Preliminary

Real Exchange Rate Determination and Commodity Currencies

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Abstract

The real exchange rate reflects the relative competitiveness between trading partners, of which can have a large impact on a small open economy. This study uses a vector error correction model (VECM) to empirically examine the relative importance of structural macroeconomic and monetary variables in determining the real exchange rate, both in the short run and long run, in particular for the two countries with commodity currencies, Australia and New Zealand. We then use impulse response analysis to assess the impact of a standard deviation shock on each of these variables and on the real exchange rate. Our results confirm the validity of the Balassa-Samuelson effect regarding the persistence of the impact of changes in the terms of trade. The model suggests that a good understanding of the economic fundamental variables will help the policy makers predict the future value of the real exchange rate between Australia and New Zealand.

Keywords: Exchange rates; Balassa-Samuelson effect; Purchasing power parity; Monetary policy;

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1. Introduction

The real exchange rate is a price that reflects the relative competitiveness of trade partners. Changes in the real exchange rate can have a relatively large impact on a small open economy. Real disturbances, including changes in terms of trade, tax systems, or productivity, are considered to cause the fluctuation and then lead the real exchange rate into a new equilibrium. While the nominal monetary shocks have only temporary effects due to the long-run neutrality of money, these real disturbances can induce movements in the real exchange rate that persist in the long run (see Dornbusch, 1976). The potential of real variables to cause permanent deviations from the purchasing power parity (PPP) may be tested for by testing for the presence of a unit root in a bilateral real exchange rate. Most empirical studies have not been able to reject the null hypothesis of a unit root in bilateral real exchange rate series.[1]

A PPP-based approach is a useful tool in analyzing international competitiveness. Nevertheless, this approach is incomplete and fails to capture the impact of major changes in a country's economic policies. For example, in an economic reform program, as new policies are introduced and implemented sequentially, real prices (including real exchange rates) are supposed to adjust to new equilibrium values. If economic fundamentals are the major determination of the real exchange rate then we want to empirically test whether the fundamentals provide an essential explanation for the exchange rate movement. The likelihood of changes in fundamentals is particularly high in countries such as New Zealand where many economic reform policies necessitate the liberalization and eventual elimination of government intervention.

A number of approaches have been used to estimate the equilibrium exchange rate. Artus (1977) and Williamson (1985) explain that the fundamental equilibrium exchange rate is

[1] See Adler and Lehman, 1983; Corbae and Ouliaris, 1988; Enders, 1988; Kim and Enders, 1991; Patel, 1990, among others.

consistent with the simultaneous attainment of both an internal and external balance. The approach by Brook and Hargreaves (2000) also focuses on the role of the current account balance in determining the equilibrium exchange rate, in particular for New Zealand where the model requires an internal balance and external equilibrium. Lee (2001) uses a vector error correction model to capture the dynamics of the New Zealand real exchange rate. Koya and Orden (1994) evaluate the effects of the terms of trade on the bilateral exchange rate of New Zealand and Australia and each of these countries bilateral exchange rates with the USA. They conclude that a relative improvement in a country's terms of trade results in real appreciation of its currencies in all cases. Fisher (1996) evaluates the relative importance of real and nominal shocks in accounting for fluctuations in the real and nominal exchange rates of Australia and New Zealand.

In their recent study, Chen and Rogoff (2003) explore 'commodity currencies', and use traded commodity prices instead of terms of trade to explain the real exchange rates for Canada, Australia and New Zealand. They argue that sticky prices and different movements in the components of terms of trade make it difficult to explain the pass-through mechanism between terms of trade and the real exchange rate. The results of their study on the real exchange rate of these commodity currencies are in general shown to be consistent with the Balassa-Samuelson framework.

Rogoff (1996) discusses modifications to the PPP through the sequential inclusion of the Balassa-Samuelson effect, relative current account balances and government expenditure in explaining the real exchange rate. He also suggests a multivariate vector auto-regression model as a way of estimating convergence by accounting for both short-term variations and long-term trends. Our study is to use this multivariate, structural approach to analyze the real exchange rate between the two countries with commodity currencies: New Zealand and Australia. We also examine more systematically the impact of the Balassa-Samuelson effect. We are particularly interested in small open economies like New Zealand and Australia where macroeconomic fundamentals can act as shock absorbers. This study will enhance our understanding of the determination of the real exchange rates between the two countries where the formation of a common currency area is being discussed.[2]

We use a vector error correction model (VECM) representation form to empirically examine the relative importance of fundamental macro variables (current account balance, Balassa-Samuelson effect, terms of trade, relative real GDP, and interest differential) in determining the bilateral real exchange rate between New Zealand and Australia. While the similar topics were examined by previous studies, including the recent work by Chen and Rogoff (2003), this study contributes to the existing body of work by using multivariate analysis on time series to assess the relative importance of structural and monetary variables in determining the real exchange rate and by building an exchange rate model to provide its forecasts. The contribution and uniqueness of this study are discussed in detail in Section 3, after basic information regarding the two countries' monetary and foreign exchange policies are introduced in Section 2. Section 4 constructs the model, analyzes the short-run and long-run behavior of the real exchange rate, and then discusses the findings and forecasts. Section 5 states the conclusions.

2. Background

In July 1984, New Zealand launched into a sequence of radical economic reforms (see Evans, Grimes, Wilkinson, and Teece 1996). The new reform policies were implemented rapidly in the financial and international sectors. Pre-reform economic policies were blamed for

[2] See, for example, Lee (2003).

the poor economic performance in New Zealand for a more than a decade. In July 1984 the currency was devalued by 20 percent aiming that devaluation stimulates production of exportable goods and induces domestic residents to switch from foreign imported to domestically produced goods. The currency was floated in March 1985 and government intervention in the external sector ceased.

New Zealand is the first country that has adopted a form of inflation targeting regime in April 1988.[3] Under the Reserve Bank of New Zealand Act 1989, the primary and sole economic objective of monetary policy is to achieve and maintain stability in the general level of prices and low inflation. The initial Policy Targets Agreement (PTA) between the Governor of the Reserve Bank and the Minister of Finance specified a target range for an annual inflation rate in the range of zero to two per cent. The 1996 PTA replaced the initial target range by a new range of zero to three per cent and the current 2002 PTA shall keep future CPI inflation outcomes between one and three per cent on average over the medium term.

Traditionally, Australia is the largest trade partner and the largest source of foreign direct investment (FDI) for New Zealand. An average of 20 percent of New Zealand exports between 1997 and 2001 went to Australia and 22 percent of the imports originated from there. The share of FDI originating from Australia rose from 29 percent in 1997 to 36 percent by 2001. The portfolio investment (loans and purchases of government bonds) follows the same pattern and 8 per cent of total stock of portfolio investment in New Zealand is attracted from Australia in 2001.

New Zealand is also a significant economic partner of Australia. It was the fifth largest trade partner of Australia in 2002, for both exports and imports which explained more than 20 percent of New Zealand's total trade. For Australia, New Zealand was the source of one of the

[3] Chronologically the following countries have adopted some form of inflation targeting regime during the 1990s: New Zealand (1988), Canada (1991), the UK (1992), Sweden (1993), Finland (1993), Australia (1993), Spain (1995), and Thailand (1998).

largest current account surplus, next to Japan, and that of the large merchandise trade surplus, next to Japan and Korea. The importance of New Zealand to Australia is highlighted by the fact that Australia's chronicle trade and current account deficit has been at least partly compensated by the surplus it recorded from New Zealand.

Australia had adopted a crawling peg exchange rate system against the US dollar from November 1976 and then the currency was floated in December 1983. The accord, beginning in 1983, set out the wages policy and monetary policy to support the ultimate aim of price stability (Grenville, 2000). These monetary targets were suspended in February 1985, leaving the Reserve Bank with considerable discretion to formulate monetary policy subject to the objective of achieving non-inflationary growth. In 1993, Reserve Bank of Australia has adopted inflation targeting regime and their target range was set indefinitely at an average of two to three per cent over the medium term.

