What drives the Current Account in Commodity Exporting Countries? The cases of Chile and New Zealand*

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Abstract

This paper uses an open economy DSGE model with a commodity sector and nominal and real rigidities to ask what factors account for current account developments in two small commodity exporting countries. We estimate the model, using Bayesian techniques, on Chilean and on New Zealand data, and investigate the structural factors that explain the behaviour of the two countries' current accounts. We find that foreign financial conditions, investment-specific shocks, and foreign demand account for the bulk of the variation of the current accounts of the two countries. In the case of New Zealand fluctuations in commodity export prices have also been important. Monetary and fiscal policy shocks (deviations from policy rules) are estimated to have relatively small effects on the current account. Our model predict that the unwiding of shocks that explain the current account imbalances at the end of the sample, would imply, in the case of Chile, a small current account deterioration coupled with an output expansion, an appreciation of the currency and a fall in inflation. In the case of New Zealand, there would be a persistently large current account deficit for the next couple of years, as the lagged effects of the strong exchange rate continue to feed through to import and export volumes.

1 Introduction

As capital markets have become more integrated, savings and investment within countries have tended to become less correlated (Feldstein-Horiokia (1980) correlation), with the corollary that savings-investment gaps, i.e. current accounts, have tended to become more variable. There has also been a trend toward larger gross external asset and liability positions relative to GDP, even where net positions have changed little (Lane and Milesi Ferretti 2003). The increase in both external stocks and external flows relative to income allows a more efficient matching of borrowers and savers, but it also

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creates risks for both macroeconomic stability and financial stability associated with swings in sentiment in financial markets.

Understanding the main domestic and external factors that drive variations in the external accounts is a starting point for assessing the risks of financial and macroeconomic disruption that might be associated with adjustments. We observe the current account from three "reduced form" perspectives: (i) as current account transactions - e.g., imports, exports and interest payments on debt, (ii) as financial transactions, and (iii) as the domestic savings-investment gap. When financial accounts were closed, we used to think of developments in the terms of trade and competitiveness as driving trade flows and the current account. As capital markets have opened the role of savings-investment decisions and financial flows have come to be seen as increasingly important. None of these three "reduced form" views that we observe, however, tells us about causality, or about the endogenous interactions among factors such as interest rates, exchange rates, savings and investment. To understand the underlying driving forces, we need a structural model.

This paper uses an estimated open economy DSGE model with a commodity sector and nominal and real rigidities to ask what factors account for current account developments in two small commodity exporting countries. Seven types of domestic shocks and three external shocks are considered to explain current account fluctuations. These include variations in foreign financial conditions, foreign demand, export commodity prices, productivity and investment-specific shock and macroeconomic policy. We estimate the model on Chilean and on New Zealand data, and investigate the factors that explain the similarities and differences in the behavior of the current account between these two countries.

We are particularly interested in the role played by monetary policy. In an open economy, monetary policy may work to spill demand into the current account. Exchange rate appreciation associated with a policy tightening restrains demand for exports and import-substitutes, and initially delivers cheap imports (an effect that is later reversed with a high degree of uncertainty as to timing). So the exchange rate channel delivers a degree of monetary restraint and downward pressure on inflation. However, the fall in the price of imported goods associated with exchange rate appreciation encourages expansion of import-intensive activities such as investment. In Chile and New Zealand, investment is much more import-intensive than households consumption and government expenditure so changes in the relative price of foreign goods are expected to have a large effect on capital accumulation relative to consumption.

Chile and New Zealand share many common features. They are both small open economies whose main exports are based on natural resources. Both economies have liberalised both their trade and capital accounts. Chile implemented reforms in the 1970s, including trade and financial liberalisation, and during the 1990s it embraced a policy of bilateral trade agreements and the exchange rate was floated in 1999.[1] New Zealand's external sector reforms were mainly concentrated in a short period in 1984-85. Another common feature is the macroeconomic policy framework. The central banks of both countries gained autonomy in 1989, and both operate monetary policy in an inflation targeting framework. Both governments have a commitment to prudent fiscal policy.

Despite these similarities, there are still significant differences between these two countries. Per-

[1] After the crisis in 1982 some of the reforms were pulled-back. For instance, tariffs were increased between 1983 and 1985. During the 1990s, capital controls were introduced to slow down capital inflows. Those controls were removed in 1999.

capita income in New Zealand is more that twice that in Chile, and income distribution is more equal. In Chile, profits from commodity exports accrue to the Government and foreign investors, while in New Zealand, they accrue mainly to domestic private agents. New Zealand has faced large procyclical swings in immigration, which are not a relevant phenomena in Chile. Lastly, and potentially important for understanding current-account developments, there are important differences in the structure of external liabilities. New Zealand has a much larger net stock of external debt (70 per cent of GDP) than Chile (6 per cent of GDP at the end of 2005). Somewhat offsetting the risks of a larger external position, however, New Zealand has been able to issue external debt denominated in domestic currency, while Chile, like most emerging markets, still relies on foreign-currency denominated debt.

In our estimated model, the main factors that account for fluctuations in the current accounts of both countries are investment-specific shocks, changes in foreign financial conditions (financial factors that affect the exchange rate), and variations in foreign demand. In the case of New Zealand fluctuations in commodity export prices have also been important. In both countries foreign shocks account for about half or more than half of the variation in the current account. Monetary and fiscal policy shocks (deviations from policy rules) are estimated to play a relatively small role in both countries. Our model predict that the unwiding of shocks that explain the current account imbalances at the end of the sample, would imply, in the case of Chile, a small current account deterioration coupled with an output expansion, an appreciation of the currency and a fall in inflation. In the case of New Zealand, there would be a persistently large current account deficit for the next couple of years, as the lagged effects of the strong exchange rate continue to feed through to import and export volumes.

The paper is organised as follows: the next section briefly describes the main macro developments in New Zealand and Chile over the last twenty years. Section three presents a small open economy model meant to characterise the main features of the Chilean and New Zealand economies. Model estimation is presented in section four, where we also discuss the posterior distributions of key parameters. In section five, we analyze the main transmission mechanism implied by the model for both Chile and new Zealand, by describing the impulse-response functions to different shocks. In section six we evaluate the importance of these shock by presenting the variance decomposition and the historical decomposition of the current accounts. In section seven, we perform different simulations regarding the future trajectory of the current account and other macro variables, by allowing the underlying shocks to unwind according to their expected path. We also perform some "stress test" by analyzing alternative scenarios where those shocks follow different paths. Section eight concludes.

2 Current Account and macro framework evolution

2.1 The case of Chile

During the 1970s Chile began an extensive program of economic reforms that included profound trade and financial liberalizations. By the end of that decade, and as a way of stabilizing the economy, a fixed exchange rate system was introduced. However, the persistence of inflation lead to a substantial appreciation of the real exchange rate that was exacerbated by a surge in capital inflows. The current account deteriorated sharply between 1978 until 1981 to reach a deficit of almost 12 per cent of GDP.

During 1981, the Central Bank spent more than 4 per cent of GDP in international reserves trying to defend the peg. In June 1982, a currency crisis forced the government to abandon the peg. This currency crisis was accompanied by a financial crisis and a severe recession in which GDP felt by almost 16 per cent in 1982-83.

After this crisis, there was a virtual cessation of private capital flows into the economy. The current account deficit was mostly financed with official loans from international agencies and it was steadily reduced by a sharp increase in domestic savings. It has been argued that this increase in domestic savings is explained by the pension reform of 1981 that gradually introduced a *fully-funded* pension system (Bennett, Loayza and Schmidt-Hebbel, 2001; Morandé, 1998), and by the tax reform of 1984 (Agosín, 1998). During this period the exchange rate policy was conducted by using a crawling peg. Also, in this period some of the trade liberalization of the 1970s was reversed.

In 1989, the Central Bank of Chile, like the Reserve Bank of New Zealand, obtained autonomy in the implementation of monetary policy. The new constitutional charter that granted autonomy established two main objectives for the Central Bank: stabilizing the value of the national currency, and ensuring the normal functioning of payments –including foreign payments. In 1990, the Central Bank of Chile began to announce explicit annual targets for inflation. In addition to the inflation targets, the Central Bank maintained the crawling peg for the exchange rate put in place after the crisis of 1982. The exchange rate policy was perceived as the appropriate instrument for achieving a normal functioning of the external payments system. In addition, the Central Bank set targets for the current account deficit although they were rather loosely defined (see Massad, 2003).

By the end of the 1980s the economy entered a phase of rapid growth that ended with the 1997 Asian crisis. On average, GDP grew by more than 7.5 per cent between 1989 and 1997 and inflation was reduced from level around 30 per cent per year to around 3 per cent. The period of rapid growth, coincided with a surge in capital inflows to emerging market economies (Calvo, Leiderman, and Reinhart, 1996; Fernández-Arias and Montiel, 1996), associated to both "pull factors" and "push factors" –i.e. an increase in the appetite for investing in emerging markets economies by large foreign investors. The view that part of these capital inflows were only transitory –but with potentially long-lasting effects through their impact on the real exchange rate– motivated the introduction of capital controls by June 1991. The objectives of these capital controls were to alleviate pressures on the real exchange rate coming from the capital inflows, and to modify the composition of such inflows, favouring long-term FDI. Together with imposing capital controls, the Central Bank accumulated large amounts of international reserves in an attempt to ameliorate the systematic appreciation of the real exchange rate. The Mexican crisis of 1994 led to a small and short-lived current account reversal, that had little effect on growth. However, the Asian crisis of 1997 led to a current account reversal, a sharp real depreciation of the currency, and a significant fall in GDP growth in 1998–99. The annual inflation rate dropped from 4.6 percent in 1998 to 2.3 percent in 1999. These events led the monetary authority to substantially revise its macroeconomic framework. The main new elements were the adoption of a free-floating exchange rate regime, the deepening of the foreign exchange derivatives market, and the total opening of the capital account (see Morandé, 2002). In addition, transparency increased significantly with the publication of a regular inflation report and the public release of policy meeting minutes.

During 2001 a second key element was introduced into the macro–policy framework. The Chilean government officially started implementing its fiscal policy through a *structural balance* rule. According to this rule, the government is committed to stabilize public expenditures at a level consistent with potential output and with the long-run price of copper. Therefore, this rule prevents excessive adjustments in periods of recession or unsustainable expenditure levels in periods of booms. The commitment to debt-sustainability and fiscal discipline has communicated a clear signal to the markets, and has helped to lower the costs of external financing. Despite a period of low public savings, after the Asian crisis and below trend growth, Chilean sovereign bond spreads declined substantially and their correlations with other emerging market spreads fell. More recently, the rule has meant that the government has saved most of the windfall revenues from the high price of copper.

2.2 The case of New Zealand

New Zealand has seen a net capital inflow every year since 1973. In the decade prior to 1984, interest rates below market rates drove a wedge between savings and investment. On the trade side, competitiveness was eroded by the combination of highly controlled economy, weak monetary control, declining terms of trade and the loss of favored trading status with Britain's entry into the European Economic Community. The current account deficit was financed by public borrowing abroad which led to a buildup of public overseas debt. In 1984 external financing dried up as speculative pressures grew before the July election. Reserves were run down resulting in a foreign exchange crisis.

After the election, New Zealand embarked on a major program of economic reform that included liberalisation of prices and financial markets, privatisation, and floating of the exchange rate in March 1985. This was followed, in the early 1990s, by labour market reforms. The commitment to prudent macroeconomic policy was formalised in 1989 Reserve Bank Act which gave the central bank independence in implementation of monetary policy and made explicit the inflation target objective. Fiscal debt continued to rise with the cost of reforms, but the rising trend was reversed after the 1994 Fiscal Responsibility Act formalised a commitment to prudent fiscal policy. Public debt has subsequently declined and net external public debt is now close to zero.

In the wake of the reforms the current account improved, as the share of investment to GDP declined by almost 40 per cent from 1986 to 1992. A fall in investment is typical after a currency crisis as collateral values decline. The effect of the reforms on investment is unclear. They may have exacerbated the fall in investment due to substitution toward labour as a result of relative price movements or scarcity of capital, or they may have provided an incentive to increase investment, but been overshadowed by the lasting effects of the currency crisis.

From 1993 to 1997, New Zealand saw a period of strong GDP growth and a strong recovery in investment. During this period, the current account deteriorated from about 3 to about 7 per cent of GDP – a combination of a dip in national savings and the strong recovery of investment. During this period, the real exchange rate appreciated sharply, discouraging exports and delivering cheap imported goods.

Discomfort with the effects of the strong exchange rate on the export sector contributed to a change in the central bank's policy targets agreement in 1999 to include a secondary objective of reducing volatility in inflation, interest rates, output and the exchange rate, and to the central bank being given authority to intervene in foreign exchange markets if certain conditions are met such as the exchange rate is seen as exceptional, unjustified in terms of fundamentals.

Following the Asian crisis of 1997, slower domestic demand, particularly investment demand and a large depreciation of the NZ dollar contributed to a an improvement in the current account. Again in 2001 to 2006, a period of strong growth, expansion of investment, weak domestic saving and an appreciating exchange rate contributed to a substantial deterioration of the current account from about 3 per cent of GDP to 9.7 per cent of GDP.

From a transactions perspective, the bulk of the current account deficit is accounted for by the investment income deficit which averaged 5.9 per cent of GDP from 1990 to 2006. This comprises interest payments on external debt and returns to nonresident ownership of New Zealand assets. The net stock of external liabilities is currently about 83 per cent of GDP made up of net debt of about 70 per cent of GDP and a net equity liability of about 13 per cent of GDP.

From a domestic perspective, liberalised domestic financial markets, international financial market integration, and a willingness among nonresidents to finance New Zealand dollar debt allowed New Zealand households to increase their borrowing. At the same time, the decline in nominal interest rates has enabled households to service larger debts. Household indebtedness more than doubled as a share of disposable income from about 50 per cent in 1990 to about 150 per cent in 2006. With weak domestic savings, this borrowing has been funded externally and the fall in public sector external debt has been replaced private sector external debt.

Features of the international economy that may help to explain the widening savings-investment gap are low foreign interest rates, an appetite for risk (e.g. low spreads on emerging market and sub-investment grade debt) which have contributed to a strong New Zealand dollar. This has made imports cheap, particularly so for investment goods which are import-intensive. Export values have grown much more slowly due to weak demand in several trading partners and despite high commodity export prices.

While we don't usually associate the current account with monetary policy, in an open economy monetary policy may serve to spill demand into the current account, as exchange rate appreciation leads to cheaper imports. In the recent cycle, increases in the overnight interest rate have had relatively less effect on borrowing costs as borrowers have shifted to longer term borrowing financed by foreign capital. At the same time the strong exchange rate, supported by high domestic interest rates, has encouraged import-intensive activities such as investment. This paper aims to shed light on the relative roles of these factors in understanding fluctuations in the external accounts.

3 Model

The model is a small open economy model with sticky prices and wages, and partial indexation to past inflation. Utility exhibits habit formation in consumption. Production technology includes two inputs: labor and capital, and is subject to two stochastic shocks: a stationary shock and a stochastic shock to the labor productivity trend. The latter shock introduces a unit root in the model which is important to capture trends in the main aggregates and the responses to permanent shocks. The economy grows at rate g_y in steady state. There are adjustment costs to investment and pass-through from the exchange rate to the price of imports is imperfect in the short-run. To be consistent with the features of both

Chile and New Zealand, we include a commodity sector whose production is based on natural resources and is completely exported. Finally, monetary policy is conducted through a policy rule for the interest rate.

3.1 Households

The domestic economy is inhabited by a continuum of households indexed by $j \in [0,1]$. The expected present value of the utility of household j at time t is given by:

$$U_t = E_t \left\{ \sum_{i=0}^{\infty} \beta^i \zeta_{C,t+i} \left[\log \left(C_{t+i}(j) - \tilde{h} C_{t+i-1} \right) - \zeta_L \frac{l_{t+i}(j)^{1+\sigma_L}}{1+\sigma_L} + \frac{\zeta_{\mathcal{M}}}{\mu} \left(\frac{\mathcal{M}_{t+i}(j)}{P_{C,t+i}} \right)^{\mu} \right] \right\} \tag{1}$$

where $l_t(j)$ is labor effort, $C_t(j)$ is its total consumption, and $\mathcal{M}_t(j)$ corresponds to nominal balances held at the beginning of period t. Parameter σ_L is the inverse real-wage elasticity of labor supply. The variable $\zeta_{C,t}$ is a consumption preference shock that follows an AR(1) process subject to iid innovations. ζ_L and $\zeta_{\mathcal{M}}$ determines the weights of leisure and nominal balances in the households preferences while μ defines the semi-elasticity of money demand to the nominal interest rate. Preferences display habit formation measured by parameter $\tilde{h}$; C_t is the aggregate per capita consumption in period t.[2] The consumption bundle is given by the following constant elasticity of substitution (CES) aggregator of *home* and *foreign* goods,

$$C_t(j) = \left[\gamma_C^{1/\eta_C} \left(C_{H,t}(j) \right)^{\frac{\eta_C - 1}{\eta_C}} + (1-\gamma_C)^{1/\eta_C} \left(C_{F,t}(j) \right)^{\frac{\eta_C - 1}{\eta_C}} \right]^{\frac{\eta_C}{\eta_C - 1}}$$

where η_C is the elasticity of substitution between *home* and *foreign* goods in the bundle and γ_C defines their respective weights. The optimal composition of this bundle is obtained by minimizing its cost. This minimization problem determines the demands for *home* and *foreign* goods by the household, $C_{H,t}(j)$ and $C_{F,t}(j)$ respectively, which are given by

$$C_{H,t}(j) = \gamma_C \left(\frac{P_{H,t}}{P_t} \right)^{-\eta_C} C_t(j), \qquad C_{F,t}(j) = (1-\gamma_C) \left(\frac{P_{F,t}}{P_t} \right)^{-\eta_C} C_t(j), \tag{2}$$

where $P_{H,t}$ and $P_{F,t}$ are the price indices of *home* and *foreign* goods, and $P_{C,t}$ is the price index of the consumption bundle, defined as: $P_{C,t} = \left(\gamma_C P_{H,t}^{1-\eta_C} + (1-\gamma_C) P_{F,t}^{1-\eta_C} \right)^{\frac{1}{1-\eta_C}}$.

We consider two type of households: Ricardian households and non-Ricardian households. The first type make intertemporal consumption and savings decisions in a forward looking manner by maximizing their utility subject to their intertemporal budget constraint. In contrast, non-Ricardian households consume their after-tax disposable income. This latter type of households receive no profits from firms and have no savings. We assume that a fraction λ of households are non-Ricardian households.

3.1.1 Consumption-savings decisions by Ricardian households

Ricardian households have access to four types of assets: money $\mathcal{M}_t(j)$, one-period non-contingent foreign bonds (denominated in foreign currency) $B_t^*(j)$, one-period non-contingent foreign bonds (denominated in domestic currency) $B_t(j)$, and one-period domestic contingent bonds $\mathcal{D}_{t+1}(j)$ which pays

[2] Since the economy grows in the steady state, we adjust the habit formation parameter in the preferences to $\tilde{h} = h(1+g_y)$ where h corresponds to the habit formation parameter in an economy without steady-state growth.

out one unit of domestic currency in a particular state (state contingent securities). The budget constraint of households j is given by:

$$P_{C,t}C_t(j) + E_t\{d_{t,t+1}\mathcal{D}_{t+1}(j)\} + \frac{\mathcal{E}_t B_t^*(j)}{\left(1+i_{f,t}^*\right)\Theta_f(\mathcal{B}_t)} + \frac{B_t(j)}{\left(1+i_{d,t}^*\right)\Theta_d(\mathcal{B}_t)} + \mathcal{M}_t(j) =$$
$$W_t(j)l_t(j) + \Pi_t(j) - \mathcal{T}_{p,t} + \mathcal{D}_t(j) + \mathcal{E}_t B_{t-1}^*(j) + B_{t-1}(j) + \mathcal{M}_{t-1}(j),$$

where $\Pi_t(j)$ are profits received from domestic firms, $W_t(j)$ is the nominal wage set by the household, $\mathcal{T}_{p,t}$ is per-capita lump-sum net taxes from the government, and $\mathcal{E}_t$ is the nominal exchange rate (expressed as units of domestic currency per one unit of foreign currency). Variable $d_{t,t+1}$ is the period t price of one-period domestic contingent bonds normalized by the probability of the occurrence of the state. Assuming the existence of a full set of contingent bonds ensures that consumption of all Ricardian households is the same, independently of the labor income they receive each period.

