

Exports are lower initially in response to lower export prices but increase gradually as the real exchange rate depreciates. Demand for imports remains below control until the real exchange rate returns to equilibrium.

The depreciation in the real exchange rate first leads to a moderate increase in inflation. The initial excess supply then reduces inflation to control. Finally the excess demand owing to higher net exports results in stronger inflationary pressure. Notice how the forward-looking monetary authority looks through the initial inflation volatility and begins to tighten the monetary conditions five quarters after the shock.

Note that demand for the domestic good declines initially due to the initial monetary tightening and lower household real disposable income arising from higher unemployment. The demand for domestic goods then begins to increase in response to the subsequent easing in monetary conditions.

6.2 A temporary world import price shock

This experiment involves a 3 percentage point increase in the world price of New Zealand imports. The size and the duration of the terms of trade shock are similar to the previous experiment and the responses to this shock are shown in Figure 17.

As in the previous shock, worsening the terms of trade induces a real exchange rate depreciation. However, unlike the previous shock, the initial fall in exports is much smaller and the initial decrease in the demand for imports is much larger. Consequently, it results in excess domestic demand, which kicks off an inflation and the monetary policy response. The monetary authority raises interest rates sharply after the shock, illustrated by the yield curve.

There is an initial increase in employment which reduces the unemployment rate. As the cost of imports increases, firms substitute labour for imports in production. Firms continue to take on workers while the real exchange rate remains above control.

6.3 A permanent increase in world export prices

In this experiment shown in Figure 18, we investigate the dynamic path of a permanent improvement in the terms of trade arising from a permanent 1% rise in export prices. The world price of imports remained unchanged. The impact of the permanent shock leads to a new long-run equilibrium path. The long-run properties of the steady state model with a permanent shock to the world export prices have been discussed in detail in the previous section.

Given that the desired foreign debt ratio has not changed, the real exchange rate must appreciate to achieve the desired target in the long-run equilibrium, which reduces the cost of imports and make more resources available for the domestic goods sector. The welfare gain from the permanent increase in world export prices can be estimated roughly by the amount of increased demand for domestic goods.

Initially, the dynamic adjustment path is similar to that of the temporary world price shock. The shock affects the current account balance first through rising world prices and hence the foreign debt position is lower than the desired level. Consequently, the real exchange rate appreciates and overshoots the new equilibrium level.

The impact of higher world export prices on export volumes is fully offset by the real exchange rate appreciation by the end of the first year. Combined with the increase in imports, lower foreign demand for exports generates a decline in aggregate demand.

As a result, there is downward pressure on inflation and the level of unemployment is above its equilibrium. The forwarding-looking monetary authority projects that inflation will fall below the target and therefore loosens monetary policy, which helps to stimulate domestic demand, and the demand for domestic goods gradually converges to its new equilibrium.

After seven years, the real exchange rate returns to its new equilibrium as the desired foreign debt to GDP ratio is achieved.

6.4 A temporary increase in nominal wages

This shock, shown in Figure 19, involves a temporary increase in nominal wages, which raises the real wage by close to a percentage point. The increase in real wages stimulates consumption demand, which in turn causes inflation to rise. Monetary policy tightens to prevent inflation from rising. On the supply side, firms take on fewer workers and more imports in response to higher real wages. Higher input costs also make the export sector less competitive internationally. As a result, the level of the current account deficit is above its equilibrium and hence leads to higher foreign debt.

In order to attain the external balance, real exchange rate must depreciate. The real wage is gradually reduced to its equilibrium as price inflation picks up and rising unemployment begins to dampen nominal wages growth.

6.5 A temporary demand shock

This shock is intended to illustrate how a temporary increase in aggregate demand is transmitted through the economy and is shown in Figure 20. Consumption increases by 0.5 per cent and both business and residential investment increase by 1 per cent. The shock lasts for one quarter.

The increase in demand leads to an increase in inflation and the monetary authority tightens monetary policy instantly to prevent inflation expectations from rising. Strengthening domestic demand fuels import growth. Exports increase as a result of stronger investment growth. However, net exports are below equilibrium and cause the current account deficit to rise. This causes the real exchange rate to depreciate. It takes about two years for inflation expectations to return to control.

6.6 A permanent increase in the level of productivity

In this shock, the level of productivity increases permanently by 1 per cent. The results are shown in Figure 21. The dynamic path of the shock is very similar to that of a permanent increase in world export prices. Both shocks permanently raise the level of the living standard by increasing private consumption and investment in the long run. The initial negative output gap reflects the higher productivity of the firm and hence the deflationary impact of the shock.

Consequently, the monetary authority needs to loosen monetary policy to stimulate aggregate demand. In response to the monetary easing, firms increase the capital stock to its new long-run level as higher productivity raises the marginal return of capital. The benefit arising from higher productivity gradually passes to households by raising real wages. The increase in disposable income raises consumption slowly to its new equilibrium.

Initially, the adjustment to the new steady state also requires the real exchange rate to appreciate, as the desired level of foreign debt is higher than its initial equilibrium. However, it is important to note that the desired ratio of foreign debt to GDP remains unchanged and the real exchange rate rises smoothly back to its original long-run level. In response to the initial real exchange rate appreciation, firms reduce their export supply. On the back of the real exchange rate depreciation, exports begin to rise. Both imports and exports are higher in the new equilibrium by 1 per cent. In this respect, it is interesting to contrast this shock with the permanent increase in world export prices. In the export price shock, there is a permanent appreciation of the real exchange rate and exports stabilise just above their initial level.

6.7 Reducing the public liability to GDP ratio

This shock involves the government lowering the target debt to GDP from 30 per cent to 28 per cent. The results are shown in Figure 22. In order to pay off debt faster, the government has to raise the personal income tax rate sharply. Consequently, consumption falls relative to control, which in turn leads to a reduction in aggregate demand. As a negative output gap emerges, the monetary authority must loosen monetary policy in order to offset the impact of the shock.

The decline in government debt implies that there are fewer financial assets available for households' wealth. To maintain the same level of financial wealth as before, households substitute foreign assets for domestic assets. Consequently, the new desired foreign debt to GDP ratio must fall, which sets off a real exchange rate depreciation. Combined with the easing in monetary conditions, the real exchange rate depreciation raises aggregate demand above supply just one year after the shock.

7 Concluding comments

As the development of a macroeconomic model is an on-going process, the Treasury has embarked on a process of re-development of the core macroeconometric model. The main aim of the new model, the New Zealand Treasury Model, is to provide a theoretically consistent framework for forecasting. This paper has described the steady-state structure and the dynamic structure of this new model.

The model is founded on a well-developed production block with a macroeconomic balance framework on the determination of the equilibrium real exchange rate. The production block provides an estimate of potential output, which is then used to measure the output gap. Unlike the previous macroeconometric model (NZM), the process of inflation generation is based mainly on a demand-pull framework. Like other neoclassical general equilibrium models, the long-run equilibrium is characterised by a balance growth path and stock-flow consistency across all sectors.

The dynamic structure of the model is composed of two key elements. Firstly, some agents adjust partially to the long-run equilibrium, which indicates some inherent inertia in the system. Secondly, some agents in the financial market such as the monetary authority base their decision making partly on expectations. Therefore, modelling expectations formation plays a key role in the dynamic properties of the model.

One of the interesting findings from the shock experiments is that the dynamic path of the external export price shock is quite different from that of the import price shock. This result suggests that it is no longer appropriate to treat exportables and importables as a composite good when there are changes in the terms of trade.

Future developments on the model can be divided into two main areas: validation and policy simulation. Since the dynamic component of the model is based on calibration, it is important to validate the dynamic properties of the model by testing against other empirical models such as the SVAR model developed by Buckle et al (forthcoming). As with any macroeconometric model, the model needs to be continually updated in the light of new data. Hence, the specification of the model may evolve over time.

While the model development has focussed on how to inform the macroeconomic forecasts, there is potentially a role for the model in informing policy through examining the simulation of the model. This would likely involve refining the model in order to capture the greater complexity of how economic agents respond to policy changes.

References

Ando, A. and Modigliani, F. (1963) “The life-cycle hypothesis of saving: Aggregate implications and test”, *American Economic Review*, 53(1), 55-84.

Black, R., Cassino, V., Drew, A., Hansen, E., Hunt, B., Rose, D., and Scott, A. (1997), “The forecasting and policy system: the core model.” Reserve Bank of New Zealand Research Paper No. 43.

Buckle, R. A, Kim, K. H, Kirkham, H. McLellan, N. and Sharma, J. (2002) “ Trade, climate and financial influences on macroeconomic fluctuations: Analysis using an open economy SVAR model of the New Zealand economy.” The New Zealand Treasury Working Paper (forthcoming).

Downing, R. (2001), “A consumption equation.” Internal Paper, The Treasury.

Edwards, S. (1987) “ Tariffs, terms of trade, and the real exchange rate in an intertemporal optimising model of the current account.” NBER Working Paper No. 2175.

Edwards, S. (1989) “ Temporary terms of trade disturbances, the real exchange rate and the current account”, *Economica*, 56, 343-57.

Gardiner , P. (2001), “Labour market equation.” Internal Paper, The Treasury.

Haugh, D. (2001), “Foreign investment in New Zealand.” Paper presented at the New Zealand Association of Economists Conference, Wellington, June 2001.

Hodrick, R. J. and Prescott, E. C.(1997) “Post-war US business cycles: an empirical investigation.” *Journal of Money, Credit, and Banking,* 29, 1-16.

King, A. (1998), “Uncovered interest parity: New Zealand’s post-deregulation experience.” *Applied Financial Economics*, 8, 495-503.

Murphy, C. (1998), “New Zealand Model 1998”, *A Report to the New Zealand Treasury* Wellington, September 1998.

Powell, A. and Murphy, C. (1997) *Inside a Modern Macroeconomic Model*, Berlin: Springer-Verlag.

Rae, D. (1996) “ A forward –looking model of aggregate consumption in New Zealand”, Working Paper, The National Bank of New Zealand.

Svensson, L. E. O. (1999) “Price-level targeting versus Inflation Targeting: A free lunch?”, Journal of Money, Credit and Banking, 31(3), 277-295.

Szeto, K. L. (2001) “An econometric analysis of a production function for New Zealand” . The New Zealand Treasury Working Paper No. 01/30.

Szeto, K. L. and Gardiner, P. (2001) “Real exchange rates and price transmission mechanism”, Internal Paper, The Treasury.

Tobin, J. (1969) “ A general equilibrium approach to monetary theory.” *Journal of Money, Credit, and Banking,* 1, 15-29.

Wells, G. M. and Evans, L. T. (1985) “The impact of traded goods prices on the New Zealand Economy.” *The Economic Record*, 61, 421-435.

Wiliamson, J. (1985) “The exchange rate system” *Policy Analyses in International Economics*, 5, Institute for International Economics.