3. Determinants of Real Exchange Rates

A number of factors cause the shifts in the demand and supply curves in the foreign exchange market. We set out to empirically examine relative importance of the potential determinants of the real exchange rate in the short and long term. The real exchange rate is defined by the nominal spot exchange rate (Australian currency price per a unit of New Zealand dollar, AUD/NZD) adjusted by the ratio of consumer price index (CPI), P^{AUS}/P^{NZ}. Short-term cyclical movements of the real exchange rates are more likely to reflect the extent of dis-equilibrium of the economy, and the real exchange rate may act as a type of safety valve, and move to offset cyclical pressure in the economy. Over short-term, the real exchange rate can be deviated from its PPP equilibrium. According to Rogoff (1996), the consensus amongst economists is that deviation of the exchange rate from their PPP level damp out at a rate of roughly 15 per cent per year. It implies that these deviations have a 'half life' of three to five years. The observed deviations may be due to many reasons, including the Balassa-Samuelson effect (Balassa, 1964; Samuelson, 1964) that we are paying special attention to in this study.

The Balassa-Samuelson effect (B_t)[4] postulates that cross-country productivity differentials between tradable and non-tradable sectors will lead to changes in real costs and the price of tradable goods relative to the non-tradable goods, and subsequently affect the real exchange rate, in particular for the medium and long-term. Some empirical studies examine the relevance of sectorial-inflation differentials to explain the real exchange rate behavior. De Gregorio, Giovannini and Krueger (1994) find that an increase in the relative price of non-tradable goods is caused by productivity growth in the tradable goods sector, demand shift toward non-tradable goods, and real wage pressures. Technological progress in the tradable goods sector leads to an increase in real wage due to an increase in labor demand and also due to an increase in the relative price of non-tradable goods. The productivity growth in New Zealand over the previous decade has been slow, especially in industrial sector. On the other hand, Australia has been successful in achieving a moderate productivity growth. Figure 1 depicts the real exchange rate and the Balassa-Samuelson effect variable.

We use time series to test for the Balassa-Samuelson effect between two economies to explore for the existence of a direct pass-through mechanism from relative domestic production cost differences through the price mechanism to the real exchange rate. We then use impulse response analysis to assess the effect of an asymmetric positive productivity shock on the real exchange rate.

Other macroeconomic fundamentals used include relative current account balance (C_t), relative real GDP (G_t) and terms of trade shocks (T_t). As suggested by Krugman (1990) we attempt to confirm that relative current account balances trigger monetary effects that in turn

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[4] See Appendix A for the definition of variables and Appendix B for the data.

lead to transfers of capital between Australia and New Zealand, and consequently affect the real exchange rate. The effect of a shock to the relative current account balance should be of a short-term nature, given the absence of price stickiness. Figure 2 shows that the nominal exchange rate moved almost in unison with the real rate during the sample period (1985:Q4 – 2002:Q1), indicating the absence of any relative overall price stickiness.

Relative real GDP is one of the more important factors determining the overall purchasing power of the economy (Figure 3). Relative terms of trade are also used to explain movements in this real exchange rate. Figure 4 depicts the real exchange rate and the ratio of Australia to the New Zealand terms of trade. The major export commodities from New Zealand are dairy products and wool while the primary Australian exports are minerals and agricultural commodities. The real exchange rate of New Zealand and Australia moves with the terms of trade in particular of those commodities, and called 'commodity currencies' as discussed (see Koya and Orden, 1994).

Monetary theory advocates argue that monetary variables are the major determinants of the exchange rate (see, for example, Branson, 1975; Frenkel, 1976; Mussa, 1976; Whitman, 1975). A decrease in domestic interest rate leads to a depreciation of the domestic currency by creating excess supply of money. However, the issue of whether relative monetary measures provide directly or indirectly influence the long-run behavior of exchange rates has yet to be empirically shown. We address this issue with the case of bilateral real exchange rate between the two countries of concern by including the ratio of three-month T-bill rate in New Zealand to 13-week T-bill rate in Australia (M_t) and the co-movement between the real exchange rate and M_t is exhibited in Figure 5.

In the absence of exchange controls the internal and external balances are related through the exchange rate. New Zealand has traditionally run a relatively large current account deficit, which exceeded more than 5 percent of total GDP in some years (Figure 6). Annual total investment in New Zealand during 2000 constituted about 10 per cent of GDP and FDI accounted for 30 per cent of total investment. Total cumulative investment in New Zealand has increased over time and by March 2000 stood at $135 billion. As a result, net foreign income flows have been deteriorated since 1990. Most of the foreign acquisitions were in such non-tradable sectors as communication and banking. The profile of relative current account balance is depicted along with the real exchange rate in Figure 6. Appendix A discusses the definition of each variable and Appendix B explains the data in detail.

The next section examines the stationarity of the variables included in the analysis. Since the variables are non-stationary we estimate the reduced form by using the vector error correction model (VECM) representation (see Johansen, 1988, 1991; Jonhansen and Juselius, 1990). We then use impulse response techniques to assess the magnitude and duration of the effect of shocks from both the real and monetary factors.

4. Methodology

4.1. Cointegration

Cointegration analysis is used to examine the long run relationship among the key variables. It allows us to examine the deviation from long-run equilibrium conditions for a stationary group of dynamic variables, which individually are non-stationary. If a policy change is introduced at some point, economic forces should drive the cointegrating variables toward the new long run equilibrium conditions. The analysis is therefore ideal for the study of the effects of an economic reform program that New Zealand and Australia have experienced.

Any equilibrium relationship among a set of non-stationary variables implies that they share a common trend (see Stock and Watson, 1988). Dynamic movements of such variables will bear some relationship to the current deviation from the long run equilibrium. Recent works by Johansen (1988, 1991) and Johansen and Juselius (1990) on the cointegration of a group of dynamic variable models explain the long run equilibrium relationship with short run dynamic fluctuations. Procedures for evaluating the long-run equilibrium relationship within the framework of cointegration testing are developed in Johansen (1988, 1991, 1992), Stock and Watson (1988), Ahn and Reinsel (1988, 1990), and Reinsel and Ahn (1992).

First, we performed the Augmented Dickey-Fuller test (see Dickey and Fuller, 1979, 1981) to determine the order of integration of each time series data. Suppose that the data were generated from AR (p) process, $Y_t = \alpha + \sum_{i=1}^{p} \phi_{t-i} Y_{t-i} + \varepsilon_t$, then we can rewrite the process in an error correction form,

$$\Delta Y_t = \alpha + cY_{t-1} + \sum_{i=1}^{p-1} \varphi_{t-i} \Delta Y_{t-i} + \varepsilon_t, \qquad (1)$$

where $\Delta Y_t = Y_t - Y_{t-1}$, $c = -1 + \sum_{i=1}^{p} \phi_i$ and $\varphi_i = -(\phi_{i+1} + \cdots + \phi_p)$ for $i = 1, \cdots, p-1$.

The error correction form in the above is convenient since only one term, Y_{t-1}, is integrated process of order one, I(1), under the unit root hypothesis, and the rest of terms are stationary. The regression "t-ratio" of the estimator of c to its "standard error" from OLS regression of (1) is used to test the null hypothesis of a unit root with the critical values. Relatively high p-values (Table 1) indicated that we can not reject the null hypothesis of a unit root in each series, i.e., every series is I(1). However, all the variables are found to be stationary in first difference. We also perform the Phillips-Perron unit root test and the results are shown in Table 2 that are consistent with the results from ADF test.