Variable $i_{f,t}^*$ is the interest rate on foreign bond denominated in foreign currency, and $i_{d,t}^*$ is the interest rate on foreign bond denominated in domestic currency. The terms $\Theta_f(.)$ and $\Theta_d(.)$ are the premiums domestic households have to pay when they borrow from abroad, either in foreign or domestic currency. They are functions of the net foreign asset positions relative to GDP, $\mathcal{B}_t$, which is given by

$$\mathcal{B}_t = \frac{\mathcal{E}_t B_t^*}{P_{Y,t}Y_t} + \frac{B_t}{P_{Y,t}Y_t}$$

where $P_{Y,t}Y_t$ is nominal GDP, B_t^* and B_t are the aggregate net asset position of the economy denominated in foreign and domestic currency, respectively.[3]

The fact that the premium depends on the aggregate net asset position –and not the individual position– implies that Ricardian households take it as an exogenous variable when optimizing.[4] In the steady state we assume that $\Theta_f(.) = \Theta_f$ and $\Theta_d(.) = \Theta_d$ (constants), and that $\frac{\Theta_f'}{\Theta_f}\mathcal{B} = \varrho_f$ and $\frac{\Theta_d'}{\Theta_d}\mathcal{B} = \varrho_d$. When the country is a net debtor, ϱ_f and ϱ_d correspond to the elasticities of the upward-slopping supply of international funds.

Each Ricardian household chooses a consumption path and the composition of its portfolio by maximizing (1) subject to its budget constraint. The first order conditions on different contingent claims over all possible states define the following Euler equation for consumption:

$$\beta E_t\left\{(1+i_t)\frac{P_{C,t}}{P_{C,t+1}}\frac{\zeta_{C,t+1}}{\zeta_{C,t}}\left(\frac{C_{t+1}(j) - \tilde{h}C_t}{C_t(j) - \tilde{h}C_{t-1}}\right)\right\} = 1, \quad \text{for all } j \in (\lambda, 1] \tag{3}$$

where we have used the fact that in equilibrium $1/E_t[d_{t,t+1}] = 1 + i_t$, where i_t is the domestic risk-free interest rate. From this expression and the first order condition with respect to foreign bonds denominated in foreign currency we obtain the following expression for the uncovered interest parity (UIP) condition:

$$\frac{1+i_t}{\left(1+i_{f,t}^*\right)\Theta_f(\mathcal{B}_t)} = \frac{E_t\left\{\frac{P_t}{P_{t+1}}\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}\frac{\zeta_{C,t+1}}{\zeta_{C,t}}\left(\frac{C_{t+1}(j)-\tilde{h}C_t}{C_t(j)-\tilde{h}C_{t-1}}\right)\right\}}{E_t\left\{\frac{P_t}{P_{t+1}}\frac{\zeta_{C,t+1}}{\zeta_{C,t}}\left(\frac{C_{t+1}(j)-\tilde{h}C_t}{C_t(j)-\tilde{h}C_{t-1}}\right)\right\}} \quad \text{for all } j \in (\lambda, 1]. \tag{4}$$

[3] In our notation, $B_t^* = \int_\lambda^1 B_t^*(j)dj$ and $B_t = \int_\lambda^1 B_t(j)dj$.

[4] This premium is introduced mainly as a technical device to ensure stationarity (see Schmitt-Grohé and Uribe, 2001).

Analogously, from the first order condition with respect to foreign bonds denominated in domestic currency we get the following parity condition:

$$\frac{1+i_t}{\left(1+i_{d,t}^*\right)\Theta_d\left(\mathcal{B}_t\right)}=1. \tag{5}$$

These arbitrage conditions must hold independently of whether domestic agents are borrowing in domestic or foreign currency. The foreign interest rate is assumed to be unobservable and to follow an AR(1) process subject to iid shocks. These shocks to i_t^* (which we call shocks to foreign financial conditions or UIP shocks) capture all foreign financial factors, including price, risk premia and any flow effects that influence the exchange rate.

3.1.2 Labor supply and wage setting

Each household j is a monopolistic supplier of a differentiated labor service. There is a set of perfectly competitive labor service assemblers that hire labor from each household and combine it into an aggregate labor service unit,

$$l_t=\left(\int_0^1 l_t(j)^{\frac{\epsilon_L-1}{\epsilon_L}}dj\right)^{\frac{\epsilon_L}{\epsilon_L-1}}$$

This labor unit is then used as an input in production of domestic intermediate varieties. Parameter ϵ_L corresponds to the elasticity of substitution among different labor services.

Following Erceg *et al.* (2000) we assume that wage setting is subject to a nominal rigidity à la Calvo (1983). In each period, each type of household faces a probability $1-\phi_L$ of being able to re-optimize its nominal wage. In this set-up, parameter ϕ_L is a measure of the degree of nominal rigidity. The larger is this parameter the less frequently wages are adjusted (i.e. the more sticky they are). We assume that all those households that cannot re-optimize their wages follow an updating rule considering a geometric weighted average of past CPI inflation, and the inflation target set by the authority, $\overline{\pi}_t$. Once a household has set its wage, it must supply any quantity of labor service demanded at that wage. A particular household j that is able to re-optimize its wage at t must solve the following problem:

$$\max_{W_t(j)}=E_t\left\{\sum_{i=0}^{\infty}\phi_L^i\Lambda_{t,t+i}\left[\frac{\Gamma_{W,t}^iW_t(j)}{P_{C,t+i}}l_{t+i}\left(j\right)-\zeta_L\frac{l_{t+i}(j)^{1+\sigma_L}}{1+\sigma_L}\left(C_{t+i}-\tilde{h}C_{t+i-1}\right)\right]\right\}$$

subject to labor demand and the updating rule for the nominal wage of agents who do not optimize defined by function $\Gamma_{W,t}^i$.[5] Variable $\Lambda_{t,t+i}$ is the relevant discount factor between periods t and $t+i$.[6]

[5] All those that cannot re-optimize during i periods between t and $t+i$, set their wages at time $t+i$ to $W_{t+i}(j)=\Gamma_{W,t}^iW_t(j)$, where $\Gamma_{W,t}^i=\left(T_{t+i}/T_{t+i-1}\right)\left(1+\pi_{C,t+i-1}\right)^{\chi_L}\left(1+\overline{\pi}_{t+i}\right)^{1-\chi_L}\Gamma_{W,t}^{i-1}$ and $\Gamma_{W,t}^0=1$. T_t is a stochastic trend in labor productivity. This term in the updating rule prevents an increasing dispersion in the real wages across households along the steady-state balanced growth path.

[6] Since utility exhibits habit formation in consumption the relevant discount factor is given by $\Lambda_{t,t+i}=\beta^i\left(\frac{C_t-\tilde{h}C_{t-1}}{C_{t+i}-\tilde{h}C_{t+i-1}}\right)$.

3.1.3 Non-Ricardian households

Since non-Ricardian households have no access to assets and own no shares in domestic firms, they consume all of their disposable after-tax disposable income, which consists of labor income minus per-capita lump-sum taxes:

$$C_t(j) = \frac{W_t}{P_{C,t}} l_t(j) - \frac{\mathcal{T}_{p,t}}{P_{C,t}}, \text{ for } j \in [0, \lambda] \tag{6}$$

For simplicity we have assume that non-Ricardian households set wages equal to the average wage set by Ricardian households. Given the labor demand for each type of labor, this assumption implies that labor effort of non-Ricardian households coincides with the average labor effort by Ricardian households.

3.2 Investment and capital goods

There is a representative firm that rents capital goods to firms producing intermediate varieties. This firm decides how much capital to accumulate each period. New capital goods are assembled using a CES technology that combines *home* and *foreign* goods as follows:

$$I_t = \left[\gamma_I^{1/\eta_I} I_{H,t}^{1-\frac{1}{\eta_I}} + (1-\gamma_I)^{1/\eta_I} I_{F,t}^{1-\frac{1}{\eta_I}} \right]^{\frac{\eta_I}{\eta_I - 1}} \tag{7}$$

where η_I is the elasticity of substitution between *home* and *foreign* goods, and where parameter γ_I is the share of home goods in investment. The demands for home and foreign goods by the firm are given by

$$I_{H,t} = \gamma_I \left(\frac{P_{H,t}}{P_{I,t}} \right)^{-\eta_I} I_t, \qquad I_{F,t} = (1-\gamma_I) \left(\frac{P_{F,t}}{P_{I,t}} \right)^{-\eta_I} I_t, \tag{8}$$

where $P_{I,t}$ is the investment price index, given by $P_{I,t} = \left[\gamma_I P_{H,t}^{1-\eta_I} + (1-\gamma_I) P_{F,t}^{1-\eta_I} \right]^{\frac{1}{1-\eta_I}}$, and where I_t is total investment.

The firm may adjust investment each period, but changing investment is costly. This assumption is introduced as a way to obtain more inertia in the demand for investment (see Christiano *et al.* (2005)). It represents a short-cut to more cumbersome approaches to model investment inertia, such as time-to-build.

Let Z_t be the rental price of capital. The representative firm must solve the following problem:

$$\max_{K_{t+i}, I_{t+i}} E_t \left\{ \sum_{i=0}^{\infty} \Lambda_{t,t+i} \frac{Z_{t+i} K_{t+i} - P_{I,t+i} I_{t+i}}{P_{C,t+i}} \right\},$$

subject to the law of motion of the capital stock,

$$K_{t+1} = (1-\delta) K_t + \zeta_{I,t} S \left(\frac{I_t}{I_{t-1}} \right) I_t, \tag{9}$$

where δ is its depreciation rate. Function $S(.)$ characterizes the adjustment cost for investment. This adjustment cost satisfies: $S(1+g_y) = 1$, $S'(1+g_y) = 0$, $S''(1+g_y) = -\mu_S < 0$. The variable $\zeta_{I,t}$ is a stochastic shock that alters the rate at which investment is transformed into productive capital. A rise in ζ_I implies the same amount of investment generates more productive capital.[7]

The optimality conditions for the problem above are the following:

$$\begin{aligned} \frac{P_{I,t}}{P_{C,t}} &= \frac{Q_t}{P_{C,t}}\left[S\left(\frac{I_t}{I_{t-1}}\right)+S'\left(\frac{I_t}{I_{t-1}}\right)\frac{I_t}{I_{t-1}}\right]\zeta_{I,t}- \\ & E_t\left\{\Lambda_{t,t+1}\frac{Q_{t+1}}{P_{C,t+1}}\left[S'\left(\frac{I_{t+1}}{I_t}\right)\left(\frac{I_{t+1}}{I_t}\right)^2\right]\zeta_{I,t+1}\right\}, \end{aligned} \tag{10}$$

$$\frac{Q_t}{P_{C,t}} = E_t\left\{\Lambda_{t,t+1}\left(\frac{Z_{t+1}}{P_{C,t+1}}+\frac{Q_{t+1}}{P_{C,t+1}}(1-\delta)\right)\right\}. \tag{11}$$

These two equations simultaneously determine the evolution of the shadow price of capital, Q_t, and real investment expenditure.

3.3 Domestic production

There is a large set of firms that use a CES technology to assemble *home* goods using domestic intermediate varieties. These firms sell *home* goods in the domestic market and abroad. Let $Y_{H,t}$ be quantity of *home* goods sold domestically, and $Y^*_{H,t}$ the quantity sold abroad. The demands for a particular intermediate variety z_H by these assemblers are given by:

$$Y_{H,t}(z_H) = \left(\frac{P_{H,t}(z_H)}{P_{H,t}}\right)^{-\epsilon_H} Y_{H,t}, \qquad Y^*_{H,t}(z_H) = \left(\frac{P^*_{H,t}(z_H)}{P^*_{H,t}}\right)^{-\epsilon_H} Y^*_{H,t}, \tag{12}$$

where $P_H(z_H)$ is the price of the variety z_H when used to assemble *home* goods sold in the domestic market, and $P^*_{H,t}(z_H)$ is the foreign-currency price of this variety when used to assemble *home* goods sold abroad. Variables $P_{H,t}$ and $P^*_{H,t}$ are the corresponding aggregate price indices.

Intermediate varieties are produced by firms that have monopoly power that variety. These firms maximize profits by choosing the prices of their differentiated good subject to the corresponding demands, and the available technology. Let $\mathbf{Y}_{H,t}(z_H)$ be the total quantity produced of a particular variety z_H. The available technology is given by

$$\mathbf{Y}_{H,t}(z_H) = A_{H,t}\left[T_t l_t(z_H)\right]^{\eta_H}\left[K_t(z_H)\right]^{1-\eta_H}, \tag{13}$$

where $l_t(z_H)$ is the amount of labor utilized, and $K_t(z_H)$ is the amount of physical capital rented. Parameter η_H defines their corresponding shares in production. Variable $A_{H,t}$ represents a stationary productivity shock common to all firms. The variable T_t is a stochastic trend in labor productivity, given by

$$\frac{T_t}{T_{t-1}} = \zeta_{T,t} \tag{14}$$

The exogenous shocks to both types of technology process are given by

$$A_{H,t} = A_{H,t-1}^{\rho_{a_H}} \exp \varepsilon_{a_H,t} \qquad \zeta_{T,t} = (1+g_y)^{1-\rho_T}\,\zeta_{T,t-1}^{\rho_T} \exp \varepsilon_{T,t}$$

[7] Greenwood *et al.* (2000) argue that this type of investment-specific shocks are relevant to explain business cycle fluctuations in US.

where $\varepsilon_{a_H,t} \sim N\left(0,\sigma_{a_H}^2\right)$ and $\varepsilon_{T,t} \sim N\left(0,\sigma_T^2\right)$ are i.i.d innovations

In every period, the probability that a firm receives a signal for adjusting its price for the domestic market is $1-\phi_{H_D}$, and the probability of adjusting its price for the foreign market is $1-\phi_{H_F}$. These probabilities are the same for all firms, independently of their history. If a firm does not receive a signal, it updates its price following a simple rule that weights past inflation and the inflation target set by the central bank. Thus, when a firm receives a signal to adjust its price for the domestic market it solves:

$$\max_{P_{H,t}(z_H)} E_t \left\{ \sum_{i=0}^{\infty} \Lambda_{t,t+i} \phi_{H_D}^i \frac{\Gamma_{H_D,t}^i P_{H,t}(z_H) - MC_{H,t+i}}{P_{C,t+i}} Y_{H,t+i}(z_H) \right\},$$

subject to (12) and the updating rule for prices, $\Gamma_{H_D,t}^i$. Analogously, if the firm receives a signal to adjust optimally its price for the foreign market, then it solves:

$$\max_{P_{H,t}^*(z_H)} E_t \left\{ \sum_{i=0}^{\infty} \Lambda_{t,t+i} \phi_{H_F}^i \frac{\mathcal{E}_{t+i} \Gamma_{H_F,t}^i P_{H,t}^*(z_H) - MC_{H,t+i}}{P_{C,t+i}} Y_{H,t+i}^*(z_H) \right\},$$

subject to (12) and the updating rule for firms that do not optimize prices defined by $\Gamma_{H_F,t}^i$.[8] Given this pricing structure, the optimal path for inflation is given by a New Keynesian Philips curve with indexation. In its log-linear form, Inflation depends on both last period's inflation, expected inflation next period and marginal cost.

The variable $MC_{H,t}$ corresponds to marginal costs of producing variety z_H, which are given by,

$$MC_{H,t} = \frac{1}{\eta_H} W_t \frac{l_t(z_H)}{\mathbf{Y}_{H,t}(z_H)}. \tag{15}$$

Given the constant return to scale technology available to firms, and the fact that there are no adjustment costs for inputs which are hired from competitive markets, marginal cost is independent of the scale of production. More precisely, $l_t(z_H)/\mathbf{Y}_{H,t}(z_H)$ is just a function of the relative price of inputs.

3.4 Import goods retailers

We introduce local-currency price stickiness in order to allow for incomplete exchange rate pass-through into import prices in the short-run. This feature of the model is important in order to mitigate the expenditure switching effect of exchange rate movements for a given degree of substitution between foreign and home goods.

There is a set of competitive assemblers that use a CES technology to combine a continuum of differentiated imported varieties to produce a final *foreign* good Y_F. This good is consumed by households and used for assembling new capital goods. The optimal mix of imported varieties in the final *foreign* good defines the demands for each of them. In particular, the demand for variety z_F is given by:

$$Y_{F,t}(z_F) = \left(\frac{P_{F,t}(z_F)}{P_{F,t}}\right)^{-\epsilon_F} Y_{F,t}, \tag{16}$$

[8] If the firm does not adjust its price for the domestic market between t and $t+i$, then the price it charges at $t+i$ will be $P_{H,t+i}(z_H) = \Gamma_{H_D,t}^i P_{H,t}(z_H)$, where $\Gamma_{H_D,t}^i = \Gamma_{H_D,t}^{i-1}(1+\bar{\pi}_{t+i})^{1-\chi_{H_D}} \left(P_{H,t+i}/P_{H,t+i-1}\right)^{\chi_{H_D}}$ and $\Gamma_{H_D,t}^0 = 1$. If the firm does not adjust its price for the foreign market, then the price charged at $t+i$ will be $P_{H,t+i}^*(z_H) = \Gamma_{H_F,t}^i P_{H,t}^*(z_H)$, where $\Gamma_{H_F,t}^i = \Gamma_{H_F,t}^{i-1}\left(P_{F,t}^*/P_{F,t-1}^*\right)^{1-\chi_{H_F}} \left(P_{H,t+i}^*/P_{H,t+i-1}^*\right)^{\chi_{H_F}}$ and $\Gamma_{H_F,t}^0 = 1$.

where ϵ_F is the elasticity of substitution among imported varieties, $P_{F,t}(z_F)$ is the domestic-currency price of imported variety z_F in the domestic market, and $P_{F,t}$ is the aggregate price of import goods in this market.

Importing firms buy varieties abroad and re-sales them domestically to assemblers. Each importing firm has monopoly power in the domestic retailing of a particular variety. They adjust the domestic price of their varieties infrequently, only when receiving a signal. The signal arrives with probability $1-\phi_F$ each period. As in the case of domestically produced varieties, if a firm does not receive a signal it updates its price following a "passive" rule.[9] Therefore, when a generic importing firm z_F receives a signal, it chooses a new price by maximizing the present value of expected profits:

$$\max_{P_{F,t}(z_F)} E_t \left\{ \sum_{i=0}^{\infty} \Lambda_{t,t+i} \phi_F^i \frac{\Gamma_{F,t}^i P_{F,t}(z_F) - \mathcal{E}_{t+i} P_{F,t+i}^*(z_F)}{P_{C,t+i}} Y_{F,t+i}(z_F) \right\},$$

subject to the domestic demand for variety z_F (16) and the updating rule for prices. For simplicity, we assume that $P_{F,t}^*(z_F) = P_{F,t}^*$ for all z_F.

In this setup, changes in the nominal exchange rate will not immediately be passed through into prices of imported good sold domestically. Therefore, exchange rate pass-through will be incomplete in the short-run. In the long-run firms freely adjust their prices, so the law-of-one-price holds up to a constant.

3.5 Commodity sector

We assume that a single firm produces a homogenous commodity good that is completely exported abroad. Production evolves with the same stochastic trend as other aggregate variables and requires no inputs:

$$Y_{S,t} = \left[\frac{T_t}{T_{t-1}} Y_{S,t-1}\right]^{\rho_{y_S}} [T_t Y_{S,0}]^{1-\rho_{y_S}} \exp(\varepsilon_{y_S,t}),$$

where $\varepsilon_{y_S,t} \sim N(0, \sigma_{y_S}^2)$ is a stochastic shock and ρ_{y_S} captures the persistence of the shock to the production process.[10] This sector is particularly relevant for the two economies, as it captures the developments in the copper sector in the case of Chile, and natural resources production in the case of New Zealand.

