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Abstract

In this paper we use a small open economy model to identify the causal factors that drive New Zealand's current account. The model features nonseparable preferences, habit in consumption, imperfect capital mobility, permanent productivity shocks, fiscal shocks and two foreign shocks to explore features that are important in understanding the dynamics of the current account. The results suggest that permanent technology shocks and world cost of capital shocks account for the bulk of variation in the current account at short horizons; at longer horizons, external valuation shocks (reflecting terms of trade and exchange rate developments) account for most of the variance. Habit in consumption and a debt-sensitive risk premium are features that improve overall model fit as measured by posterior odds ratios. These features, and the contribution of foreign and permanent technology shocks, help to explain why the one shock present value model of the current account fails to appropriately characterise the dynamics of the New Zealand current account, as discussed in Munro and Sethi (2006).

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1 Introduction

Between 2001 and 2006, New Zealand's annual current account deficit (CAD) deteriorated from 2.8 percent of GDP to 9.7 percent. At this level, the CAD is among the highest in the OECD, and one that many economic commentators and policymakers consider to be unsustainable.[1] If such deficits persist in the medium-term, New Zealand's net external liability position, which is already among the OECD's largest at 85 percent of GDP, will grow.[2]

Over the same period, the domestic economy has been characterised by: strong growth, with an unemployment rate that is low both by historical and international standards; inflationary pressures stemming from private domestic demand and capacity constraints; increasing rates of public and private investment; and increases in asset prices (especially house prices), fueled by immigration and historically high household debt levels. This period has also seen already weak household savings rates decline further.[3]

These domestic drivers of growth have found support in an international environment that has featured high prices for commodity exports, a low cost of capital, and an appetite for risk (reflected in low spreads on sub-investment grade and emerging market bonds). Each of these factors has contributed to sustained strength in the exchange rate.[4]

The defining features of New Zealand's current account are the dominant position of the investment income deficit, the relatively quick mean-reversion of the deficit in a time-series sense – consistent with its perceived shock-absorbing role – and

[1] See Kim, Buckle, and Hall (2006) and Edwards (2006) for an academic perspective; Bollard (2005), IMF (2006a) and IMF (2006b) for policy implications; and news reports by Wolf (2004) and Simensen and Tucker (2006).

[2] Factors that may mitigate a further increase in the net external deficit are the strong public sector position (the overwhelming majority of international liabilities are private sector obligations) and the domestic currency composition of the debt, which is held either outright or through hedging contracts. Collectively, these mitigating factors imply small exchange rate valuation effects. The short term maturity profile of about half of the gross debt suggests that liquidity risks may pose more immediate threats to New Zealand's financial system. These concerns are alleviated to some degree by a profitable, well-capitalized banking system and the availability of credit lines.

[3] See Buckle and Drew (2006) for a summary assessment of the performance of the New Zealand economy and for an evaluation of fiscal, monetary and other policies over this period.

[4] In foreign currency terms, the ANZ index of New Zealand commodity prices increased by over 40 percent from 2000 to 2006.

the negative correlation between current account deficits and the real exchange rate.[5]

Many arguments are advanced as to whether or not the large deficit provides cause for concern. The main concern is rollover risk relating to financing the stock of short term debt plus the current account deficit. Should market appetite for New Zealand dollar debt fall, financial conditions could become very tight, leading to sharply higher lending rates which would be painful for a leveraged household sector. The tightening in financial conditions may be accompanied by a fall in house prices or a recession that affects employment. If the private sector is unable to cope with the increase in debt servicing costs, significant pressures could build on financial institutions, and ultimately on the stability of the financial system. These effects may be prolonged if there is an accompanying sharp rise in debt service costs and loan defaults.[6]

From a more sanguine perspective, a fall in appetite for New Zealand dollar debt would mainly be accommodated in repricing: a rise in interest rates and a fall in the New Zealand dollar. The latter is benign due to small positive valuation effects on net foreign assets and relatively low pass-through from exchange rates to import prices.[7] Credit lines for bank funding would also moderate the impact. Moreover, a large current account deficit is a rational response to a low cost of capital resulting from high private savings in other countries.

In a companion paper (see Munro and Sethi 2006) we revisit the present value model (PVM) of the current account. The PVM is a simple one-shock representative-agent model that describes the dynamics of inter-temporal consumption smoothing. We find that the cross-equation restrictions that are implied by the PVM are rejected when tested on New Zealand data. The failure could mean that the PVM is too simple to explain current account dynamics, or that the statistical tests are inadequate.

In this paper we use a richer structural framework to explore New Zealand's cur-

[5] The investment income deficit comprises, in the most part, payments on the outstanding stock of net liabilities which have averaged about 6 percent of GDP since 1990. It is only in very recent years that the balance on trade, too, has contributed to the deficit.Edwards (2006) defines a 'persistently high' CAD as one that persists for more than five years at a level that is in the 90^{th} percentile of the deficits of peer-group countries. By this definition, Edwards finds that New Zealand and Ireland are the only two countries to exhibit persistently high deficits. Finally, Edwards also notes that a strong New Zealand dollar tends to coincide with larger current account deficits.

[6] See IMF (2006a).

[7] For more detail see Buckle and Drew (2006).

rent account dynamics. Following Nason and Rogers (2006), we employ a small open economy model that features habit formation in consumption, preferences that are non-separable in consumption and leisure, imperfect capital mobility, capital accumulation with investment adjustment costs, a high rate of time preference, a permanent shock to technology, and three transitory shocks – to government spending, the world real interest rate and the terms of trade.

Two recent studies, Liu (2005) and Santacreu (2006), estimate habit formation to be important for New Zealand, implying a high degree of additional smoothing in consumption. With habit formation in consumption, utility is derived both from the level of consumption and from the increase over last period's consumption level, or the increase over the steady state consumption level. Such additional smoothing in consumption implies more volatility in the current account. For example, in the absence of habit formation, permanent shocks lead to an immediate adjustment in consumption to the new optimal path, with no effect on the current account. When habits are a feature of consumption choices, a substantial component of *permanent* shocks may be initially absorbed in the current account if agents wish to adjust consumption gradually to a new optimal level.

Nonseparable preferences dampen the response of consumption and labour input to inter-temporal incentives, and may add an additional degree of smoothing to these variables, thereby also increasing volatility in the current account.

Given New Zealand's large stock of net external liabilities, a rate of time preference above that implied by the world real interest rate (what Nason and Rogers 2006 call the 'impatient' small open economy) may also help explain the strong domestic demand for borrowing.

For a small open economy, external shocks (terms of trade, exchange rate, world cost of capital) introduce additional volatility in the current account. As mentioned earlier, there have been large movements in the terms of trade and the exchange rate, and an unusually low world cost of capital in recent years. New Zealand's large stock of liabilities likely affects the response of the economy to shocks, particularly shocks to the cost of capital which affect debt service costs. We would like to know if the current account has played a role in absorbing foreign shocks.

The model is estimated using Bayesian methods on New Zealand data from 1990 to 2005. We use estimated models to calculate posterior odds ratios to assess the importance of the various structural elements of the model in explaining both overall model fit and the fit of the model-implied current account to the data.

We find that habit in consumption and an endogenous risk premium (that is a function of the debt to output ratio) are important features in overall model fit. Permanent technology shocks, and shocks to the foreign cost of capital and to the terms of trade are important for matching current account dynamics. A variance decomposition of the current account attributes the bulk of short-term current account variation to shocks to permanent technology and the world cost of capital, and to external valuation shocks in the medium term. Fiscal shocks are estimated to play a small role. Overall, foreign shocks account for more than half the current account variance.

The remainder of the paper is organised as follows. Section 2 presents the model used in this analysis. Section 3 describes the model estimation and the properties of the estimated model. Section 4 considers the relative importance of various shocks and model features in reproducing the observed current account dynamics, and section 5 concludes.

2 The model

In this section, we set out a small open economy model that includes the features discussed in the previous section. The model is based on that of Nason and Rogers (2006) and Kano (2003). Kano extends the former to include habit formation in consumption. The model provides a richer specification of domestic savings-investment decisions than the PVM, but still employs a relatively parsimonious representation of the external sector.

A representative, infinitely-lived household maximises expected future utility from consumption (C) and leisure (L), invests in production, from which the household receives all profits, and buys and issues internationally traded bonds. These choices are made subject to a resource constraint, a production function, and a law of motion for capital.

The utility maximisation problem is given by,

$$\max_{\{C_\tau, L_\tau\}_{\tau=t}^{\infty}} \quad E_t \sum_{j=0}^{\infty} \beta^j \frac{[(C_{t+j} - hC_{t+j-1})^{\phi} L_{t+j}^{1-\phi}]^{1-\gamma} - 1}{1-\gamma}, \tag{1}$$

which is subject to the resource constraint,

$$Y_t = C_t + I_t + G_t + NX_t, \quad \forall t \tag{2}$$

where Y_t is output, I_t is new investment, G_t is net government spending, and NX_t is net exports. The parameter $h \in [0,1]$ governs the degree of habit in consumption with higher values indicating that greater utility is derived from the *change* in the level of consumption. The elasticity of substitution between consumption and leisure is determined by $0 < \phi < 1$.