Appendix 1: Variable Listing

Code	Description
A1	labour efficiency scale parameter
A3	imports efficiency scale parameter
A5	exports inefficiency scale parameter
AR	medium-run actual rate of return on capital
CESRATIO_EQ	ratio of CEXP to CEXPS
CEXP	commodity exports
CEXPS	commodity export supply
CON	real consumption (model-basis)
COND	equilibrium CON
CONH	private consumption - housing
CONO	private consumption - other
CPI_TAR	annual CPI inflation target - 0.014884
CPIX	consumer price index
CURB	balance on current account
DEM	domestic good - sales
DGDPR	real foreign debt to RGDP
DGDRATIO_EQ	ratio of RZA to PUBDER
DIFD	benefit-survey unemployment rates
DR_EQ	depreciation rate for business capital stock
DRRB_EQ	depreciation rate for housing stock
E	TWI (model basis)
EKBF	equilibrium KBF
EKH	equilibrium KH
EKIE	equilibrium KIE
EKINR	equilibrium KINR
ERE	equilibrium RE
ERGDP	equilibrium RGDP
ERPM	equilibrium RPM
ERWA	equilibrium RWA
ETWIT	trade weighted index
EXRSR	short-run equilibrium exports
FDGDPR	real foreign debt to real GDP ratio
FGDRATIO_EQ	ratio of ZG/RE to PUBDER
FPDRATIO_EQ	ratio of private foreign debt contracted in foreign currency to total private foreign debt
GDPZ	nominal gdp (model-basis)
GGCO	general govt consumption - purchases
GGCO_EQ	steady-state general govt consumption - purchases
GGIF	government - fixed investment

Code	Description
GGIF_EQ	steady-state govt - fixed investment
GNEZ	nominal gne (model-basis)
GR	equilibrium real growth factor
IBAL	investment balances
IBF	private investment - fixed - business
IH	private investment - fixed - housing
IIE	inventory investment – commodity exports
IINR	inventory investment - non exports (model-basis)
IM	imports
IMSR	short-run equilibrium IM
INF	inflation rate of CPIX
INF_CPIX	annual inflation rate of CPIX
INF_PCONH	inflation rate of housing services (CONH) deflator
INF_PYD	inflation rate of domestic good (YD)
INF_TAR	inflation target
INF_TAR_EQ	steady-state inflation target
INF_WA	wage inflation
INFE	inflation expectation
KBF	stock of private business fixed capital
KBF1	stock of private business fixed capital (end of period)
KH	stock of housing
KH1	stock of housing (end of period)
KIE	stock of commodity exports
KIE1	stock of commodity exports (end of period)
KINR	stock of non-export inventories
KINR1	stock of KINR1 (end of period)
KSRATIO	ratio of CONH to KH
LDGDPR	LOG(DGDPR/FDGDPR)
LGAP	private sector production output gap
NA1	private consumption
NA10	gdp (production-based estimate)
NA12	exports of goods and services
NA13	imports of goods and services
NA14	gdp (expenditure-based estimate)
NA15	private consumption - housing
NA16	nominal gdp (expenditure-based estimate)
NA2	general government consumption
NA3	private investment - residential buildings
NA4	private business gross fixed capital formation
NA7	public gross fixed capital formation
NA8	inventory investment - non-commodity
NA9	inventory investment - commodities
NAIRU	long-run unemployment rate
NCEXP	non-commodity exports

Code	Description
NCTEXPSR_EQ	the share of non-commodities export supply
NGG	employment - general government
NGG_EQ	steady-state employment - general government
NSR	short-run equilibrium NT-NGG
NT	employment
NTS	labour force
PARTT	Labour force participation rate
PARTT_EQ	steady-state labour force participation rate
PCONH	nominal price of housing services
PIMF	price of imports - foreign currency
PIMF_EQ	steady-state price of imports - foreign currency
PM	domestic price of imports
PNA10	private sector production
PO_EQ	potential private sector production
POL1	income tax rate
POL11_EQ	transfers rate - other
POL12_EQ	transfers rate - public sector to foreign sector
POL14_EQ	transfers rate - foreign sector to private sector
POL3_EQ	rate of lump sum tax
POL4_EQ	rate of tax on consumption of non-housing
POL5_EQ	rate of tax on imports
POL6_EQ	rate of payroll tax
POL7_EQ	rate of tax on consumption of housing
POL8_EQ	transfers rate - superannuitants
POL9_EQ	transfers rate - unemployment
POP1	population - aged 0-4
POP2	population - aged 5-14
POP3	population - aged 15-64
POP4	population - aged 65+
POP1_EQ	steady state population - aged 0-4
POP2_EQ	steady state population - aged 5-14
POP3_EQ	steady state population - aged 15-64
POP4_EQ	steady state population - aged 65+
POPGR_EQ	working-age population trend growth rate
PTEX	domestic price of exports
PTEXF	world price of exports - foreign currency
PTEXF_EQ	steady-state world price of exports - foreign currency
PUBDER	real public liabilities
PYD	price of YD
RATB_EQ	non-interest income from public to private sector
RB	real domestic bonds + cumulated equity disinvestment
RCS	90-day bank bills
RCSFB	foreign 90-day bank bills
RDOS	real net capital inflow

Code	Description
RE	equilibrium real exchange rate index
RER	real exchange rate index
RFDEBT	real foreign debt
RGDP	real GDP
RGSPEND	real government spending
RI	real interest rates
RIF	real foreign interest rates
RINCOME	real household income
RL	10-yr bond rate
RLFB	foreign 10-yr bond rate
RLPCON	price of consumption (model-basis)
RMTRANSFER	real migrant transfer
RP	risk premium for residential investment
RP1	risk premium for business investment
RPCONH	real price of housing services
RPCONHD	equilibrium real price of housing services
RPKLR	long-run equilibrium price of capital services
RPM	the relative price of imports
RPOP3	POP/(POP3+POP4)
RPRCS	risk premium for 90 day rate
RPTEX	the relative price of exports
RPTLR	real long-run equilibrium price of gross output
RPTSR	real short-run equilibrium price of gross output
RPUBDE_EQ	ratio of real public debt to RGDP
RPUBS	real government saving (crown accounts)
RPUDOS1	real net public capital inflow (previous quarter)
RPYD	unity
RPYDMR	real short-run equilibrium PYD
RPYLR	long-run equilibrium price of primary factors
RPYSR	real short-run equilibrium price of primary factors
RS	real 90-day rate
RSF	real foreign 90-day rate
RTROSPR	real net transfers from foreign sector to private sector
RTRPUOS	net transfers from public sector to foreign sector
RTRPUPR	net transfers from public sector to private sector
RWA	real average earnings (nat. ac. basis): incl. payroll tax
RWEALTH	real household wealth
RYOSPR	real net income from foreign sector to private sector
RYOSPU	real net income from foreign sector to public sector
RYPUPR	real net income from public to private sector
RZ_OSPR_EQ	RYOSPR residual
RZ_OSPU_EQ	RYOSPU residual
RZGA	real public foreign debt denominated in $NZ
RZPA	real private foreign debt denominated in $NZ

Code	Description
SHARE	the ratio of expenditure on housing services to others
SSRATIO_EQ	inventory investment to sale ratio for domestic good
TBAL	trade balances
TBQ	Tobin-q for business investment
TBQH	Tobin-q for residential investment
TEXP	total exports
TEXPS	total export supply
TFBAL	transfer balances
TRBASE	transfers base
TREND	time trend
TSR	quantity of gross output
UNB	number of people on unemployment benefits
URT	unemployment rate
WA	average earnings: incl. payroll tax
YCURVE	yield curve
YD	domestic good - production
YSR	quantity of primary factors
Z_CON	CON equation residual
Z_CEXP	CEXP equation residual
Z_NCEXP	NCEXP equation residual
Z_IBF	IBF equation residual
Z_IH	IH equation residual
Z_INF	INF equation residual
Z_NA1	NA1 equation residual
Z_NA13	NA13 equation residual
Z_NA15	NA16 equation residual
Z_NA2	NA2 equation residual
Z_NA3	NA3 equation residual
Z_NA4	NA4 equation residual
Z_NA7	NA7 equation residual
Z_NA8	NA8 equation residual
Z_NT	NT equation residual
Z_W	INF_WA equation residual
ZG	public foreign debt denominated in foreign currency
ZP	private foreign debt denominated in foreign currency

Appendix 2: Equations for the steady state model

The model equations are reported using TROLL syntax. Each equation begins with a label, which indicates the endogenous variable in the system. All the variables with a suffix _eq are steady state values and all the nominal variables are deflated by PYD.

PRODUCTION BLOCK

```
RPTSR:  RPTSR=((RPTEX/(A5))**(THETA/(THETA-1))
              +(RPYD/A6A)**(THETA/(THETA-1)))**((THETA-1)/THETA),

RPYSR:  RPYSR=A4A*(RPTSR**(DELTA/(DELTA-1))
              -(RPM/(A3))**(DELTA/(DELTA-1)))**((DELTA-1)/DELTA),

RWA:  RWA=(A1)*(RPYLR**(RHO/(RHO-1))
              -(RPKLR/A2A)**(RHO/(RHO-1)))**((RHO-1)/RHO),

YSR:  YSR=1000000*(((A1)*NSR/1000000)**RHO
              +(A2A*KBF/1000000)**RHO)**(1/RHO),

KBF: KBF=1/A2A*(A1)*NSR*((RPYSR/(RWA/(A1)))
         **(RHO/(RHO-1))-1)**(1/RHO),

YD:  YD=TSR/A6A*(RPYD/(A6A*RPTSR))**(-1/(1-THETA)),

TSR:  TSR=((A4A*YSR)**DELTA+((A3)*IMSR)**DELTA)**(1/DELTA),

EXRSR:  EXRSR=TSR/(A5)*(RPTEX/((A5)*RPTSR))**(1/(THETA-1)),

IMSR:  RPM=(A3)*RPTSR*((IMSR*(A3)/(YSR*A4A))**(-DELTA)+1)
              **((1-DELTA)/DELTA),

RPTLR:  RPTLR=RPTSR,

RPYLR:  RPYLR=RPYSR,

RPKLR:  RPKLR=RPKLR_EQ,

AR:  AR=RPKLR,

PNA10: PNA10=TEXPS+YD-IM,

A1: A1=A1(-1)*EXP((BETA)*0.25),
```

A3: A3=A3(-1)*EXP(π_1*0.25),

A5: A5=A5(-1)*EXP(π_2*0.25),

GR: GR=EXP((BETA)*0.25)*EXP(POPGR_EQ),

GR_1: GR_1=(GR-1),

LABOUR MARKET

NTS: PARTT=100*NTS/(RPOP3*(POP3_EQ+POP4_EQ)),

NSR: URT=100*(1-(NSR+NGG_EQ)/NTS),

NT: NT=NSR+NGG_EQ,

PARTT: PARTT=PARTT_EQ,

URT: URT= NAIRU,

POPGR_EQ: POPGR_EQ=LOG(POP3_EQ+POP4_EQ)-

LOG(POP3_EQ(-1)+POP4_EQ(-1)),

CONSUMPTION SECTOR

COND: LOG(COND)=C0101+C0102*LOG((1-POL1)*RWA*NT+RTRPUPR
+RTROSPR+RMTRANSFER)

+(1-C0102)*LOG((RB-RZPA-ZP/RE)+KH+KBF) -RLPCON,

RLPCON: RLPCON=LOG((CONO*(1+POL4_EQ)+CONH*RPCONH)/CON),

RPCONH: LOG(RPCONH/(1+POL4_EQ))=C0200+C0202*LOG(CONH/CONO)+

C0201*TREND,

CONH: CONH=CON-CONO,

SHARE: CONH=(SHARE/(1+SHARE))*(COND*EXP(RLPCON))/RPCONH,

CON: CON=COND,

RINCOME: RINCOME=(1-POL1)*RWA*NT+RTRPUPR +RTROSPR+RMTRANSFER,

RWEALTH: RWEALTH= (RB-RZPA-ZP/RE)+KH+KBF,

STOCK and INVESTMENT

DEM: IINR=YD-DEM,

CONO: DEM=CONO+(IH+IBF+GGCO_EQ+GGIF_EQ),

KINR1: KINR1=KINR+IINR,

IINR: IINR=SSRATIO_EQ*YD,

KINR: KINR=KINR1(-1),

KH: KH=CONH/(KSRATIO),

IH: IH=(DRRB_EQ+GR_1)*KH,

KH1: KH1=KH*(1-DRRB_EQ)+IH,

IBF: IBF=KBF1-KBF*(1-DR_EQ),

KBF1: KBF1=KBF*GR,

IIE: IIE=CESRATIO_EQ*CEXPS,

KIE: KIE =KIE1(-1),

KIE1: KIE1=KIE+IIE,

RP1: RP1=AR-(DR_EQ+RI),

RP : RP= KSRATIO*(RPCONH-POL7_EQ)-(DRRB_EQ+RI),

FOREIGN SECTOR

RYOSPR: RYOSPR=-((RLFB/400)*(ZP/RE)+(RL/400)*RZPA),

RYOSPU: RYOSPU=-((RLFB/400)*(ZG/RE)+(RL/400)*RZGA),

EXPORTS AND IMPORTS

TEXPS: TEXPS=EXRSR,

TEXP: TEXP=CEXP+NCEXP,

NCEXP: NCEXP=EXRSR*NCTEXPSR_EQ,

CEXPS: CEXPS=EXRSR-NCEXP,

CEXP: CEXP=CEXPS-IIE,

IM: IM=IMSR,

GOVERNMENT SECTOR

RB: RB=PUBDER-(RZGA+ZG/RE),

PUBDER: PUBDER=(RPUBDE_EQ)*RGDP,

POL1: RPUBS=-(RGSPENDRPYD*GGIF_EQ)+(POL1*RWA*(NSR+NGG_EQ)