An increase in commodity production implies directly an increase in domestic GDP. Because there are no inputs, an increase in production comes as a windfall gain. It also may increase exports, if no counteracting effect on home goods exports dominates. We would expect that, as with any increase of technological frontier of tradable goods, a boom in this sector would induce an exchange rate appreciation. The magnitude of the appreciation would depend on the structural parameters governing the degree of intratemporal and intertemporal substitution in aggregate demand and production.

[9] This "passive" rule is defined by $\Gamma_{F,t}^i = \Gamma_{F,t}^{i-1}(1+\bar{\pi}_{t+i})^{1-\chi_F}(P_{F,t+i}/P_{F,t+i-1})^{\chi_F}$ and $\Gamma_{F,t}^0 = 1$.

[10] Production in this sector could be interpreted as the exogenous evolution of a stock of natural resources, and in the case of New Zealand, factors such as weather.

3.6 Fiscal policy

Let $B^*_{G,t}$ and $B_{G,t}$ be the net asset position of government in foreign and domestic currency, respectively. The evolution of the total the net position of the government is given by:

$$\frac{\mathcal{E}_t B^*_{G,t}}{(1+i^*_t)\,\Theta\left(\frac{\mathcal{E}_t B^*_t}{P_{Y,t}Y_t}\right)} + \frac{B_{G,t}}{(1+i_t)} = \mathcal{E}_t B^*_{G,t-1} + B_{G,t} + \mathcal{T}_t - P_{G,t}G_t,$$

where $(1+i^*_t)\,\Theta(.)$ is the relevant gross interest rate for public asset denominated in foreign currency while $(1+i_t)$ is the one for public asset denominated in domestic currency. Variable G_t is government expenditure and $\mathcal{T}_t$ are total net fiscal nominal revenues (income tax revenues minus transfers to the private sector). We assume that the basket consumed by the government includes both home and foreign goods:

$$G_t = \left[\gamma_G^{\frac{1}{\eta_G}} G_{H,t}^{\frac{\eta_G-1}{\eta_G}} + (1-\gamma_G)^{\frac{1}{\eta_G}} G_{F,t}^{\frac{\eta_G-1}{\eta_G}}\right]^{\frac{\eta_G}{\eta_G-1}}$$

The government decides the composition of its consumption basket by minimizing its cost. The demands for the two types of goods from the government is given by

$$G_{H,t} = \gamma_G\left(\frac{P_{H,t}}{P_{G,t}}\right)^{-\eta_G} G_t, \qquad G_{F,t} = (1-\gamma_G)\left(\frac{P_{F,t}}{P_{G,t}}\right)^{-\eta_G} G_t,$$

where the deflator of government expenditure (which is defined as the minimum expenditure required to buy one unit of G_t) is given by: $P_{G,t} = \left[\gamma_G P_{H,t}^{1-\eta_G} + (1-\gamma_G)P_{F,t}^{1-\eta_G}\right]^{\frac{1}{1-\eta_G}}$. To simplify the model we assume the government consumes only *home* goods: $\gamma_G = 1$.

Fiscal policy is defined by the four variables $B^*_{G,t}$, $B_{G,t}$ $\mathcal{T}_{,t}$ and G_t. Therefore, given the budget constraint of the government, it is necessary to define a behavioral rule for three of these four variables.

Portfolio considerations can give rise of a preferable composition for the public asset holdings either in foreign and domestic currency. When agents are Ricardian, defining a trajectory for the primary deficit is irrelevant for the households decisions, as long as the budget constraint of the government is satisfied. On the contrary, when a fraction of the agents are non-Ricardian then the trajectory of the public debt and the primary deficit are relevant. In addition, the path of public expenditure may be relevant on its own as long as its composition differs from the composition of private consumption.

3.6.1 Chile

In the case of Chile we assume that a relevant fraction of households are non-Ricardian ($\lambda > 0$). Hence, the timing of the fiscal variables is relevant for the private sector. We also consider that public asset position is denominated in foreign currency. Fiscal revenues come from two sources: tax income from the private sector, which is a function of GDP, $\mathcal{T}_{p,t} = (\tau_t P_{Y,t}Y_t)$, and revenues from copper which are given by $P_{S,t}\chi Y_{S,t}$, where $\chi Y_{S,t}$ are copper sales from the state company. The parameter χ defines the domestic share of ownership in total copper production which, in turn, it is assumed to be only public in the case of Chile. The variable τ_t corresponds to the average income tax.

More importantly, we consider that the Chilean government follows the structural balance fiscal rule (see Medina and Soto, 2006a). This implies that government expenditure as a share of GDP is given by the following expression:

$$\begin{aligned} \frac{P_{G,t}G_t}{P_{Y,t}Y_t} &= \left\{ \left(1 - \frac{1}{\left(1+i^*_{t-1}\right)\Theta_{t-1}}\right) \frac{\mathcal{E}_t}{\mathcal{E}_{t-1}} \frac{\mathcal{E}_{t-1}B^*_{G,t-1}}{P_{Y,t-1}Y_{t-1}} \frac{P_{Y,t-1}Y_{t-1}}{P_{Y,t}Y_t} + \right. \\ & \left. \tau\left(\frac{\overline{Y}_t}{Y_t}\right) + \mathcal{E}_t \overline{P}^*_{S,t}\chi \frac{Y_{S,t}}{P_{Y,t}Y_t} - \frac{B_{S,t}}{P_{Y,t}Y_t} \right\} \exp\left(\zeta_{G,t}\right) \end{aligned} \tag{17}$$

where $\overline{P}^*_{S,t}$ is the long-run ("reference") price of copper, and $\zeta_{G,t}$ is a shock that captures deviation of government expenditure from this fiscal rule. This shock follows an AR(1) process with i.i.d. innovations. The purpose of this fiscal rule is to avoid excessive fluctuations in government expenditure coming from transitory movements in fiscal revenues. For example, in the case of a transitory rise of fiscal revenues originated by copper price increases, the rule implies that this additional fiscal income should be mainly save. Notice that the level of public expenditure that is consistent with the rule includes interest payments. Therefore, if the net position of the government improves, current expenditure may increase.

3.6.2 New Zealand

In the case of New Zealand we assume that all households are Ricardian ($\lambda = 0$). Therefore, *Ricardian equivalence* holds and the particular mix of assets and liabilities that finance government absorption is irrelevant. For that reason, and without lost of generality, we abstract from government debt and assume that lump-sum taxes are adjusted in every period to keep the government budget balanced. Its expenditure follows a stochastic process given by

$$G_t = \left[\frac{T_t}{T_{t-1}}G_{t-1}\right]^{\rho_G} \left[T_t G_0\right]^{(1-\rho_G)} \exp\left(\varepsilon_{g,t}\right), \tag{18}$$

where $\varepsilon_{g,t} \sim N(0, \sigma_g^2)$ is an iid shock to government expenditure and $\rho_G \in (0,1)$ determines its persistence.

An important difference in the policy rule assumed for Chile from the rule for New Zealand is that the former allows for accumulation or de-accumulation of net assets by the government. However, the effects of a shock under either rule would be the same if all agents are Ricardian.

3.7 Monetary policy rule

3.7.1 Chile

Monetary policy in the case of Chile is characterized as a simple feedback rule for the *real* interest rate. Under the baseline specification of the model, we assume that the central bank responds to deviations of CPI inflation from target and to deviations of output from its trend. We also allow the central bank to react to deviations of the real exchange from a long-run level. This is meant to capture the fact that the CBC had a target for the exchange rate over most of the sample period. We approximate the monetary policy rule by:

$$\frac{1+r_t}{1+r} = \left(\frac{1+r_{t-1}}{1+r}\right)^{\psi_i} \left(\frac{Y_t}{\overline{Y}_t}\right)^{(1-\psi_i)\psi_y} \left(\frac{1+\pi_t}{1+\overline{\pi}_t}\right)^{(1-\psi_i)(\psi_\pi - 1)} \left(\frac{RER_t}{R\bar{E}R}\right)^{(1-\psi_i)\psi_{rer}} \exp\left(\nu_t\right) \tag{19}$$

where $\pi_t = P_{C,t}/P_{C,t-1} - 1$ is consumer price inflation and $\overline{\pi}_t$ is the inflation target set for period t, and $r_t = (1+i_t)/(P_{C,t}/P_{C,t-1}) - 1$ is the net (ex-post) real interest rate. $(RER_t/\overline{RER})$ is the deviation of real exchange rate deviations from its long-run level. Variable ν_t is a monetary policy shock that corresponds to a deviation from the policy rule and it is assumed to be an iid innovation.

We define a rule in terms of the real interest rate to be consistent with the practice of the CBC during most part of the sample period utilized to estimate the model.[11] As mentioned before, at the end of 1999 Chile adopted a fully-fledged inflation targeting framework and abandoned the target zone for the exchange rate. In order to capture this policy shift, we allow for a discrete change in the parameters of the monetary policy rule. Let $\boldsymbol{\varpi}(t)$ be a vector containing the parameters of the monetary policy rule in period t. We assume that:

$$\boldsymbol{\varpi}(t) = \begin{cases} \boldsymbol{\varpi_1}, & \text{if} \quad t \leq 1999\text{:Q4} \\ \boldsymbol{\varpi_2}, & \text{if} \quad t > 1999\text{:Q4} \end{cases}$$

Hence, $\boldsymbol{\varpi}_1$ captures the value of the monetary policy coefficients for the first period of the sample and $\boldsymbol{\varpi}_2$ for the second period. To be consistent with the adoption of the fully-fledged inflation targeting framework after 1999, we impose $\psi_{rer,2} = 0$ for the second period.[12]

3.7.2 New Zealand

Monetary policy in New Zealand is characterized as a simple feedback rule for the *nominal* interest rate. The inflation target objective set out in the Policy Targets Agreement (PTA) between the Bank and the Government, is specified in terms of CPI inflation and a target band. As monetary policy influences the economy with a lag, this may be seen as an inflation forecast rule.[13]

Here the central bank is assumed to respond to deviations of CPI inflation from target (assumed to be 2 per cent for the period) and to deviations of output from its trend.[14] The latter improves empirical fit and adds a degree of forward-lookingness to the rule without increasing the state-space of the model.

$$\frac{1+i_t}{1+i} = \left(\frac{1+i_{t-1}}{1+i}\right)^{\psi_i} \left(\frac{Y_t}{\overline{Y}_t}\right)^{(1-\psi_i)\psi_y} \left(\frac{1+\pi_t}{1+\overline{\pi}_t}\right)^{(1-\psi_i)\psi_\pi} \exp(\nu_t) \tag{20}$$

As in the case of Chile, π_t is the inflation rate measured by the consumer price index, $\overline{\pi}_t$ is the inflation target for period t, and ν_t is a monetary policy shock which it is assumed to be an iid innovation.

[11] From 1985 to July 2001 the CBC utilized an index interest rate as its policy instrument. This indexed interest rate corresponds roughly to an ex-ante real interest rate (Fuentes *et al.*, 2003).

[12] This change in parameter values is assumed to be permanent and unanticipated. This means that when agents make decisions, they expect that these parameters will remain constant for ever.

[13] The policy rule in the Bank's forecasting model features inflation 6 to 8 quarters ahead. The PTA also requires the Bank to avoid unnecessary instability in output, interest rates and the exchange rate. The Bank did explicitly respond to exchange rate developments in 1986-1988 when a monetary conditions index was used to guide policy between forecast rounds. However, several papers suggest that including the exchange rate in the rule gains little, even if the exchange rate is included in the loss function, because of unfavorable volatility tradeoffs. See West (2003). The gain in empirical fit from including the exchange rate in the rule is small.

[14] In practice, the target has changed over the period. Initially it was set at 0 to 2 per cent, and later changed to 0 to 3 percent and then 1 to 3 per cent.

3.8 Foreign sector

Foreign agents demand both the *commodity* good and *home* goods. The demand for the commodity good is completely elastic at the international price $P^*_{S,t}$. The law of one price holds for this good. Therefore, its domestic-currency price is given by,

$$P_{S,t} = \mathcal{E}_t P^*_{S,t}, \tag{21}$$

We assume that the real price of the commodity good abroad, $Pr^*_{S,t} = P^*_{S,t}/P^*_t$ follows an autoregressive process of order one. The variable P^*_t is the foreign price index, i.e., the price of a "representative" bundle abroad.

The real exchange rate is defined as the relative price of the foreign "representative" bundle and the price of the consumption bundle in the domestic economy:

$$RER_t = \frac{\mathcal{E}_t P^*_{F,t}}{P_{C,t}}. \tag{22}$$

Foreign demand for the *home* good depends on its relative price and the total foreign aggregate demand, Y^*_t:

$$Y^*_{H,t} = \gamma^* \left(\frac{P^*_{H,t}}{P^*_{F,t}} \right)^{-\eta^*} Y^*_t, \tag{23}$$

where γ^* corresponds to the share of domestic intermediate goods in the consumption basket of foreign agents, and η^* is the price elasticity of demand. This demand function can be derived from a CES utility function with an elasticity of substitution across varieties equal to η^*. Foreign output is assumed to have a stochastic trend similar to the one in the domestic economy.

$$Y^*_t = \left[\frac{T_t}{T_{t-1}} Y^*_{t-1} \right]^{\rho_{Y^*}} \left[T_t Y^*_0 \right]^{1-\rho_{Y^*}} \exp\left(\varepsilon_{Y^*,t}\right), \tag{24}$$

where $\varepsilon_{Y^*,t} \sim N(0, \sigma^2_{Y^*})$ is a shock to foreign output and $\rho_{Y^*} \in (0,1)$ determines its persistence.

3.9 Aggregate equilibrium

Firms producing varieties must satisfy demand at the current price. Therefore, the market clearing condition for each variety implies that:

$$\mathbf{Y}_{H,t}\left(z_H\right) = \left(\frac{P_{H,t}(z_H)}{P_{H,t}} \right)^{-\epsilon_H} Y_{H,t} + \left(\frac{P^*_{H,t}(z_H)}{P^*_{H,t}} \right)^{-\epsilon_H} Y^*_{H,t}$$

where $Y_{H,t} = C_{H,t} + I_{H,t} + G_t$, and where $Y^*_{H,t}$ is defined in (23). Equilibrium in the labor market implies that total labor demand by producers of by intermediate varieties must be equal to labor supply: $\int_0^1 l_t(z_H) dz_H = l_t$.

Since the economy is open and there is no international reserves accumulation by the central bank and no capital transfers, the current account is equal to the financial account. We differentiate the case of Chile and New Zealand. For Chile, we assume that all debt is denominated in foreign currency. For the case of New Zealand we assume that all foreign debt is denominated in domestic currency. Hence, the net foreign asset position to GDP ratio, $\mathcal{B}_t$ for each country is given by:

$$\mathcal{B}_t = \begin{cases} \frac{\mathcal{E}_t B_t^*}{P_{Y,t} Y_t} & \text{in the case of Chile} \\ \frac{B_t}{P_{Y,t} Y_t} & \text{in the case of New Zealand} \end{cases}.$$

Using the equilibrium conditions in the goods and labor markets, and the budget constraint of households and the government, we obtain the following expression for the evolution of the net foreign asset position in the case of Chile:

$$\frac{\mathcal{B}_t}{(1+i_{f,t}^*)\Theta_f(\mathcal{B}_t)} = \frac{\mathcal{E}_{t-1}}{\mathcal{E}_t} \frac{P_{Y,t-1} Y_{t-1}}{P_{Y,t} Y_t} \mathcal{B}_{t-1} - (1-\chi) \frac{P_{S,t} Y_{S,t}}{P_{Y,t} Y_t} + \frac{P_{X,t} X_t}{P_{Y,t} Y_t} - \frac{P_{M,t} M_t}{P_{Y,t} Y_t}, \tag{25}$$

where χ is the share of the domestic agents (only government in the case of Chile) in the revenues from the commodity sector ($(1-\chi)$ is the share of foreigners) and $P_{Y,t} Y_t = P_t C_t + P_{H,t} G_t + P_{I,t} I_t + P_{X,t} X_t - P_{M,t} M_t$ is the nominal GDP –measured from demand side. Nominal imports and exports are given by $P_{M,t} M_t = \mathcal{E}_t P_{F,t}^* Y_{F,t}$ and $P_{X,t} X_t = \mathcal{E}_t \left(P_{H,t}^* Y_{H,t}^* + P_{S,t}^* Y_{S,t} \right)$, respectively.

Analogously, we obtain the following expression for the evolution of the net asset position of New Zealand:

$$\frac{\mathcal{B}_t}{(1+i_{d,t}^*)\Theta_d(\mathcal{B}_t)} = \frac{P_{Y,t-1} Y_{t-1}}{P_{Y,t} Y_t} \mathcal{B}_{t-1} - (1-\chi) \frac{P_{S,t} Y_{S,t}}{P_{Y,t} Y_t} + \frac{P_{X,t} X_t}{P_{Y,t} Y_t} - \frac{P_{M,t} M_t}{P_{Y,t} Y_t}. \tag{26}$$

Notice that in the case of Chile, changes in the nominal exchange rate directly affect the net foreign asset position when measured in domestic currency through valuation effects, while in the case New Zealand those valuation effects are not present. In other words, in the external asset position, the risk of devaluation is held by domestic agents in the case of Chile while it is held by foreign investors in the case of New Zealand. Therefore, the transmission mechanism for monetary policy –and other shocks– works differently in both countries.

4 Model estimation

The model is estimated using Bayesian methods (see DeJong, Ingram, and Whiteman (2000), Fernández-Villaverde and Rubio-Ramírez (2004), and Lubik and Schorfheide (2005)).[15] The Bayesian methodology is a full information approach to jointly estimate the parameters of the DSGE model. The estimation is based on the likelihood function obtained from the solution of the log-linear version of the model. Prior distributions for the parameters of interest are used to incorporate additional information into the estimation.[16]

The log-linear version of the model developed in the previous section form a linear rational expectations system that can be written in canonical form as follows,

$$\mathbf{\Gamma}_0(\boldsymbol{\vartheta})\,\mathbf{z}_t = \mathbf{\Gamma}_1(\boldsymbol{\vartheta})\,\mathbf{z}_{t-1} + \mathbf{\Gamma}_2(\boldsymbol{\vartheta})\,\boldsymbol{\varepsilon}_t + \mathbf{\Gamma}_3(\boldsymbol{\vartheta})\,\boldsymbol{\xi}_t,$$

[15] Fernández-Villaverde and Rubio-Ramírez (2004) and Lubik and Schorfheide (2005) discuss in depth the advantages of this approach to estimating DSGE models.