4.2. *Tests for Stationarity and Structural Breaks*

As shown by Perron (1989), standard stationary tests are biased toward nonstationarity due to the misinterpretation of structural breaks as stochastic disturbances. The inflation target monetary policy was adopted first by New Zealand in March 1990 and then by Australia in 1993, which might misguide us to that misinterpretation. Accordingly, Perron's structural break unit root tests are carried out with two candidate break points. We consider three types of structural change to occur:

Model A: $\Delta Y_t = \mu + \theta DU_t + \beta t + dD(TB)_t + \alpha Y_{t-1} + \sum_{i=1}^{k} c_i \Delta Y_{t-i} + \varepsilon_t$

Model B: $\Delta Y_t = \mu + \beta t + \gamma DT_t^* + \alpha Y_{t-1} + \sum_{i=1}^{k} c_i \Delta Y_{t-i} + \varepsilon_t$

Model C: $\Delta Y_t = \mu + \theta DU_t + \beta t + \phi DT_t + dD(TB)_t + \alpha Y_{t-1} + \sum_{i=1}^{k} c_i \Delta Y_{t-i} + \varepsilon_t$,

where $DU_t = 1$ if $t > T_B$ (T_B = 1990:Q1 for New Zealand, or 1993:Q1 for Australia),

$= 0$ otherwise;

$D(TB)_t = 1$ if $t = T_B+1$,

$= 0$ otherwise;

$DT^*_t = t - T_B$ if $t > T_B$,

$= 0$ otherwise, and

$DT_t = t$ if $t > T_B$,

$= 0$ otherwise.

Models A and B capture a change in the intercept and a change in the slope of trend function, respectively, while Model C accounts for a simultaneous change in the intercept and the slope of the trend function as reported in Table 3 in the case of New Zealand. The unit root hypothesis cannot be rejected at the 5 percent level for every variable and there are no signs of existence of the structural breaks between pre- and post- inflation target monetary policy. Both Australia and New Zealand generate the same results.[5]

4.3. *Error Correction Model*

We further test the cointegration relationship among six variables based on the maximal eigenvalue and trace statistic tests (Table 4). We consider a 6-dimensional VAR(p) model for $Z_t = (R_t, B_t, C_t, G_t, T_t, M_t)'$,

$$Z_t = \delta + \sum_{i=1}^{p} \Phi_i Z_{t-i} + \varepsilon_t, \tag{2}$$

where δ is a 6×1 vector of constant term, Φ_i is a 6×6 matrix of parameters, and ε_t is a white noise with positive definite covariance matrix Σ_ε.

We can rewrite the model (2) in a Vector Error Correction Model (VECM) representation form,

$$W_t = \delta + \Phi Z_{t-1} + \sum_{i=1}^{p-1} \Phi_i^* W_{t-i} + \varepsilon_t, \tag{3}$$

where $W_t = Z_t - Z_{t-1}$, $\Phi = -I_6 + \sum_{i=1}^{p} \Phi_i$, $\Phi_i^* = -\sum_{k>i}^{p} \Phi_k$, and I_6 is a 6×6 identity matrix.

The long-run behavior of Z_t is concentrated in the coefficient matrix Φ. If the rank of Φ is zero, then each component of Z_t is I(1) and there does not exist any stationary long-run equilibrium relationship among the variables. If the rank of Φ is six, then each component of Z_t is stationary. If the rank of Φ is between zero and six, i.e., $0 < r = rank(\Phi) < 6$, then Z_t is cointegrated with conintegrating rank r and Φ contains the stationary long run equilibrium information. Therefore, the rank of the coefficient matrix Φ should be examined for the long

[5] The test result for Australian case is available upon request.

run equilibrium information. We need to determine an appropriate rank of the coefficient matrix Φ as well as the AR order of the model. An appropriate AR order based on partial canonical correlation analysis (see Ahn and Reinsel, 1988) is chosen to be 5, i.e. AR(5) is chosen. We further choose the cointegrating rank of the six variables based on the maximal eigenvalue and trace test statistics using the AR(5) model, and these are summarized in Table 4. The null hypothesis that the cointegrating rank is at most r is tested against an alternative that cointegrating rank is six using the trace test statistic, and against an alternative that cointegrating rank $r+1$ using the maximal eigenvalue statistics. The cointegrating rank r is chosen as the smallest value among the values where the null hypothesis is not rejected. The trace test indicates two cointegrating equations at both 5 per cent and 1 per cent levels. However, the max-eigenvalue test indicates two cointegrating equations at the 5 per cent level and one cointegrating equation at the 1 per cent level. The max-eigenvalue test has the sharper alternative hypothesis and it is usually preferred for trying to pin down the number of cointgration vectors.

The estimated cointegration vector (β) from equation (3) is given in Table 5, along with the respective speed of adjustment coefficients (α), where $\Phi=\alpha\beta'$. The cointegration vector as an error correction mechanism can be interpreted as real exchange rate misalignment with the estimated long run equilibrium relation given by

$$R_t = 0.48B_t - 1.35C_t + 1.17G_t + 0.81T_t + 0.16M_t. \qquad (4)$$

These results are overall consistent with expectations. An increase in productivity in the non-tradable sector in New Zealand relative to Australia (i.e., a decrease in B_t, given the relative levels in the tradable sectors) would lower the value of the New Zealand currency by increasing wages in the tradable sector in New Zealand. The impact of the relative current account balance can be broken into two components – the ratio of absolute balances (C_t) and the ratio of the two incomes (G_t). The signs are as would be expected, with the combined effect being negative. Changes in the relative terms of trade (T_t) in favor of Australia have a similar and slightly stronger effect, as does changes in the relative overall levels of productivity. An increase in the Australian relative interest rates must work through the capital account, increasing demand for Australian currency and lowering the value of the New Zealand currency. The magnitude of the impact is smaller than that of relative changes in the non-tradable sector productivity.

4.4. Impulse Response Analysis

Previous section found that the long-term trend of real exchange rates between Australia and New Zealand are appropriately explained by such variables as the Balassa-Samuelson effect, relative current account balance, relative real GDP, terms of trade shocks and interest rate differentials between the two countries. This section analyses the short-run dynamic effects of the shock in certain variables on the real exchange rate.

The VECM estimated in the previous section is used to generate the impulse response of each of the six variables to a positive, one standard deviation shocks in the residuals. We focus on the response of the real exchange rate to unexpected increases in the other variables in our model (Figure 7). The shocks to the Balassa-Samuelson effect, terms of trade and monetary variables have a strong and positive impact on the real exchange rate.

First, our results are consistent with what was predicted by the Balassa-Samuelson effect. A change in the ratio of productivity in the non-tradable to the tradable sector in favor of Australia (i.e., an increase in B_t) causes a decrease in the value of the Australian currency. The impact of a shock is persistent over the long run and the magnitude of the impact is larger than that of all other variables. The impact of monetary policy is persistent, contrary to the expectations of the neutrality of money. This suggests an indirect effect through wealth flows. An increase in New Zealand interest rates relative to those of Australia, other things being equal, would trigger loan financing into New Zealand, an increase in the balance on the capital account and an upward impact on the exchange rate that persists in the long run. This relationship can be indirectly verified by the significant and persistent impact of the current account balance on the relative interest rates (Figure 8). In that case, half of the adjustment occurs in the first three years. Changes in the terms of trade also trigger significant and persistent changes in the real exchange rate. The terms of trade in turn respond more to changes in elative productivity in the non-tradable sectors, with most of the adjustment occurring within two and a half years (Figure 9). Finally, the combined effect of a shock to the relative current account balances is relatively small and the half-life is just about three and a half years.

4.5. Actual Exchange Rate vs. Equilibrium Exchange Rate

The equilibrium real exchange rate derived from our model is plotted along with the actual real rate in Figure 10. The equilibrium rate traces the actual rate very closely and it accurately tracks turning points over the sample period, which indicates our exchange rate model with economic fundamentals explains accurately the fluctuation and trends of the bilateral real exchange rate between Australia and New Zealand. Any deviation of the actual real exchange rate from the equilibrium real exchange rate can be interpreted as a residual that can not be explained by the fundamentals in our model. Financial factors and speculative behavior, including asset price bubbles and changes in portfolio diversification, could be incorporated into the model. The substantial appreciation of New Zealand dollar against Australian dollar during 1986-7 followed by its steep depreciation in 1988 is well traced by the economic fundamentals. However, the moderate deviation of the actual rate from the equilibrium rate during 1991 and 1999-2000 might be due to speculative behavior and changes in portfolio preferences. The equilibrium real exchange rate derived from our exchange rate model will provide the policy makers with a useful tool for predictions of the trend movements in the future exchange rate if a good expectation on the economic fundamentals can be formed.