The constant relative risk aversion (CRRA) utility is non-separable between consumption and leisure, except when $\gamma = 1$, its lower bound, in which case it converges to a log-separable utility function.

Output is produced with constant returns to scale technology,

$$Y_t = K_t^{\theta}[A_t N_t]^{1-\theta}, \qquad 0 < \theta < 1, \tag{3}$$

where A_t is country-specific technological progress. A_t drives permanent movements in Y_t, C_t, I_t, G_t, NX_t, movements in the capital and bond stocks, and plays the role of the domestic disturbance to permanent income. The logarithm of A_t follows a unit root process with drift $\alpha > 0$.

There are adjustment costs to the evolution of the capital stock. Specifically, we assume that these costs rise as the investment to capital ratio increases, implying that it is increasingly expensive to absorb new investment.[8] The law of motion of capital is thus:

$$K_{t+1} = (1-\delta)K_t + \left(\frac{I_t}{K_t}\right)^{\sigma} I_t, \qquad 0 < \sigma,\ \delta < 1. \tag{4}$$

where δ is the rate of depreciation.

The household accumulates internationally traded bonds B_t. The nominal change in the stock of domestic currency bond holdings between periods is equal to the current account balance (the investment income balance rB_t plus the nominal trade balance NX_t/s_t):

$$B_{t+1} - (1+r_t)B_t = NX_t/s_t, \tag{5}$$

where r_t is the real interest rate paid on the bond. We call s_t an 'external valuation' shock. This shock drives a wedge between the resource constraint and debt dynamics. For a given volume of net exports in the resource constraint, this shock

[8] This capital adjustment process is similar to that of Nason and Rogers (2006), but with the opposite sign on sigma. In that case, old capital and investment are combined using Cobb-Douglas technology to form new capital, which means that a unit of investment produces more than one unit of new capital. Here there are adjustment costs so that a unit of investment produces less than one unit of capital.

reduces the value of net exports for debt repayment. A rise in s_t reduces the value of net exports and increases the burden of the debt. As such it will account for some import and export price fluctuations and effects of exchange rate fluctuations on the value of net exports.

The interest rate paid on bonds, r_t, is the world real interest rate q_t plus an endogenous country-specific risk premium.[9] This risk premium is internalised in decisions made by households, and increases with the stock of debt outstanding:[10]

$$r_t = q_t - \varphi \frac{B_t}{Y_t}, \qquad 0 < \varphi < 1 \tag{6}$$

There are four exogenous processes. The log of the technology shock, A_t, follows a random walk with drift,

$$A_t = A_{t-1} e^{\alpha + \varepsilon_{a,t}}, \quad 0 < \alpha, \quad \varepsilon_{a,t} \sim N(0, \sigma_a^2). \tag{7}$$

Government spending is assumed to be proportional to output, with a constant long-run ratio g^*, and follows a stationary AR(1) process,

$$\frac{G_t}{Y_t} = g_t = g^{*1-\rho_g} g_{t-1}^{\rho_g} e^{\varepsilon_{g,t}}, \quad |\rho_g| < 1, \quad \varepsilon_{g,t} \sim N(0, \sigma_g^2) \tag{8}$$

Similarly q_t and s_t follow stationary AR(1) processes:

$$\begin{aligned} (1+q_t) = (1+q^*)^{(1-\rho_q)} (1+q_{t-1})^{\rho_q} e^{\varepsilon_{q,t}}, \quad |\rho_q| < 1, \quad \varepsilon_{q,t} \sim N(0, \sigma_q^2) \\ s_t = s^{*(1-\rho_s)} s_{t-1}^{\rho_s} e^{\varepsilon_{s,t}}, \quad |\rho_s| < 1, \quad \varepsilon_{s,t} \sim N(0, \sigma_s^2) \end{aligned} \tag{9}$$

Maximising (1) subject to equations (2), (3), (4), (5) and (6) yields the stochastic discount factor, Γ_{t+1},

$$\Gamma_{t+1} = \beta \left(\frac{C_{t+1} - hC_t}{C_t - hC_{t-1}} \right)^{\phi(1-\gamma)-1} \left(\frac{1 - N_{t+1}}{1 - N_t} \right)^{(1-\phi)(1-\gamma)} \tag{10}$$

and the optimality conditions in labour, capital and bond holdings:

$$\left(\frac{1-\phi}{\phi} \right) \left(\frac{C_t - hC_{t-1}}{1 - N_t} \right) = (1-\theta) \frac{Y_t}{N_t} \left[1 + \varphi s_t \left(\frac{B_t}{Y_t} \right)^2 \right] \tag{11}$$

[9] There is no *direct* role for monetary policy in our model. One interpretation is that the agent borrows far enough out on the yield curve where the influence of the foreign cost of capital on the interest rate is stronger than that of domestic monetary policy. However, monetary policy adjustments may appear indirectly in our model: if high domestic interest rates put upward pressure on the exchange rate then monetary policy may be included in the external valuation shock.

[10] See Schmitt-Grohe and Uribe (2003).

$$\left(\frac{K_t}{I_t}\right)^{\sigma} = E_t\Gamma_{t+1}\left\{\theta(1+\sigma)\frac{Y_{t+1}}{K_{t+1}}\left[1+\varphi s_{t+1}\left(\frac{B_{t+1}}{Y_{t+1}}\right)^2\right]\right.$$
$$\left. + \left[1-\delta-\sigma\left(\frac{I_{t+1}}{K_{t+1}}\right)^{1+\sigma}\right]\left(\frac{K_{t+1}}{I_{t+1}}\right)^{\sigma}\right\} \tag{12}$$

$$1 = E_t\Gamma_{t+1}\frac{s_{t+1}}{s_t}\left[1+r_{t+1}-\varphi\frac{B_{t+1}}{Y_{t+1}}\right] \tag{13}$$

Equation (10) defines the stochastic discount factor – the rate at which agents discount future returns – as the ratio of the shadow price (or marginal utility) of consumption at time $t+1$ divided by the shadow price of consumption at time t. In the basic present value model with no habit in consumption (ie $h=0$), separable utility ($\gamma=1$) and a constant world real interest rate, the stochastic discount factor is the familiar $\beta(C_t/C_{t+1})$. With nonseparable preferences, $\gamma\neq 1$, fluctuations in labour input affect the marginal utility of consumption and therefore the stochastic discount factor. Habit formation in consumption ($h\neq 0$) implies that higher consumption at t lowers the marginal utility of consumption at $t+1$ and increases the rate at which consumption at $t+1$ is discounted.

Equation (11) equates the marginal rate of substitution between consumption and labour to the marginal product of labour, which is the increase in production adjusted for its effect in reducing the risk premium. The risk premium increases debt servicing costs, reducing disposable income and so leads to a compensatory increase in steady-state employment above that under perfect capital mobility. Similarly, a rise in s_t increases the marginal rate of substitution between consumption and leisure, implying an increase in labour input.

Equation (12) equates the marginal cost at time t of increasing capital at time $t+1$, $(I_t/K_t)^{\sigma}$, to the expected discounted benefit of an extra unit of capital at time $t+1$. The benefit of the extra unit of capital comes from increased production, which increases income and reduces the risk premium, and from lower adjustment costs in the next period. This benefit is smaller than that under perfect capital mobility due to the presence of the risk premium. These gains are moderated by higher depreciation next period.

Equation (13) describes the optimality condition for international borrowing. It equates the marginal benefit of additional borrowing (an additional unit of consumption) to the marginal cost of that borrowing (the interest rate net of the increase in the risk premium). The external valuation shock introduces volatility in the cost of debt repayment. An increase in s_t increases the cost of debt repayment in t, reducing it in subsequent periods.

Finally, transversality conditions ensure that the household cannot increase the capital stock or its stock of debt indefinitely,

$$\lim_{i\to\infty} \beta E_t \lambda_{B,t+1} B_{t+i+1} = 0 \quad \text{and} \quad \lim_{i\to\infty} \beta E_t \lambda_{K,t+1} K_{t+i+1} = 0,$$

where $\lambda_{B,t}$ and $\lambda_{K,t}$ are shadow prices associated with the evolution of the debt and capital stocks in (4) and (5). To solve the model, a log-linear approximation is taken around the steady state. First, all variables except labour and interest rates/discount factors are stochastically detrended by the random walk path of technology. A first order Taylor expansion of each of the equilibrium conditions is taken around the steady state. The model is solved using the method of Sims (2002). The log linear equations are presented in appendix A.

3 Model estimation

The model is estimated using Bayesian methods. Our prior parameter distributions are chosen to match aspects of the New Zealand data such as a large debt liability, the observed (risk) premium that is paid in excess of world real interest rates, and major national accounts ratios.