[16] One of the advantages of the Bayesian approach is that it can cope with potential model mis-specification and possible lack of identification of the parameters of interest (Lubik and Schorfheide, 2005).

where $\mathbf{z}_t$ is a vector containing the model variables expressed as log-deviation from their steady-state values. It includes endogenous variables and but the ten exogenous processes, $\zeta_{C,t}$, i_t^*, $\zeta_{T,t}$, $A_{H,t}$, $\zeta_{I,t}$, $Y_{S,t}$, $Pr_{S,t}^*$, $\zeta_{G,t}$ (G_t in the case of New Zealand), ν_t, and Y_t^*.[17] In their log-linear form, each of these variables is assumed to follow an autoregressive process of order one. The vector $\boldsymbol{\varepsilon}_t$ contains white noise innovations to these variables, and $\boldsymbol{\xi}_t$ is a vector containing rational expectation forecast errors. The matrices $\boldsymbol{\Gamma}_i$ $(i = 0, \ldots, 3)$ are non-linear functions of the structural parameters contained in vector $\boldsymbol{\vartheta}$. The solution to this system can be expressed as:

$$\mathbf{z}_t = \boldsymbol{\Omega}_z(\boldsymbol{\vartheta})\,\mathbf{z}_{t-1} + \boldsymbol{\Omega}_{\boldsymbol{\varepsilon}}(\boldsymbol{\vartheta})\,\boldsymbol{\varepsilon}_t, \tag{27}$$

where Ω_z and $\Omega_{\boldsymbol{\varepsilon}}$ are functions of the structural parameters. A vector of observable variables, $\mathbf{y}_t$, is related to the variables in the model through a measurement equation:

$$\mathbf{y}_t = H\mathbf{z}_t + \mathbf{v}_t \tag{28}$$

where H is a matrix that relates elements from $\mathbf{z}_t$ with observable variables. $\mathbf{v}_t$ is a vector with iid measurement errors. Equations (27) and (28) correspond to the state-space form representation of $\mathbf{y}_t$. If we assume that the white noise innovations and measurement errors are normally distributed we can compute the conditional likelihood function for the structural parameters, $\boldsymbol{\vartheta}$, using the Kalman filter, $L(\boldsymbol{\vartheta} \mid \mathcal{Y}^T)$, where $\mathcal{Y}^T = \{\mathbf{y}_1, ..., \mathbf{y}_T\}$. Let $\mathbf{p}(\boldsymbol{\vartheta})$ denote the prior density on the structural parameters. We can use data on the observable variables $\mathcal{Y}^T$ to update the priors through the likelihood function. The joint posterior density of the parameters is computed using Bayes' theorem

$$\mathbf{p}\left(\boldsymbol{\vartheta} \mid \mathcal{Y}^T\right) = \frac{L(\boldsymbol{\vartheta} \mid \mathcal{Y}^T)\mathbf{p}(\vartheta)}{\int L(\boldsymbol{\vartheta} \mid \mathcal{Y}^T)\mathbf{p}(\boldsymbol{\vartheta})\,d\boldsymbol{\vartheta}} \tag{29}$$

An approximated solution for the posterior distribution is computed using the Metropolis-Hastings algorithm (see Lubik and Schorfheide (2005)). The parameter vector to be estimated is $\boldsymbol{\vartheta} = \{\sigma_L,\, h,\, \phi_L,\, \chi_L,\, \eta_C,\, \eta_I,\, \mu_S,\, \phi_{H_D},\, \chi_{H_D},\, \phi_{H_F},\, \chi_{H_F},\, \phi_F,\, \chi_F,\, \boldsymbol{\varpi}',\, \eta^*,\, \varrho,\, \rho_{a_H},\, \rho_{y_S},\, \rho_{Y^*},\, \rho_{i^*},\, \rho_{\zeta_C},\, \rho_G,\, \rho_{\zeta_I},\, \rho_T,\, \sigma_{a_H},\, \sigma_{y_S},\, \sigma_{Y^*},\, \sigma_{i^*},\, \sigma_m,\, \sigma_{\zeta_C},\, \sigma_g,\, \sigma_{\zeta_I},\, \sigma_{\zeta_T}\}$. $\boldsymbol{\varpi}$ is a vector with the parameters describing the monetary policy in both countries. For Chile, $\boldsymbol{\varpi}' = \{\psi_{i,1},\, \psi_{\pi,1},\, \psi_{y,1},\, \psi_{rer,1},\, \psi_{i,2},\, \psi_{\pi,2},\, \psi_{y,2}\}$. For New Zealand this vector of parameters consists of only $\{\psi_i,\, \psi_\pi,\, \psi_y\}$. Other parameters of the model are not estimated but are chosen to match the steady-state of the model with long-run trends in the Chilean and New Zealand economies. Calibrated parameters are reported in table 1.

For Chile, we assume annual long run labor productivity growth, g_y, of 3.5%.[18] The long-run annual inflation rate is set to 3%, which is the midpoint target value for headline inflation defined by the CBC since 1999. The subjective discount factor, β, is set to 0.995 (annual basis) to give an annual nominal interest rate of around 7.0 % in the steady state. The share of *home* goods in the consumption and investment baskets, γ_C and γ_I, are set to 70% and 40%, respectively. These figures imply that investment is more intensive in *foreign* goods than consumption. The share of the commodity sector

[17] These variables correspond to a preference shock, a foreign interest shock, a stochastic productivity trend shock, a stationary productivity shock, an investment adjustment cost shock, a commodity production shock, a commodity price shock, a government expenditure shock, a monetary shock, and a foreign output shock, respectively.

[18] This is consistent with 5% long run GDP growth and 1.5% of labor force growth.

in total GDP is set to 10%.[19] The net export to GDP ratio, $\frac{X-M}{Y}$, in steady state is equal to 2% which is consistent with its average value over the sample period. The government share of commodity production, χ, is set to 40% which is consistent with the average fraction of CODELCO (the state owned company) in the total production of copper in Chile. Consistent with the fact that Chile is a net debtor in the international financial markets, we calibrate the steady-state current account/GDP ratio to -1.8%.

For New Zealand, we assume annual long run labor productivity growth, g_y, of 1.5%. The long-run annual inflation rate is set to 2%, which is the midpoint target value for CPI inflation. The subjective discount factor, β, is set to 0.985 (annual basis) to give an annual real interest rate of around 3.0 % in the steady state. The share of *home* goods in the consumption basket, γ_C, is 70% (the same as in Chile), but the share of home goods in the investment basket, γ_I, is lower at 25%. So the investment response to changes in relative prices will be larger in the New Zealand case. The share of the commodity sector in total GDP is a little larger than in the Chilean case at 14%.[20] The net export to GDP ratio, $\frac{X-M}{Y}$, in steady state is equal to 1.3% which is consistent with its average value over the sample period. In contrast to the Chilean case where ownership of commodity production is government and foreign, in New Zealand ownership of commodity production is mainly domestic private, $\chi = 0.9$. Consistent with the fact that New Zealand has large net external liabilities, the investment income deficit is assumed to be about -6.3% to give a steady-state current account/GDP ratio of -5.0%.

We calibrate some other parameters to make them consistent with previous empirical studies. The depreciation rate of capital is set to 6.8% for Chile and 8.0% for New Zealand on an annual basis. The production function of domestic producers is assumed to have labor share of about two thirds. We do not have country specific information on price and wage markups. Therefore, we use values consistent with those utilized by studies of other countries. In particular, we set $\epsilon_L = \epsilon_{H_D} = \epsilon_{H_F} = \epsilon_F = 11$.[21] We use OLS estimates of the whole sample period for the underlying parameters governing the AR(1) process of commodity prices. The point estimate $\rho_{p_S^*}$ is 0.98 for the international copper price with a standard deviation equal to 8.5%, and 0.99 for New Zealand's export commodity price index with a standard deviation of 3.5%. Finally, we assume that monetary shocks are i.i.d., which implies that ρ_ν is zero. Finally, as mentioned before the fraction Ricardian household is set to 100% for New Zealand and 50% for Chile.

4.1 Data

To estimate the model we use Chilean quarterly data for the period 1990:Q1 to 2005:Q4. We choose the following observable variables: real GDP, Y_t, real consumption, C_t, real investment, INV_t, real government expenditure/GDP ratio, G_t/Y_t, short-run real interest rate, r_t, a measure of *core* inflation computed by the Central Bank ("IPCX1") as a proxy for inflation, the real exchange rate, $\widehat{rer}_t$, current

[19] Value-added of the mining sector accounts for 10% of total GDP in Chile.

[20] This includes primary production plus some commodity based manufactures such as agricultural processing and pulp and paper

[21] Christiano *et al* (2005) use $\epsilon_L = 21$ and $\epsilon_H = 6$ for a closed economy model calibrated for US. Adolfson *et al* (2005) use the same values for an open economy model calibrated for Euro area. Brubakk *et al* (2005) use $\epsilon_L = 5.5$ and $\epsilon_H = 6$ for a calibrated model of the Norwegian economy. Jacquinot *et al* (2005) calibrate $\epsilon_L = 2.65$ and $\epsilon_H = 11$ for a model of the Euro Area.

account/GDP ratio, $\frac{CA_t}{P_{Y,t}Y_t}$, and real wages, $W_t/P_{C,t}$. We also include as observable variable the international price of Copper (in dollars, deflated by a proxy of the foreign price index) as a proxy for the real price of the commodity good, $\widehat{pr}^*_{S,t}$. In total, we have ten observable variables. The inflation rate is expressed as deviation from its target, $\widehat{\pi}_t$. In the case of real quantities we use the first difference of the corresponding logarithm (except for government expenditure/GDP ratio):

$$\mathbf{y}_t^{CH} = \left\{ \Delta \ln Y_t, \Delta \ln C_t, \Delta \ln INV_t, r_t, \widehat{\pi}_t, \widehat{rer}_t, \frac{CA_t}{P_{Y,t}Y_t}, \frac{G_t}{Y_t}, \Delta \ln \left(\frac{W_t}{P_{C,t}} \right), \widehat{pr}^*_{S,t} \right\}$$

The short-run real interest rate corresponds to the monetary policy rate. This was an indexed rate from the beginning of the sample until July 2001. After July 2001 the monetary policy has been conducted by using a nominal interest rate. Therefore, for the later period we construct a series for the real interest rate computing the difference between the nominal monetary policy rate and current inflation rate.

For New Zealand, we use quarterly data for the period 1989:Q2 to 2005:Q4. We choose the following observable variables: real GDP, real consumption, real investment, commodity production (primary production plus commodity-based processing), $Y_{S,t}$, short-run nominal interest rate, $\widehat{i}_t$, CPI inflation, the real exchange rate, current account/GDP ratio and real wages. We also include as observable variable the ANZ commodity export price index (in US dollars, deflated by the foreign price index) as a proxy for the real price of the commodity good. In total, we have ten observable variables.

As in the case of Chile, real variables are expressed in first log difference and inflation as deviation from its target. The set of observable variables for New Zealand is the following:

$$\mathbf{y}_t^{NZ} = \left\{ \Delta \ln Y_t, \Delta \ln C_t, \Delta \ln INV_t, \Delta \ln Y_{S,t}, \widehat{i}_t, \widehat{\pi}_t, \widehat{rer}_t, \frac{CA_t}{P_{Y,t}Y_t}, \Delta \ln \left(\frac{W_t}{P_{C,t}} \right), \widehat{pr}^*_{S,t} \right\}$$

The short-run nominal interest rate is the overnight interest rate (The Call Rate prior to March 1999 and the Official Cash Rate after March 1999). We subtract the inflation target from the nominal interest rate to make this variable stationary.

4.2 Prior distributions

Prior parameter density functions reflect our beliefs about parameters values. In general, we choose priors based on evidence from previous studies for Chile and New Zealand. When the evidence on a particular parameter is weak or non-existent we impose more diffuse priors by setting a relatively large standard deviation for the corresponding density function. Table 2 presents the prior distribution for each parameter contained in the parameter vector, $\boldsymbol{\vartheta}$, its mean and an interval containing 90% of probability.

For the inverse elasticity of labor supply, σ_L, we assume a gamma distribution with mode equal to 1.0 and one degree of freedom. This implies that with 90% of probability σ_L takes values between 0.05 and 3.0. This is a wide range and reflects the uncertainty we have regarding the value of this parameter. The habit formation parameter, h, is constrained to be between zero and one. We assume it has a beta distribution with mean 0.5 and a standard deviation of 0.25. Therefore, a 90% confidence interval for this coefficients lies between 0.1 and 0.9. This range is much wider than the one considered by Adolfson *et al* (2005) for the same coefficient in the Euro area, reflecting again our uncertainty on the value for this parameter. The elasticity of substitution between *home* and *foreign* goods in consumption, η_C, and the elasticity of substitution between these goods in investment, η_I, are assumed to have an inverse gamma distribution with a unitary mode and 5 degrees of freedom. This implies that, with 90% of probability, each of these elasticities lie between 0.66 and 3.05. The price elasticity of foreign demand for domestic goods, η^*, has also an inverse gamma distribution with a unitary mode. For this parameter we choose 4 degrees of freedom to set our prior. This implies a wider range for this parameter: with 90% of probability it takes values between 0.64 and 3.66. These values are pretty much in line with Adolfson *et al* (2005).

The parameter μ_S has an inverse gamma distribution with mode 2.0 and 3 degrees of freedom. As a consequence, this parameter can take values between 1.3 and 9.8 with 90% of probability. This is a wide range reflecting, again, the uncertainty we have with respect to μ_S. The elasticities of the international supply of funds, ϱ_f and ϱ_d, are assumed to have an inverse gamma distribution with four degrees of freedom. For Chile, we assign a mode of 0.01 for these elasticities. For New Zealand we assume a deeper financial integration with the rest of the world, and in consequences, the mode of these elasticities is 0.001.

The prior distributions of each parameter in the policy rule take into account values that have been reported in other empirical studies.[22] In particular, the policy inertia parameter, ψ_i, has a beta distribution with a standard deviation of 0.10. Previous estimation shows that the policy smoothing has been bigger in New Zealand than Chile. Hence, we assume a mean for ψ_i equal to 0.70 and 0.75 for Chile and New Zealand, respectively. The combined parameter defining the policy response to inflation –when the policy instrument is the nominal interest rate–, φ_π, has a gamma distribution with mode 1.50 and standard deviation equal to 0.15 for Chile and to 0.10 for New Zealand. These values are coherent with parameter φ_π lying between 1.26 and 1.75 in the case of Chile with 90% of probability and between 1.34 and 1.67 in the case of New Zealand . The parameter defining the policy response to output, φ_y, also follows a gamma distribution with mean 0.5 and a standard deviation of 0.15 for Chile and 0.10 for New Zealand. In the case of Chile, we need to define a prior distributions for the reaction coefficient of interest rate to real exchange rate for the period 1990-99, ψ_{rer}. This parameter has a gamma distribution with mean 0.2 and standard deviation equal to 0.1.

Parameters defining the probability of resetting nominal wages and prices are assumed to have distributions bounded by the interval $[0, 1]$ interval. The parameters ϕ_L, ϕ_{H_D}, ϕ_{H_F} and ϕ_F have beta distributions with means 0.75 and standard deviations of 0.1. Those values imply that the probabilities of resetting nominal wages and prices can take values between 0.57 and 0.90 with 90% of probability. These numbers are coherent with wages and prices that can be optimally reset every 2.3 and 10 quarters. Parameters χ_L, χ_{H_D}, χ_{H_F} and χ_F have also beta distributions with means 0.50 and standard deviations of 0.25. These distribution cover a range of values between 0.1 and 0.9 with 90% of probability. Hence, we do not impose very strong priors on the degree of inertia in wages and prices.

The autoregressive parameters of the stochastic shocks, ρ_{a_H}, ρ_{y_S}, ρ_{y^*}, ρ_{ζ_L}, ρ_{ζ_I}, ρ_{i^*}, ρ_{π^*}, $\rho_{\zeta_F^*}$, ρ_{y_S}, ρ_g, ρ_{ζ_Θ} have beta distributions. We do not impose tight priors on these distributions. For all these

[22] For Chile, see Schmidt-Hebbel and Tapia (2002), Caputo (2005) and Céspedes and Soto (2005). For New Zealand, see Liu (2006) and Lubik and Schorfheide (2006).

parameters we set the prior mean to 0.7 and the standard deviation to 0.20. Therefore, with 90% probability, the values of these parameters lie between 0.32 to 0.96. The variances of the shocks are assumed to be distributed as an inverse gamma with 3 degrees of freedom. This distribution implies diffuse priors for these parameters to reflect our uncertainty about the unobservable shock processes. The corresponding means and modes are set based on previous estimations and on trials with weak priors. In particular, σ_{a_H}, σ_{ζ_C}, σ_{ζ_L}, σ_{ζ_I}, σ_{C^*}, $\sigma_{\zeta_F^*}$, σ_{y_S} and σ_g have a prior mode of 1.0 which implies, with 90% of probability, values between 0.64 and 4.89. For σ_{i^*} the mode is set to 0.5 implying values that go from 0.32 to 2.45, whereas for σ_{π^*}, σ_{ζ_Θ} and σ_ν the modes are set to 0.25, 0.25 and 0.20, respectively.

4.3 Posterior distributions

Table 3 presents the mode of the posterior distributions of the parameters for Chile and New Zealand. Consistent with other studies, the degree of habit in consumption is a little higher for New Zealand at 0.81 than for Chile at 0.57. The inverse elasticity of substitution for labour supply is very low for New Zealand. For Chile this eslasticiy is a little bit above other studies where only Ricardian households were considered.The elasticity of substitution for consumption is about 1.2 for both Chile and New Zealand, which is relatively low. The posterior estimate for the intra-temporal elasticity of substitution for investment is very close to the prior estimate and may not be well identified in the data. The price elasticity of foreign demand, η^*, is two in New Zealand compared to one in Chile. This means that exports respond more strongly to price signals (e.g. a currency depreciation) in New Zealand.

For Chile, wage rigidities are substantially lower than previous estimates. Wages are estimated to be reoptimized every 5 periods and only about 6 per cent of households that do not optimise are estimated to index wages to last period's inflation. The rest increase wages according to the central bank's 3 per cent p.a. inflation target. For New Zealand wages are estimated to be reoptimised less often at 11 quarters with about 10 percent of nonoptimising households indexing wages to last period's inflation, and the rest increasing wages according to the central bank's 2 per cent p.a. inflation target. The less frequent wage adjustment in New Zealand may reflect a higher degree of credibility on the monetary policy, which make costly adjustment to be less necessary.

Price rigidities in Chile are also lower than other estimates (Medina and Soto, 2006b; Caputo, Medina and Soto, 2006). Domestic prices are optimally adjusted frequently in both countries: on average every two quarters for Chile and every 3 quarters for New Zealand. The prices of home goods sold abroad are reoptimised much less frequently: on average every 29 quarters in Chile and every 12 quarters in New Zealand. Import prices are estimated to be reoptimised less frequently in New Zealand (30 quarters) compared to Chile (6 quarters), suggesting more local current pricing in New Zealand, but the degree of indexation of import prices is estimated to be much higher in Chile at 80 per cent.

Estimated monetary policy parameters are reasonable for both countries. For Chile we attempt to identify two policy rules: one for the period 1990-1999 and another for the period 2000-2005. In general the degree of interest rate smoothing and the responses to both inflation and output growth are estimated to be higher for New Zealand. These parameters are not, however, directly comparable because the policy rule is estimated in real terms in Chile and in nominal terms for New Zealand;

and because the rule for the earlier period in Chile includes an exchange rate term. Nevertheless, it is interesting that the rule for the later period in Chile and the estimated New Zealand rule, both of which are characterised by pure inflation targeting, are quite similar (the interest rate smoothing parameters of 0.8 for Chile and 0.9 for New Zealand, the response to deviations of inflation from target are 1.6 and is 1.5; and the response to the deviation of output growth from steady state are estimated at 0.31 and 0.39).

The estimated volatility and persistence of the shocks are more similar than different. The only big difference in shock volatility is a much larger commodity production shocks in the case of Chile which likely reflects the fact that there is a single commodity rather than a basket in the case of New Zealand. Commodity production shocks are, however, less persistent in Chile (AR(1) coefficient of 0.64 compared to 0.91 for New Zealand) perhaps due to the agricultural nature of commodity production in New Zealand. In general, Chile appears to face more persistent domestic shocks. Investment specific shocks are estimated to be more persistent in Chile (AR(1) coefficient of 0.86 compared to 0.41 for New Zealand), as are labour productivity shocks (AR(1) coefficient of 0.99 compared to 0.16 for New Zealand) and to a lesser degree transitory productivity shocks (AR(1) coefficient of 0.90 compared to 0.69 for New Zealand).

5 Impulse-response analysis

To analyze the main transmission mechanisms implied by the model in this section we describe the effects of the shocks on the current account and some other variables for Chile and New Zealand. Figures 2 through 5 present the impulse responses to all the shocks in the model.

In the case of Chile two sets of results are shown: One for the responses under the policy rule prevailing before 2000 and the other for the responses under the rule in place estimated for 2000 to 2005. In the description below we emphasized a qualitative description of the effects of the shocks. In general, the differences under these two rules are mostly quantitative. We do not comment further on them.