4.6. Pseudo Out-of-Sample Forecasting

We perform a pseudo out-of-sample forecasting to test its forecasting performance in future time. First we estimate the model over the period 1985:Q4-2000:Q1 and then we forecast the values of the real exchange rate over the next eight quarters by re-estimating the regression with the additional forecasted data until the end of sample period, 2002:Q1. The forecasts do not capture the downward pressure during 2000; however, they reasonably replicate the actual rate toward the end of the sample period and they outperform a random walk model (Figure 11).

5. Conclusion

Our results validate the relationship of changes in real variables and the real exchange rate. There has been a high degree of economic integration between New Zealand and Australia with linked capital and labor markets. When their economies are highly integrated each other changes in monetary policy are likely to have a long-lasting impact due to their effect on capital flows. An improvement in terms of trade leads to a relative improvement in overall productivity and real per capita income, which is likely to strengthen the real exchange rate. A shock to the relative productivity of the non-tradable sector has an insignificant direct impact on growth. The pass-through mechanism, however, works through the real exchange rate and, for those countries with significant market power, through the terms of trade. This result has important implications for wage policies in developing countries that rely on commodity exports produced with relatively unskilled labor. Productivity increases in small but skill intensive sectors such as electricity and telecommunications could have wage implications for the export sectors. The impact of wage push cost increases is likely to be persistent, though not apparent directly in the short term. Our results also cast doubt on the law of one price, but they do fortify the links between domestic sector productivity and monetary policy to the external sector. This link operates through the long-term trend of the bilateral real exchange rate of trade partners. Bilateral exchange rate stability therefore may require coordination of policies in the domestic sectors. The model suggests that a good understanding of the economic fundamental variables will help the policy makers predict the future value of the real exchange rate between Australia and New Zealand.

Appendix A: Variables

Every variable is normalized to be a unity at 1990:Q1.

R_t: Real Exchange Rate $\left(\frac{AUD}{NZD}\frac{P_{NZ}}{P_{AU}}\right)$

B_t: Balassa-Samuelson Effect

$$\left(\frac{\text{Productivity in Tradable Sector }(NZ)/\text{Productivity in Nontradable Sector }(NZ)}{\text{Productivity in Tradable Sector }(AU)/\text{Productivity in Nontradable Sector }(AU)}\right)$$

C_t : Relative Current Account $\left(\frac{NZ\left(\frac{Debit\ of\ CA}{Credit\ of\ CA}\right)}{AU\left(\frac{Debit\ of\ CA}{Credit\ of\ CA}\right)}\right)$,

Debit of CA = Import (Goods and Services) + Investment Income Payment + Outflow of transfer income

Credit of CA = Export (Goods and Services) + Investment Income Receipt + Inflow of transfer income

G_t: Relative Real GDP $\left(\frac{NZ(\text{Real }GDP)}{AU(\text{Real }GDP)}\right)$

T_t: Relative Terms of Trade $\left(\frac{Terms\ of\ Trade\ (NZ)}{Terms\ of\ Trade\ (AU)}\right)$

M_t: Interest Differential $\left(\frac{3\ Month\ \ T-Bill\ Rate\ (NZ)}{13\ Weeks\ \ T-Bill\ Rate\ (AU)}\right)$

Appendix B: Data

Each of the time series data covers from 1985:Q4 to 2002:Q2. The spot nominal exchange rates for New Zealand and Australia, consumer price index (CPI), Australia 13-week T-bill rate, New Zealand 90-day T-bill rate, and the real GDPs were collected from IFS CD-ROM (International Monetary Fund, 2003). Australia terms of trade were collected from Australian Bureau of Statistics (ABS) and New Zealand terms of trade were collected from PC-INFOS in Statistics New Zealand. Seasonally adjusted real GDP by industry and the employment in the labor force by industry (NZSIC) derived from a survey (Household Labour Force Survey) in New Zealand were collected from PC-INFOS in Statistics New Zealand.

The labor productivity is defined by the ratio of GDP to the number of employment. The tradable sectors in New Zealand consist of agriculture, hunting, forestry, and fishing; mining and quarrying; and manufacturing sectors. The non-tradable sectors in New Zealand include electricity gas and water; building and construction; wholesale and retail trade; transport, storage and communications; business and financial services; community, social and personal services; and others.

Seasonally adjusted real GDP by industry and the employment in the labor force by industry (ANZSIC) were collected from Australian Bureau of Statistics. The labor productivity is defined analogously. The tradable sectors in Australia include agriculture, forestry and fishing; mining; manufacturing; and electricity, gas and water supply. The non-tradable sectors in Australia include construction; wholesale trade; retail trade; accommodations, cafes and restaurants; transport and storage; communication services; finance and insurance; property and business services; education; health and community services; cultural and recreational services; and personal and other services.

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Table 1

Augmented Dickey-Fuller Tests

	Level Form			First Difference Form		
Variable	Lag Length	ADF Test Statistics	P-values	Lag Length	ADF Test Statistics	P-values
R_t (Real Exchange Rate)	6	-1.13	0.23	1	-6.13	<0.0001
B_t (Balassa-Samuelson)	3	-1.68	0.44	2	--8.94	<0.0001
C_t (Current Account)	4	-0.43	0.54	2	-3.76	0.0003
G_t (Relative GDP)	1	-0.97	0.29	3	-8.86	<0.0001
M_t (Interest Differential)	2	-0.81	0.36	1	-5.95	<0.0001
T_t (Relative terms of trade)	1	--2.22	0.20	1	-7.09	<0.0001

Table 2

Phillips-Perron Unit Root Tests

	Level Form			First Difference Form		
Variable	Lag Length	Test Statistics	P-values	Lag Length	ADF Test Statistics	P-values
R_t (Real Exchange Rate)	1	-2.28	0.18	1	-6.10	<0.0001
B_t (Balassa-Samuelson)	1	-1.59	0.48	1	-8.99	<0.0001
C_t (Current Account)	1	-0.88	0.33	1	-16.71	<0.0001
G_t (Relative GDP)	1	-1.38	0.15	1	-8.83	<0.0001
M_t (Interest Differential)	1	-2.49	0.12	1	-5.78	<0.0001
T_t (Relative ToT)	1	-2.28	0.18	1	-7.06	<0.0001