Where the observed data are not informative, we draw on standard RBC practice for our priors. The posterior distributions and impulse response functions are discussed below. Appendix B provides further detail on estimation of the model.

3.1 Posterior distributions

The prior and posterior distributions of the parameters are shown in figure 2 and table 2. We calibrate the subjective rate of time preference, β at 0.99 which is less than $1/(1+q*)$ where q^* is the steady state foreign real interest rate. Given efficient markets, β should equal $1/(1+q^*)$ – as is assumed in the present value model. However, for New Zealand, this assumption yields steady state debt that is about 30 percent of GDP, a level that is much smaller than the observed 80 percent of GDP. When $\beta < 1/(1+q*)$ the small open economy discounts the future more heavily than the rest of the world, thus front-loading consumption. By setting $\beta = 0.99$ we put a wedge between the rate of time preference and the world cost of capital of about 200 basis points, which is similar to the observed premium that New Zealand borrowers pay over the wholesale world real interest rate.

In estimating the model, we find that the data are informative about all parameters except the mean of the valuation shock (which is unity by construction) and perhaps the debt-elasticity of the domestic interest rate.

We estimate the mean posterior value of h to be 0.82. This implies a moderate degree of habit formation in consumption; the bulk of consumption utility is still derived from the level of consumption, and a small amount from the increase in consumption. The estimated value is similar to estimates of h in Liu (2005) and Santacreu (2006) for Gali-Monacelli type models. Such models incorporate a richer trade side and more complex price rigidities than the model considered here, but typically forgo the inclusion of capital and debt stocks.

The mean posterior value of the inter-temporal substitution coefficient γ is 2.7, which is not significantly differently from our prior mean of 2. The data reject the restriction of a separable tradeoff between consumption and leisure ($\gamma = 1$). The estimated value for γ implies that fluctuations in consumption and labour affect inter-temporal incentives.

The estimated mean of θ, the capital share, is 0.25, which is lower than the commonly accepted value of about a third. The depreciation rate, δ, is estimated to be substantially higher at 18 percent per annum than our prior (10 percent per year). The steady state growth rate of labour productivity α is 1 percent per year compared to the prior of 1.4 percent per year.

At the mode of the joint distribution of posterior parameter estimates, private consumption is 59 percent of GDP, business and government investment 21 percent and government consumption 18 per cent, ratios similar to those observed in the data. The bond/annual GDP ratio is 75 percent of GDP compared to the 70 percent net foreign debt/GDP and 85 percent net international investment/GDP positions observed in the data. As discussed above, to shift the steady state values toward the observed level of debt, there is a wedge of about 200 basis points (in annual interest rate terms), between the complete markets discount rate $1/(1+q^*)$ and the agent's discount rate β calibrated in the model. Such a wedge may reflect, in part, the difference between the wholesale world real interest rate used and the retail nature of some of the representative agent's decisions.

The steady state world real interest rate is estimated to be 2.1 percent per year, the risk premium is about 165 basis points (annual) and the domestic real interest rate is about 3.8 per cent per year. The rate of time preference is 4.1 percent per year. The investment income deficit, rB, is 1.5 percent of GDP, net exports are 2.1 percent of GDP and the steady state current account deficit is 0.3 percent of GDP. The observed investment income and current account deficits are about 4 percent larger mainly due to high observed rates of return on foreign equity investment in New Zealand, an effect that is not modeled here. At the mode of the posterior, the steady state labour share of income is 0.49. Given that the share of time devoted to market activities is generally thought to be about one third, the estimated steady state labour share is somewhat high. It is likely that this reflects New Zealand's high labour input compared to the OECD average. This is a robust feature of the data that has been reasonably invariant to changes in income growth and continued increases in participation rates. The high labour share may also be due to the habit formation that is estimated to be a significant factor in agents' consumption decisions.

3.2 Impulse responses

Figures 3 to 6 document the responses of various model variables and selected economic aggregates to impulses from the four structural shocks.[11] A positive permanent technology shock increases the productivity of labour. The agent supplies less labour, which partly offsets the increase in output.[12] The shock also increases the marginal product of capital, inducing the agent to increase investment until the capital stock reaches its new steady state level. With habit in consumption, the agent increases consumption slowly, so that initially the rise in investment is financed through higher domestic savings. As consumption moves to the new higher path, the increase in investment is financed through external borrowing. The net effect of these decisions on the current account/GDP ratio is a transitory improvement followed by a prolonged increase in the current account deficit.

In a closed economy, a rise in government expenditure crowds out consumption and investment. In this small open economy model, the crowding out effect is moderated by spilling the fiscal shock into the current account. The temporary increase in the stock of debt, however, leads to a rise in the risk premium which increases debt repayment costs. The agent increases labour input in order to increase income and moderate the fall in consumption and to reduce the risk premium.

[11] The impulse response functions are calculated from model simulations based on the last 10,000 of 50,000 draws from the posterior parameter space. Median responses are plotted together with 10 and 90 percentile bounds which are not necessarily symmetric.

[12] The responses for output, consumption, investment, government spending and the capital and bond stocks are plotted relative to the new level of technology. Output, consumption and government spending all increase relative to the level of technology at $t-1$.

A rise in the world cost of capital feeds directly into the domestic interest rate which is the world interest rate plus an endogenous risk premium. Since the cost of borrowing is now higher, the capital stock declines such that the marginal product of capital again equals the new, higher, interest rate. Consequently, investment falls for a prolonged period and the external balance improves. The net effect of lower debt and higher domestic interest rates on the investment income balance is an initial deterioration that reverses after about 5 months. The intra-temporal response of aggregate demand (mainly the fall in investment) to the rise in the interest rate leads to a roughly opposite effect on the trade balance. At the posterior mean, the trade balance dominates, but as shown by the error bands, the net effect is subject to a lot of uncertainty.

A rise in the external valuation shock, s_t increases the burden of outstanding debt, because a given volume of net exports is worth less. Thus s_t could loosely be interpreted as a negative terms of trade shock. The rise in s_t increases the income effects of the risk premium in the markets for capital and labour (equations 11 and 12). A rise in s_t increases the returns to both capital and labour because the associated increase in production reduces the risk premium. Thus the small open economy deals with the increase in the debt burden by expanding production, improving the current account deficit in the medium-term. Because the shock is persistent (with a half life of two years) the current account deficit is persistent, but turns to surplus after about 5 years.

4 What drives the New Zealand current account?

Using the estimated the model we construct a forecast error variance decomposition to isolate the impact of each of the four shocks on the New Zealand current account. We find that permanent technology shocks and world cost of capital shocks dominate the others in driving current account fluctuations in the short term. External valuation shocks are more important at medium term horizons. Overall, the two foreign shocks explain more than half of the variation in the current account. Next, we construct historical shock decompositions to show the implied impact of each of the four shocks on the New Zealand current account since 1990. Finally, we explore the contribution of several structural model features to model fit in general (using posterior odds ratios) and to the fit of the current account in particular (using in-sample forecast errors). The results suggest that habit formation in consumption and the small country risk premia are important features in explaining the New Zealand current account, and therefore the failure of the simple present value model (see Munro and Sethi 2006).

4.1 Variance decomposition

The contemporaneous variance decomposition (table 3) shows that technology and world cost of capital shocks each account for about 40 percent of the variance in the current account in this model. The remaining 20 percent of the contemporaneous variance stems from external valuation shocks, while fiscal shocks are found to be unimportant.

The relative contributions of the four shocks change significantly over different horizons once we consider a forecast error variance decomposition.[13] The results in table 4 show that external valuation shocks become increasingly important as the forecast horizon increases, technology and world cost of capital shocks play a reduced role, while fiscal shocks, which are less persistent, contribute little.[14]

4.2 Historical analysis

Historical shocks

Following the method detailed in Hamilton (1994), we incorporate the structural shocks into the state vector in the Kalman filter. This enables us to recover historical estimates of the technology, world cost of capital, government spending, and external valuation shocks over 1990-2005 (figure 7).

The first panel of figure 7 shows the estimated technology shocks. In our model, the permanent technology process induces a trend in labour productivity and provides the trend rate of growth of the economy. The 'technology' shocks may also incorporate factors such as variations in migration, which would increase labour input encouraging investment in new capital. Negative shocks to technology are estimated at the time of a recession in New Zealand in the early 1990s, and again at the time of the Asian crisis in 1997 and the drought in 1998. The mid 1990s

[13] We follow the method described in Hamilton (1994), chapter 11.

[14] In practice world cost of capital and external valuation shocks are related through uncovered interest parity. The historical effects of the two shocks are very similar as shown in figure 7. A richer trade side and an endogenous exchange rate process would better distinguish between the effects of the two shocks.

boom and the period since 2002 have been associated with positive technology shocks in the context of our model.

Sustained negative world cost of capital shocks are estimated over 2002-2005, coinciding with the decline in observed US interest rates between 2001 and 2003 and a low risk premium reflected in low spreads on high risk securities.