Productivity and endowment shocks There are two productivity shocks, a permanent one and a transitory shock, and a shock to the endowment of commodities. The identified *transitory productivity shock* has a larger standard deviation and is more persistent in Chile than in New Zealand. In both economies, this shock raises output (y), reduces employment and boosts real wages. It also reduces inflation (pic) and initially depreciates the real exchange rate (rer). The fall in labor is explained by the slow expansion of aggregate demand (which is persistent because of intertemporal smoothing in consumption, habit in consumption and investment adjustment costs), and because of the monetary policy response to the shock, which is not very expansive. In both countries, consumption (c) rises –although initially in Chile it decreases slightly due to the presence of non-Ricardian households, whose labor income falls. In Chile, investment (inv) increases as the marginal productivity of capital rises. After few quarters, however, it falls below its trend level. For New Zealand, the productivity shock is not persistent enough to induce an expansion in investment, and this variable falls below trend immediately after the shock. In both countries, the transitory output expansion coupled with consumption smoothing

–and the fall in investment in the case of New Zealand– plus the expenditure switching effect induced by a temporary real depreciation of the exchange rate, lead to an improvement in the current account measured as fraction of GDP (`ca_y`).

A *permanent labour productivity shock* increases output on impact, but not all the way to the new steady state level.[23] This permanent productivity shock lowers the current account in both economies. As domestic households anticipate higher income in the future, they increase their consumption today. For the same reason, firms anticipate higher profits in the future and look to expand their production by increasing their capital stock. The increase in both consumption and investment leads to a lowering in the current account.

A rise in the *endowment of commodities* (an exogenous increase in the production of these type of goods) implies directly an increase in domestic GDP, both in Chile and New Zealand. In Chile the shock is more volatile but less persistent than in New Zealand. In both economies this shock increases exports and appreciates the real exchange rate. Consumption and investment also raise, and so do imports. However, the expansion of exports is larger and the current account improves in response to this shock in both economies.

Foreign shocks There are three foreign shocks: a commodity price shock, a foreign output shock and a foreign interest rate shock. The *commodity price shock* is larger and more persistent in the case of Chile than in New Zealand (in the case of Chile, it corresponds to a copper price shock while for New Zealand it is a shock to a commodity export price index). For Chile, the shock implies a windfall revenue for the government. Despite the intertemporal government consumption smoothing implied by the fiscal rule, the persistence of the shock leads the government to raise its expenditure on home goods, as its debt service falls. This expansion in aggregate demand raises output. Private consumption increases because of the increase in current income of non-Ricardian households, and also because the shock raises the overall wealth of the country. The expansion in output increases the marginal product of capital and this leads to a boom in investment. In the case of New Zealand the windfall is received by households which own 90% of commodity export firms. Thus, the shock raises permanent income and consumption increases smoothly over time. The increase in consumption leads to a rise in output an upward pressure on inflation and an increase in investment. In both economies, the shock induces an improvement in the current account. This positive effect of the shock on the current account is moderated to some degree by a decline in export volumes, rising investment in response to higher demand –which increases imports–, and the exchange rate appreciation.[24] In the case of New Zealand, the higher debt repayments in response to monetary tightening that follows the shock also dampens its effect on the current account. For both countries the trade balance measured at constant prices (`tb_yr`) declines as a consequence of the fall in exports and the increase in imports.

A *foreign demand shock* increases demand for home goods, and domestic output in both economies

[23] Note that the variables are detrended by labour productivity.

[24] For New Zealand, the currency appreciation –"commodity currency" effect– is, however, smaller than that implied by reduced form estimates (here a 10% rise in commodity export prices leads to an exchange rate appreciation about 1%, compared to 5 to 7% in reduced form estimates). The difference may be the result of our model or of the covariance of world commodity prices with other factors such as world demand or the UIP shock. Certainly, a larger commodity currency effect would reduce the positive effect of this shock on the current account.

raises. Consumption increases with income which puts upward pressure on domestic prices, and the monetary policy tightening leads to an exchange rate appreciation. In both countries, investment increases to boost production, but only slowly due to adjustment costs. The stronger exchange rate reduces the cost of imports which also contributes to the expansion in investment since investment is import intensive. However, despite the increase in imports, the direct effect of foreign output increase on exports dominates and the current account improves in response to this shock.

A *foreign interest shock*, in our model, corresponds to a shock on the UIP condition. It captures not only movements in the international interest rate but also the unobserved currency risk premium and any capital flow movements that could affect the exchange rate – not necessarily reflected in observed interest rate differentials. This shock implies a 4 per cent real depreciation of the domestic currency (rise in rer) in both countries. The real exchange rate depreciation triggers an expenditure switching effect that raises exports and lowers imports. In Chile, the contraction of imports in much larger and in New Zealand, the expansion of export is much larger. This is the result of different pricing structures for imports and the currency denomination of foreign liabilities. In Chile, import prices are re-optimised more often (every 6 quarters compared to every 31 quarters in New Zealand) and there is a very high degree of indexation to last period's inflation. Therefore higher import prices in domestic currency lead to much more persistent effects on inflation. As a result the depreciation leads to a strong monetary policy response which depresses consumption and investment, reinforcing the effect of higher import prices on consumption and especially investment which is import intensive, leading to lower imports. In New Zealand this effect is muted by a high degree of local currency pricing (very infrequent reoptimisation and indexation mainly to the inflation target). In Chile, the depreciation also leads to valuation effects: the domestic currency value of foreign currency liabilities increases leading to higher debt repayment which crowds out consumption and investment, further depressing aggregate demand. In New Zealand a larger export response and smaller fall in aggregate demand prevent a fall in output. In both countries, this shock leads to a current account improvement.

Expenditure shocks A *consumption preference shock* leads to a consumption boom that raises output and increases demand for labor and capital inputs. It also pushes up inflation. The monetary policy response to the shock leads to an increase in the interest rate and appreciation of the real exchange rate. Despite the increase in the demand for capital, and a small fall in the cost of imports, the intertemporal substitution effect driven by the monetary policy response generates a contraction in investment. This shock leads to a deterioration of the current account. Initially, the rise in consumption stimulates imports. Exports fall because of the real appreciation of the currency. In the case of New Zealand, the fall in investment shortly dominates the boom in consumption so that imports fall below trend. This effect, however, is not strong enough to improve the current account. In the case of Chile, the fall in imports due to the contraction in investment leads to a slight improvement in the current account after several quarters.

Identified *investment shocks* –a decrease in the cost of transforming one unit of investment into one unit of capital– are a little larger in New Zealand but more persistent in Chile. They lead to a boom in investment that increases output and employment. In the case of Chile, the increase in output raises current income and non-Ricardian household consumption surges. Therefore, despite the monetary contraction, total consumption also rises. In the case of New Zealand, since all households are assumed to be Ricardian, the monetary contraction leads to a fall in consumption. The fall in inflation in both countries (in Chile there is a slight increase in this variable right after the shock) is explained by the fall in the cost of investing. For both countries, the current account initially deteriorates, mainly due the investment-driven rise in imports. However, the increase in the capital stock eventually leads to higher production and higher exports, so that the current account balance moves above trend after a couple of years.

A *government expenditure shock*, in the case of Chile, corresponds to a deviation from the structural balance rule described before. It implies an impulse to aggregate demand that boosts output and employment, and raises inflation. The monetary policy response to the shock –an increase in the interest rate– depresses investment and consumption despite of the increase in consumption by non-Ricardian households. The shock also implies an appreciation of the exchange rate because of both the rise in the interest rate and the rise in inflation and because of the composition of government spending –which is biased towards home goods. Although the fiscal balance worsens in response to this shock, the contraction in private expenditure leads to a current account improvement. This current account improvement, however, is small in magnitude and not very persistent. In the case of New Zealand, this expenditure shock also boosts output and depresses consumption and investment. Since the government consumes only home goods whereas households consume both home and foreign goods, and also because investment utilizes foreign goods, the crowding out effect of public spending in New Zealand implies a short-run improvement in the current account. As monetary policy tightens and the interest rate increases, debt service also increases and the current account deteriorates. On a medium-run horizon, when the interest rate has eased, the current account improves again as a consequence of the fall in imports.

Monetary shock A monetary shock induces a contraction in aggregate demand (consumption and investment), output and employment. Inflation falls in response to both the contraction in activity and the appreciation of the currency which puts downward pressure on the price of imported goods. In both Chile and New Zealand, exports and imports fall in response to the monetary shock. The former, because of the appreciation of the currency and the later because of the contraction of consumption and investment. In the case of Chile, given the estimated elasticities of substitution and the calibrated shares of foreign goods in consumption and investment, the intertemporal positive effect of a contractive monetary policy shock dominates its negative intratemporal effects. As a result, the current account improves. Several quarters after the shock, as imports pick up led by the recovery in investment and exports remain depressed, the current account deteriorates a little. In the case of New Zealand, the effect of this shock on the current account is ambiguous. On impact, the current account improves because of the contraction in imports. However, one quarter after the shock, it deteriorates. This is explained by the fact that in the case of New Zealand foreign investment income depends on the domestic interest rate (see equations 5 and 26). The higher domestic interest rate due to tighter monetary policy implies larger debt service payments. So despite an improvement in the trade balance, the current account falls. After some quarters, the trade balance effect dominates and the current account improves but it falls again as imports pick while exports remain low.

6 What drives the current account in Chile and New Zealand?

We use the estimated model to tell a "story" about the evolution of the current account in both countries. We first discuss the variance decomposition of the current account, without conditioning on the historical evolution of the exogenous processes. We then use our identified shocks to show the contribution of each type of shock to the historical evolution of the current account of both countries over the sample period. It is worth noting that the variance and historical decompositions abstract from the steady state current account position, which is 1.8% in the case of Chile, and in the case of New Zealand is about 6 per cent of GDP and is mainly associated with investment income payments on New Zealand's large stock of external liabilities.

6.1 Variance decomposition

Table 4 presents the variance decomposition of the current account for Chile and New Zealand. We group shocks in four categories as before: foreign shocks, domestic supply shocks, domestic demand shocks and monetary shocks.

In both countries, *foreign shocks* explain about half or more than half of the variation in the current account at all horizons. For both countries, the most important foreign shock is the foreign interest rate shock (UIP shock). As discussed earlier, this shock includes fluctuations in the foreign interest rate, unobserved current risk premium and any capital flow effects that influence the exchange rate. This shock is very persistent in both countries (with estimated AR(1) coefficients of 0.985 in Chile and 0.923 in New Zealand) and has its main effect on the current account with a lag of about 2 years. It accounts for 58 to 71 per cent of current account variance at the 3 to 4 year horizon in Chile, and 40-44 per cent in New Zealand. The foreign demand shock has a strong but transitory short term effect on the current, accounting for about 40 per cent of current account variation in the first year after the shock.

While the effects of these two shocks are similar, the effect of the third foreign shock, the commodity export price shock, is quite different in the two countries. In Chile a change in the copper price has a brief short term effect, accounting for about two per cent of current account variation in the first year.[25] In New Zealand, a change in the price of agricultural exports has a larger and more medium term effect, accounting for 15 to 20 per cent of current account variation at the two and three year horizons. The difference likely reflects the different ownership structures, with the windfall gains going to private agents in New Zealand and to the government and foreign investors in Chile, and the fact that Chile's government has saved a large fraction of the windfall revenues from copper.[26]

Domestic supply and demand shocks in Chile account for about half of the remaining variation in the current account each, with monetary policy shocks accounting for very little. In New Zealand, domestic demand shocks are relatively more important, and again monetary policy shocks explain very little. The

[25] The variance decomposition is computed using the sample estimate of the variance of each shock. The recent copper price shock has been much larger than historical shocks. Therefore, the share of this shock in explaining the recent current account event is likely much higher. See the historical decomposition below.

[26] De Gregorio (2006) argues that despite the structural balance rule was not in place before 2000, the government behaved very much like as if the rule would have been in place already during the 90s. In fact, during most of our sample period there existed a stabilization fund linked to the copper price that smoothed out the effects of shocks to this variable.

policy shocks are deviations from the policy rule, and the endogenous component of monetary policy –the parameterisation of the reaction function– may be important.

The contribution of *domestic demand shocks* to variation in the current account mainly comes from the investment-specific shock. In Chile this accounts for 30 to 40 per cent of current account variation in the first two years, and in New Zealand for 40 per cent in the first year, with persistent effects at longer horizons. The contribution of *domestic supply shocks* is more broadly based. In Chile, commodity output fluctuations have important short term effects (17 to 20 per cent of the variance in the first year), and permanent labour productivity shocks have important longer term effects (16 to 20 per cent of current account variance in the third and fourth years). In New Zealand, variations in commodity production affect the current account with a similar magnitude, but with the main effect in the second year; and both permanent and transitory productivity shocks are important.

Government spending shocks are estimated to account for a small part of current account variance in both countries. In New Zealand, the effect is a little larger, and probably understated a little due to our assumption that the government consumes only home goods. In the case of Chile, these shocks correspond to deviations of the government from the policy rule described previously. Therefore, they do not capture in full the effects of fiscal policy –broadly defined– on the evolution of the current account.

Overall, the current account appears to be playing a positive shock absorber role in both countries, with respect to both foreign and domestic shocks. With an open capital account, households, in aggregate, can smooth consumption in the face of shocks by using the current account to borrow and lend, much as an individual uses a bank account.

6.2 Historical decomposition of the current account

In this subsection we highlight how some major developments are interpreted by the model, in terms of the model shocks, and the current account responses to those shocks. In Figures 6 and 7 we present the sample evolution of the identified socks for Chile and New Zealand. Figures 8 and 9 present the historical contribution of each of them to the evolution of the current account for both countries.

Chile The evolution of the current account in Chile over the period is characterized by a phase of moderate deficits from 1990 until 1999-2000 and then by a period where the current account oscillated between small deficits and surpluses. The deficits observed at the beginning of the 90s are explained mostly by a boom in investment, triggered by favorable domestic conditions, and by a weakness in foreign activity that depressed exports (Figure 8). The small reversal of the current account in 1995, according to the model, is explained by favorable external conditions that boosted exports. The growth rate of an index of foreign output constructed by averaging output from Chile's main trade partners grew more than 4,5% at the beginning of that year.

Foreign financial conditions also played an important role in explaining the evolution of the current account over the 90s. From 1991 until 1999, easing foreign financial conditions –large capital inflows – put a downward pressure on the current account. The current account reversed dramatically in 2000, after the Asian crisis and coincidentally with Argentina's crisis. Notice, however, that the reversal in the current account began before the reversal in foreign financial conditions. During 1999 there was a dramatic negative investment shock that depressed investment and imports. While there was an important contractive monetary shock in late 1998, the model does not attribute a large share of responsibility for the fall in investment to that shock.

Despite the fact that the country's spread has been falling, the model identifies tightening external financial conditions as one of the reasons why the current account improved after 2000. As mentioned before, these UIP shocks capture more than the observed movements in the foreign interest rate and the risk premium faced by the country. They also capture any change in market conditions that affect the exchange rate above and beyond what the UIP condition would predict. The decline in natural resources GDP and a small investment boom after 2002 would have lead to a current account deficit, had no other shock hit the economy. More recently, an export expansion triggered by more robust growth in trading partners, and the copper-price boom, explain the current account surpluses observed over recent quarters.

New Zealand From a policy perspective, the main features of interest are the recent deterioration of the current account from about 2.9 per cent of GDP in 2001 to 9.7 per cent per cent of GDP in June 2006, similarities and/or differences with the current account deterioration from 1992 to 1997, and the factors that led to an improvement in the current account between these periods.

As shown in Figure 9, in the context of our model, the most important factors driving the New Zealand current account over the estimation period have been the price of commodity exports, shocks to foreign demand, the effects of foreign financial conditions on the exchange rate and investment-specific shocks.

Perhaps the largest swings in the current account during the period have come from the investment-specific shock. In the model, a positive investment adjustment shock means that a given amount of investment is transformed more efficiently into productive capital, and so reduces the cost of capital. This shock may also capture effects such as collateral constraints that affect investment. Historically investment specific shocks were negative during the labour market reforms of the early 1990s (perhaps due to a fall in marginal cost or increase in the marginal product of labour), positive in the mid-1990s (a period of rising investment) and negative in the late 1990s (possibly related to the end of the domestic housing boom or financial crises in other countries). This shock has had a relatively small effect on the recent current account deterioration compared to that in the mid-1990s. While both periods have been characterised by investment booms and a current account deterioration, the effects of foreign financial conditions on the exchange rate are estimated to have been more important in recent years.

A fall in the cost of financing, i_F, represents an appreciation of the New Zealand dollar. The estimated historical shocks show periods of New Zealand dollar strength in 1996 and in 2004-5, and weakness in 2000-2001. The foreign interest rate/UIP shock is not only persistent, but it has its main effect on the current account through the volumes of imports and exports with a lag of about 2 years. Thus, the weak NZ$ of 2000-2001 had a positive influence on the current account balance in 2002-3 (see Figure 9). The lagged response implies that the strong NZ$ seen in 2004-5 may continue to have a negative effect on the current account balance through 2007, all else being equal. The appreciation of the exchange rate after 2001 has been relatively important in the recent deterioration.

The estimated foreign demand shock shows weak foreign demand in the early 1990s (following recession in some trading partners), strong foreign demand through the rest of the 1990s and weak foreign demand after about 2001. The foreign demand shock has a strong, but transitory short term effect and so the effect on the current account follows a similar pattern. This shock appears to pick up the effect of government imports (in the model the government is assumed to consume only home goods). This is seen clearly in the two spikes in 1997 and 1999 that correspond to the import of two Navy frigates. There has been an expansion in government imports in the past year or two on a smaller scale so that the effect of foreign demand is likely to be overstated and government spending correspondingly understated.

The shock to the world price of commodity exports is estimated to have its main impact on the current account through the value of exports in the second year after the shock. The historical shocks follow a path similar to the path of commodity export prices, measured in foreign currency. As shown in Figure 9, the relatively low world price of commodity exports in 1998-2003 had a negative effect on the current account position, while the rise in commodity export prices in 2004-5 has had a positive effect on the current account position, much as one would expect.

From 1997 to 2002, the main factors that are estimated to have led to an improvement in the current account position were the investment specific shock and the contribution of changes in foreign financial conditions to the depreciation of the New Zealand dollar.

7 Scenarios for the current account adjustment

In this section we explore scenarios for the future evolution of the current account of Chile and New Zealand. First, we present a current account path whereby all past shocks are allowed to unwind at their estimated rates of decay. This gives a gradual current account adjustment path. Next we ask, in the case of Chile, what would be the path of the current account and other variables should the copper price suffer a sharp fall. We also analyze a combined scenario of a sharp copper price fall and a tightening of international financial conditions faced by the country. In the case of New Zealand, we ask what would the current account path would look like with a more rapid rise in the cost of external financing (which leads to a more rapid exchange rate depreciation). This allows us to explore the consequences of a more rapid current account reversal for this country. Then, we add to the second scenario an increase in the domestic interest rate due to a tightening in the monetary policy meant to sustain the exchange rate.

For Chile the scenarios are shown in figures Figure 10 to 12. In the baseline scenario, latent variables unwind at their estimated rates of decay back to steady state. At the end of the sample period the current account balance for this country is 2% of GDP above its long-run level. The main sources of imbalance are the delayed effects of the normalization of foreign financial conditions, a high copper price and a recent strong foreign demand. All of these shocks, have contributed to a strong current account position. On the contrary, low commodity production and a strong investment have ameliorated the effects of the previous shocks. The unwinding of these shocks is benign. GDP rises above trend due to the delayed effects of the investment boom and the positive effects of foreign financial conditions that improved marginally by the end of 2005. Also, the still high copper price, which has persistent effects and unwinds slowly, affects positively output. The trade balance deteriorates due to the increase in demand for imports that results from persistent effects of the investment shock and the UIP shock, an also because of the effect of the copper price shock on the real exchange rate. The current account dips below steady state as copper price falls and the quantity effects of the trade balance dominate, but recovers quickly as investment income payments on copper related profits fall off. The real appreciation of the currency implies by the persistent copper price shock lead to a fall in inflation that lasts for several quarters.

In the alternative scenario A, the copper price falls more rapidly in the first period. In this case, the positive effects of the high copper price are shorter lived. The expansion in aggregate demand and the rise in GDP are more modest. As a result, the increase in the demand for imports is less persistent, and the trade balance rises toward steady state more quickly. Also, copper related investment income payments fall more quickly, and the current account returns to steady state faster. In this scenario, since the real appreciation of the currency is less persistent, returns much faster back to its long-run level.