+POL4_EQ*RPYD*CONO +POL5_EQ*PIMF_EQ/RE*IMSR

+POL6_EQ*RWA*(NSR)+POL7_EQ*RPYD*CONH+POL3_EQ*RGDP),

RGSPEND: RGSPEND=RWA*NGG_EQ+RPYD*(GGCO_EQ+GGIF_EQ)

+RTRPUPR+RTRPUOS+RYPUPR-RYOSPU,

RYPUPR: RYPUPR =(RL/400)*RB+RATB_EQ*RGDP,

RPUBS: RPUBS=RPYD*GGIF_EQ-PUBDER*GR_1,

PUBDER1: PUBDER1=PUBDER*GR,

RTROSPR: RTROSPR=POL14_EQ*RGDP,

RTRPUOS: RTRPUOS=POL12_EQ*RGDP,

RTRPUPR: RTRPUPR=(1-POL1)*RWA*TRBASE,

TRBASE:TRBASE=POL8_EQ*POP4_EQ+POL9_EQ*UNB+

POL11_EQ*(POP1_EQ+POP2_EQ+POP3_EQ+POP4_EQ),

UNB: UNB=(1+DIFD)*NTS-(NSR+NGG_EQ),

EXCHANGE RATES

RGDP: RGDP=RPTEX*TEXPS+RPYD*YD-RPM*IMSR+NGG_EQ*RWA

+CONH*RPCONH+POL4_EQ*RPYD*CONO,

RPM: RDOS= -1*(RPTEX*TEXP-(RPM/(1+POL5_EQ))*IMSR

+RTROSPR-RTRPUOS+RYOSPR+RYOSPU),

RE: RE=(1+POL5_EQ)*(PIMF_EQ)/RPM,

RER: RER=RE,

RPTEX: RPTEX=(PTEXF_EQ)/RE,

TBAL: TBAL=TEXP*RPTEX-IM*RPM/(1+POL5_EQ),

IBAL: IBAL=RYOSPR+RYOSPU,

TFBAL: TFBAL=RTROSPR-RTRPUOS,

ZP: (RB-RZPA-ZP/RE)=PAGDPR*RGDP,

RFDEBT: RFDEBT=((ZP/(FPDRATIO_EQ*RE)+RZGA+ZG/RE)),

RDOS: RDOS-RMTRANSFER=((ZP/(FPDRATIO_EQ*RE)+RZGA+ZG/RE))*GR_1,

DGDPR: DGDPR=RFDEBT/RGDP,

FDGDPR: FDGDPR=DGDPR,

CURB: CURB=-1*(RDOS-RZ_OSPR_EQ-RZ_OSPU_EQ)/RGDP*100,

RPUDOS1: RPUDOS1*EXP(GR_1)=RZGA*(EXP(GR_1)-1)+ZG/RE*(EXP(GR_1)-1),

RZPA: RZPA=ZP/(FPDRATIO_EQ*RE)-ZP/RE,

RZGA: RZGA=DGDRATIO_EQ*PUBDER,

ZG: ZG=FGDRATIO_EQ*RE*PUBDER,

INTEREST RATES

RCS: RCS=RL,

RL: RL= RLFB+RPRCS,

RI: RI= (1+RL/400)/EXP(1.489/400)-1,

SNA VARIABLES

NA14: NA14=TEXPS+YD-IM+CONH+(NA15-CONH),

NA15: NA15 =CONH,

NA1: NA1=NA15+(C2600+C2601*TREND+Z_NA1)*CONO,

NA2: NA2=(C2700+C2701*TREND+Z_NA2)*(GGCO_EQ+C5000*NGG_EQ),

NA3: NA3=(C2800+C2801*TREND+Z_NA3)*IH,

NA4: NA4=(C2900+C2901*TREND+Z_NA4)*IBF,

NA7: NA7=(C3200+C3201*TREND+Z_NA7)*GGIF_EQ,

NA9: NA9=IIE,

NA8: NA8=IINR+Z_NA8,

NA10: NA10=(NA14-Z_NA8),

NA12: NA12=TEXP,

NA13: NA13=IM,

Appendix 3: Consumption equation

log(COND)=C0101+C0102*log(RINCOME)+C0103*log(RWEALTH)-

RLPCON+C104*DUMMY

The dependent variable used in the regression is the logarithm of real consumption expenditure (log(COND)+RLPCON).

Table A3.1 Estimation of a long-run consumption equation

Sample period	87:2-01:4	87:2-96:4	87:2-01:4	87:2-01:4
	C0103=(1-C0102)	**C0103=(1-C0102)**	**C0103=(1-C0102)**	**C0102=1 , C0103=0**
log(RINCOME)	0.982	0.563	0.665	1
	(0.0519)	(0.0990)	(0.0844)	(na)
log(RWEALTH)		1-C401	1-C401	
DUMMY[1]			0.0614	
			(0.01381)	
Constant	-0.004	-1.216	-0.993	0.0503
	(0.1586)	(0.3070)	(0.2616)	(0.0040)
Cointegration tests				
Dickey-Fuller	**		**	
Augmented Dickey-Fuller	**		**	**

1 Note that the variable takes the value 1 if t > 1996:4 and 0 otherwise. This dummy variable is to capture a structural break in the consumption behaviour such as the effects of greater access to credit.

Table A3.2 Unit root tests (Levels)

	Lag length p	ADF test statistic
log(COND)+RLPCON	4	-2.605
log(RINCOME)	2	-2.439
log(RWEALTH)	0	-2.266

Table A3.3 Unit root tests (First Differences)

	Lag length p	ADF test statistic
log(COND)+RLPCON	2	-2.996**
ln(RINCOME)	0	-9.800*
ln(RWEALTH)	1	-2.997**

* significantly different from 0 at 1% level.

** significantly different from 0 at 5% level.

The critical values are based on MacKinnon[8] critical values for unit root tests.

[8] See Mackinnon, J. G. (1991) "Critical values for cointegration tests," Chapter 13 in R. F. Engle and C. W. J. Granger (eds), Long-run economic relationships: readings in cointegration, Oxford University Press.

Appendix 4: Demand for housing services

Log(PCONH/(PYD*(1+POL4))= C0200+C0201*TREND+C0202*Log(CONH/CONO)

Table A4.1 Estimation of the long-run demand for housing consumption

Sample period	87:2-01:4	91:1-01:4
log(CONH/CONO)	-0.189	-1.590
	(0.1626)	(0.2248)
TREND	0.017	-0.022
	(0.0031)	(0.0060)
Constant	-0.542	-1.903
	(0.1689)	(0.2211)
Cointegration tests		
Dickey-Fuller	**	
Augmented Dickey-Fuller	**	

Table A4.2 Unit root tests (Levels)

	Lag length p	ADF test statistic
log(PCONH/(PYD*(1+POL4))	4	-0.811
log(CONH/CONO	2	-1.940

Table A4.3 Unit root tests (First Differences)

	Lag length p	ADF test statistic
log(PCONH/(PYD*(1+POL4))	4	-2.95**
log(CONH/CONO	0	-7.806*

* significantly different from 0 at 1% level.

** significantly different from 0 at 5% level.

The critical values are based on MacKinnon critical values for unit root tests.

Appendix 5: Equations for the dynamic model

PRODUCTION BLOCK

NSR: NSR=1000000/(a1)*((YSR/1000000)**RHO
-(A2A*KBF/1000000)**RHO)**(1/RHO),

RPYSR: RPYSR=RWA/(a1)*(((a1)*NSR/(A2A*KBF))
(-RHO)+1)((RHO-1)/RHO),

RPTSR: RPTSR=((RPYSR/A4A)**(DELTA/(DELTA-1))
+(RPM/(A3))**(DELTA/(DELTA-1)))**((DELTA-1)/DELTA),

RPYDMR: RPYDMR=A6A*(RPTSR**(THETA/(THETA-1))
-(RPTEX/(A5))**(THETA/(THETA-1)))**((THETA-1)/THETA),

TSR: TSR=A6A*YD*(RPYDMR/(A6A*RPTSR))**(1/(1-THETA)),

YSR: YSR=1/A4A*(TSR**DELTA-((A3)*IMSR)**DELTA)**(1/DELTA),

EXRSR: EXRSR=TSR/(A5)
*(RPTEX/((A5)*RPTSR))**(1/(THETA-1)),

IMSR: IMSR=A4A*YSR/(A3)*((RPM/((A3)*RPTSR))**(DELTA/(1-DELTA))-1)
**(-1/DELTA),

A1: A1=A1(-1)*EXP(BETA*0.25),

A3: A3=A3(-1)*EXP(π_1*0.25),

A5: A5=A5(-1)*EXP(π_2*0.25),

RGDP: RGDP=RPTEX*TEXP+RPYD*YD-RPM*IM+NGG*RWA

+CONH*RPCONH+RPTEX*IIE+POL4_EQ*RPYD*CONO,

GR: LOG(GR)=0.5*POPGR_EQ+0.5*POPGR_EQ(-1)

+0.5*(BETA*0.25)+0.5*(BETA(-1)*0.25),

REAL EXCHANGE RATES

RPM: RPM=(1+POL5_EQ)*PIMF/(RER),

RPTEX: RER=(PTEXF)/(RPTEX),

LDGPR: LDGDPR=LOG(DGDPR/FDGDPR),

RE: RE = (((0.25*ERE+0.25*ERE(-1)*EXP(INF_TAR)

+0.25*ERE(-2)*EXP(INF_TAR*2)+0.25*ERE(-3)*EXP(INF_TAR*3))

- 1.2* LDGDPR(4)-1.2*LDGDPR(5))),

RER: RER=(1-C1600)*RER(-1)*EXP(INF_TAR)+

C1600*RE*(1+RCS/400-INF) /(1+(RCSFB+RPRCS)/400-INFW)

LABOUR MARKET

NTS: PARTT=100*NTS/(RPOP3*(POP3+POP4)),

PARTT: PARTT= C2001*PARTT(-1)+C2002*(PARTT_EQ)+C2003*(NAIRU(-1)-URT(-1)),

NT: LOG(NT-NGG_EQ) = (C1001*LOG((NSR(-1))*EXP(POPGR_eq))

+(1-C1001)*LOG((NT(-1)-NGG_EQ(-1))*EXP(POPGR_eq)))+Z_NT,

POPGR_EQ: POPGR_EQ=LOG(POP3_EQ+POP4_EQ)

-LOG(POP3_EQ(-1)+POP4_EQ(-1)),

URT: URT=100*(1-NT/NTS),

CONSUMPTION SECTOR

COND: LOG(COND)=C0101+C0102*LOG((1-POL1)*RWA*(NT)+RTRPUPR

+RTROSPR+RMTRANSFER)+

(1-C0102)*LOG(RB-RZPA-ZP/RER+KH+KBF)-RLPCON,

RPCONHD: LOG(RPCONHD)=(C0200+C0202*LOG(CONH/CONO)+C0201*TREND)
+LOG(1+POL4_EQ),

RPCONH: LOG(RPCONH/RPCONH(-1))=

C0601*LOG(RPCONH(-1)/RPCONH(-2))+C0602*(LOG(CONO(-1)/CONH(-1))