In the third panel, the estimated fiscal shocks clearly pick up the effect of increased government spending on naval frigates in 1997 and 1999. Sustained positive government spending shocks in the early 1990s quickly dissipate after the New Zealand fiscal reforms of 1994. With these exceptions, fiscal shocks have generally been small and negative, turning positive in 2005.

Finally, the fourth panel shows the estimates of our external valuation shock over time, which is, as mentioned earlier, a proxy for terms of trade effects. Because of the parsimonious formulation of the traded goods sector, the interpretation of this shock is not straightforward. In general terms, an exchange rate appreciation and a fall in terms of trade, as observed in the period 1993-1997, map to positive shocks. The exchange rate depreciation and improvement in terms of trade coincide, in 2000-2001, correspond to negative valuation shocks in our model. When exchange rate and terms of trade dynamics have differing implications for competitiveness, as in 2002-2005, then the implications of these for our valuation shocks are more ambiguous.

Historical decomposition

Using the estimated historical shocks in a two-sided Kalman-smoothing procedure, we construct the current account implied by the model over history. The model-implied series (shown in figure 5) is constructed by choosing a starting point (we chose March 1990 to coincide with the start of our sample) and then running the estimated model forward, subject to the estimated shocks shown in figure 7. To enable direct comparison with the dynamics of the observed current account, we add the observed current account mean to the model-implied series.

The dynamic properties of the model-implied current account map well with those of the actual current account: turning points are more or less identified correctly; the series exhibit comparable volatility and the variation about the mean is similar. The recent deterioration in the current account is consistent with the observed data.

Which of these four shocks is responsible for the recent deterioration? To isolate the impact of individual shocks, we again run the estimated model forward; this time sequentially subjecting it to a single shock rather than all four shocks. The resulting model implied current accounts are shown as red dots in figure 5. It is important to note that the shocks are not additive, that is the effects on the current account stemming from each of the individual shocks cannot be added to yield the net effect of all four shocks. In figure 11, the solid black lines are identical across all panels and depict the model-implied current account generated jointly by all four shocks shown in red in figure 11.

In the period since 2002, during which the current account deficit has increased from 3 to 9 percent of GDP, permanent technology shocks, world cost of capital shocks and external valuation shocks have all been important in driving the deterioration, in the framework of our model.

The sequence of positive 'technology shocks' implies a cyclical deterioration in the current account as agents borrow to increase the capital stock in response to a higher marginal product of capital.

Fiscal shocks contributed to current account deficits in the early 1990s and again to a smaller degree in the early 2000s, and briefly with one off purchases of frigates in 1997 and 1999. Since 2002, fiscal shocks have generally acted to reduce the current account deficit, but an increase in government spending as a share of GDP in 2005 contributed to the current account deterioration at the end of the sample.

World cost of capital shocks appear to play a very similar role to valuation shocks in the recent deterioration. The decline in the foreign cost of capital since 2002 (measured in this case by 2-year US interest rates) has likely increased incentives to borrow abroad to finance domestic consumption and investment expenditure. The contribution of the external valuation shock is more suggestive of exchange rate appreciation contributing to a fall in net exports, and expansion of investment which is import-intensive, rather than recent improvements in the terms of trade, which would suggest the opposite.

4.3 Model specification tests

Table 5 summarises the seven different restrictions we consider in our model specification tests. Our aim is to establish which of the structural elements, when omitted, contributes most to the decrease in model fit as measured by posterior odds ratios relative to the unrestricted model, and to the fall in the fit of the current account as measured by in-sample forecast errors.

Let the unrestricted model be denoted $\mathscr{M}_0$, and the model being tested by $\mathscr{M}_j$ with $j \in [1,7]$ indexing one of seven restrictions considered as in table 5. We calculate the posterior odds

$$PO_{j0} = \frac{p(\mathscr{M}_j|y)}{p(\mathscr{M}_0|y)} = \frac{p(\mathscr{M}_j)}{p(\mathscr{M}_0)} \frac{p(y|\mathscr{M}_j)}{p(y|\mathscr{M}_0)} \tag{14}$$

where $p(\mathscr{M}_x)$ is the prior weight on model x. Given that we only ever compare a restricted model against the unrestricted baseline rather than against other restricted models, we assume our model space is 'complete' in the sense $p(\mathscr{M}_0) + p(\mathscr{M}_j) = 1$ for every j. More specifically, we assume $p(\mathscr{M}_0) = p(\mathscr{M}_j) = 0.5$. In this case the posterior odds ratio above is simply the ratio of marginal likelihoods, the Bayes factor:

$$BF_{0j} = \frac{p(y|\mathscr{M}_j)}{p(y|\mathscr{M}_0)} \tag{15}$$

The posterior odds ratio for a model that omits habit in consumption is small (arbitrarily close to zero), meaning that the data imply a much higher posterior probability to the unrestricted model than to the restricted version. Similarly, a model that imposes perfect capital mobility ($\varphi \to 0$, no endogenous risk premium), or one that excludes technology and external valuation shocks, has a very low posterior probability. Thus these features are important in explaining model fit.

In contrast, other posterior odds ratios in table 5 imply that the restrictions that impose separable preferences or small fiscal shock variances improve the likelihood of the model given the observed data. For example, a model that incorporates the restriction of separable preferences is about 0.86 times as likely as an unrestricted model. That is, the posterior probability of the restricted model is about 46 percent suggesting that even though the data tend to favour the restriction on the whole, they do not do so unequivocally. A model that imposes a small world cost of capital shock variance is about seven times as as likely as an unrestricted model (i.e. the probability of the data given the restriction is 0.87).

These results need to be interpreted in the context of the measurement equations. The fiscal shocks and world cost of capital shocks are tightly constrained by the measurement equations, since G/Y and q are observed, while A_t and s_t are unobserved and therefore unconstrained. Moreover, the series G/Y includes a combination of fairly persistent swings in government spending and two large 'frigate' shocks that are not persistent. In the model both types of shock share the same AR(1) coefficient, compromising model fit.

5 Conclusion

In this paper, an estimated small open economy model was used to examine the sources of current account variation and to identify which model features improved overall model fit and fit of the current account in particular.

On the whole, the model, which is based on optimising agents' decisions about consumption, investment and debt, was able to replicate historical current account dynamics well, including the recent current account deterioration.

The variance decompositions attribute the bulk of current account variance to technology shocks and world cost of capital shocks in the short term and to external valuation shocks and technology shocks at longer horizons.

The historical decomposition attributes the 2001-2005 current account deterioration to a combination of: positive technology shocks (improvements in labour productivity increase the marginal product of capital and therefore investment), a low world cost of capital (that reduces the cost of borrowing), and external valuation shocks (probably related to the strong exchange rate that reduce the value of net exports). Fiscal shocks have helped to stem the deterioration of the current account in recent years, except at the end of the sample, when a rise in the government spending to GDP ratio contributed to the increase in the deficit.

Overall the results provide some comfort: current account behaviour, including the recent deterioration of the current account, can be reasonably well described by a model based on optimising agents. The results also help in interpreting the failure of the simple present value model of the current account (as discussed in Munro and Sethi 2006): foreign shocks, habit in consumption (which induces additional smoothing) and an endogenous risk premium are important for understanding current account dynamics in the context of our model. While this framework is richer than the present value model, the model still lacks features that are likely to be relevant for current account behaviour including an explicit exchange rate process, a richer trade side including a role for commodity export prices and, of interest to a central bank, the role of monetary policy.

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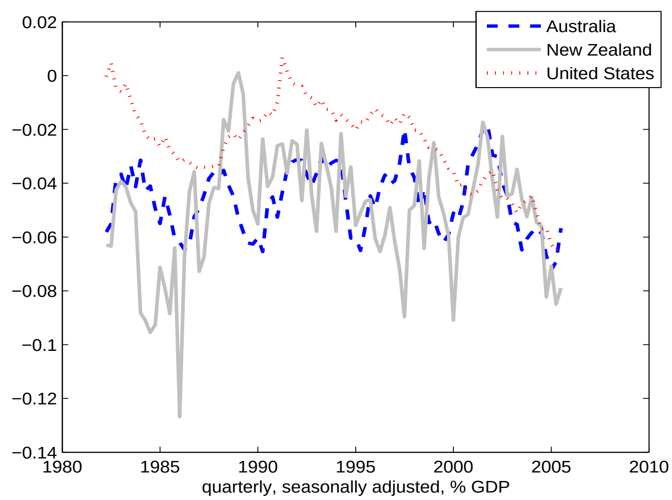
Figure 1
Australia, New Zealand and US current accounts



Note: Quarterly, seasonally adjusted data from Balance of Payments Accounts.
Sources: Australian Bureau of Statistics, Statistics New Zealand, US Bureau of Economic Analysis.