In the alternative scenario B, the sharp fall in the copper price is combined with a tightening of foreign financial conditions. The latter implies a depreciation of the Peso which boosts exports and makes imports more expensive, depressing aggregate demand. The depreciation also leads to a rise (in domestic currency term) of foreign currency debt, leading to higher investment income debits further depressing (crowding out) aggregate demand. The fall in aggregate demand leads to an improvement in the trade and current accounts. In this scenario, there is no period of high growth, with GDP a little below steady state levels for most of the adjustment period. Inflation rises due to the effect of the depreciation on the price of imports, which is persistent due to a high degree of indexation to past inflation.

For New Zealand the scenarios are shown in figures Figure 13 to 15. The three shock processes that deviated significantly from their steady-state values at the end of the period (2005q4) were the UIP shock (a strong NZ$), commodity production was below steady-state and world demand was still relatively weak (see Figure 7). The unwinding of each of these would contribute to an improvement in the current account position. The baseline unwinding of shocks gives a persistently large current account deficit for the next couple of years, as the lagged effects of the strong exchange rate continue to feed through to import and export volumes, and the current account doesn't return to steady-state until 2011/2012.

In the alternative scenario A (Figure 14), foreign financial conditions (foreign interest rate/UIP shock) tighten, implying a 30 per cent real exchange rate depreciation which leads to a more rapid reversal of the current account. In this case the current account returns to its steady state value in 2007/8, but the reversal is still benign in terms of GDP growth, with a shift from domestic to foreign absorption.

The final scenario (Figure 15), features a rise in the domestic cost of borrowing (e.g. a rise in the risk premium) in addition to the unwinding of shocks and the 30 per cent exchange rate depreciation. Here we proxy the rise in the domestic risk premium by a monetary policy shock in the model, though we do not interpret it as a monetary policy response. It is included to assess the effects should a tightening of foreign financial conditions translate into a rise in domestic cost of borrowing. In this case, the current account returns to steady state very quickly, but the adjustment is less benign, with GDP growth well below steady state for a year or more. In practice, this type of scenario whereby the cost of domestic currency financing rises would be more complicated than the channels in our model. Given the recent shift in domestic borrowing to longer, fixed term interest rates, the rise in the interest rate would feed through to households only gradually, and likely be associated with a larger effect on the cost of short term working capital and bank profitability in the interim.

8 Conclusions

This paper used an open economy DSGE model with a commodity sector and nominal and real rigidities to ask what factors account for current account developments in two small commodity exporting countries. From a policy perspective, we are interested in understanding these factors to better understand the macroeconomic and financial stability risks associated with the increase in both external stocks and external flows relative to income associated with financial market integration.

The model was estimated, using Bayesian techniques, on Chilean and on New Zealand data. The structural factors that explain the behavior of the current account were fairly similar for the two countries. We find that foreign financial conditions, investment-specific shocks, and foreign demand account for the bulk of the variation of the current accounts of the two countries. Monetary and fiscal policy shocks (deviations from policy rules) are estimated to have relatively small effects. For New Zealand, fluctuations in export commodity prices have also been important to explain the current account.

In both countries foreign shocks account for about half, or more than half, of current account variation at horizons up to 4 years. The most important foreign shock was found to foreign financial conditions, a combination of the effects of the foreign cost of capital, currency risk premium and effects of capital flows on the exchange rate. This shock is very persistent and has its main effect after a lag of about 2 years. The other two foreign shocks, world demand shocks and commodity export price shocks were also found to be important, the former having a strong but transitory short term effect and the latter a medium term effect.

The most important domestic shock in both countries was the investment specific shock. This shock affects the efficiency with which investment is transformed into productive capital. This shock played an important role in the improvement in both countries' current account positions in the late 1990s.

Monetary and fiscal policy shocks were found to have relatively small effects. However, these shock represent deviations from estimated policy rules, leaving open the possibility that the endogenous component of policy.[27] In Chile, monetary policy leads to an improvement in the current account as aggregate demand contracts, leading to lower imports (despite price effects) and lower exports (because of price effects). In New Zealand, the effect of a monetary policy shock on the current account is more ambiguous. The same positive effect works through aggregate demand, but the rise in the domestic interest rate increases debt service payments on the large stock of external liabilities, worsening the investment income account. The net effect on the current account is small, fluctuating around zero.

Policy experiments were carried out to explore scenarios of current account adjustment. In the case of Chile, unwinding of these shocks pushes GDP above trend due to the delayed effects of the investment

[27] The parameterisations of the policy rules may still be important, but this is left for further study.

boom and the positive effects of foreign financial conditions that improved marginally by the end of 2005. Also, the still high copper price, which has persistent effects and unwinds slowly, affects positively output. The trade balance deteriorates slightly due to the increase in demand for imports. The current account dips below steady state, but recovers as investment income payments on copper related profits fall off. A scenario that features a more rapid fall in the price of copper gives a more rapid improvement in the trade balance and fall in investment income payments as the positive effects of the high copper price on investment and negative effect on the investment income balance are shorter lived. In this scenario, the current account returns to the steady state deficit more rapidly. A third scenario also includes a tightening of foreign financial conditions which implies an appreciation of the Peso which depresses aggregate demand. In this scenario GDP is slightly below trend for much of the adjustment period. The current account goes into surplus for a few years, as the depreciation spurs exports and depresses imports, before returning to steady state.

New Zealand's imbalances at the end of the sample period were much larger. In the June 2006 quarter, the current account deficit was 9.7 per cent of GDP. A scenario in which shocks unwind at their estimated rates of persistence provides a benign adjustment process. Exchange rate depreciation is an important contributor to this adjustment. Because most of New Zealand's external liabilities are either denominated in New Zealand dollars, or the currency risk is hedged, a currency depreciation does not inflate the debt and debt service payments in domestic currency terms. However, exchange rate fluctuation feed through to the trade balance and current account with a lag, which means that the current account deficit corrects only slowly. A scenario that featured a larger depreciation led to a more rapid, but still benign adjustment adjustment. A scenario that added a rise in the domestic interest rate risk premium was more rapid but less benign. In this scenario, higher interest rated depressed aggregate demand which was also crowded out by higher investment income payments leading to below trend GDP for a year or more.

Overall out results suggest that the current account of New Zealand and Chile are playing a useful role as shock absorbers, particularly with respect to foreign shocks and investment-specific shocks. In our models, households are able to smooth consumption in the face of shocks by borrowing from and lending to nonresidents.

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Table 1: Calibrated parameters

Parameter	Chile	New Zealand	Definition
g_y (annual basis)	3.0%	1.5%	per capita productivity growth
π (annual basis)	3.0%	2.0%	inflation rate
r (annual basis)	4.1%	3.0%	real interest rate
δ (annual basis)	6.8%	8.0%	depreciation rate of capital
χ	0.40	0.90	domestic ownership of commodity production
$\frac{X-M}{Y}$	2%	1.3%	net export-GDP ratio
$\frac{CA}{Y}$	-1.8%	-5.0%	current account - GDP ratio
B	-0.30	-0.70	-(debt-GDP ratio)
$\frac{G}{Y}$	12%	17%	government expenditure - GDP ratio
$\frac{Y_S}{Y}$	10%	14%	commodity production - GDP ratio
$\frac{I}{Y}$	26.6%	22.8%	Investment-GDP ratio
$\frac{C}{Y}$	59.3%	58.8%	Consumption-GDP ratio
γ_C	70%	70%	home goods share in consumption
γ_I	40%	25%	home goods share in investment
$\rho_{p_S^*}$	0.98	0.99	auto-regressive coefficient of commodity price
$\sigma_{p_S^*}$	8.85	3.51	standard deviation of commodity price innovation
ρ_ν	0.00	0.00	auto-regressive coefficient of monetary policy shocks
η_H	0.66	0.68	labor share in the home goods production
λ	0.50	0.00	fraction of non-Ricardian households

Table 2: Prior Distributions

Parameter	Country	mean/mode	s.d./d.f.	Shape	90% Interval
σ_L	Both	1.000	1.000	Gamma	0.051 - 2.996
h	Both	0.500	0.250	Beta	0.097 - 0.903
ϕ_L	Both	0.750	0.100	Beta	0.570 - 0.897
χ_L	Both	0.500	0.250	Beta	0.097 - 0.903
η_C	Both	1.000	5.000	Inv. Gamma	0.655 - 3.045
η_I	Both	1.000	5.000	Inv. Gamma	0.655 - 3.045
μ_S	Both	2.000	3.000	Inv. Gamma	1.271 - 9.784
ϕ_{H_D}	Both	0.750	0.100	Beta	0.570 - 0.897
χ_{H_D}	Both	0.500	0.250	Beta	0.097 - 0.903
ϕ_{H_F}	Both	0.750	0.100	Beta	0.570 - 0.897
χ_{H_F}	Both	0.500	0.250	Beta	0.097 - 0.903
ϕ_F	Both	0.750	0.100	Beta	0.570 - 0.897
χ_F	Both	0.500	0.250	Beta	0.097 - 0.903
ψ_i	Chile	0.700	0.100	Beta	0.524 - 0.853
ψ_π	Chile	1.500	0.150	Gamma	1.262 - 1.755
ψ_y	Chile	0.500	0.150	Gamma	0.281 - 0.770
ψ_{rer}	Chile	0.200	0.100	Gamma	0.068 - 0.388
ψ_i	New Zealand	0.750	0.100	Beta	0.570 - 0.897
ψ_π	New Zealand	1.500	0.100	Gamma	1.339 - 1.668
ψ_y	New Zealand	0.500	0.100	Gamma	0.348 - 0.675
η^*	Both	1.000	4.000	Inv. Gamma	0.645 - 3.659
ϱ_f	Chile	0.010	4.000	Inv. Gamma	0.006 - 0.037
ϱ_d	New Zealand	0.001	4.000	Inv. Gamma	0.001 - 0.004
ρ_{a_H}	Both	0.700	0.200	Beta	0.321 - 0.965
ρ_{y_S}	Both	0.700	0.200	Beta	0.321 - 0.965
ρ_{Y^*}	Both	0.700	0.200	Beta	0.321 - 0.965
ρ_{ζ_C}	Both	0.700	0.200	Beta	0.321 - 0.965
ρ_{ζ_I}	Both	0.700	0.200	Beta	0.321 - 0.965
ρ_G	Both	0.300	0.050	Beta	0.221 - 0.385
ρ_{i^*}	Both	0.950	0.050	Beta	0.849 - 0.998
ρ_T	Both	0.700	0.200	Beta	0.321 - 0.965
σ_{a_H}	Both	1.000	3.000	Inv. Gamma	0.635 - 4.892
σ_{y_S}	Both	1.000	3.000	Inv. Gamma	0.635 - 4.892
σ_{Y^*}	Both	1.000	3.000	Inv. Gamma	0.635 - 4.892
σ_{i^*}	Chile	0.250	3.000	Inv. Gamma	0.159 - 1.223
σ_{i^*}	New Zealand	0.500	3.000	Inv. Gamma	0.318 - 2.446
σ_m	Both	0.200	3.000	Inv. Gamma	0.127 - 0.978
σ_{ζ_C}	Both	1.000	3.000	Inv. Gamma	0.635 - 4.892
σ_G	Both	1.000	3.000	Inv. Gamma	0.635 - 4.892
σ_{ζ_I}	Both	1.000	3.000	Inv. Gamma	0.635 - 4.892
σ_T	Both	0.200	3.000	Inv. Gamma	0.127 - 0.978

For inverse gamma distributions, degrees of freedom are presented

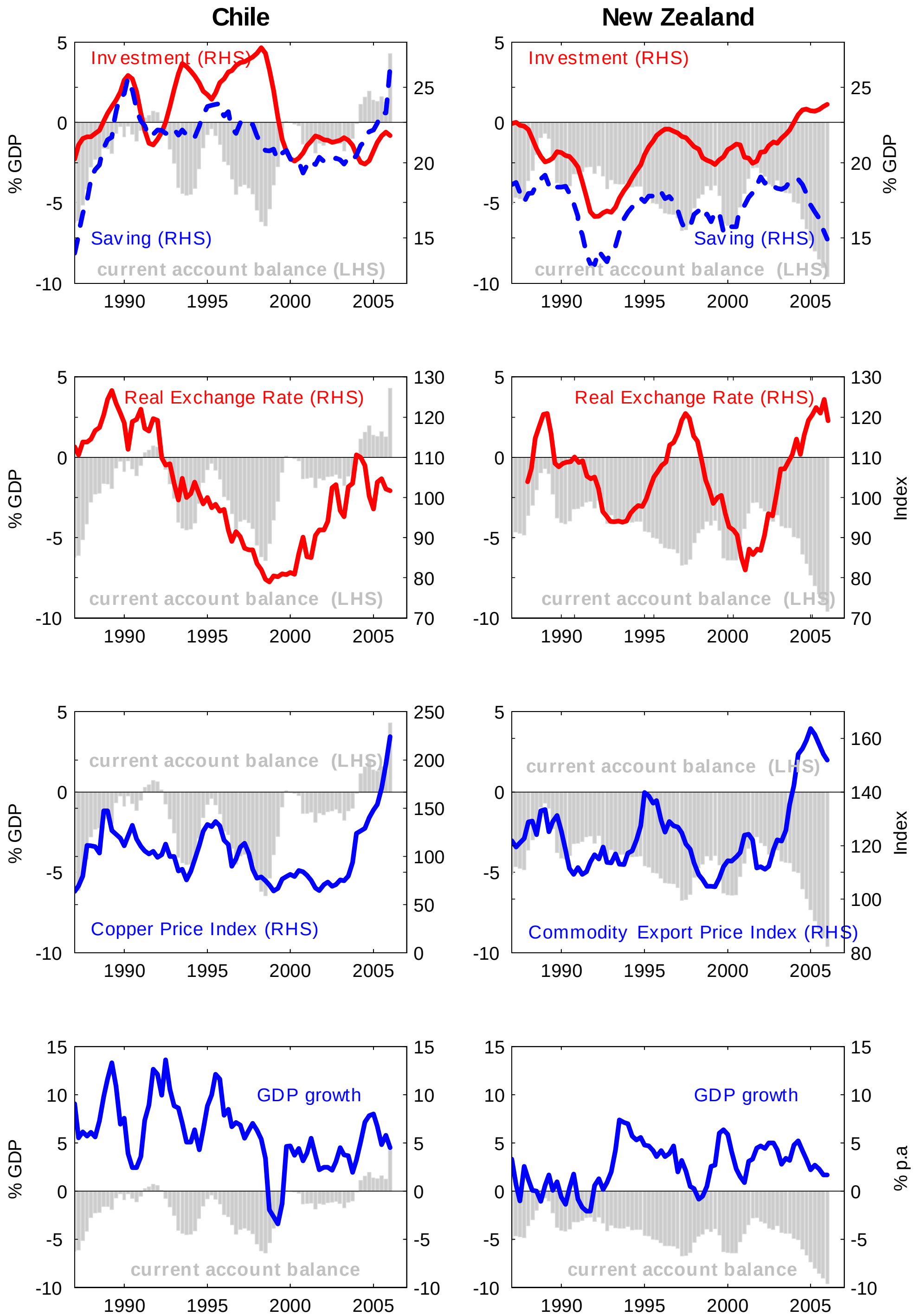
Table 3: Posterior Distributions (mode)

Parameter	Posterior mode	
	Chile	New Zealand
σ_L	0.164	0.001
h	0.572	0.813
ϕ_L	0.806	0.911
χ_L	0.058	0.102
η_C	1.221	1.239
η_I	1.107	1.031
μ_S	2.288	1.694
ϕ_{H_D}	0.486	0.631
χ_{H_D}	0.127	0.086
ϕ_{H_F}	0.966	0.915
χ_{H_F}	0.227	0.181
ϕ_F	0.838	0.968
χ_F	0.806	0.178
$\psi_{i,1}, \psi_i$	0.670	0.897
$\psi_{\pi,1}, \psi_\pi$	1.244	1.455
$\psi_{y,1}, \psi_y$	0.184	0.389
$\psi_{rer,1}$	0.052	-
$\psi_{i,2}$	0.778	-
$\psi_{\pi,2}$	1.632	-
$\psi_{y,2}$	0.305	-
η^*	0.999	2.007
ϱ	0.016	0.001
ρ_{a_H}	0.901	0.690
ρ_{y_S}	0.642	0.907
ρ_{Y^*}	0.736	0.653
ρ_{ζ_C}	0.227	0.332
ρ_{zeta_I}	0.862	0.412
ρ_{ζ_G}, ρ_G	0.315	0.393
ρ_{i^*}	0.985	0.923
ρ_T	0.987	0.156
σ_{a_H}	1.498	1.915
σ_{y_S}	28.418	1.993
σ_{Y^*}	10.275	8.847
σ_{i^*}	0.332	0.360
σ_m	0.392	0.189
σ_{ζ_C}	5.032	6.291
$\sigma_{\zeta_G}, \sigma_g$	12.180	9.739
σ_{ζ_I}	7.125	10.291
σ_T	0.190	0.498

Table 4: Current Account Variance Decomposition

	Chile 1990-1999				Chile 2000-2004				New Zealand			
					Foreign shocks							
Horizon (years)	Foreign Demand	Commodity Exp. Price	UIP	*Total*	Foreign Demand	Commodity Exp. Price	UIP	*Total*	Foreign Demand	Commodity Exp. Price	UIP	*Total*
1	40.9%	1.6%	5.3%	*47.8%*	45.3%	2.0%	3.4%	*50.6%*	39.6%	7.5%	2.3%	*49.3%*
2	1.7%	0.1%	45.6%	*47.4%*	3.3%	0.2%	44.7%	*48.2%*	11.1%	19.9%	27.4%	*58.4%*
3	3.9%	0.2%	71.3%	*75.4%*	4.6%	0.2%	69.1%	*73.9%*	1.0%	15.6%	44.1%	*60.6%*
4	6.2%	0.1%	62.0%	*68.3%*	8.2%	0.2%	57.5%	*65.9%*	1.5%	9.3%	39.6%	*50.3%*
					Domestic Supply Shocks							
	Productivity		Comm.	*Total*	Productivity		Comm.	*Total*	Productivity		Comm.	*Total*
	Trans.	Perm.	Output		Trans.	Perm.	Output		Trans.	Perm.	Output	
1	1.4%	3.1%	17.2%	*21.6%*	0.5%	0.8%	20.5%	*21.8%*	5.6%	0.3%	4.5%	*10.4%*
2	0.7%	12.1%	0.7%	*13.6%*	0.4%	9.2%	1.7%	*11.3%*	10.0%	5.4%	13.2%	*28.6%*
3	0.1%	16.5%	1.7%	*18.2%*	0.0%	17.6%	2.3%	*19.8%*	3.4%	6.8%	7.7%	*17.8%*
4	0.6%	19.7%	2.7%	*22.9%*	0.2%	23.0%	4.1%	*27.2%*	0.4%	3.8%	1.9%	*6.0%*
					Domestic Demand Shocks							
	Inv. Specific	Cons. Pref.	Govt Exp.	*Total*	Inv. Specific	Cons. Pref.	Govt Exp.	*Total*	Inv. Specific	Cons. Pref.	Govt Exp.	*Total*
1	30.0%	0.2%	0.1%	*30.2%*	26.7%	0.1%	0.1%	*26.9%*	39.0%	0.5%	0.3%	*39.7%*
2	39.0%	0.0%	0.0%	*39.0%*	40.4%	0.0%	0.0%	*40.4%*	11.6%	0.2%	0.2%	*12.0%*
3	6.2%	0.0%	0.0%	*6.2%*	6.0%	0.0%	0.0%	*6.0%*	21.1%	0.2%	0.1%	*21.4%*
4	8.7%	0.0%	0.0%	*8.7%*	6.5%	0.0%	0.0%	*6.5%*	41.0%	1.3%	0.5%	*42.7%*
					Monetary Shocks							
1	0.4%			*0.4%*	0.8%			*0.8%*	0.6%			
2	0.0%			*0.0%*	0.1%			*0.1%*	1.0%			
3	0.1%			*0.1%*	0.2%			*0.2%*	0.2%			
4	0.1%			*0.1%*	0.3%			*0.3%*	0.9%			

Figure 1: Chile and New Zealand



Source: ANZ National Bank, Banco Central de Chile, Reserve Bank of New Zealand, Statistics New Zeala

