Sources of Australian Real Exchange Rate Fluctuations: How Important is the Relative Price of Nontradable Goods?[1]

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Abstract

This study investigates sources of fluctuations in the real Australian exchange rate relative to the U.S. and the New Zealand dollars. In particular, it examines the empirical validity of the traditional theoretical view such as Balassa (1964) and Samuelson (1964) that movements in the real exchange rate are driven by productivity differentials through the relative price of nontradable goods. Using a framework of VAR modelling, our finding goes against the theoretical proposition and reinforces other recent empirical studies which employ different approaches to address the issue. The VAR analysis shows that the key channel through which shocks impact on the real exchange rate is the deviation from the law of one price among tradable goods rather than the relative price of nontradable goods. Further, productivity shocks are found to play a less important role than other types of real shocks in accounting for the real exchange rate volatility.

Keywords: Real exchange rates, Structural VAR, Long-run restrictions, Balassa-Samuelson hypothesis
JEL Classifications: C32, C53, F31

1. Introduction

The real exchange rate is a measure of a country's overall price relative to another country's. If the nominal exchange rate is defined as the price of one currency in terms of another, then

[1] This paper draws on Chapter 3 of my Honours thesis at the University of New South Wales. I am grateful to my supervisors, Lance Fisher and Glenn Otto for support and guidance. I also thank Renee Fry and Warwick McKibbin at CAMA, ANU for their useful comments.

the real exchange rate is the nominal exchange rate adjusted for relative national price level differences. This definition allows a decomposition of the real exchange rate into a component that is associated with the price of tradable goods and another component that is associated with the relative price of nontradable goods. Theoretical views influenced by the seminal works of Balassa (1964) and Samuelson (1964) assume that the tradable component is transitory and hence attribute movements in the real exchange rate to movements in the relative price of nontradable goods. They emphasise the role of productivity differentials between the tradable and nontradable sectors in determining the relative price of nontradable to tradable goods across countries which in turn influences movements of the real exchange rate.

In the last four decades, the insights of the Balassa-Samuelson hypothesis have provided the guiding principles for most theoretical research on real exchange rates. For instance, Mendoza (1991), Robelo and Vegh (1995) and Stockman and Tesar (1995) present models in which the real exchange rate is precisely the relative price of nontraded to traded goods across countries, and movements in the relative prices of traded goods play no role. This theoretical proposition has recently come under scrutiny especially after an influential study by Engel (1999). He demonstrates that changes in the relative prices of nontraded goods account for almost none of the variations in the U.S. real exchange rate relative to other major OECD countries. More recent studies including Burstein et al (2005), Betts and Kehoe (2006) and Chaban (2006) draw a similar conclusion against the Balassa-Samuelson hypothesis and many theoretical models of real exchange rate that place emphasis on the relative price of nontradable goods.

This paper provides an empirical test, for the case of the Australian real exchange rates against the U.S. dollar and the New Zealand dollar, of the Balassa-Samuelson hypothesis that real exchange rate movements are driven by productivity differentials through the relative price of nontradable goods. Previous studies (Engle, 1999; Betts and Kehoe, 2001) use the ratio of changes in the tradable component of the real exchange rate to changes in the real exchange rate at different horizons as a measure of the relative importance between the tradable and nontradable components in determining movements in the real exchange rate. This study adopts a different approach whereby a structural vector autoregression (VAR) model is used to determine whether or not the relative price of nontradable to tradable goods across countries is the primary driver of the real exchange rate movements as theoretical models such as Balassa (1964) and Samuelson (1964) posit.

The structural VAR model central to the analysis of this paper is an extension of the prototype VAR model of real and nominal exchange rates of Lastrapes (1992)[2] whereby the nontradable and tradable components of the real exchange rate are included in the VAR system as separate variables. This extension allows us to gain a deeper insight into sources of real exchange rate fluctuations by uncovering the primary channel through which various shocks impact upon the real exchange rate and the primary sources of fluctuations in each component of the real exchange rate. It is found that various types of shocks impact on the real exchange rates predominantly through the tradable component of the real exchange rate rather than the relative price of nontradable goods. Moreover, productivity shocks are found to play a less important role than shocks to the deviation from the law of one price among tradable goods in accounting for the variability of the real exchange rate. These findings, consistent with Engel (1999) essentially present that the conclusion against the theoretical proposition influenced by

[2] Examples of succeeding studies that use the exchange rate VAR model of Lastrapes (1992) include Enders and Lee (1997) and Gallagher and Kavahagh (2002).