Figure 2
Prior and posterior parameter distributions

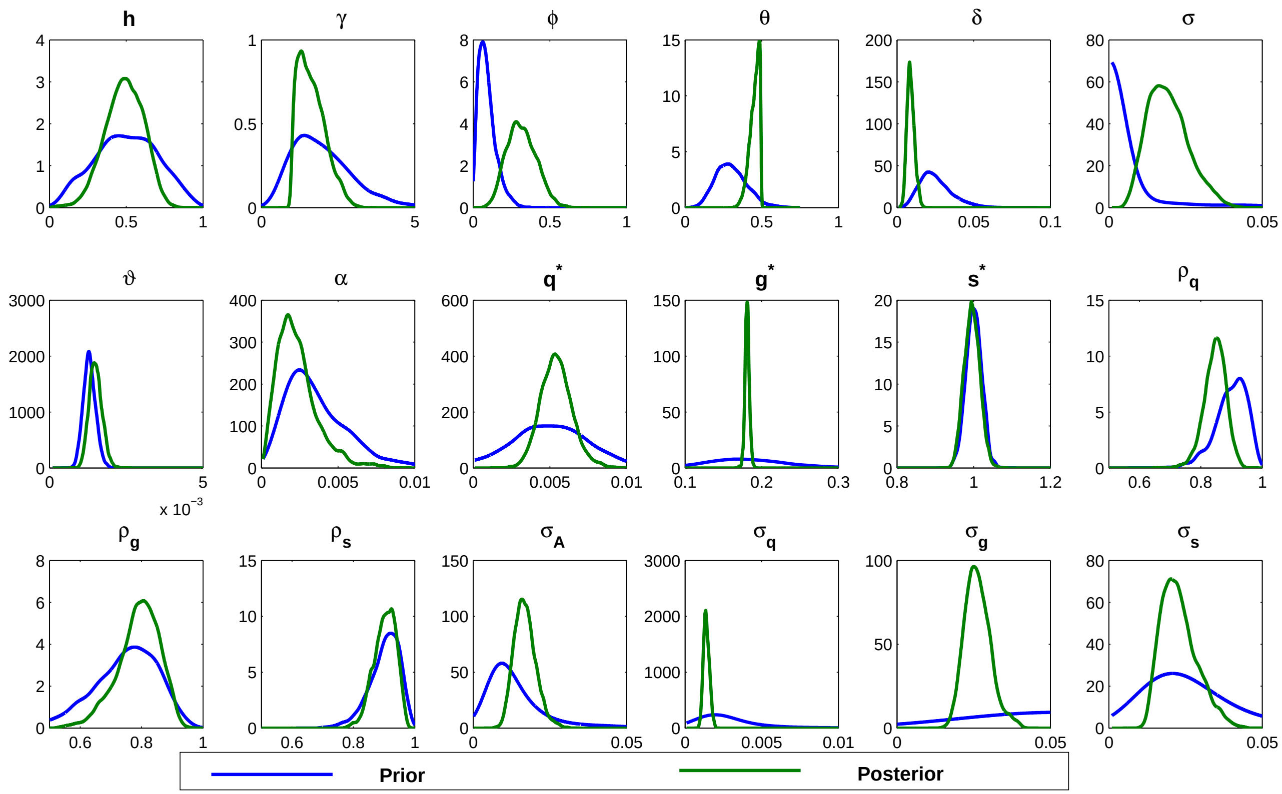


Figure 3
Response to a positive 1% permanent technology shock

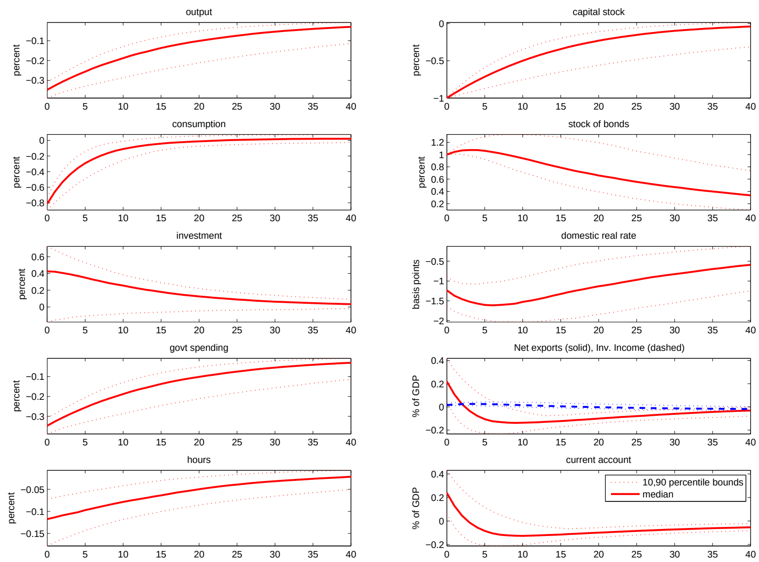


Figure 4
Response to a fiscal shock (1% of GDP)