-LOG(CONO(-2)/CONH(-2)))+C0603*(LOG(RPCONH(-1)/RPCONHD(-1))),

CONO: CONO=CON-CONH,

CON: LOG(CON) = C0401*LOG(COND)+(1-C0401)*LOG(CON(-1)*GR)

+C0402*(YCURVE(-2))+C0403*(RPM(-1)-ERPM(-1))+

C0404*(RPM(-2)-ERPM(-2))+Z_CON,

CONH: CONH=KSRATIO*KH,

RINCOME: RINCOME=(1-POL1)*RWA*(NT)+RTRPUPR

+RTROSPR+RMTRANSFER,

RWEALTH: RWEALTH= (RB-RZPA-ZP/RER+KH+KBF),

RLPCON: RLPCON=LOG((CONO*(1+POL4_EQ)+CONH*RPCONH)/CON),

HOUSING SECTOR

IH: IH/KH=C0501*(IH(-1)/KH(-1))+(1-C0501)*(GR(-4)+DRRB_EQ-1)

+C0502*(KSRATIO*(RPCONH(-2)-POL7_EQ(-2)) –

(DRRB_EQ+IR_EQ+RP(-2)))

+C0503*YCURVE(-2)+C0504*YCURVE(-3)+Z_IH,

TBQH: TBQH=(KSRATIO*(RPCONH(-2)-POL7_EQ(-2)) –

(DRRB_EQ+IR_EQ+RP)),

KH: KH= KH1(-1),

KH1: KH1=(1-DRRB_EQ)*KH+IH,

INVESTMENT EQUAITON

IBF: IBF/KBF=C1301*(IBF(-1)/KBF(-1))+(1-C1301)*(GR(-4)+DR_EQ-1)

+C1302*(AR(-1)-(DR_EQ+IR_EQ+RP1(-1)))
+C1303*YCURVE(-2)+C1304*YCURVE(-3) +Z_IBF,

TBQ: TBQ=(AR(-1)-(DR_EQ+IR_EQ+RP1(-1))),

KBF1: KBF1=(1-DR_EQ)*KBF+IBF,

KBF: KBF=KBF1(-1)+Z_IBF*KBF1(-1),

AR: AR=0.25*(RPKLR)+0.25*(RPKLR(-1))+0.25*(RPKLR(-2))+0.25*(RPKLR(-3)),

RPTLR: RPTLR=((RPTEX/(A5))**(THETA/(THETA-1))
+(RPYDMR/A6A)**(THETA/(THETA-1)))**((THETA-1)/THETA),

RPYLR: RPYLR=A4A*(RPTLR**(DELTA/(DELTA-1))
-(RPM/(A3))**(DELTA/(DELTA-1)))**((DELTA-1)/DELTA),

RPKLR: RPKLR=A2A*(RPYLR**(RHO/(RHO-1))-

(RWA/A1)**(RHO/(RHO-1)))**((RHO-1)/RHO),

STOCK

IINR: LOG(IINR)=LOG(YD*SSRATIO_EQ)+C0701*LOG(KINR(-1)/EKINR(-1)),

KINR1: KINR1=IINR+KINR,

KINR: KINR=KINR1(-1),

KIE: KIE =KIE1(-1),

KIE1: KIE1=KIE+IIE,

IIE: IIE =CEXPS-CEXP,

DEM: DEM=CONO+(IH+IBF+GGCO+GGIF),

YD: YD=(IINR+DEM),

EXPORT SECTOR

TEXPS: LOG(TEXPS) =C1101*LOG(GR(-4)*EXP(-1*π_2/4)*EXRSR(-1))
+(1-C1101)*LOG(GR(-4)*EXP(-1*π_2/4)*TEXPS(-1)),

CEXPS: CEXPS/TEXPS=(1-NCTEXPSR_EQ),

CEXP: LOG(CEXP)=LOG((1-CESRATIO_EQ)*CEXPS)+C1401* LOG(KIE(-1)/EKIE(-1))

Z_CEXP,

NCEXP: LOG(NCEXP)=C1501*LOG(TEXPS*NCTEXPSR_EQ)

+(1-C1501)*LOG(GR*EXP(-1*π_2/4)*NCEXP(-1))+Z_NCEXP,

TEXP: TEXP=CEXP+NCEXP,

IMPORT SECTOR

IM: LOG(IM)= C0901*LOG(GR(-4)*EXP(-1*π_1/4)*IMSR(-1))
+(1-C0901)*LOG(GR(-4)*EXP(-1*π_1/4)*IM(-1))+Z_IM,

EXTERNAL SECTOR

CURB: CURB=-1*((RDOS-RZ_OSPR_EQ-RZ_OSPU_EQ)/RGDP)*100,

TBAL: TBAL=TEXP*RPTEX-IM*RPM/(1+POL5_EQ),

IBAL: IBAL=RYOSPR+RYOSPU,

TFBAL: TFBAL=RTROSPR-RTRPUOS,

RDOS: RDOS=-1*(TBAL)-1*(RTROSPR-RTRPUOS+RYOSPR+RYOSPU),

RTROSPR: RTROSPR= POL14_EQ*RGDP,

RPUDOS1 = (ZG/RER-ZG(-1)/RER(-1))+RZGA-RZGA(-1),

ZP: ZP/RER =(ZP(-1)/RER(-1)+FPDRATIO_EQ*(RDOS(-1)-RPUDOS1)),

RZPA: RZPA = RZPA(-1) + (1-FPDRATIO_EQ)*(RDOS(-1)-RPUDOS1),

RFDEBT: RFDEBT=RFDEBT(-1)+RDOS(-1)-RMTRANSFER(-1),

RYOSPU: RYOSPU=-((RLFB(-1)/400)*(ZG/RER)+(RL(-1)/400)*RZGA),

RYOSPR: RYOSPR=-(RLFB(-1)/400*(ZP/RER)+ RL(-1)/400*(RZPA)),

DGDPR: DGDPR=RFDEBT/ERGDP,

GOVERNMENT SECTOR

RTRPUOS: RTRPUOS=POL12_EQ*ERGDP,

RTRPUPR: RTRPUPR=(1-POL1)*RWA*TRBASE,

TRBASE: TRBASE=POL8_EQ*POP4+POL9_EQ*UNB

+POL11_EQ*(POP1+POP2+POP3+POP4),

UNB: UNB=(1+DIFD)*NTS-(NT),

RGSPEND: RGSPEND=RWA*NGG+RPYD*(GGCO+GGIF)

+RTRPUPR+RTRPUOS+RYPUPR-RYOSPU,

RPUBS: RPUBS=-(RGSPEND-RPYD*GGIF)+(POL1*RWA*(NT)

+POL4_EQ*CONO*RPYD +POL5_EQ*PIMF/RER*IM

+POL6_EQ*RWA*(NT-NGG)+POL7_EQ*CONH*RPYD+POL3_EQ*ERGDP),

PUBDER: PUBDER-PUBDER(-1)=RPYD*GGIF(-1)-RPUBS(-1),

RZGA: RZGA=DGDRATIO_EQ*PUBDER,

ZG: ZG=FGDRATIO_EQ*RER*PUBDER,

RB: RB=PUBDER-(RZGA+ZG/RER),

RYPUPR: RYPUPR =(RL(-1)/400)*RB+RATB_EQ*ERGDP,

FORWARD LOOKING FISCAL RULE

POL1:POL1=POL1(-1)+C8001*(PUBDER(8)/ERGDP(8)-PUBDE_EQ(8))

+C8002*((PUBDER(9)/ERGDP(9)-RPUBDE_EQ(9))-(PUBDER(8)/ERGDP(8)-RPUBDE_EQ(8)))

+C8003*(RPUBDE_EQ-RPUBDE_EQ(-1)),

MONETARY SECTOR

PNA10: PNA10=TEXP+IIE+YD-IM,

LGAP: LGAP=LOG(PNA10/PO_EQ),

INF_TAR = 0.8*INF_TAR(-1)+0.2*INF_TAR_eq,

INF_PYD:(INF_PYD-INF_TAR)=C1201*(C1202*(INFE(-1)-INF_TAR)

+(1-C1202)*(INF_PYD(-1)-INF_TAR))+

(1-C1201)*(C1203*LGAP(-1)+C1204*LGAP(-2)+

C1205*LGAP(-3)+C1206*LOG(RPYDMR(-1))),

INF_WA: (1+INF_WA)=EXP(INFE(-1))*(C0301*A1(-3)/A1(-4)+C0302*A1(-4)/A1(-5)

+C0303*A1(-5)/A1(-6)+C0304*A1(-6)/A1(-7))+C0305*(URT(-2)-NAIRU)+

C0306*LOG(ERWA(-2)/RWA(-2))+C0307*LOG(RPYDMR(-1))+Z_W

RCS: RCS=(C6001*(INF_CPIX(5)-CPI_TAR)+C6002*(INF_CPIX(6)-

CPI_TAR)+C6003*(INF_CPIX(7)-CPI_TAR)+C6004*(RCS-RCS(-1))+RL)+Z_RCS,

RWA: RWA=RWA(-1)*(1+INF_WA)/EXP(INF_PYD),

INF: INF= ((1-(SHARE/(1+SHARE)))*(INF_PYD)

+(SHARE/(1+SHARE))*(INF_PCONH))
+Z_INF,

INFE: (1+INFE)=0.05*(1+INF)+0.95*(1+INFE(1)),

CPIX: CPIX=CPIX(-1)*EXP(INF),

INF_CPIX: INF_CPIX=LOG(CPIX/CPIX(-4)),

INF_PCONH: EXP(INF_PCONH)=RPCONH/RPCONH(-1)*EXP(INF_PYD),

PYD: PYD=PYD(-1)*EXP(INF_PYD),

INTEREST RATES AND EXCHANGE RATES

E: RE=E*PYD,

ETWIT: ETWIT=E*EXP(C4800+C4801*TREND),

RI: RI = ((1+RL/400)/EXP(INFE)-1),

RIF: RIF=((1+RLFB/400)/EXP(INFW)-1),

RS: RS=(1+RCS/400)/EXP(INF)-1,

RSF: RSF=(1+(RCSFB+RPRCS)/400)/EXP(INFW)-1,

RL: RL= ((1-.95)*RCS+.95*RL(1)),

YCURVE: YCURVE= RCS-RL,

SNA VARIABLES

NA14: NA14=TEXPS+YD-IM+C5000*NGG+CONH

+(NA15-CONH)+Z_NA8+C5001*CONO,

NA15: NA15 =(C3600+C3601*TREND+Z_NA15)*CONH,

NA1: NA1=NA15+(C2600+C2601*TREND+Z_NA1)*CONO,

NA2: NA2=(C2700+C2701*TREND+Z_NA2)*(GGCO+C5000*NGG),

NA3: NA3=(C2800+C2801*TREND+Z_NA3)*IH,

NA4: NA4=(C2900+C2901*TREND+Z_NA4)*IBF,

NA7: NA7=(C3200+C3201*TREND+Z_NA7)*GGIF,

NA10: NA10=(NA14-Z_NA8),

NA9: NA9=IIE,

NA8: NA8=IINR+Z_NA8,

NA12: NA12=TEXP,

PTEX: PTEX=RPTEX*PYD,

PM: PM=RPM*PYD,

WA: WA=RWA*PYD,

GDPZ: GDPZ=GNEZ+PTEX*TEXP-(PM/(1+POL5_EQ)*IM),

GNEZ: GNEZ=PYD*(YD)+PTEX*IIE+PCONH*CONH+WA*NGG

+POL4_EQ*PYD*CONO,

NA16: NA16=GDPZ*(1+0)+PCONH*(NA15-CONH)+PYD*(NA8-IINR),

NA13: NA13=IM;