Figure 2: Impulse-Responses. Chile

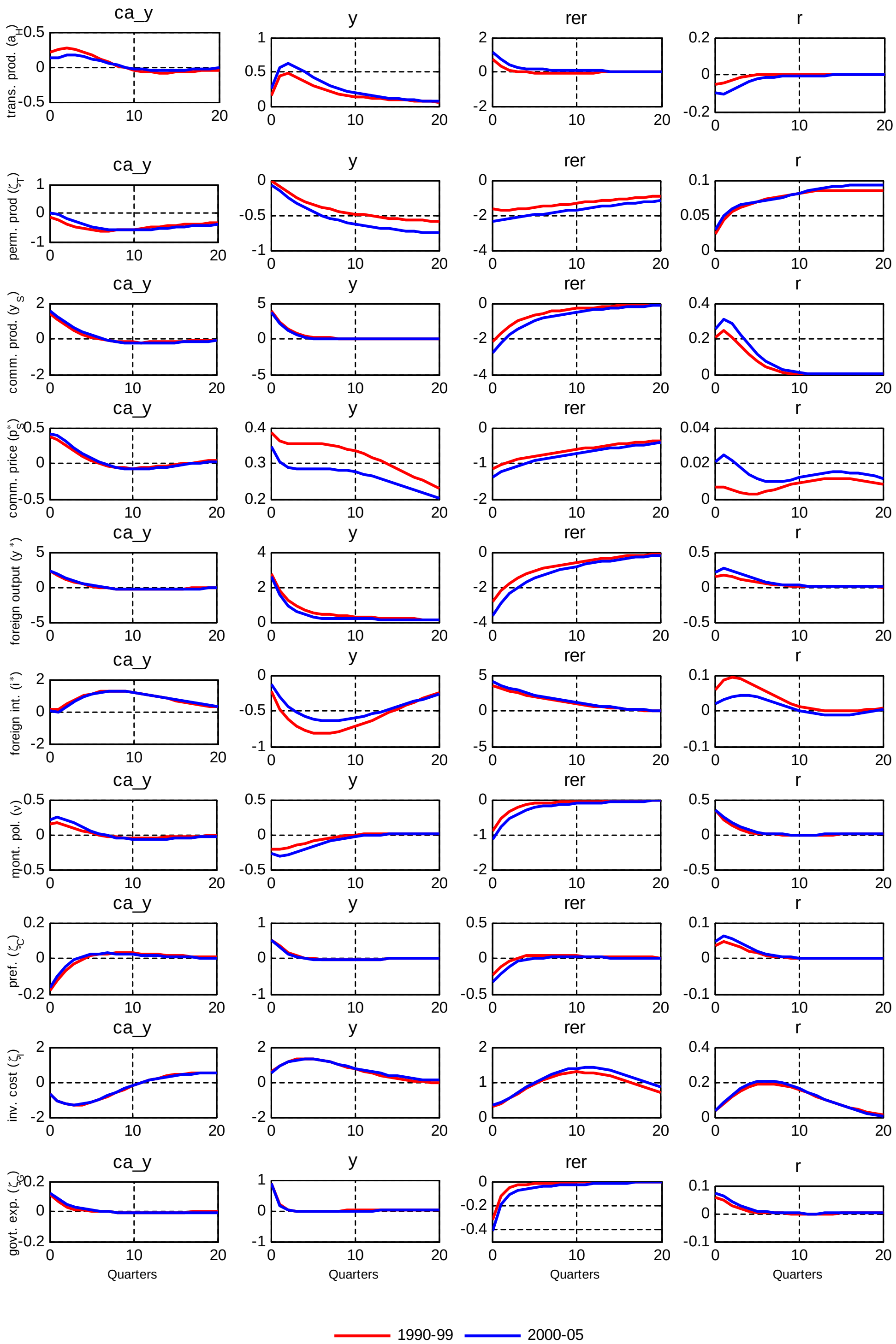


Figure 3: Impulse-Responses. Chile (cont.)

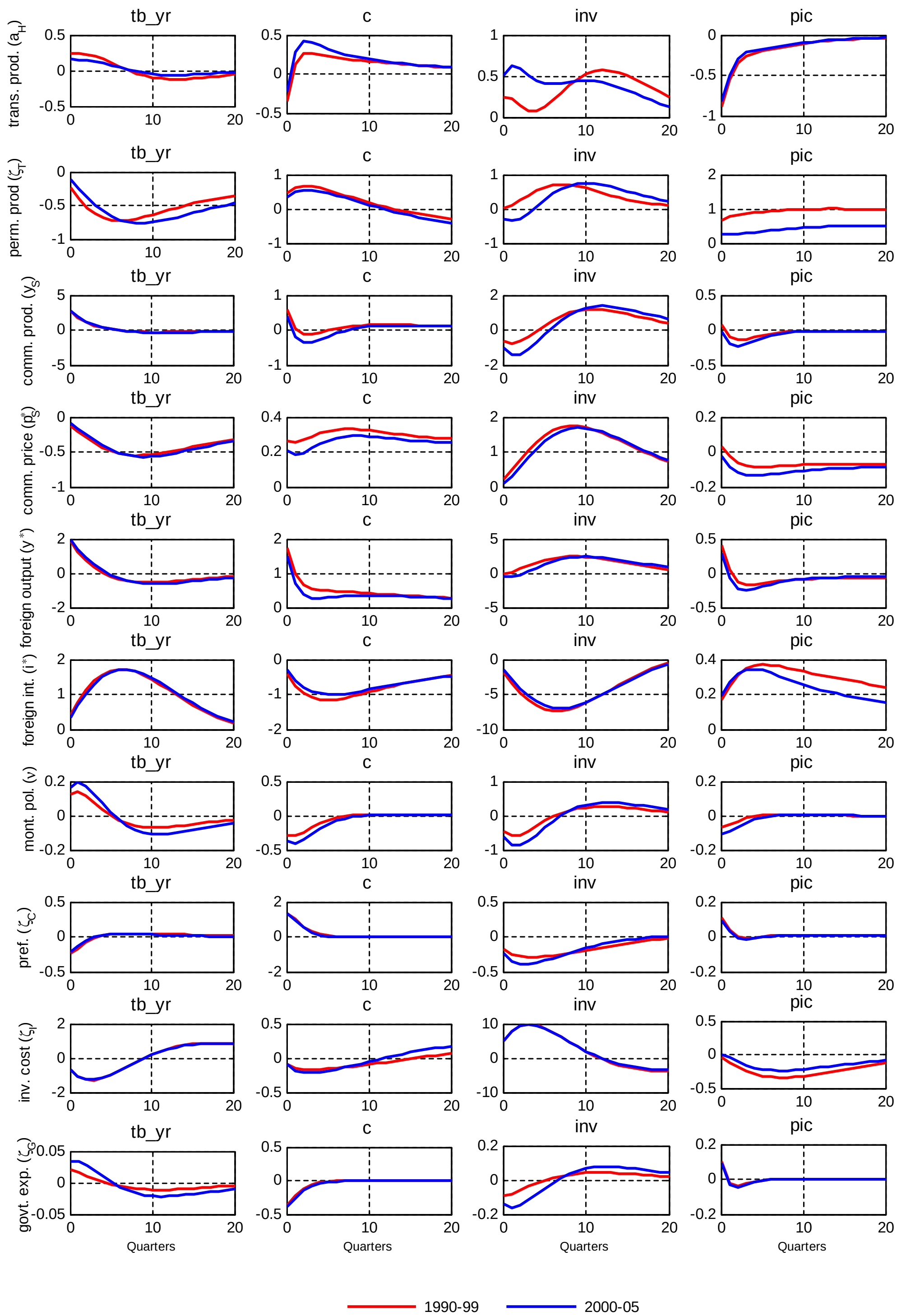


Figure 4: Impulse-response. New Zealand

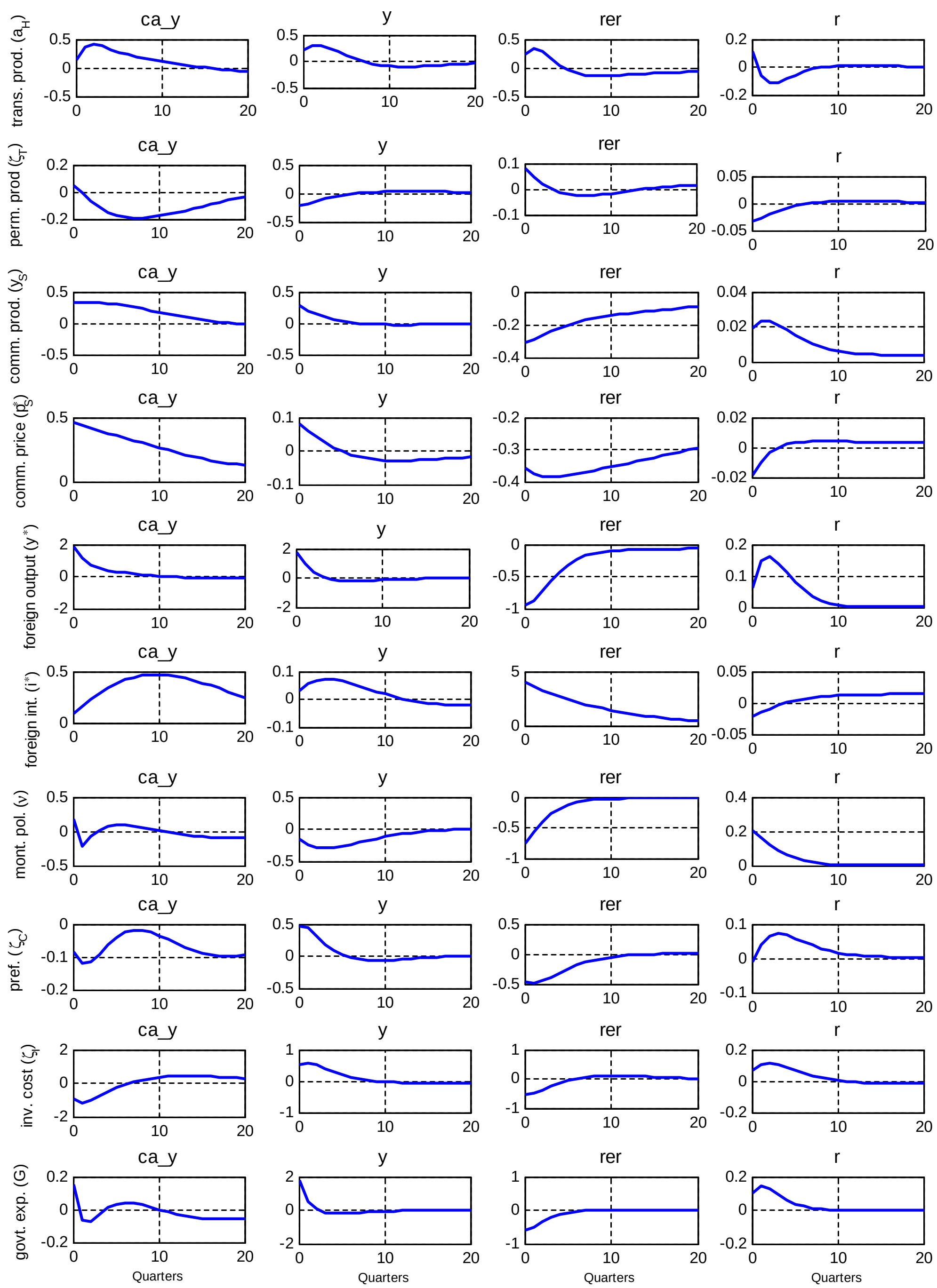


Figure 5: Impulse-Responses. New Zealand (cont.)