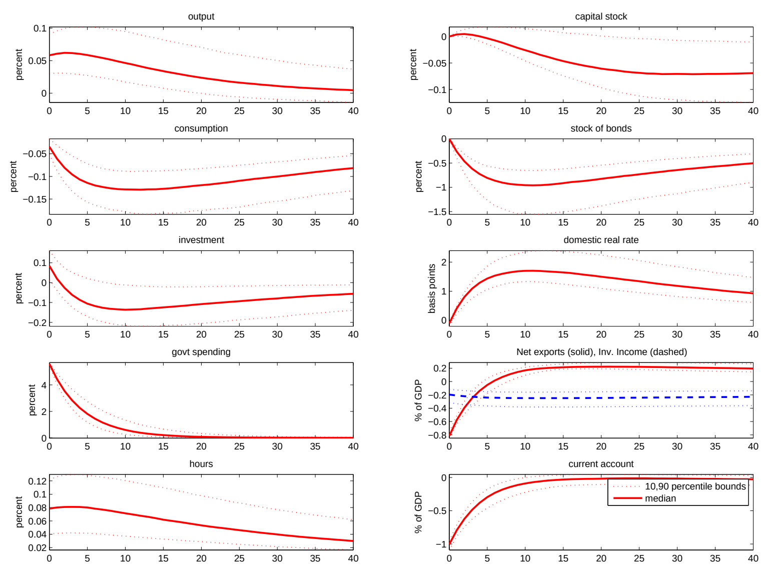


Figure 5
Response to a 100 basis point world cost of capital shock

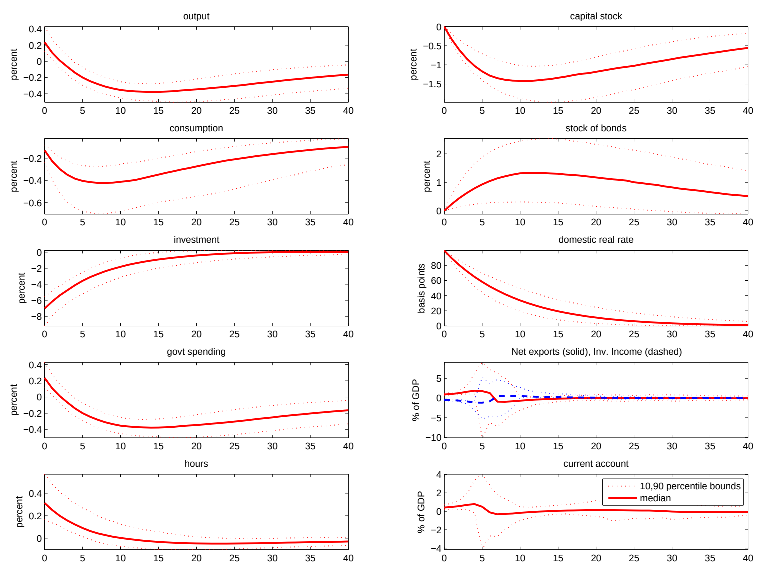


Figure 6
Response to a positive 1% external valuation shock

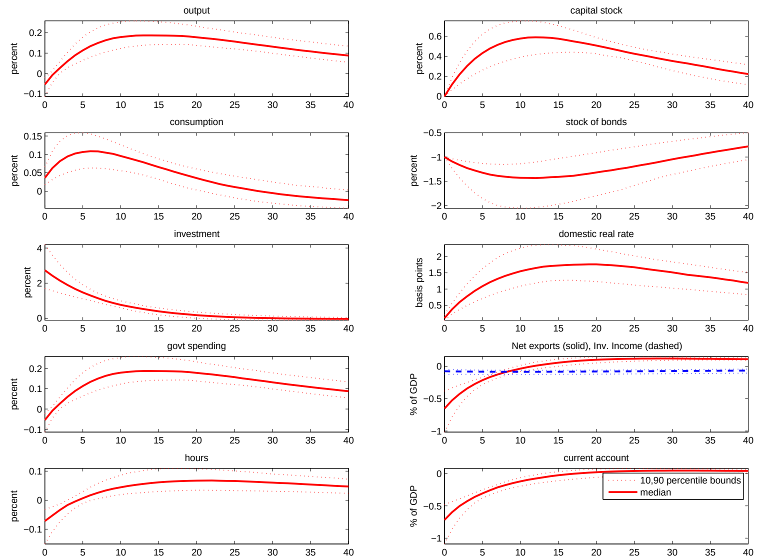


Figure 7
Estimated historical shocks

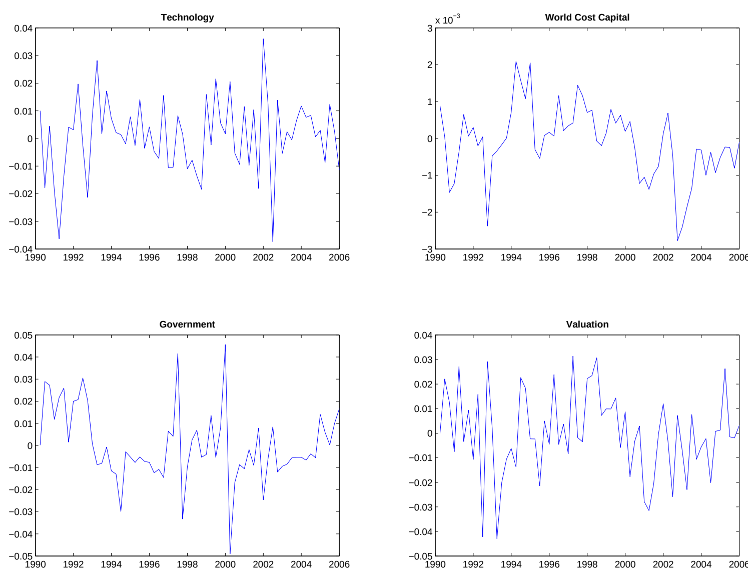


Figure 8
Measurement equation fit

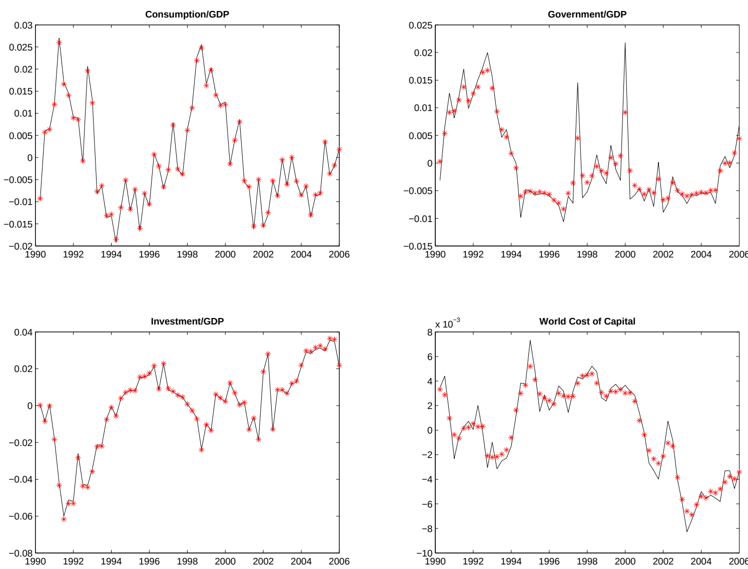


Figure 9
Model implied current account

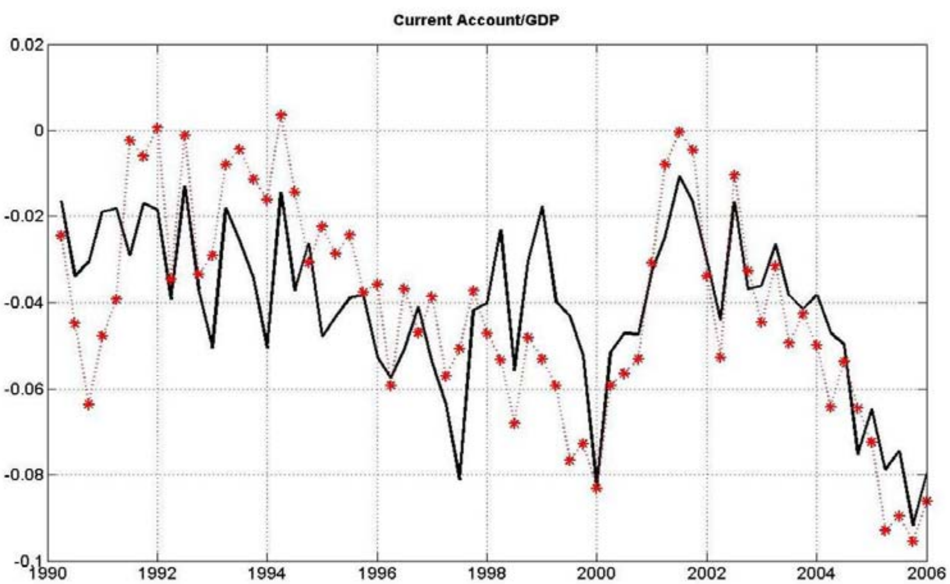


Figure 10
Individual shock drivers of the current account

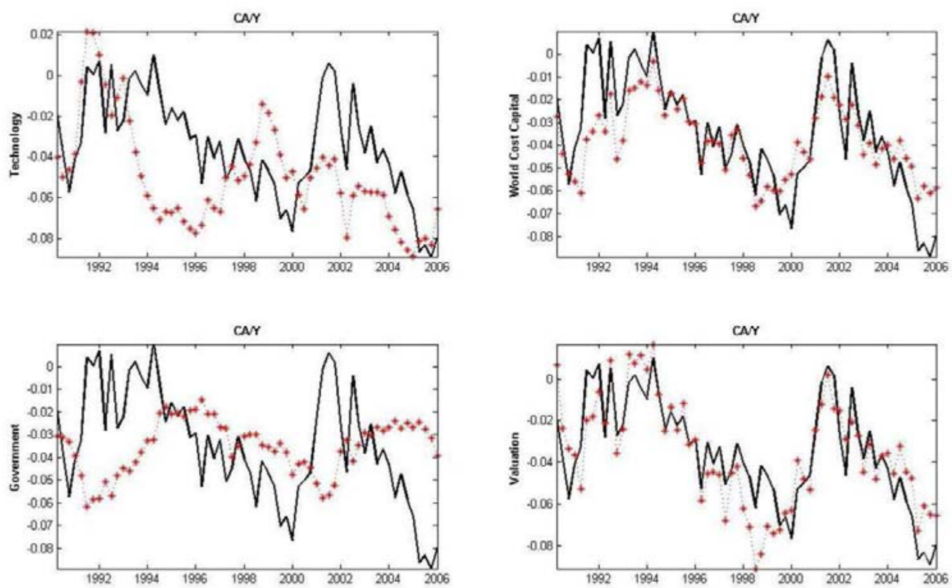


Table 1
Persistence of Australian, New Zealand and US current account/GDP ratios

	New Zealand	Australia	United States
Unit root tests			
ADF	-4.34**	-2.63	-0.25
Ng Perron	-22.51**	-9.39*	1.96
Phillips Perron	1.21**	3.15	39.00
AR(1) estimates			
constant	-0.017	-0.007	-0.001
t-value	-3.95**	-2.59*	-1.15
beta	0.646	0.840	.994
t-value	7.91**	-13.73**	38.9**
Implied half life (quarters)	2	4	>100
Implied steady State	-4.8	-4.7	-14.0

Note: data are seasonally adjusted current account as a share of seasonally adjusted GDP for period 1982Q2 to 2005Q2. Sources: Australian Bureau of Statistics, Statistics New Zealand, US Bureau of Economic Analysis. Significance at the five percent level is indicated by * and at the one percent level by **.

Table 2
Prior and posterior parameter distributions for the unrestricted model

	Prior				Posterior			
	mean	std	90% CI		mean	std	90% CI	
β	0.99	0	[–	, –]	0.99	0	[–	, –]
h	0.5	0.2	[0.23	, 0.78]	0.827	0.074	[**0.747**	, **0.966**]
γ	2	1	[0.85	, 3.33]	**2.698**	**1.06**	[1.66	, 5.01]
ϕ	0.18	0.08	[0.028	, 0.168]	0.231	0.08	[**0.128**	, **0.406**]
θ	0.3	0.1	[0.18	, 0.44]	**0.254**	**0.014**	[0.236	, 0.321]
δ	0.025	0.01	[0.013	, 0.038]	**0.0446**	**0.013**	[0.0181	, 0.0642]
σ	0.005	0.0025	[0.017	, 0.067]	0.0148	0.0034	[**0.0125**	, **0.0315**]
φ	0.0013	0.0002	[0.0010	, 0.0016]	0.0014	0.0002	[0.0011	, 0.0017]
α	0.0036	0.002	[0.0014	, 0.0062]	**0.0025**	**0.002**	[0.0010	, 0.0078]
q^*	0.005	0.0025	[0.0018	, 0.0082]	0.0054	0.001	[0.0033	, 0.0077]
g^*	0.18	0.05	[0.12	, 0.25]	0.18	0.0026	[0.175	, 0.185]
s^*	1	0.02	[0.97	, 1.03]	0.99	0.0200	[0.968	, 1.032]
ρ_q	0.9	0.05	[0.83	, 0.96]	0.917	0.0282	[0.854	, 0.958]
ρ_g	0.75	0.1	[0.62	, 0.87]	0.798	0.0668	[0.678	, 0.902]
ρ_s	0.9	0.05	[0.83	, 0.96]	0.907	0.0328	[0.825	, 0.945]
σ_a	0.009	0.005	[0.006	, 0.028]	**0.0256**	**0.0039**	[0.0149	, 0.0320]
σ_q	0.0018	0.005	[0.0012	, 0.0053]	**0.0010**	**0.0002**	[**0.0009**	, **0.0015**]
σ_g	0.05	0.005	[0.03	, 0.15]	**0.0245**	**0.0040**	[**0.0201**	, **0.0333**]
σ_s	0.02	0.005	[0.0132	, 0.0614]	0.0156	0.0045	[**0.0115**	, **0.0323**]

Note: Figures in bold indicate that the posterior is significantly different from the prior as measured by a t-type statistic: [mean(posterior) - mean(prior)]/std(posterior).