Table 3

Perron's Unit Root Test with Structural Break

Variable	Model	λ	Lag	μ	θ	β	d	γ	ϕ	α	Critical Value (5%)	DW
R_t	A	0.27	2	0.049** (2.27)[a]	0.0015 (0.10)[a]	-0.0004 (-1.00)[a]	0.028 (0.825)[a]	-	-	-0.183 (-2.41)[a]	-3.76	1.905 (0.218)[b]
	B	0.27	2	0.039 (1.76)*	-	0.0015 (1.11)	-	-0.002 (-1.42)	-	-0.232 (-2.84)	-3.87	1.925 (0.242)
	C	0.27	2	0.033 (1.34)	0.039 (1.33)	0.0023 (1.25)	0.027 (0.78)	-	-0.003 (-1.50)	-0.232 (-2.83)	-4.17	1.939 (0.219)
B_t	A	0.27	2	-0.92* (-1.72)	0.086 (1.35)	0.004** (2.13)	-0.99 (-0.79)	-	-	-0.367 (-2.95)	-3.76	1.869 (0.178)
	B	0.27	2	-0.226** (-2.37)	-	0.016** (2.55)	-	-0.012* (-1.99)	-	-0.351 (-3.25)	-3.87	1.845 (0.156)
	C	0.27	2	-0.223** (-2.20)	0.231** (2.02)	0.016* (1.95)	-0.096 (-0.76)	-	-0.012 (-1.52)	-0.357 (-2.89)	-4.17	1.839 (0.124)
C_t	A	0.27	2	-0.045** (-3.92)	-0.025** (-2.07)	0.0002 (0.58)	0.009** (3.74)	-	-	-0.229 (-3.54)	-3.76	1.993 (0.333)
	B	0.27	2	-0.039** (-2.32)	-	-0.0001 (-0.16)	-	-0.0001 (-0.02)	-	-0.183 (-2.60)	-3.87	2.006 (0.351)
	C	0.27	2	-0.056** (-3.08)	-0.012 (-0.58)	0.0012 (0.86)	0.099** (3.68)	-	-0.001 (-0.76)	-0.227 (-3.49)	-4.17	2.007 (0.306)
G_t	A	0.27	4	0.354** (2.75)	0.003 (0.18)	0.005 (1.41)	0.012 (0.35)	-	-	-0.216 (-2.86)	-3.76	1.874 (0.165)
	B	0.27	4	0.258* (1.89)	-	0.003* (1.97)	-	-0.003* (-1.68)	-	-0.183 (-2.43)	-3.87	1.978 (0.288)
	C	0.27	4	0.192 (1.31)	0.072** (2.01)	0.006** (2.27)	0.007 (0.21)	-	-0.005** (-2.10)	-0.159 (-2.04)	-4.17	2.055 (0.345)
M_t	A	0.27	2	-0.027 (-0.90)	-0.013 (-0.29)	0.0001 (0.11)	0.053 (0.51)	-	-	-0.214 (-2.88)	-3.76	2.025 (0.363)
	B	0.27	2	-0.127* (-1.96)	-	0.007 (1.65)	-	-0.008* (-1.71)	-	-0.261 (-3.46)	-3.87	2.096 (0.468)
	C	0.27	2	-0.199** (-2.66)	0.173** (2.00)	0.015** (2.47)	0.059 (0.60)	-	-0.015** (-2.49)	-0.280 (-3.69)	-4.17	2.147 (0.501)
T_t	A	0.27	2	-0.012 (-0.67)	-0.021 (-0.56)	0.002 (0.21)	0.078 (0.21)	-	-	-0.432 (-2.22)	-3.76	1.98 (0.623)
	B	0.27	2	-0.202 (-1.32)	-	0.03 (1.11)	-	-0.032* (-1.89)	-	-0.134 (-2.99)	-3.87	1.96 (0.973)
	C	0.27	2	-0.231** (-2.79)	0.198** (2.54)	0.19** (2.98)	0.26 (0.44)	-	-0.22** (-2.78)	-0.30 (-3.97)	-4.17	1.89 (0.259)

a) The values in the parenthesis are the t-ratios.
b) The values in the parenthesis are the p-values.

Table 4

Cointegration Rank Tests

H_0	Eigen Values	Trace Statistic	Max-Eigen Value Statistic	CRITICAL VALUES AT 5%*		CRITICAL VALUES AT 1%*	
				Trace	Max	Trace	Max
$r = 0$	0.59295	122.422	54.82791	82.49	36.36	90.45	41.00
$r \leq 1$	0.43444	67.5945	34.76690	59.46	30.04	66.52	35.17
$r \leq 2$	0.27037	32.8276	19.22874	39.89	23.80	45.58	28.82
$r \leq 3$	0.11048	13.5989	7.142115	24.31	17.89	29.75	22.99
$r \leq 4$	0.09588	6.45683	6.148741	12.53	11.44	16.31	15.69
$r \leq 5$	0.00503	0.30809	0.308094	3.84	3.84	6.51	6.51

* The critical values are taken from Osterwald-Lenum, M. (1992)

Table 5

Normalized Cointegration Vector and Adjustment Coefficients

Variable	α	β
R_t (Real Exchange Rate)	-0.188 (0.050)	1
B_t (Balassa-Samuelson Effect)	0.119 (0.087)	-0.481 (0.187)
C_t (Relative Current Account)	-0.441 (0.121)	1.353 (0.229)
G_t (Relative GDP)	-0.147 (0.059)	-1.169 (0.202)
M_t (Interest Differential)	0.302 (0.210)	-0.16 (0.08)
T_t (Relative Terms of Trade)	0.048 (0.053)	-0.805 (0.249)

Figures in parentheses are standard errors.