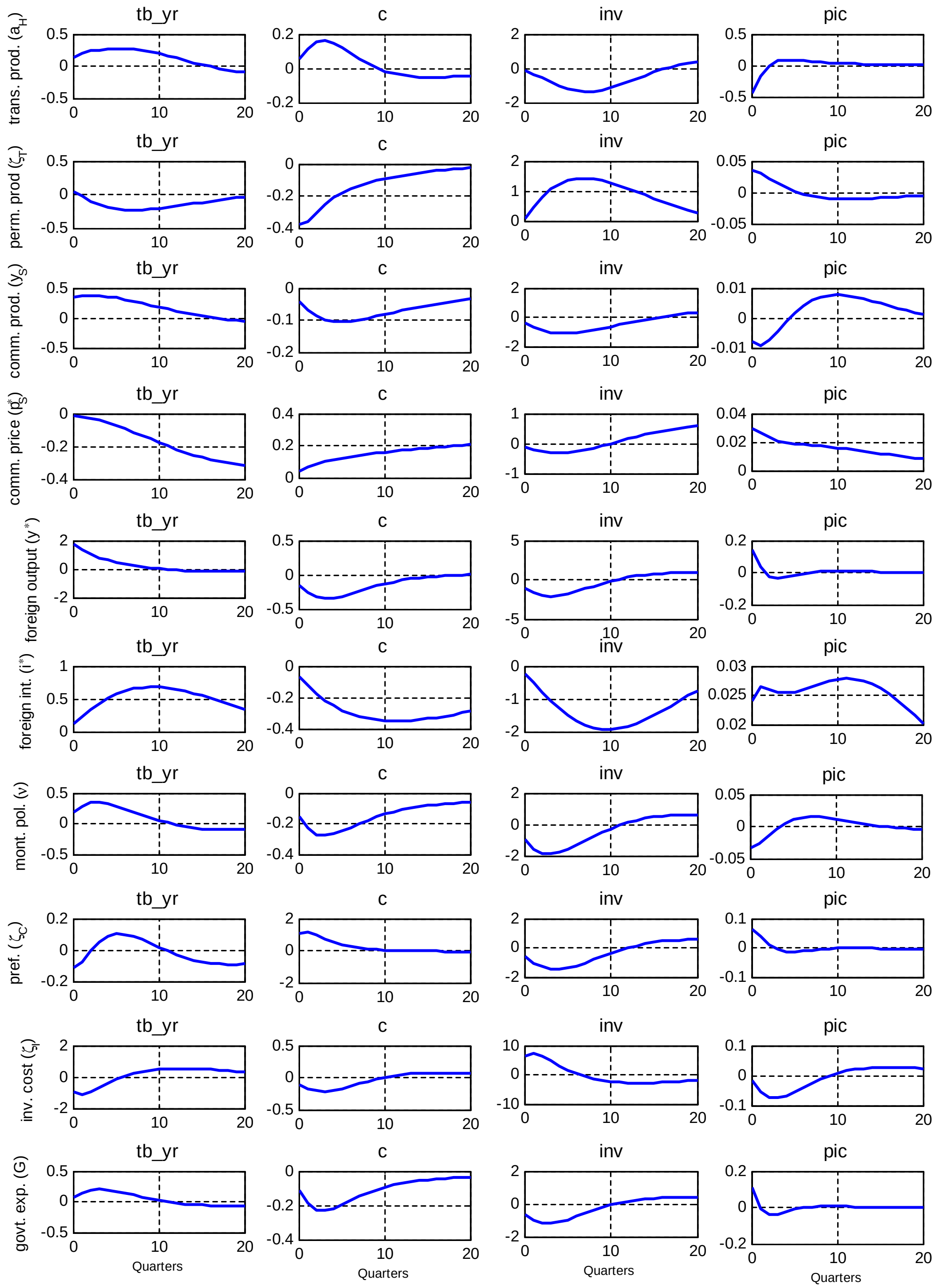


Figure 6: Latent Variables. Chile 1990-2005

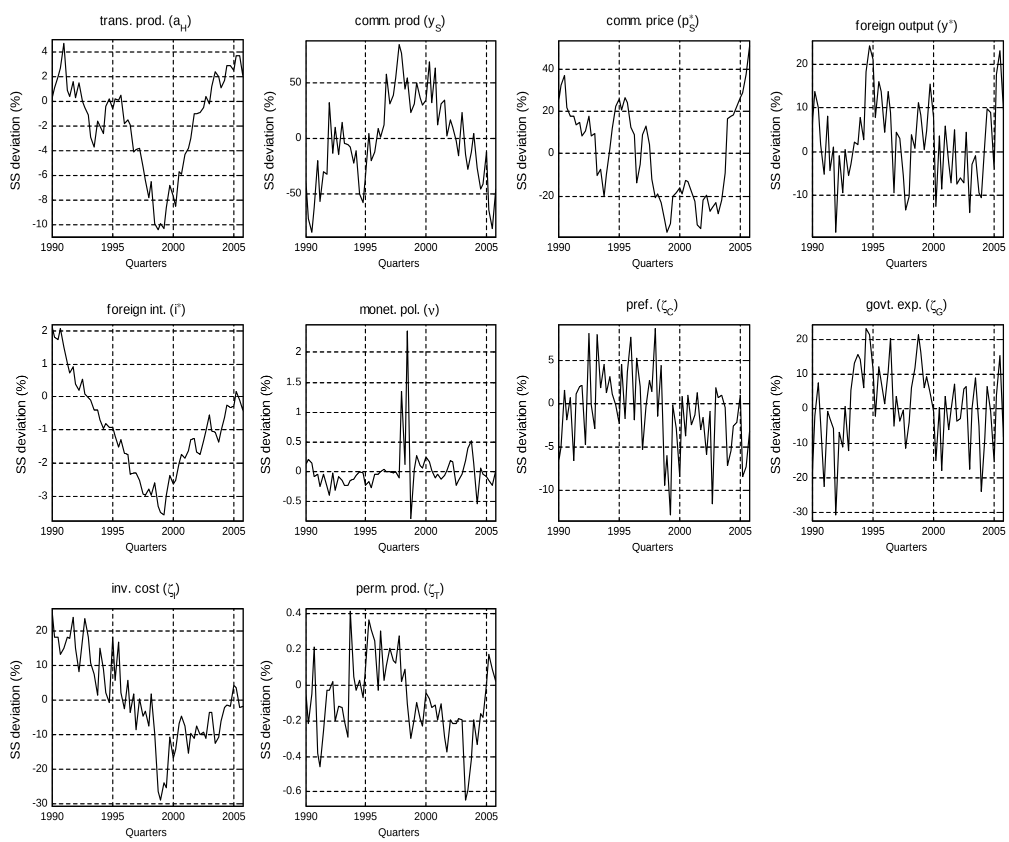


Figure 7: Latent Variables. New Zealand 1990-2005

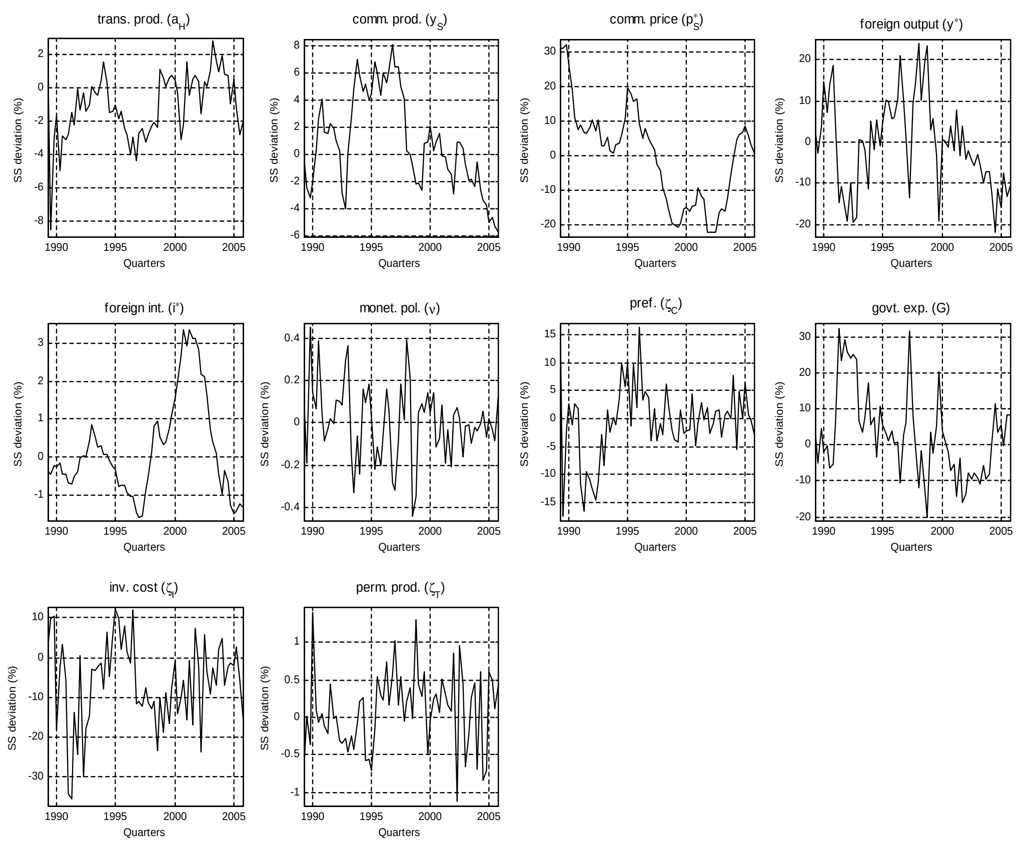


Figure 8: Chile. Current Account Historical Decomposition. 1990-2005

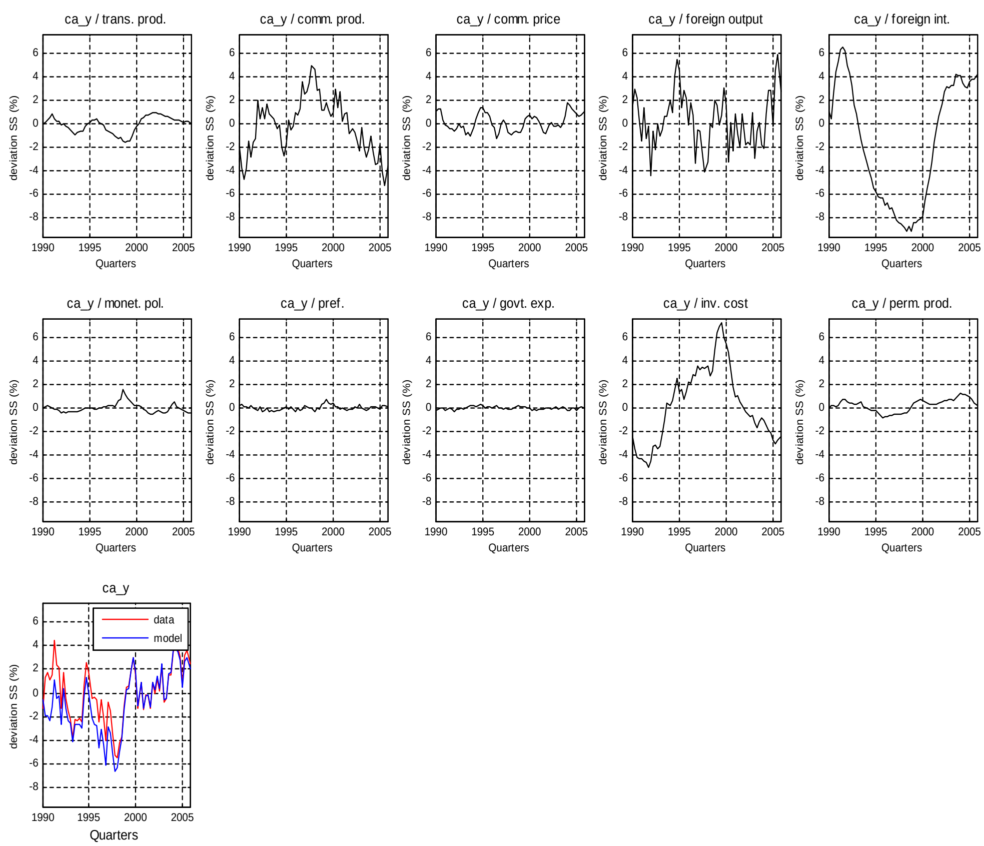


Figure 9: New Zealand. Current Account Historical Decomposition. 1990-2005

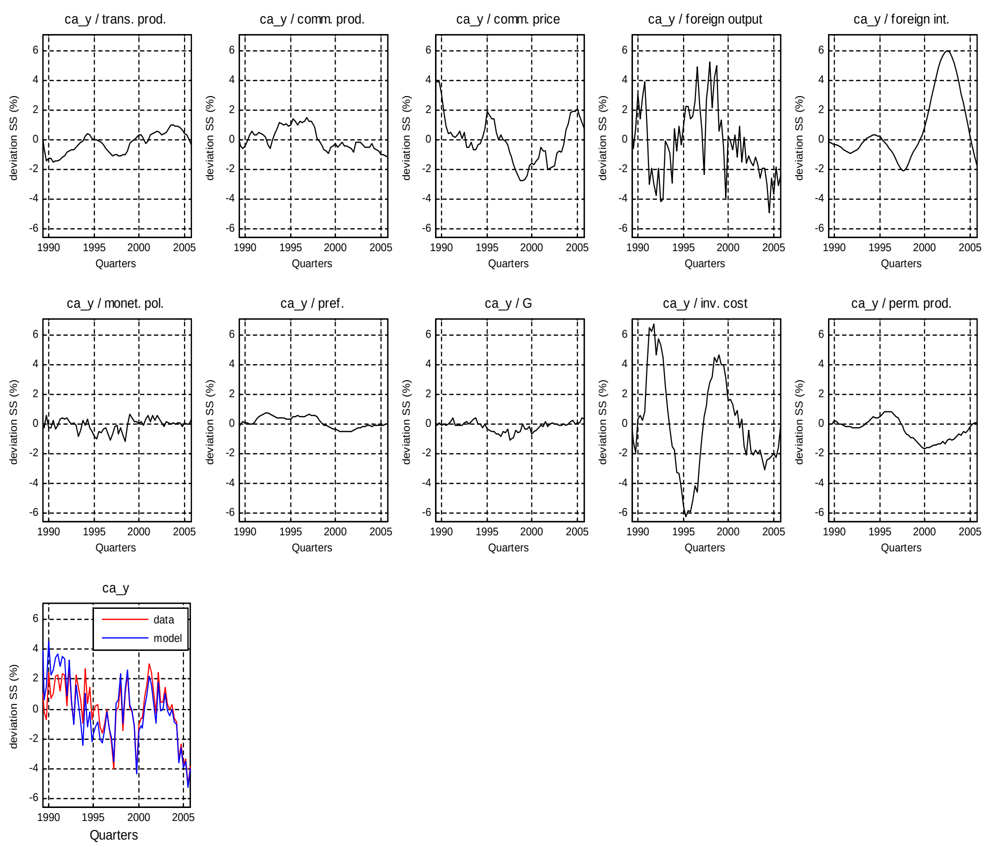


Figure 10: Chile. Baseline scenario

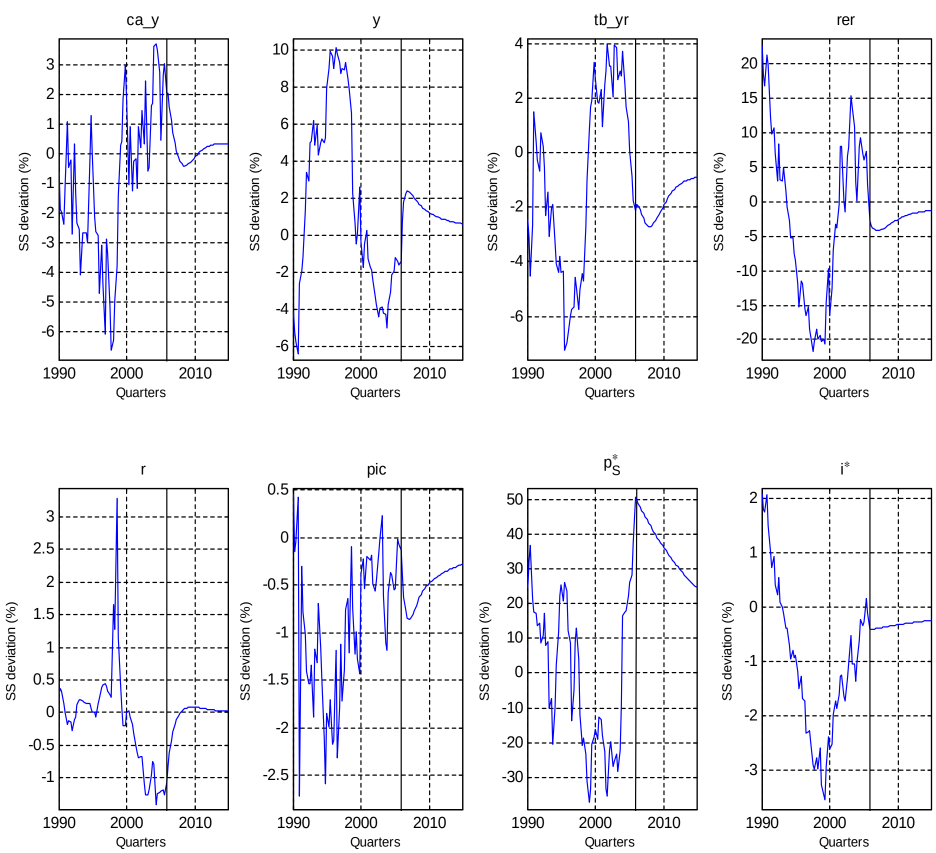


Figure 11: Chile. Alternative scenario A: Sharp decrease in the copper price.

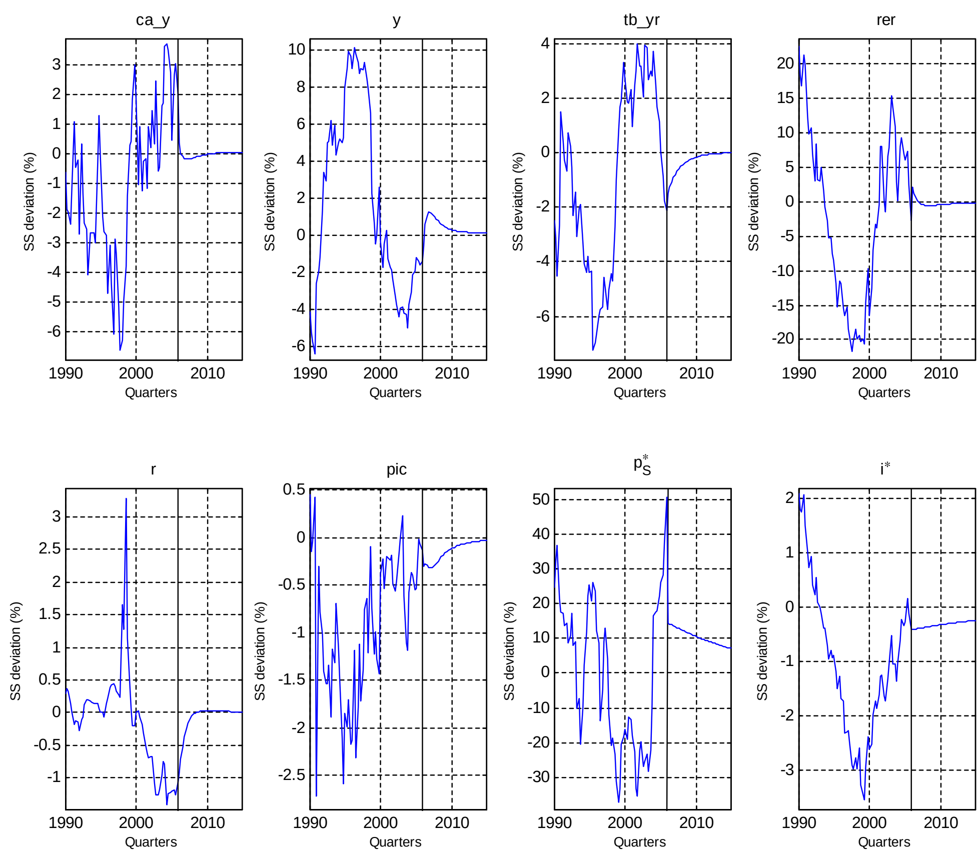


Figure 12: Chile. Alternative scenario B. Sharp decrease in the copper price and worsening in the financial conditions

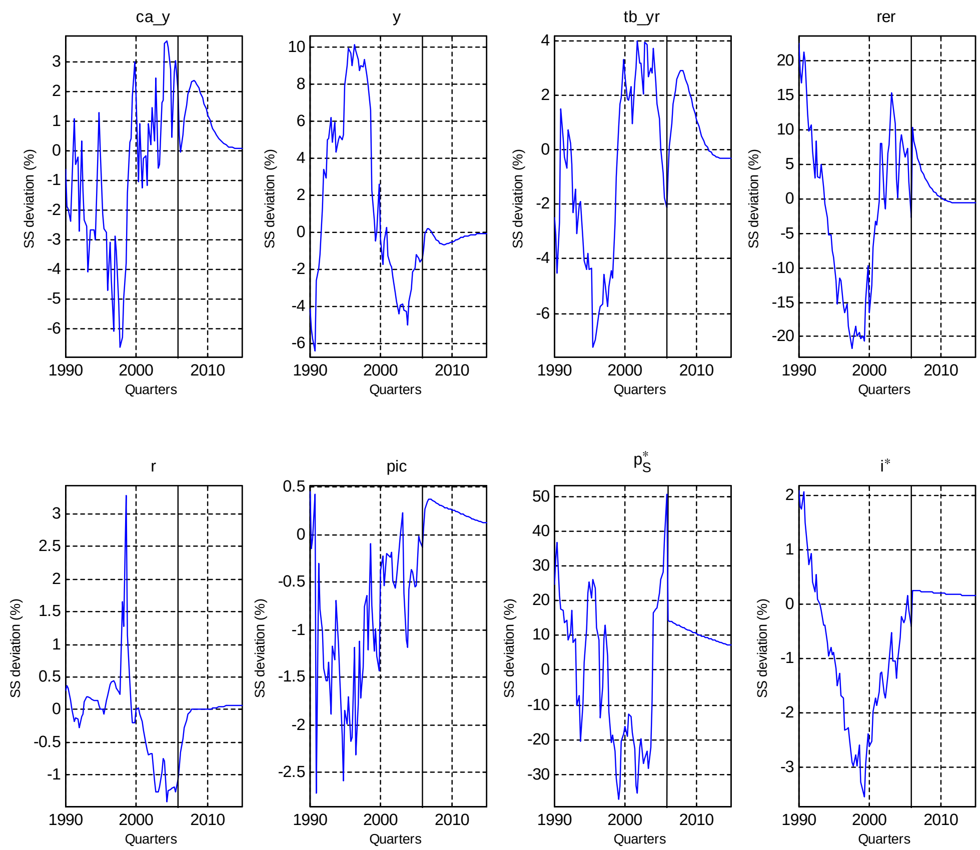


Figure 13: New Zealand. Baseline scenario.

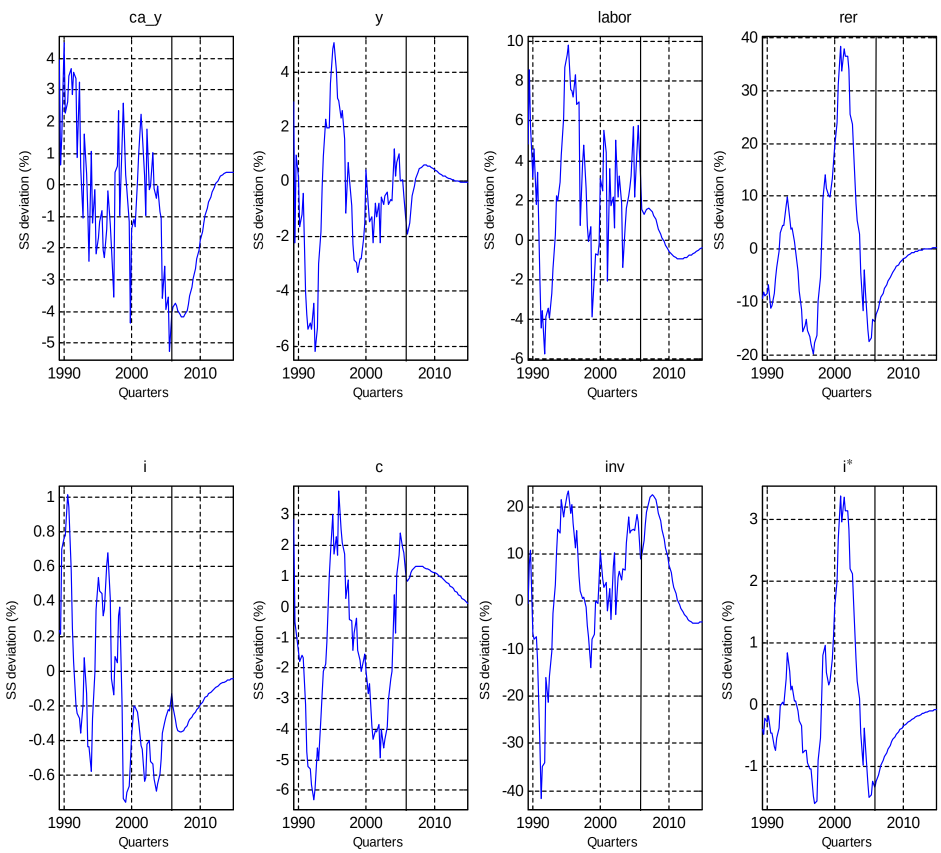


Figure 14: New Zealand. Alternative scenario A. Worsening in the financial conditions.

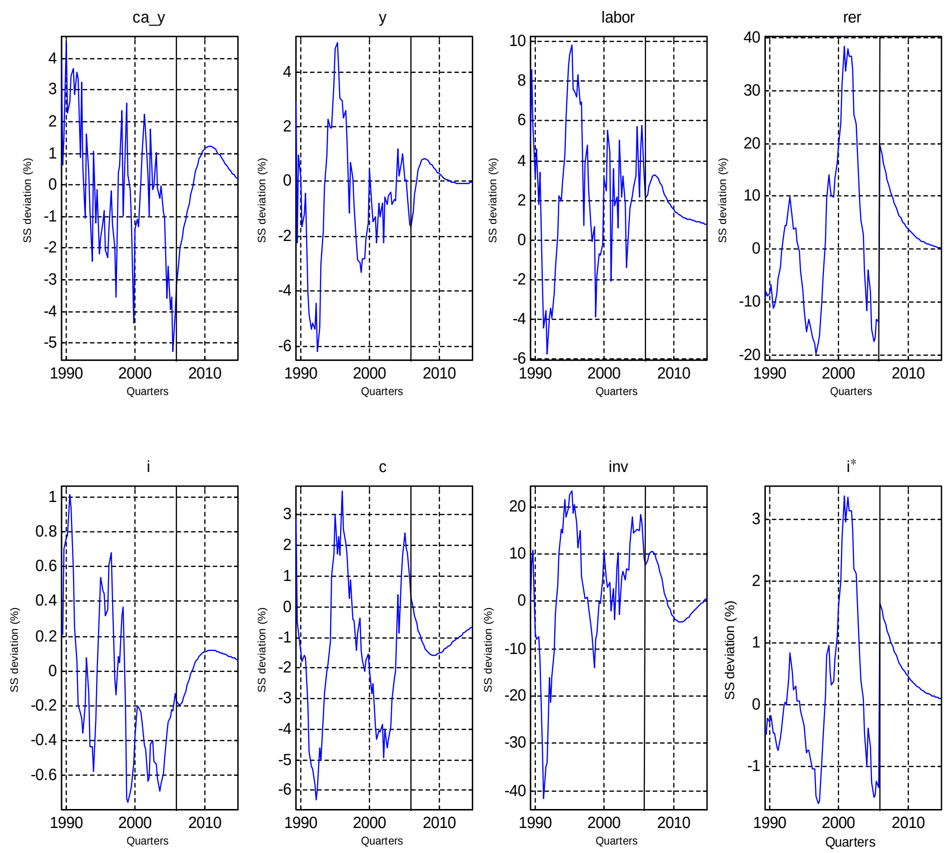


Figure 15: New Zealand. Alternative scenario B. Worsening in the financial conditions and monetary tightening.