Table 3
Contemporaneous variance decomposition of unrestricted model

Shock	Output	Consumption	Investment	NX	CA
Technology	0.588	0.318	0.672	0.253	0.395
World Cost of Capital	0.015	0.212	0.234	0.295	0.401
Fiscal	0.000	0.089	0.085	0.086	0.008
Ext Valuation	0.397	0.381	0.009	0.367	0.196

Table 4
Forecast error variance decompositions of current account dynamics

Shock	CA(0)	CA(1)	CA(4)	CA(8)	CA(12)
Technology	0.395	0.360	0.344	0.305	0.185
World Cost of Capital	0.401	0.498	0.475	0.212	0.180
Fiscal	0.008	0.032	0.000	0.000	0.000
Ext Valuation	0.196	0.111	0.181	0.483	0.635

Table 5
Summary of structural restrictions for model specification tests and posterior odds results

	Model	Model Feature	Restriction	Posterior Odds	Variance CA
Structural restrictions	$\mathscr{M}_1$	Habit in consumption	$h = 0$	4.52×10^{-18}	0.374
	$\mathscr{M}_2$	Separable preferences	$\gamma = 1$	0.86	0.901
	$\mathscr{M}_3$	Perfect capital mobility	$\varphi = 0.0001$	2.15×10^{-24}	0.653
Shock restrictions	$\mathscr{M}_4$	Technology	$\varepsilon_\alpha \to 0$	1.81×10^{-28}	0.798
	$\mathscr{M}_5$	Fiscal	$\varepsilon_g \to 0$	19.87	0.953
	$\mathscr{M}_6$	World cost of capital	$\varepsilon_q \to 0$	6.69	0.662
	$\mathscr{M}_7$	External valuation	$\varepsilon_s \to 0$	3.24×10^{-10}	0.485

Appendices

A Log-linear equations

Table 6
Model variables and shocks

Y_t	GDP	(quarterly, real, per capita)
C_t	consumption	(quarterly, real, per capita)
I_t	investment	(quarterly, real, per capita)
G_t	government spending	(quarterly, real, per capita)
B_t	bond holdings	(quarterly, real, per capita)
K_t	capital stock	(per capita)
N_t	hours (= 1-leisure)	(quarterly, per capita)
A_t	labour augmenting technology	index
r_t	domestic real interest rate	(quarterly percent change)
q_t	world real interest rate	(quarterly percent change)
s_t	external value index	index
Γ_t	stochastic discount factor	
$\varepsilon_{a,t}$	permanent technology shock	
$\varepsilon_{q,t}$	world cost of capital shock	
$\varepsilon_{g,t}$	government spending shock	
$\varepsilon_{s,t}$	external valuation shock	

Table 7
Model parameters

β	subjective discount rate
h	degree of habit formation in consumption
γ	coefficient of relative risk aversion/intertemporal substitution
ϕ	elasticity of substitution between consumption and labour
θ	elasticity of substitution between capital and labour in production
δ	rate of capital depreciation
σ	investment adjustment cost parameter
φ	risk premium parameter
α	steady state rate of technology growth
σ_a	standard deviation of technology shocks
g^*	steady state G/Y ratio
ρ_g	persistence of government spending shock
σ_g	standard deviation of govt spending shocks
q^*	steady state world real interest rate
ρ_q	persistence of world real interest rate shock
σ_q	standard deviation of world real interest rate shocks
s^*	steady state external value
ρ_s	persistence of valuation shock
σ_s	standard deviation of valuation shock

A.1 Notation

- $x_t \equiv X_t/A_t, \quad \text{for} \quad X_t \in \{Y_t, C_t, I_t, G_t, K_t, B_t\}$
- Steady state: $\bar{x}$
  Deviation from steady state: $\tilde{x}_t = x_t - \bar{x}$
- Log (percentage) deviation from steady state: $\hat{x}_t = \frac{x_t - \bar{x}_t}{\bar{x}_t}$

A.2 Log-linear equations

Production

$$\hat{y}_t = \theta \hat{k}_t + (1-\theta)\hat{N}_t \tag{16}$$

Law of motion of capital

$$(1+\alpha)(\hat{k}_{t+1}+\varepsilon_{a,t+1}) = (1-\delta)\hat{k}_t + \left(\frac{\bar{i}}{\bar{k}}\right)^{1+\sigma}[(1+\sigma)\hat{i}_t - \sigma\hat{k}_t] \tag{17}$$

Intertemporal budget constraint

$$\begin{aligned}\bar{s}\bar{b}(1+\alpha)\hat{b}_{t+1} = \bar{s}\bar{b}[(1+\bar{r})\hat{b}_t + (\bar{r}-\alpha)\hat{s}_t + \tilde{r}_t - (1+\alpha)\varepsilon_{a,t+1}] \\ + \bar{y}\hat{y}_t - \bar{c}\hat{c}_t - \bar{i}\hat{i}_t - \bar{g}\hat{g}_t\end{aligned} \tag{18}$$

Interest rate

$$\tilde{r}_t = \tilde{q}_t - \varphi\frac{\bar{b}}{\bar{y}}(\hat{b}_t - \hat{y}_t) \tag{19}$$

Exogenous processes

$$\begin{aligned}\Delta \ln A_t &= \alpha + \varepsilon_{a,t} \\ (\hat{g}_t - \hat{y}_t) &= \rho_g(\hat{g}_{t-1} - \hat{y}_{t-1}) + \varepsilon_{g,t} && (20) \\ \tilde{q}_t &= \rho_q \tilde{q}_{t-1} + \varepsilon_{q,t} && (21) \\ \hat{s}_t &= \rho_s \hat{s}_{t-1} + \varepsilon_{s,t} && (22)\end{aligned}$$

Stochastic discount factor

$$\begin{aligned}\hat{\Gamma}_{t+1} =& (\phi(1-\gamma)-1)\left[\frac{(1+\alpha)(\hat{c}_{t+1}+\varepsilon_{a,t+1}) - h\hat{c}_t}{1-h+\alpha} - \frac{\hat{c}_t - h(1-\alpha)(\hat{c}_{t-1}-\varepsilon_{a,t})}{1-h+\alpha h}\right] \\ &+ (1-\phi)(1-\gamma)\frac{\bar{N}}{1-\bar{N}}(\hat{N}_t - \hat{N}_{t+1})\end{aligned} \tag{23}$$

Optimality conditions:

$$\frac{\hat{c}_t - h(1-\alpha)\hat{c}_{t-1} + h(1-\alpha)\varepsilon_{a,t}}{1-h(1-\alpha)} = \hat{y}_t - \frac{\hat{N}_t}{1-\bar{N}} + \frac{\varphi\bar{s}(\frac{\bar{b}}{\bar{y}})^2}{1+\varphi\bar{s}(\frac{\bar{b}}{\bar{y}})^2}(\hat{s}_t + 2\hat{b}_t - 2\hat{y}_t) \tag{24}$$

$$
\begin{aligned}
\sigma\left(\frac{\bar{k}}{\bar{i}}\right)^{\sigma}(\hat{k}_t-\hat{i}_t) = E_t \Bigg\{ & \left(\frac{\bar{k}}{\bar{i}}\right)^{\sigma}\hat{\Gamma}_{t+1} \\
& +\bar{\Gamma}\theta(1+\sigma)\frac{\bar{y}}{\bar{k}}\left(1+\bar{s}\varphi\left(\frac{\bar{b}}{\bar{y}}\right)^{2}\right)(\hat{y}_{t+1}-\hat{k}_{t+1}) \\
& +\bar{\Gamma}\theta(1+\sigma)\frac{\bar{y}}{\bar{k}}\left(\varphi\bar{s}\left(\frac{\bar{b}}{\bar{y}}\right)^{2}\right)(\hat{s}_{t+1}+2\hat{b}_{t+1}-2\hat{y}_{t+1}) \\
& +\bar{\Gamma}\sigma\left((1-\delta)\left(\frac{\bar{k}}{\bar{i}}\right)^{\sigma}+\frac{\bar{i}}{\bar{k}}\right)(\hat{i}_{t+1}-\hat{k}_{t+1})\Bigg\}
\end{aligned}
\tag{25}
$$

$$
0 = E_t\left[(\hat{\Gamma}_{t+1}+\widehat{s_{t+1}}-\hat{s}_t)+\bar{\Gamma}\tilde{r}_{t+1}-\varphi\bar{\Gamma}\frac{\bar{b}}{\bar{y}}(\hat{b}_{t+1}-\hat{y}_{t+1})\right] \tag{26}
$$