Figure 1

Real Exchange Rate and Balassa-Samuelson Effect Variable

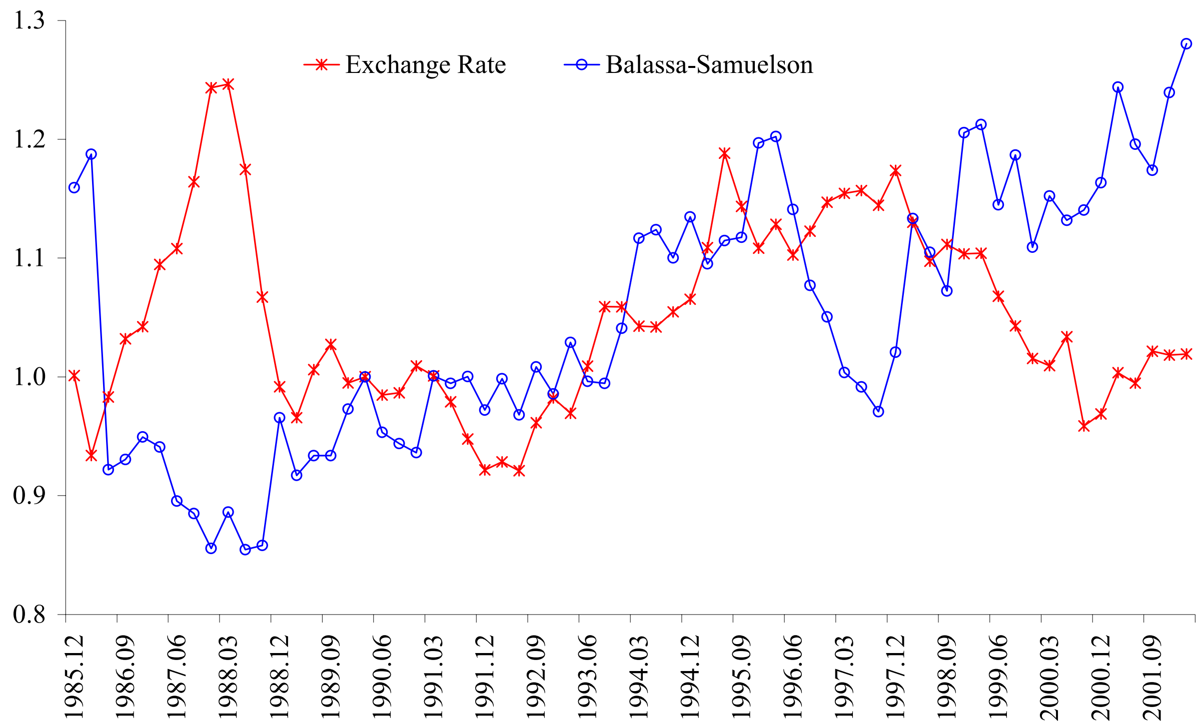

Figure 2

Nominal Exchange Rate and Real Exchange Rate

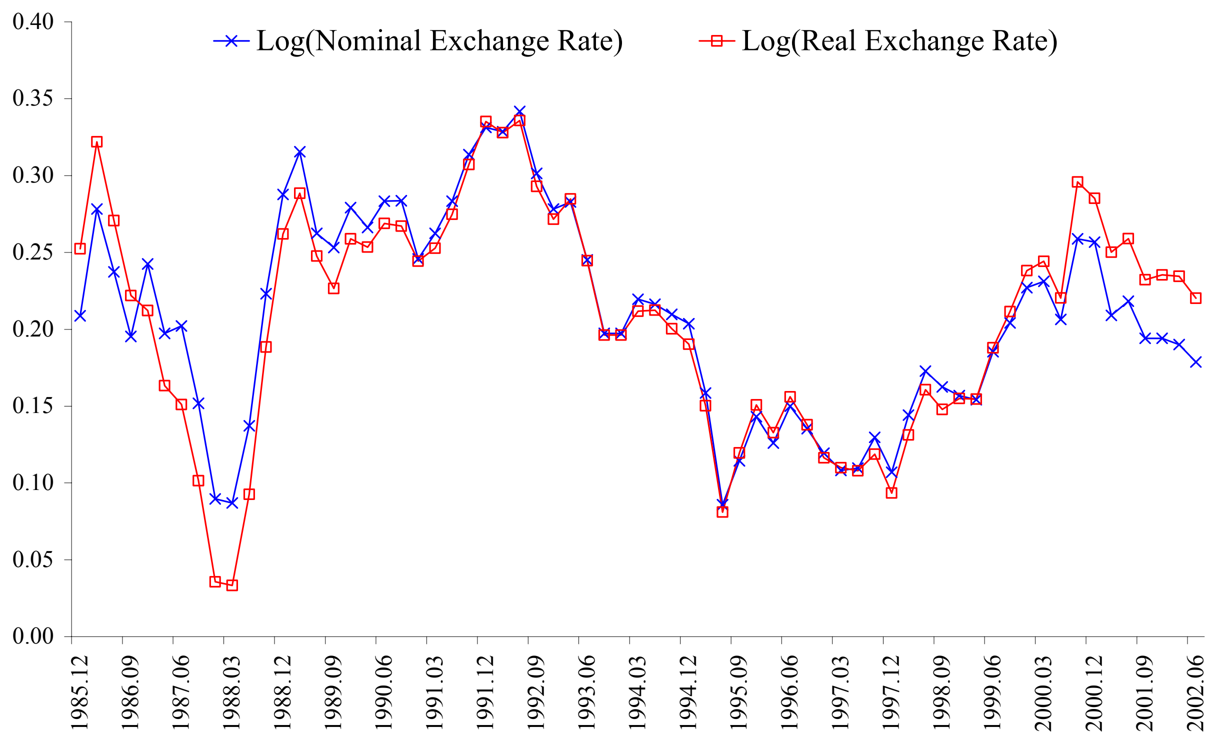

Figure 3

Real Exchange Rate and Relative Real GDP

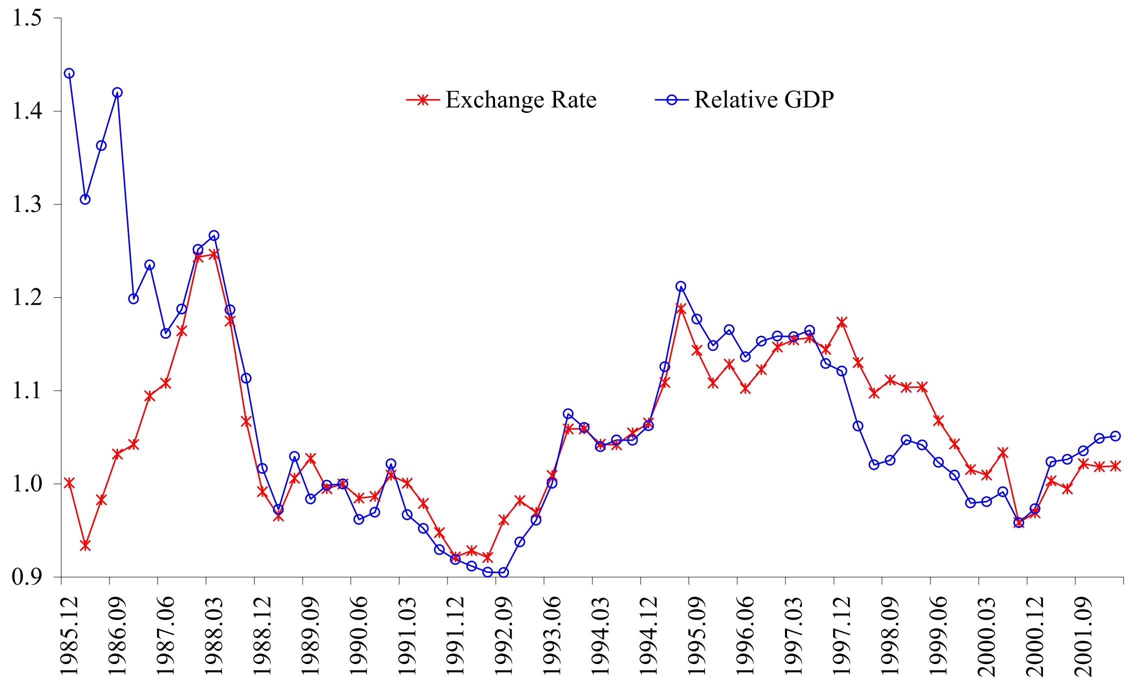

Figure 4

Real Exchange Rate and Relative Terms of Trade