Table 1: The results of the steady-state model simulation

	Private sector production	Private consumptio n	Business Investment	Residential Investment	Exports	Imports	Current account (pp)	Income tax rate (df)	Real exchange rate	
									rptex	rpm
A permanent 1 per increase in world export price	0.09-0.05	0.77	0.33	0.95	0.33	1.27	0.01	-0.001	-0.66	-1.66
A permanent 1 per cent increase in the level of productivity	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.000	0.00	0.00
Lowering the real household financial asset to GDP ratio	0.00	-0.33	0.03	1.04	0.04	-0.59	-0.21	0.001	1.10	1.10
Reducing the public liability to GDP ratio	0.00	0.23	-0.01	0.32	-0.02	0.27	0.09	-0.002	-0.50	-0.50
An increase in government consumption and investment by 10 per cent	0.00	-2.81	0.00	-4.10	0.00	0.02	-0.01	0.019	-0.05	-0.05

Percentage differences from base unless specified as percentage points (pp) from base or as differences (df) from the base

Figure 1: A flow diagram of the production block in the steady state

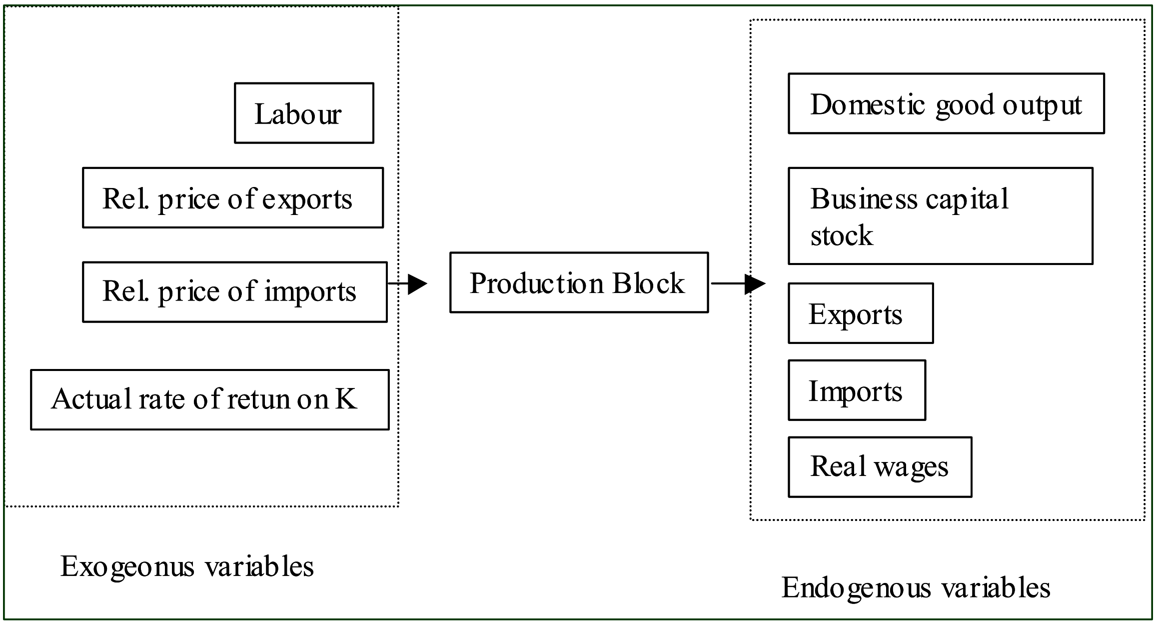

Figure 2: The logarithm of real household income and consumption expenditure

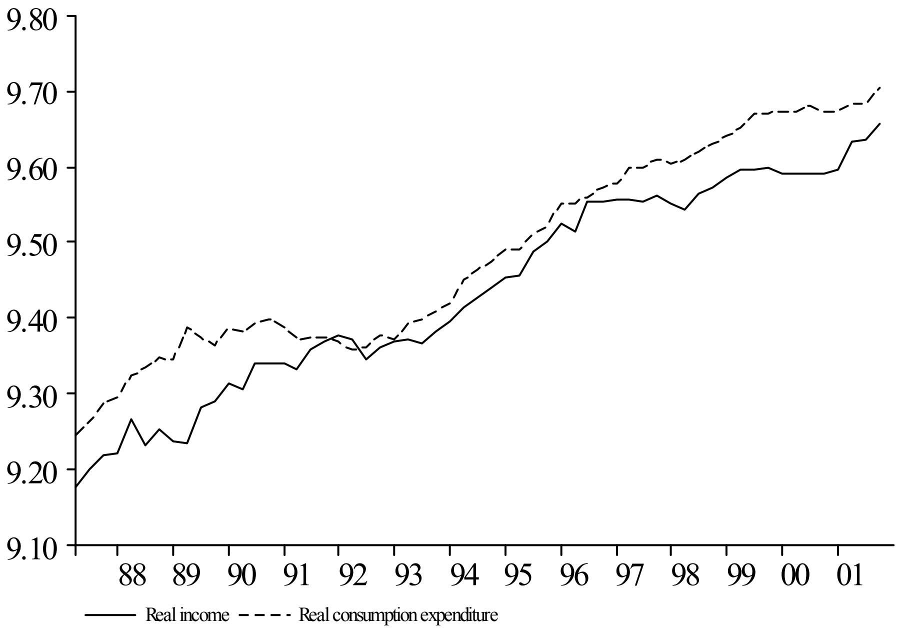

Figure 3: The logarithm of real household wealth and consumption

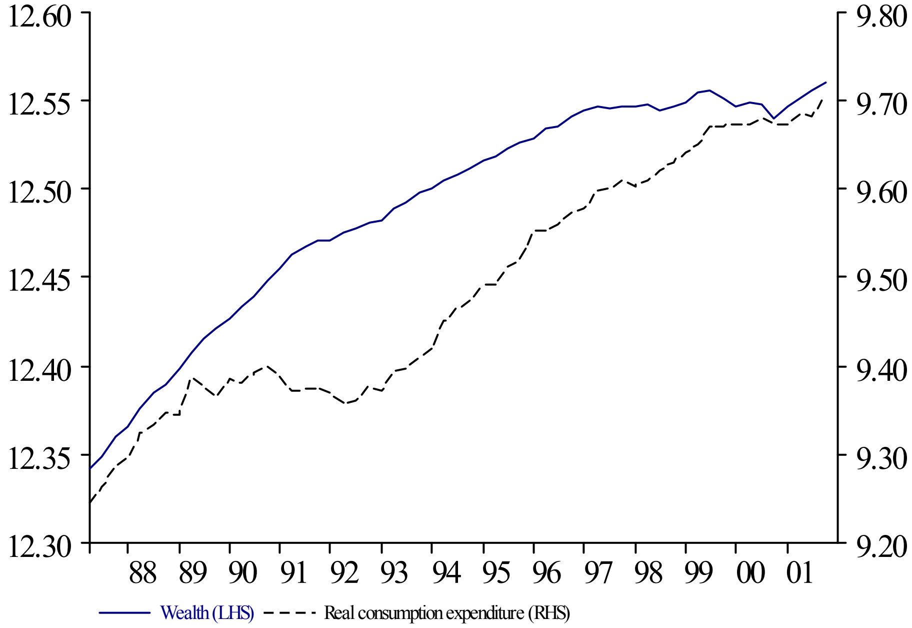

Figure 4: The ratio of CONH/CONO and its relative price

Figure 5: Unemployment rate

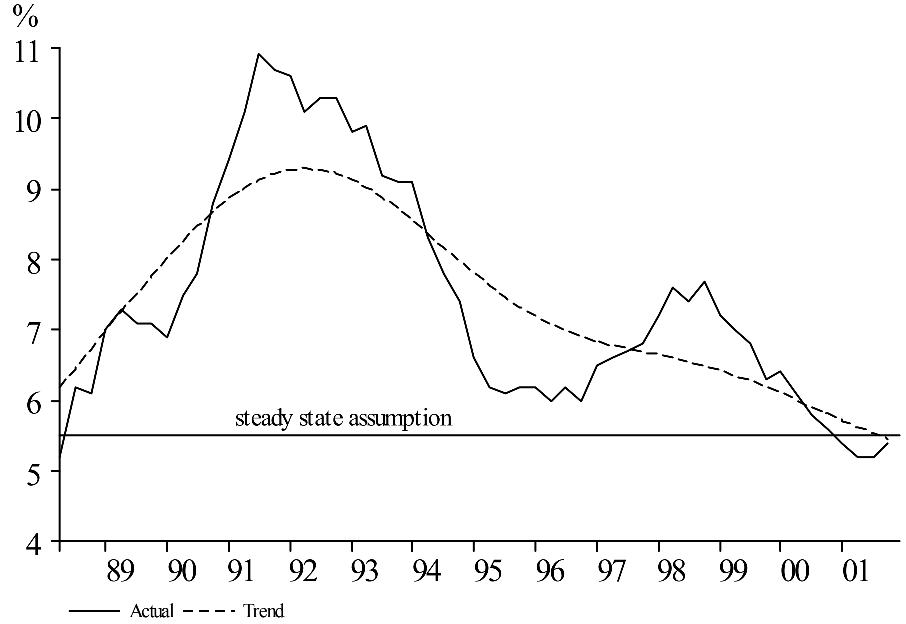

Figure 6: Participation rate

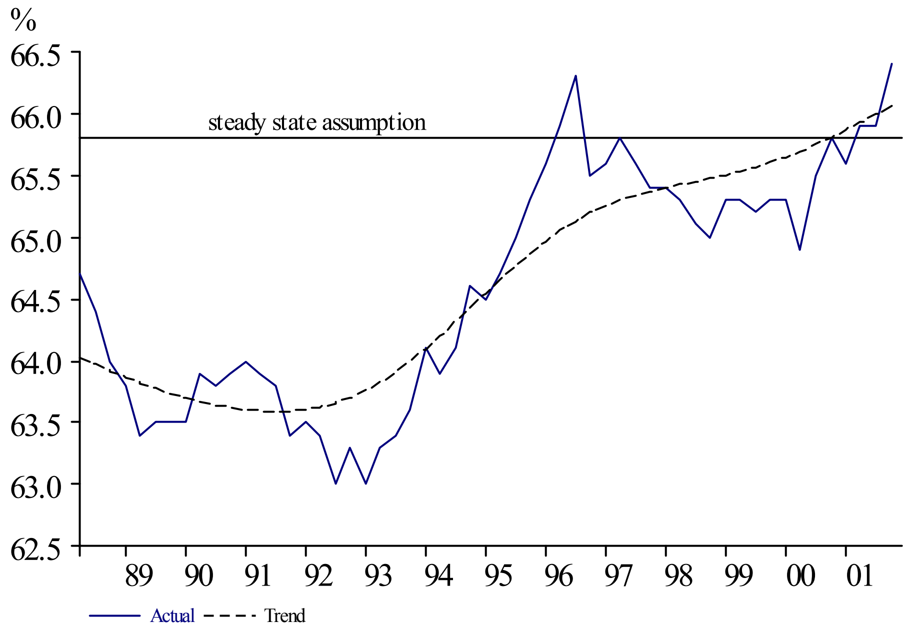

Figure 7: Net real household financial assets to GDP ratio

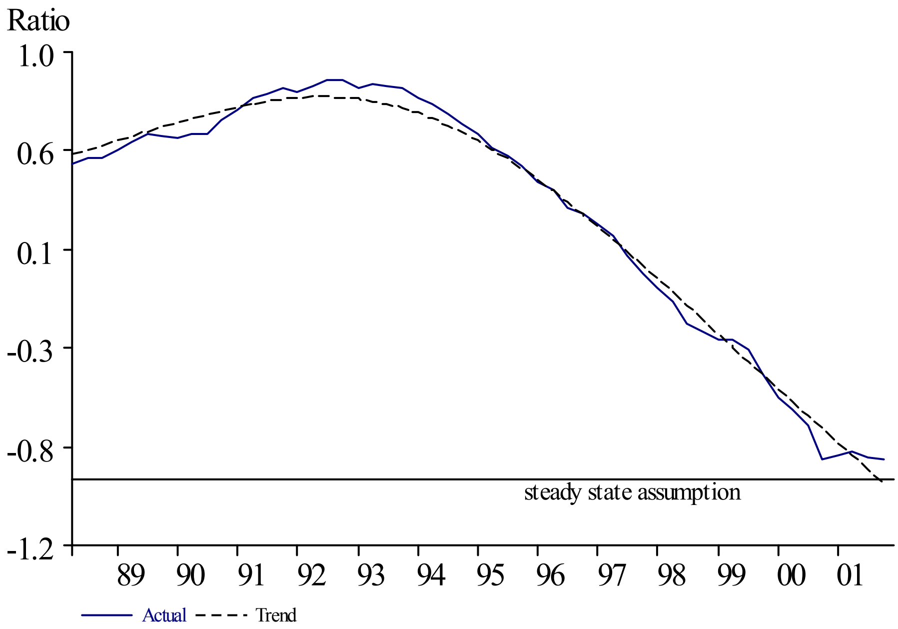

Figure 8: Net real foreign debt to GDP ratio

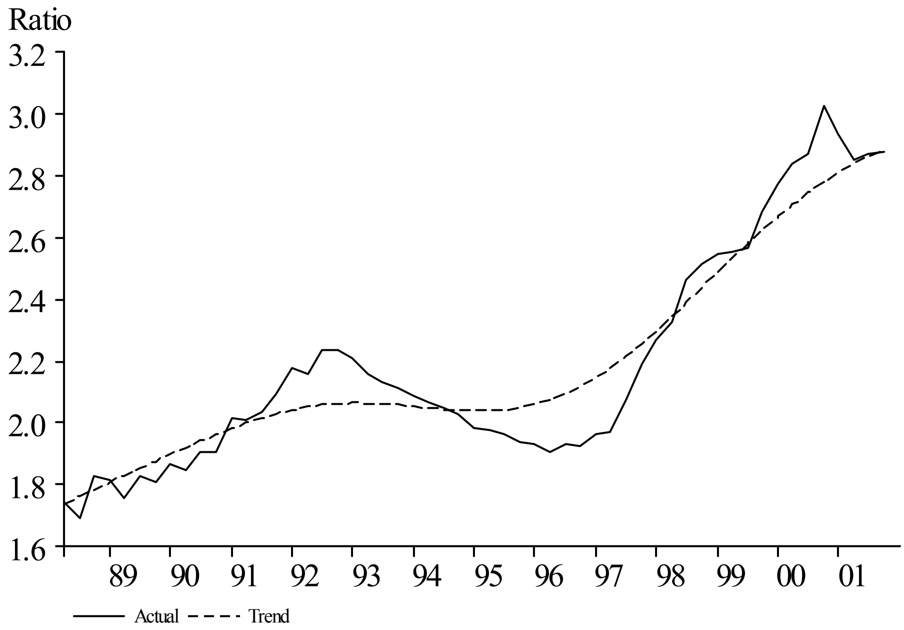

Figure 9: Net real public debt to real GDP ratio

Figure 10: Foreign import prices

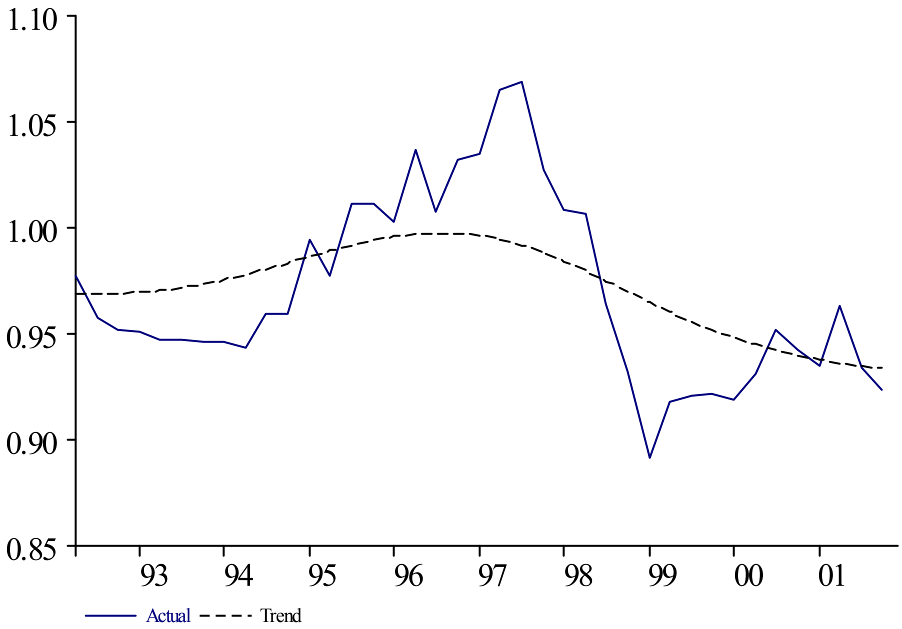

Figure 11: Foreign export prices

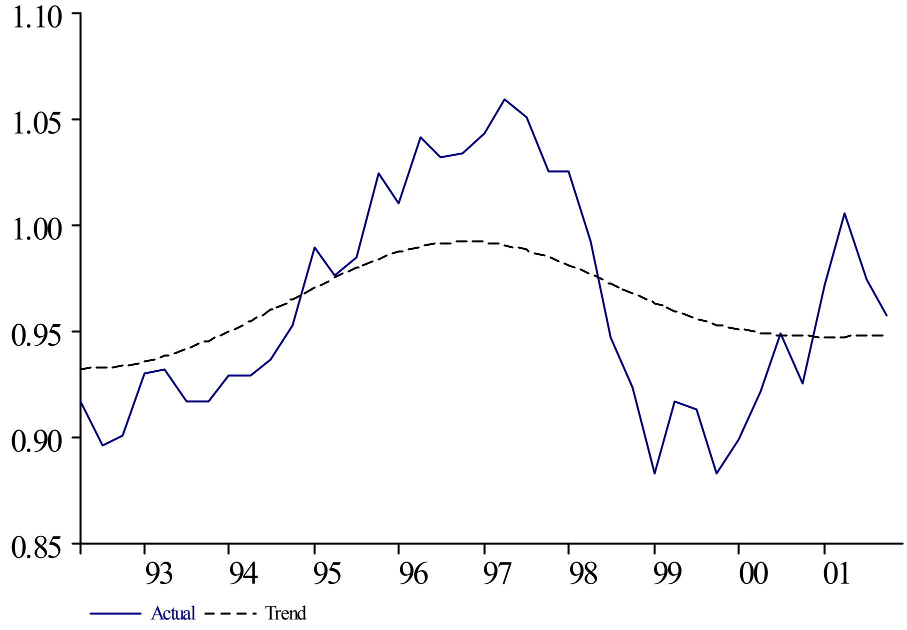

Figure 12: Measures of the output gap - total production and private business sector