B Estimation

National accounts data used for model estimation are nominal and seasonally adjusted. We use the nominal ratios of investment, consumption and net government spending to GDP. The fourth data series used in the estimation process is a world interest rate. Given that the US has absorbed three-quarters of the world's savings in recent years, and that most US liabilities are denominated in US dollars, we use a US interest rate for the world cost of capital. While the model is at a quarterly frequency, we use the 2-year real domestic interest rate to more accurately reflect the rate at which marginal borrowing decisions are being made.[15] The 90-day interest rate largely reflects domestic monetary policy while the 2-year rate is much more strongly influenced by foreign interest rates.

The model is estimated on a sample from 1992Q1 to 2005Q4, yielding 56 observations. The series used are the ratios of government spending (*Govt*) to GDP, consumption (*Cons*) to GDP, investment (*Inv*) to GDP, and a foreign real interest rate (*FRR*). Measurement errors, ξ_t^i, are included in these equations to aid estimation, which is achieved by maximum likelihood using the Kalman filter.

$$\begin{aligned}
\frac{Cons_t}{GDP_t} &= \frac{\bar{c}}{\bar{y}}(1+\hat{c}_t-\hat{y}_t)+\xi_t^1 \\
\frac{Inv_t}{GDP_t} &= \frac{\bar{i}}{\bar{y}}(1+\hat{i}_t-\hat{y}_t)+\xi_t^2 \\
\frac{Govt_t}{GDP_t} &= \frac{\bar{g}}{\bar{y}}(1+\hat{g}_t-\hat{y}_t)+\xi_t^3 \\
FRR_t &= \bar{q}(1+\hat{q}_t)+\xi_t^4
\end{aligned} \tag{27}$$

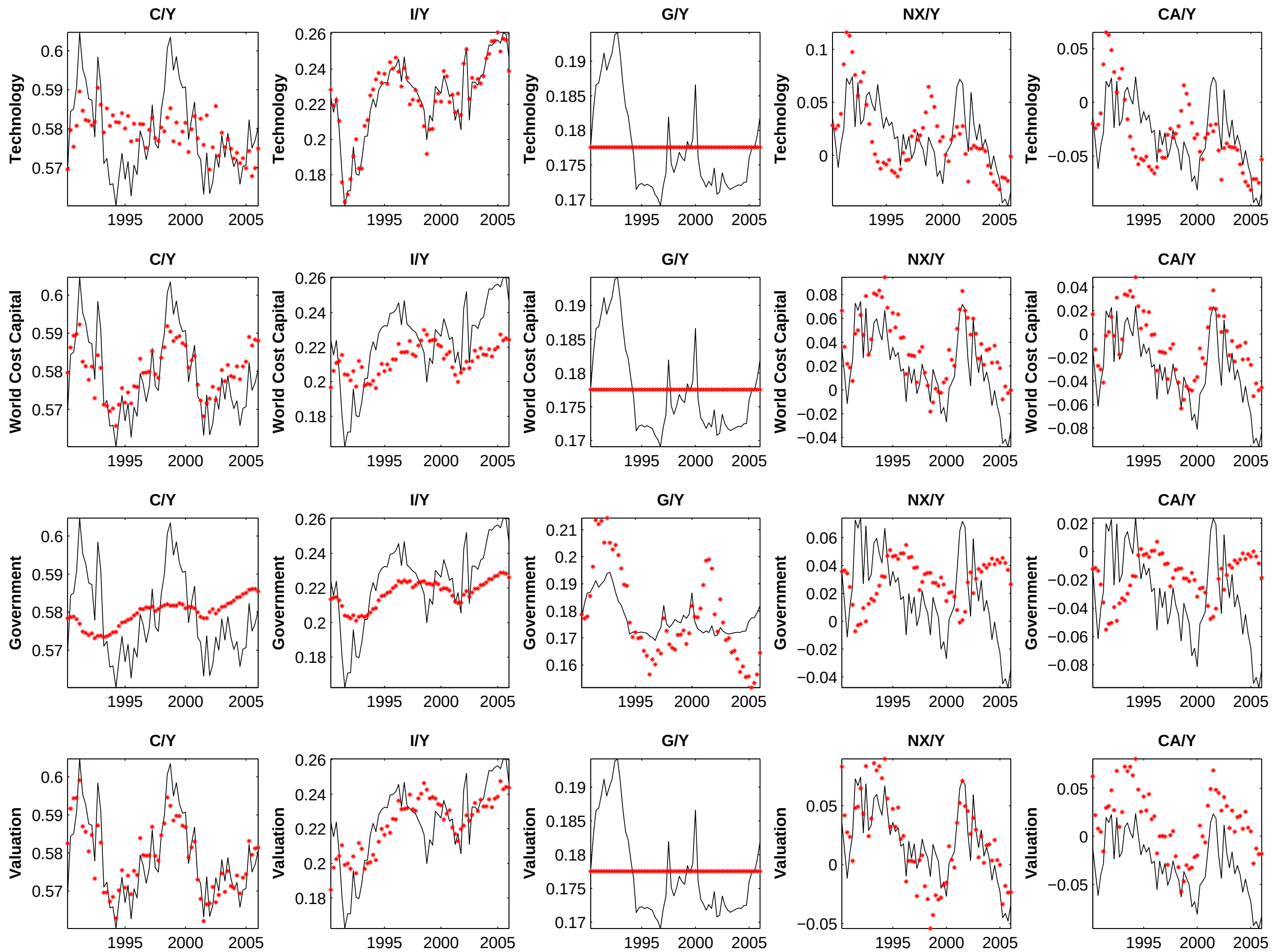
The data and fit of the measurement equations is shown in figure 8.

Most parameters are pinned down with some precision – the exception being s^*, the mean of s_t, which sits on top of the prior. Conceptually the mean of this variable needs to be unity, and so this is not an urgent concern. Further investigation of this issue together with formal convergence diagnostics on the chain are necessary.

Prior means for parameters are chosen either to be consistent with the RBC literature, or to match properties of the New Zealand data. Standard deviations are

[15] In practice agents do not repay their whole stock of debt each period.

Figure 11
Historical shock decomposition for selected variables



chosen to generate reasonably comprehensive coverage intervals. Parameters are drawn from the beta distribution,those that are theoretically bounded on the (0, 1) interval, the gamma and normal distributions (endogenous parameters), or inverse gamma distribution (exogenous shocks). 2,000 draws are taken from the prior distributions. 50,000 draws are used to generate the posterior distributions, but only the last 10,000 are used for performing the simulation and evaluation exercises in the main body of this text.

Table 8
Cross correlation of posterior parameter distribution

	β	h	γ	ϕ	θ	δ	σ	φ	α	q^*	g^*	q^*	ρ_q	ρ_g	ρ_s
β	1														
h	0	1.00													
γ	0	-0.33	1.00												
ϕ	0	-0.04	-0.18	1.00											
θ	0	0.25	0.04	0.08	1.00										
δ	0	-0.31	0.00	-0.02	-0.80	1.00									
σ	0	0.45	-0.02	0.16	0.21	-0.05	1.00								
φ	0	-0.14	0.08	0.10	-0.02	0.11	-0.07	1.00							
α	0	0.06	-0.10	-0.08	-0.08	-0.11	0.02	0.11	1.00						
q^*	0	-0.01	0.02	0.02	0.06	-0.11	-0.09	-0.04	0.03	1.00					
g^*	0	-0.06	0.01	0.03	-0.16	0.11	-0.09	0.02	0.00	0.02	1.00				
q^*	0	-0.01	0.00	0.09	-0.09	0.04	0.05	0.02	0.00	-0.06	0.08	1.00			
ρ_q	0	0.12	0.01	0.04	0.05	-0.07	-0.07	0.01	0.01	0.21	0.04	-0.02	1.00		
ρ_g	0	0.10	0.02	0.00	-0.01	0.04	0.04	0.01	0.02	-0.03	0.01	-0.01	0.04	1.00	
ρ_s	0	-0.20	-0.02	0.02	-0.13	0.11	-0.48	0.11	-0.01	0.05	0.07	0.01	0.05	-0.08	1.00