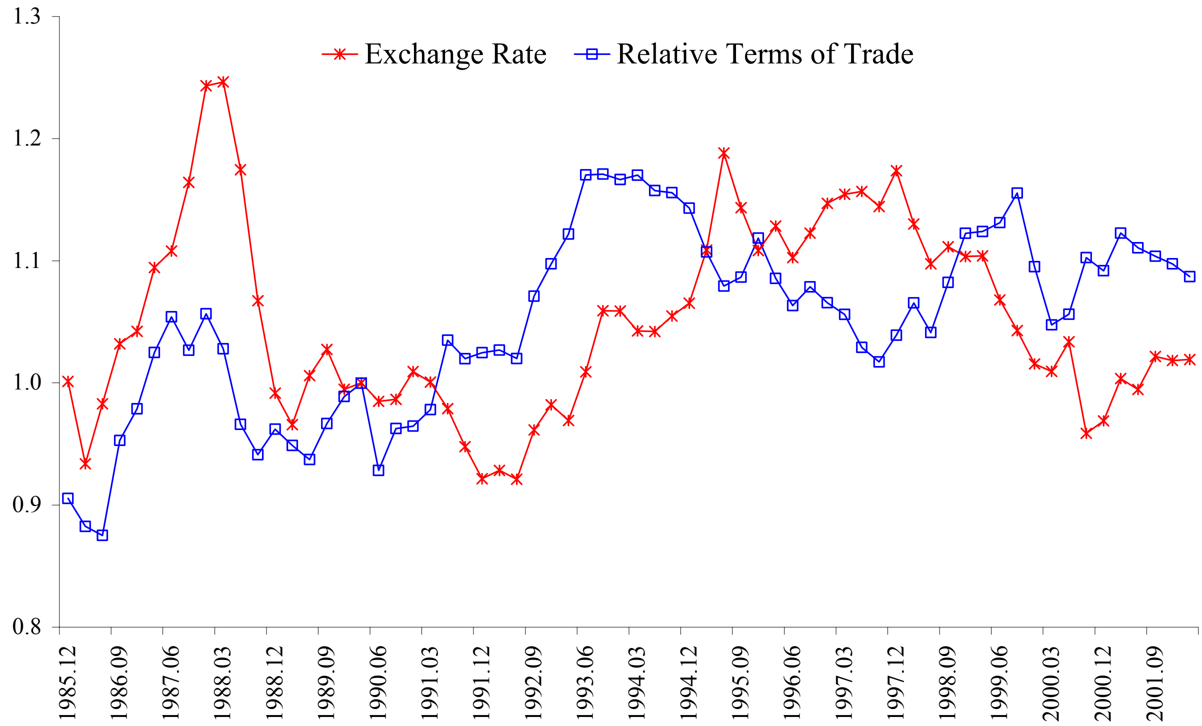

Figure 5

Real Exchange Rate and Interest Rate Differential

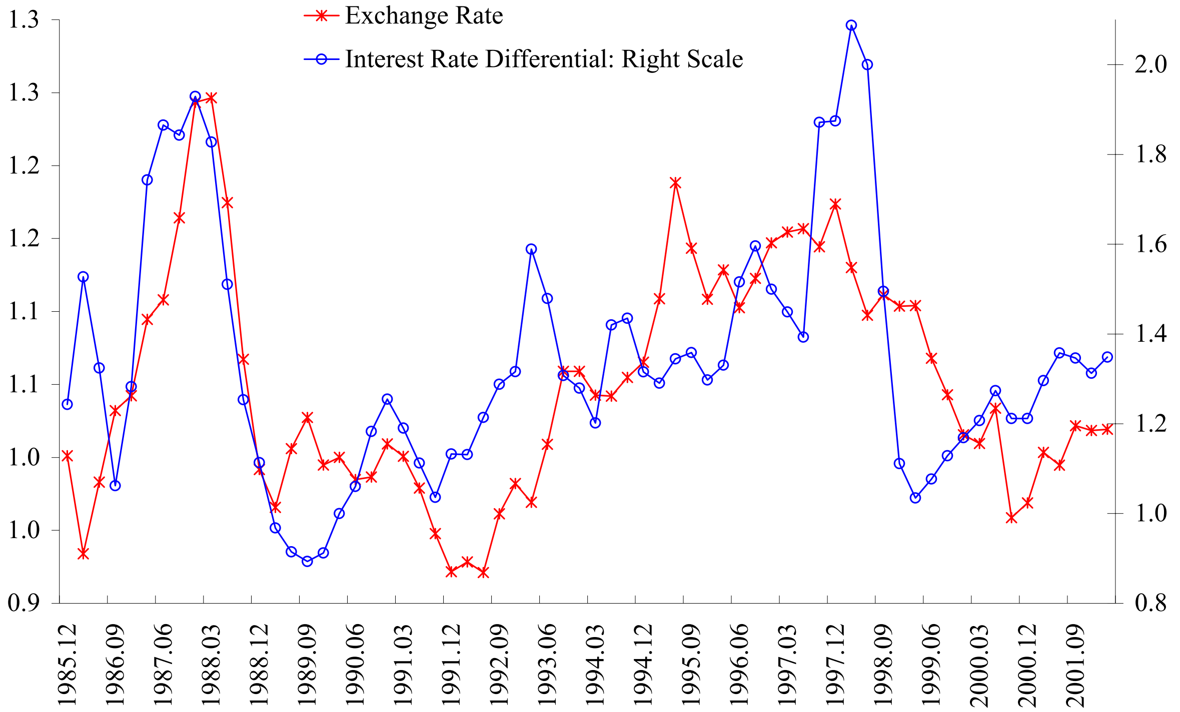

Figure 6

Real Exchange Rate and Current Account

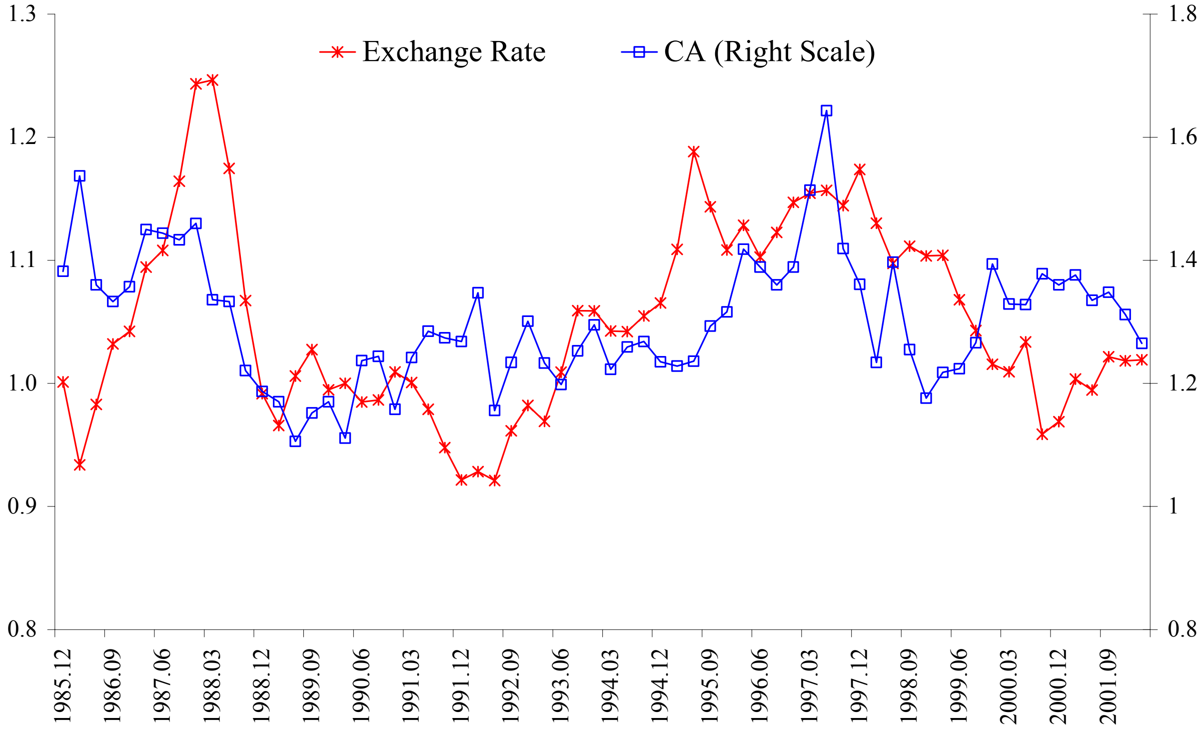

Figure 7

Response of Real Exchange Rate (R)

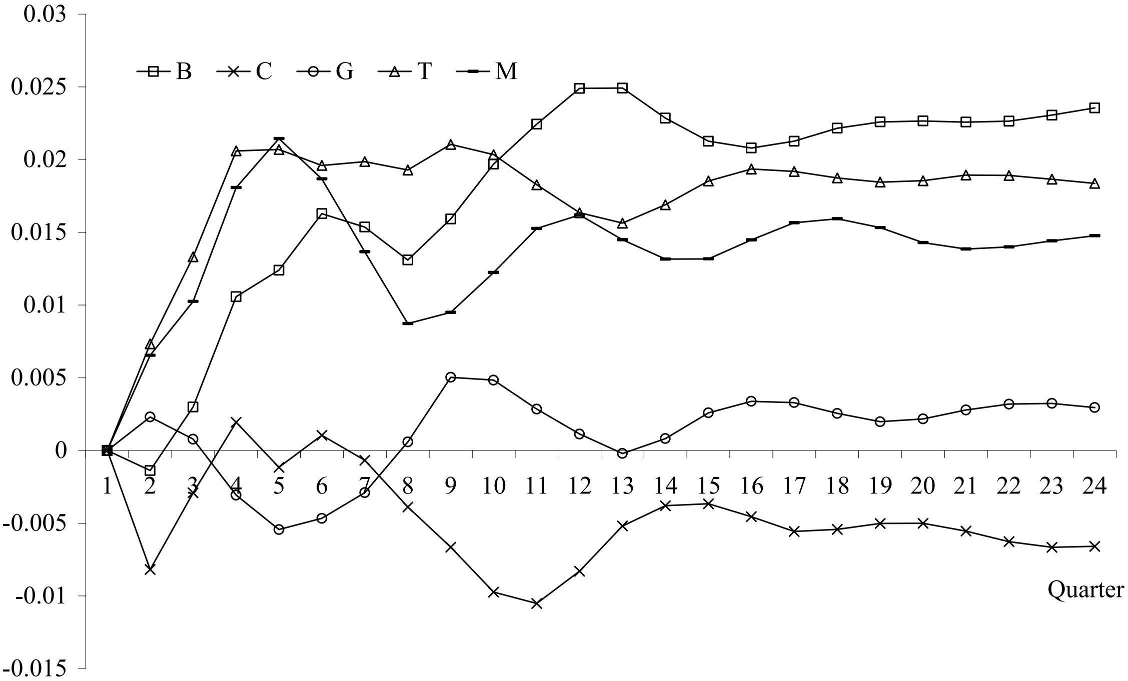

Figure 8

Response of Interest Differential (M)