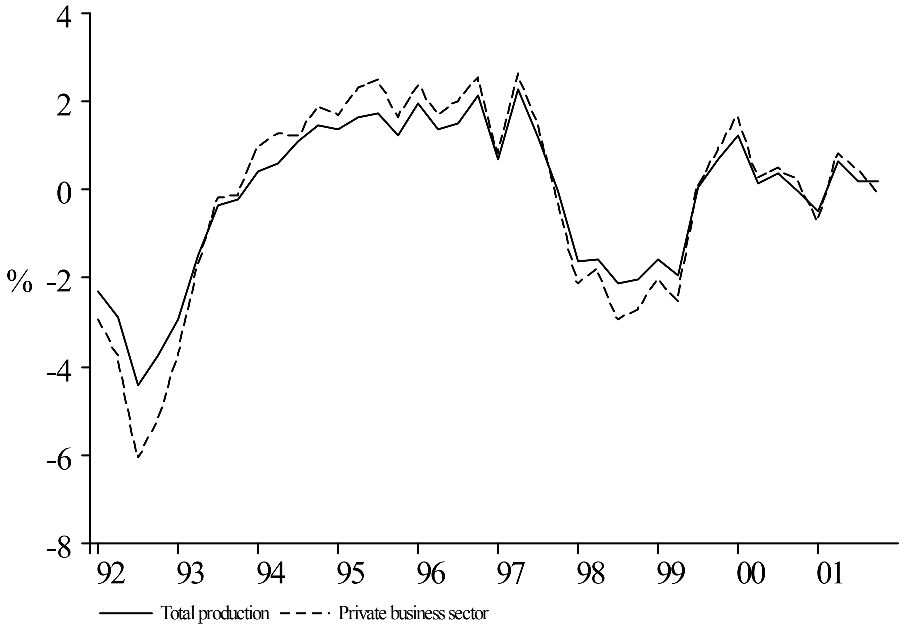

Figure 13: A comparison of two different measures of the output gap

Figure14: New Zealand's equilibrium real exchange rate: the inverse of RPM

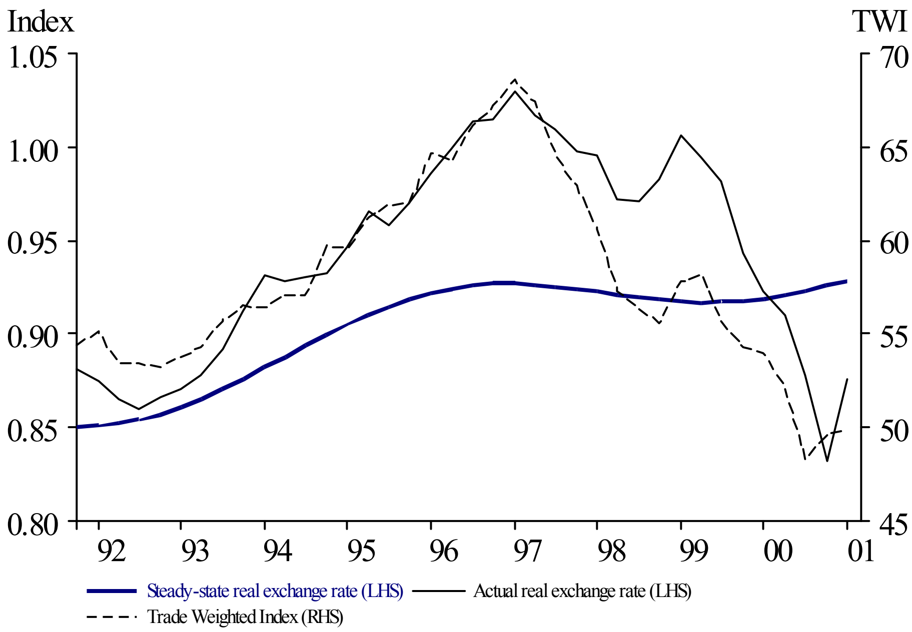

Figure 15: New Zealand real exchange rate misalignments

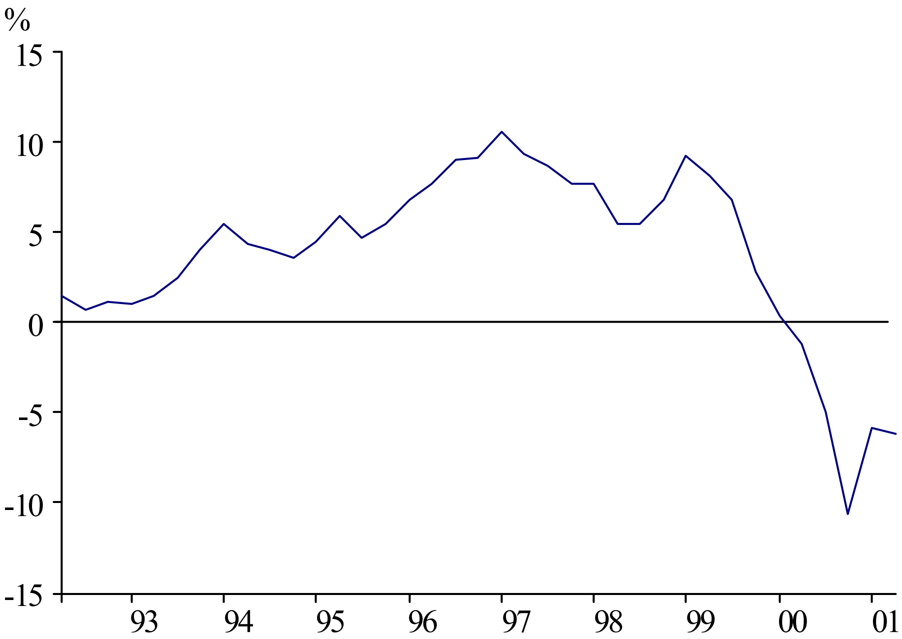

Figure 16: A temporary decrease in world export prices

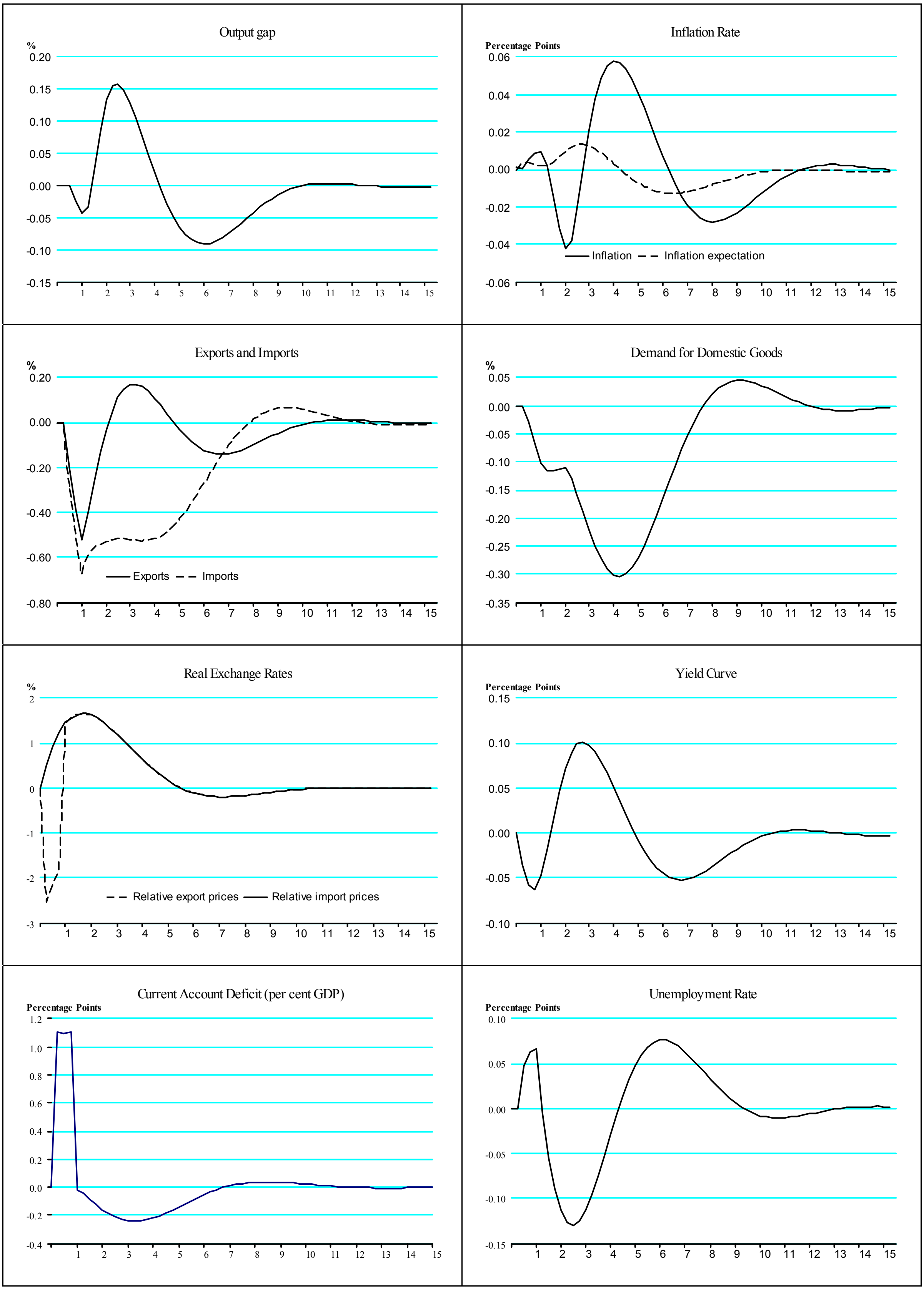

Figure 17: A temporary increase in world import prices