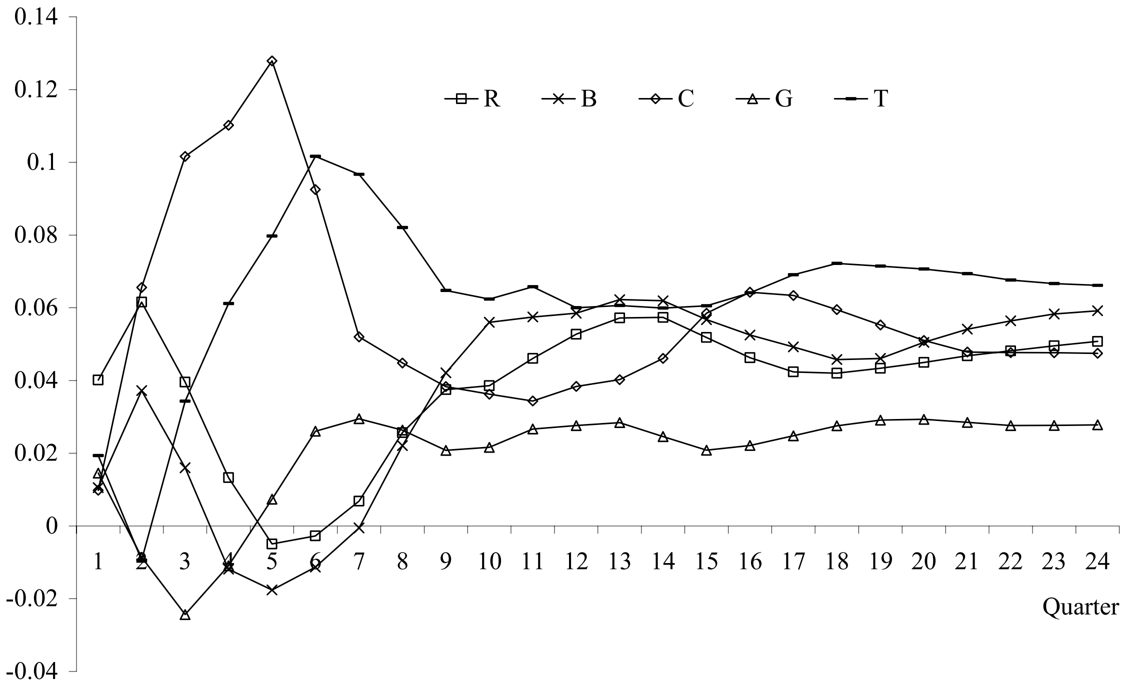

Figure 9

Response of Relative Terms of Trade (T)

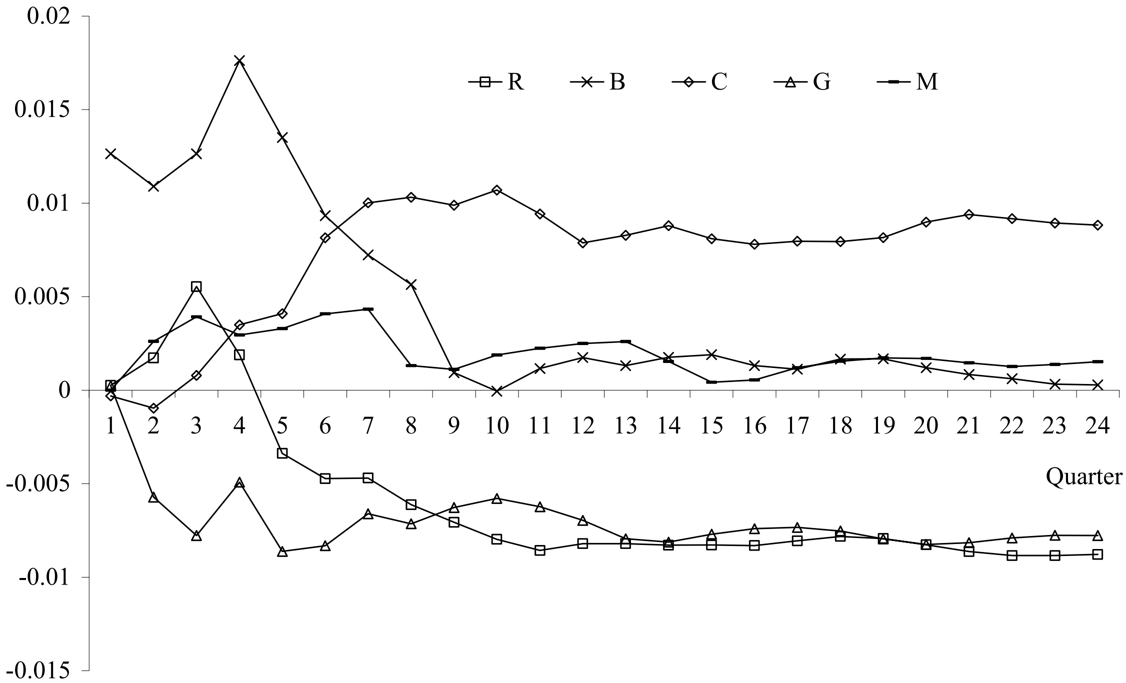

Figure 10

Estimated Equilibrium Exchange Rate and Actual Exchange Rate

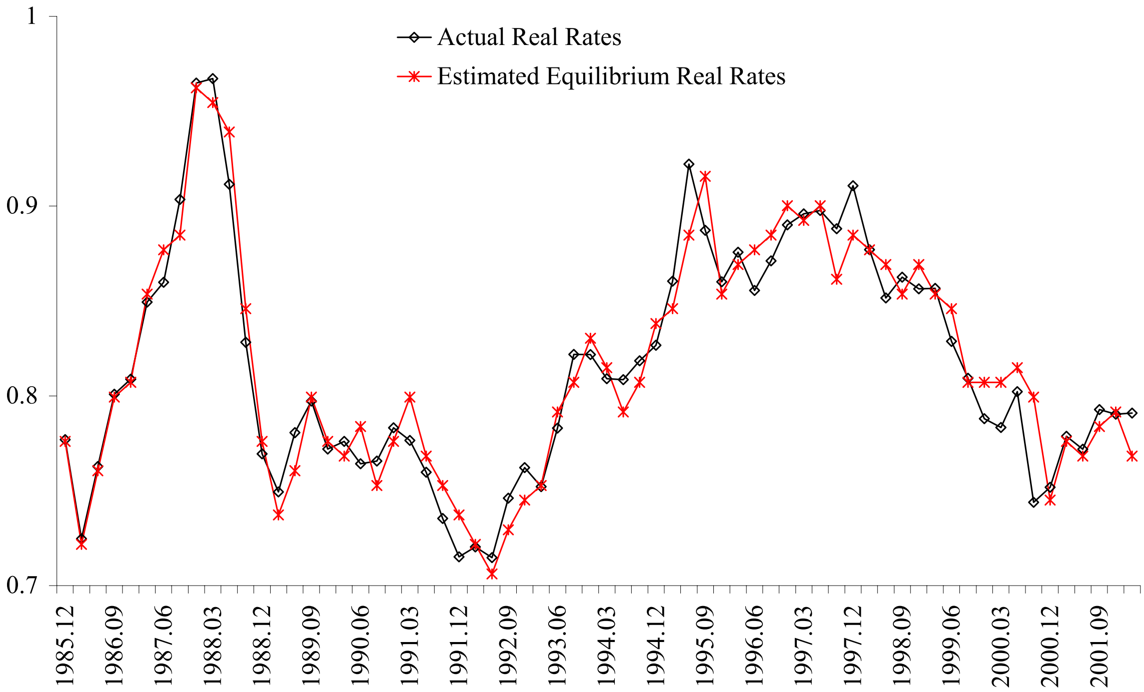

Figure 11

Pseudo Out-of-Sample Forecasts