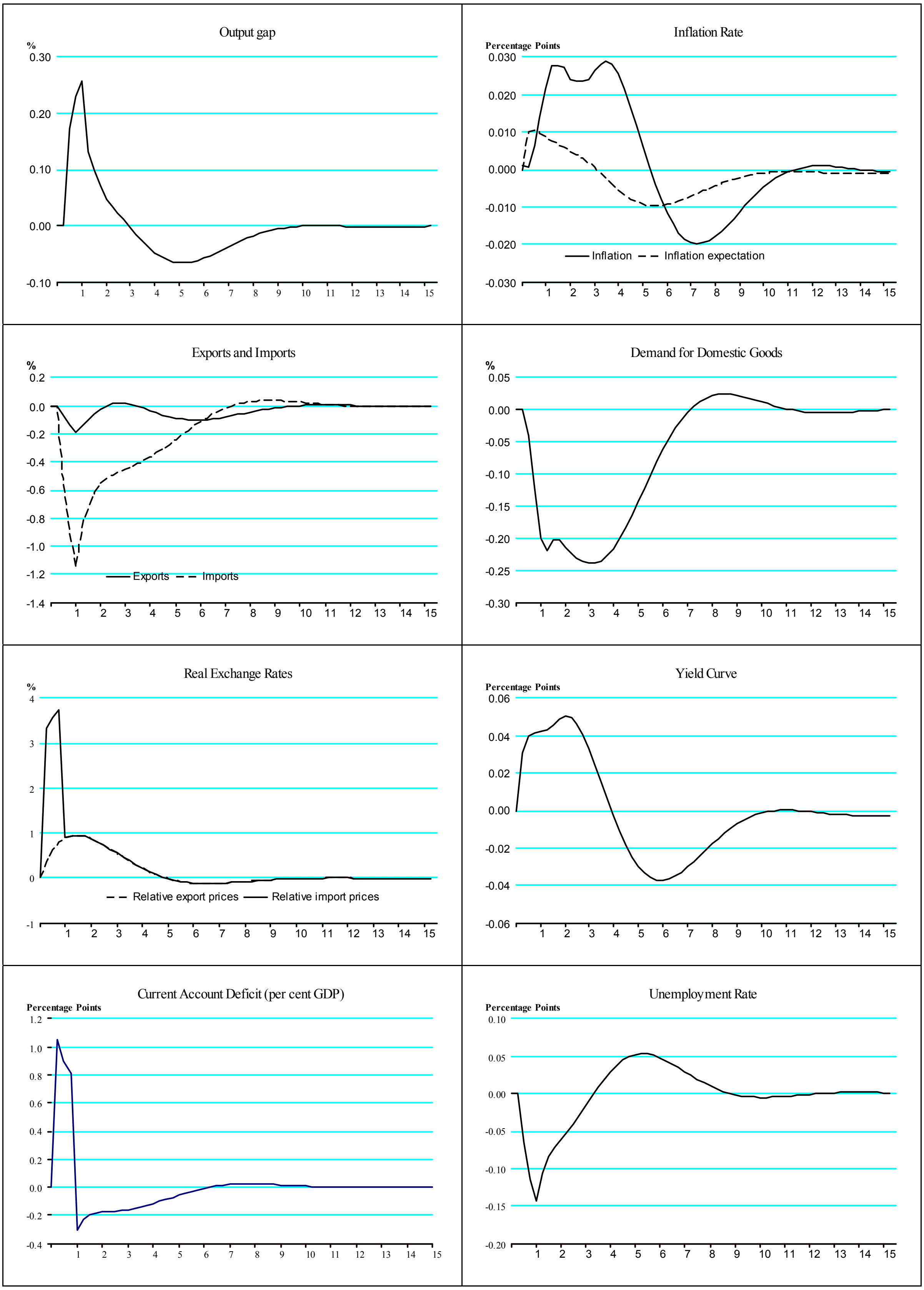

Figure 18: A permanent increase in world export prices

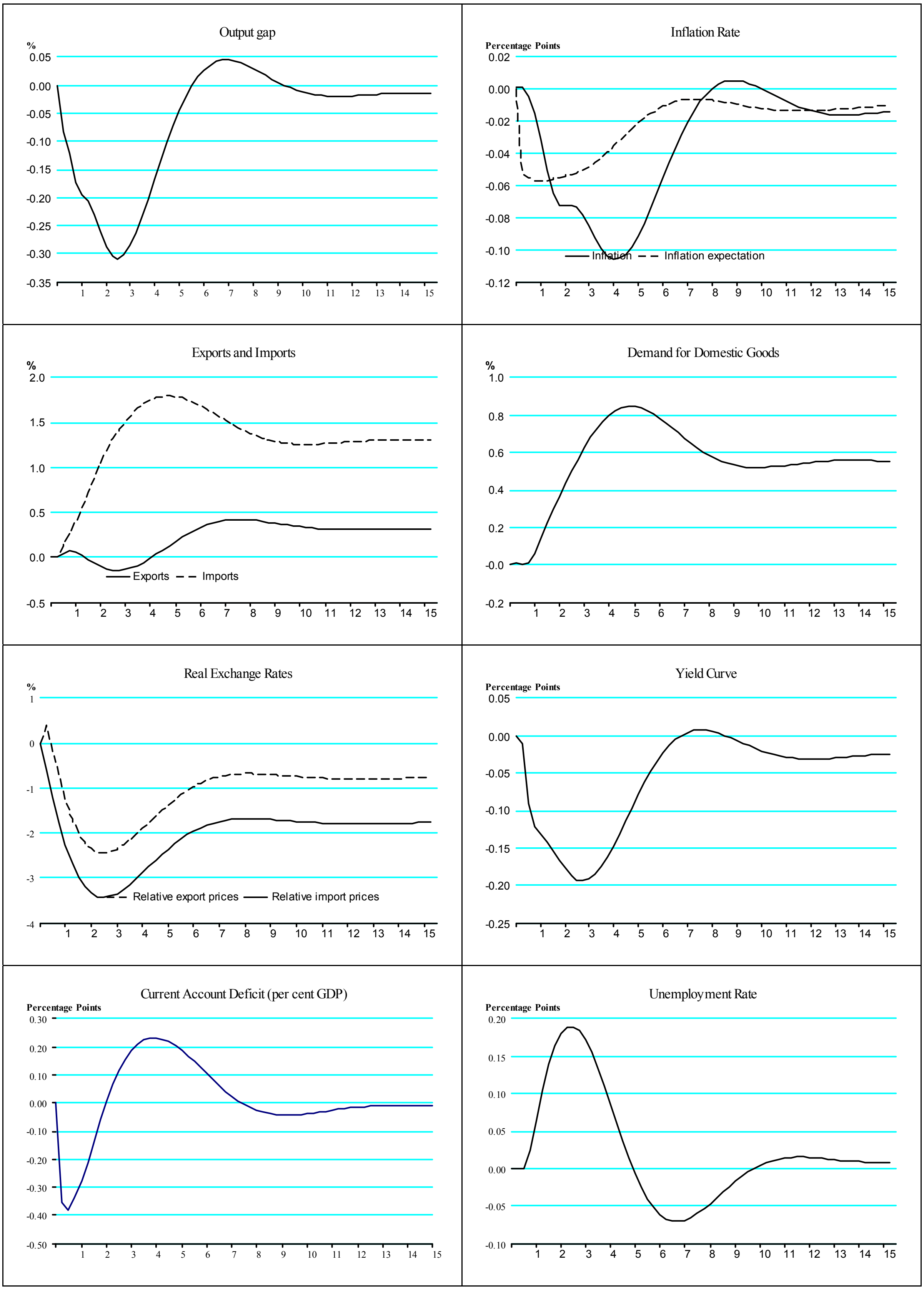

Figure 19: An increase in nominal wage demands

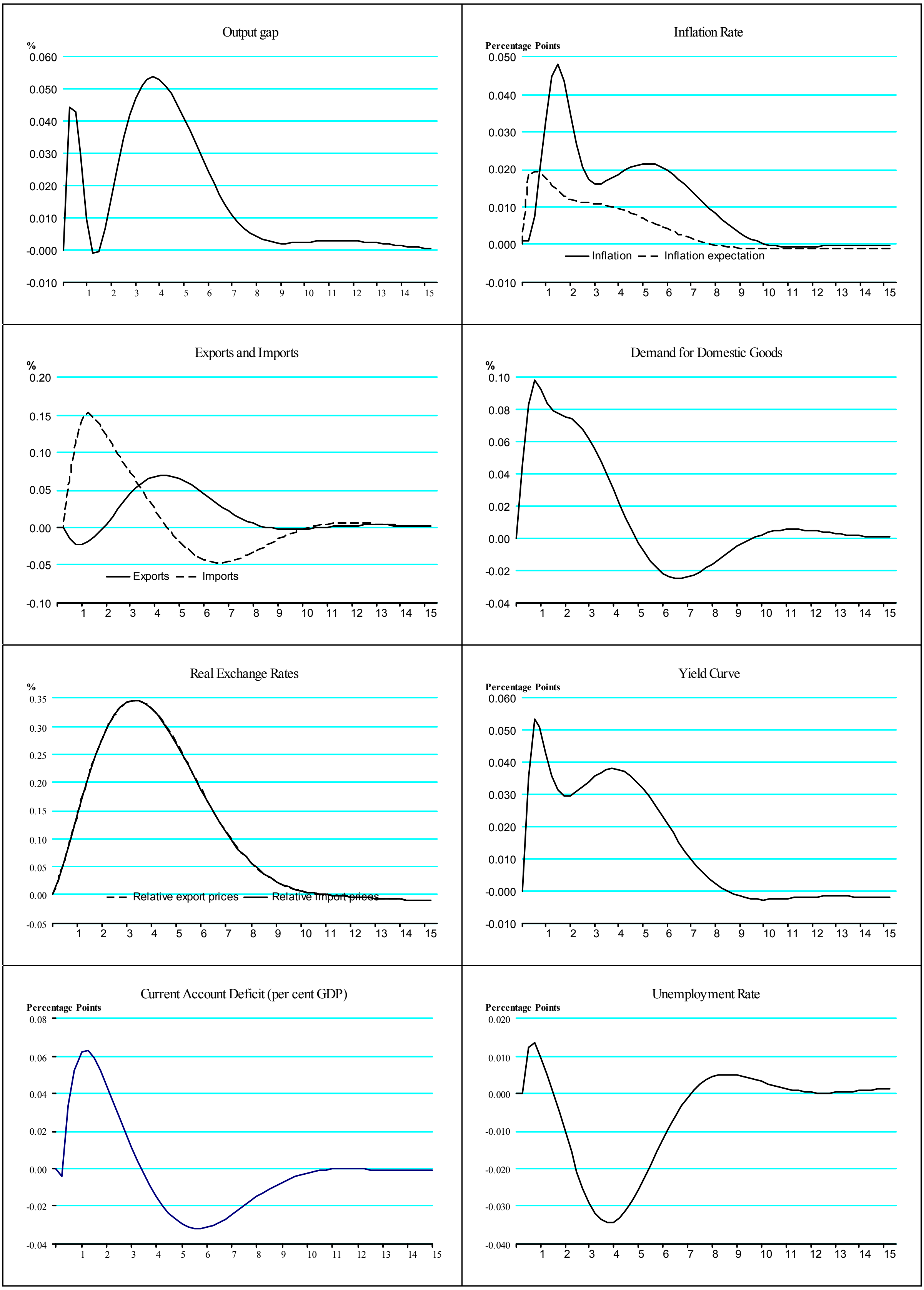

Figure 20: A temporary demand shock

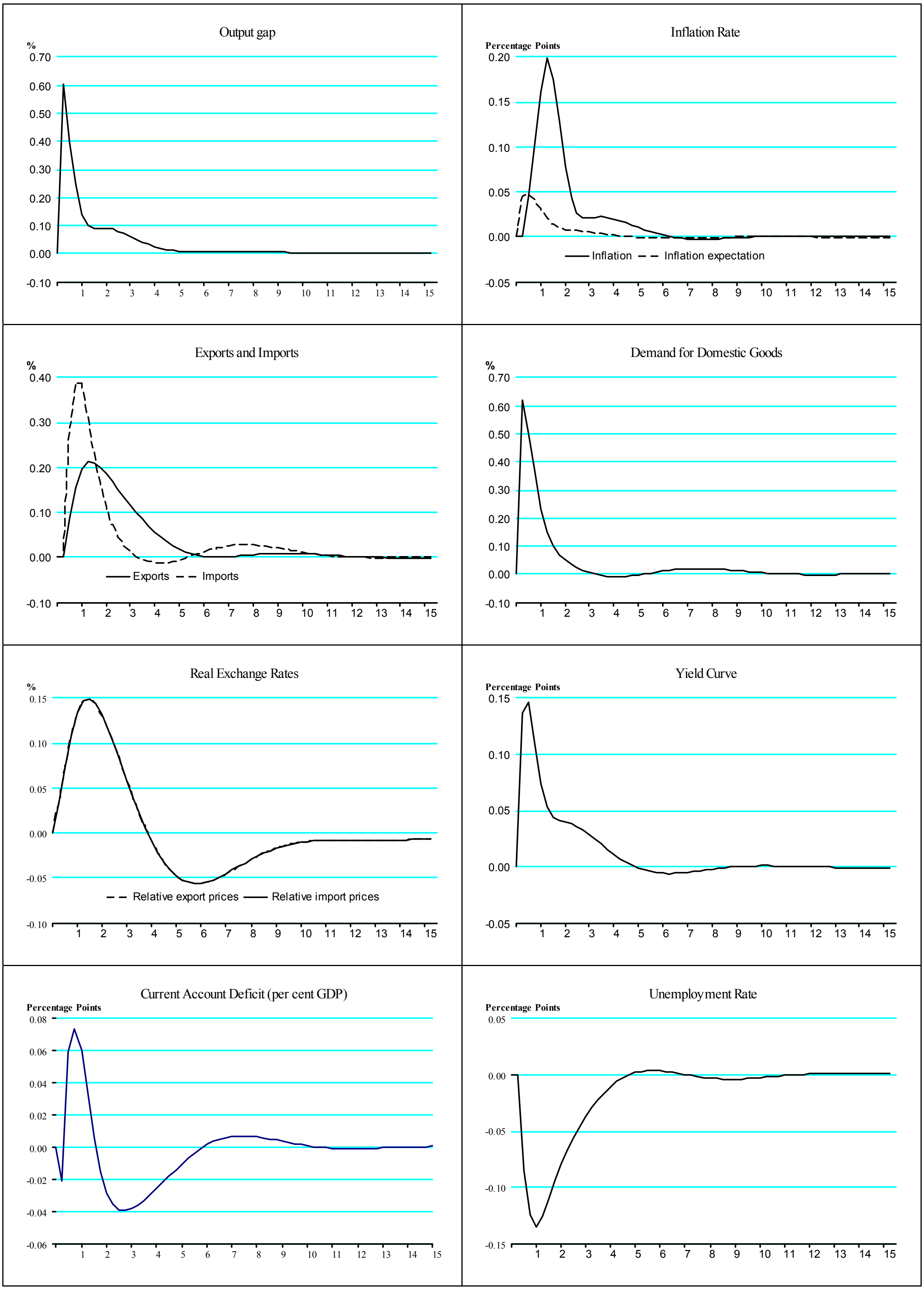

Figure 21: A permanent increase in the level of productivity

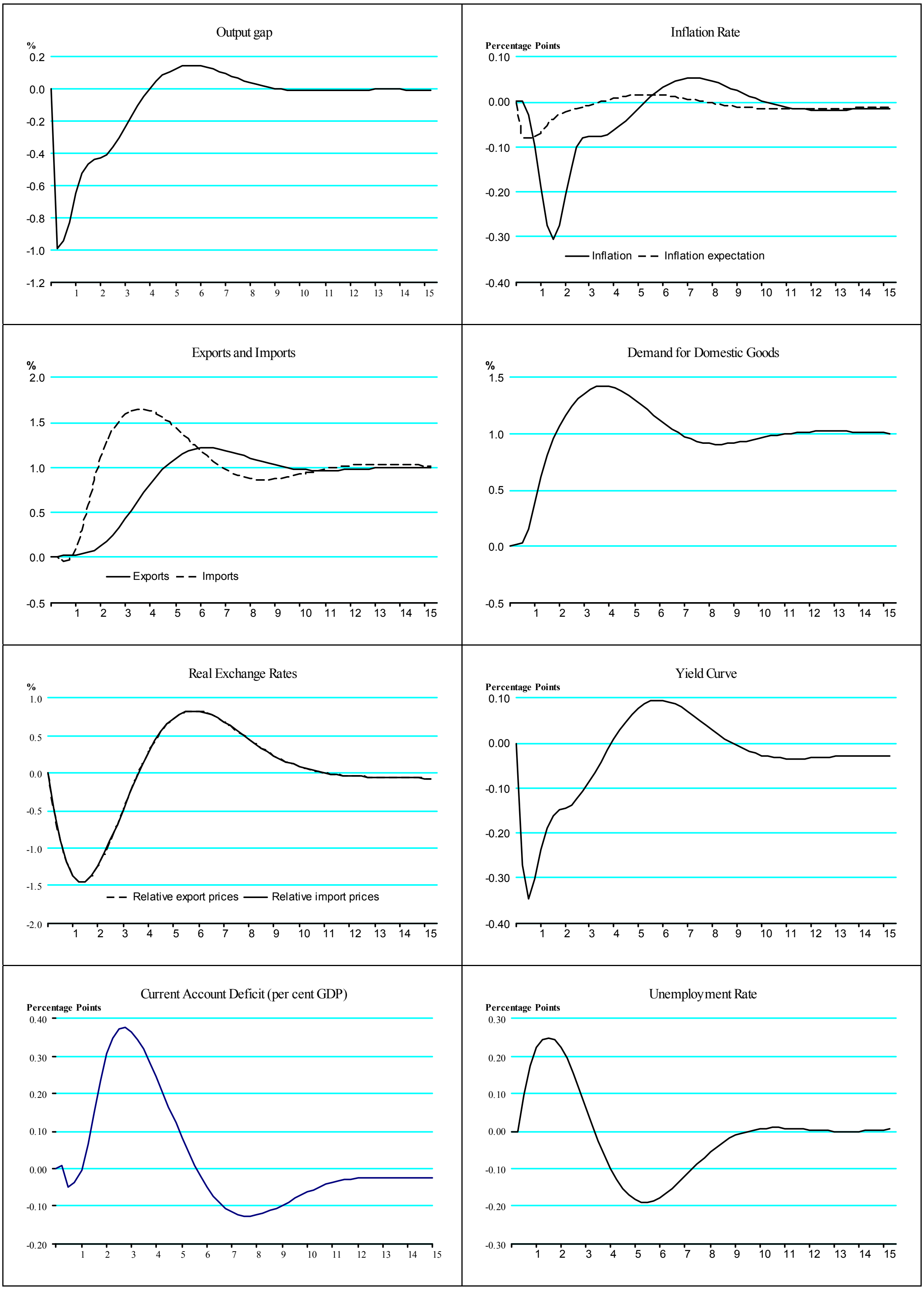

Figure 22: Reducing the public liability to GDP ratio