Balassa (1964) and Samuelson (1964) is reinforced when a different approach of testing the hypothesis is utilised.

The remainder of the paper is organised as follow. Section 2 defines the real exchange rate and its decomposition into the tradable and nontradable components. The construction of these series is also detailed. Section 3 outlines the VAR model of Lastrapes'(1992) and its modified version central to the analysis of this study. Results are presented in Section 4. Section 5 concludes.

2. Decomposition of the real exchange rate

Before discussing further the empirical strategy that will be used to address the central issue of this paper, it is instructive to explicitly define the real exchange rate equation and its decomposition. In logarithmic terms, the real exchange rate is defined as follows:

$$q_t = s_t + p_t - p_t^*, \qquad (2.1)$$

where q_t, s_t, p_t, p_t^* denote natural logarithms of the real exchange rate, the nominal exchange rate, the domestic price level and the foreign price level respectively. According to this definition, an increase in q_t corresponds to a real appreciation of domestic currency.

Suppose the price indices in both countries are constructed as follows:

$$p_t = (1-\alpha)p_t^T + \alpha p_t^N \qquad (2.2)$$

$$p_t^* = (1-\beta)p_t^{T*} + \beta p_t^{N*}, \qquad (2.3)$$

where p_t^T, p_t^N denotes respectively the log of the tradable goods price index and the log of the nontradable goods price index of the home country, an asterisk represents the foreign country, and a and b are the shares nontradable goods take in the price indices of the domestic and foreign countries.

Consequently, the real exchange rate can be decomposed into two constituent parts:

$$q_t = x_t + y_t \tag{2.4}$$

$$x_t = s_t + p_t^T - p_t^{T*} \tag{2.5}$$

$$y_t = a(p_t^N - p_t^T) - b(p_t^{N*} - p_t^{T*}) \tag{2.6}$$

Equation (2.4) indicates that the log of the real exchange rate is composed of two parts: the deviation from the law of one price among tradable goods, x_t; and the weighted relative price of nontradable to tradable goods across countries, y_t.

Traditional models of real exchange rate determination assume that the deviation from the law of one price among tradable goods, i.e. the x_t component in Equation (2.4), is small and temporary as arbitrage activities speed up tradable goods price adjustment to shocks and hence attribute all movements in the real exchange rate to changes in the y_t component. This paper tests if this proposition holds in the data for the case of the Australian real exchange rate against the New Zealand and the U.S. dollar.

The sample period covered in this study is from 1984Q1 to 2005Q1. The data is quarterly and taken from the Reserve Bank of Australia, the Reserve Bank of New Zealand and the U.S. Bureau of Labour Statistics. Each exchange rate series is expressed in natural logarithms of the foreign currency price of an Australian dollar. Consumer Price Indices are used as proxies of price levels.

The theoretical literature on real exchange rates usually relies on a neat division of goods into 'tradables' and 'nontradables'. Unfortunately, such a clean decomposition is difficult to attain in the data available to empirical researches. Determining precise indices that accurately capture the price of tradable and nontradable goods is a difficult exercise due to an obscure tradability of certain goods. For example, some goods themselves might be tradable but their prices could in fact incorporate the marketing services that are probably nontradable. Conversely, some services which are traditionally thought of as being nontradable are in fact traded across countries nowadays, such as financial services. For this reason, it is acknowledged that the price indices constructed for the purpose of this analysis might be subject to measurement errors.

Following the approach of Engel (1999), tradable and nontradable goods price indices are constructed for the U.S., Australia and New Zealand. A tradable goods price index for the U.S. is constructed from the food and all goods less food CPI sub-indices, and a nontradable goods price index is constructed from the rent and all services less rent CPI sub-indices. Since the same disaggregated data on Australian consumer price index is not available, we used the CPI-goods component and the CPI-services component as proxies of the tradable price index and nontradable price index respectively. The share of nontradable goods in the overall Australian price index is computed from the household final consumption expenditure and the estimate of 0.4935 is derived. This estimate is roughly comparable to the estimate that Engel (1999) obtained for the case of the U.S., i.e. 0.4590. For New Zealand, the CPI-tradable index, CPI-nontradable index and the estimated share that nontradable goods take in the New Zealand's CPI (equal to 0.5560) available from the Reserve Bank of New Zealand are taken directly. However, these series are only available from 1988. Hence, estimates of these indices prior to 1988 are constructed. The details of the construction of the share of nontradable goods in the overall price indices are described in the Appendix.

Figure 1: Components of Real Exchange Rates, Real and Nominal Exchange Rates (\$NZ/\$A)

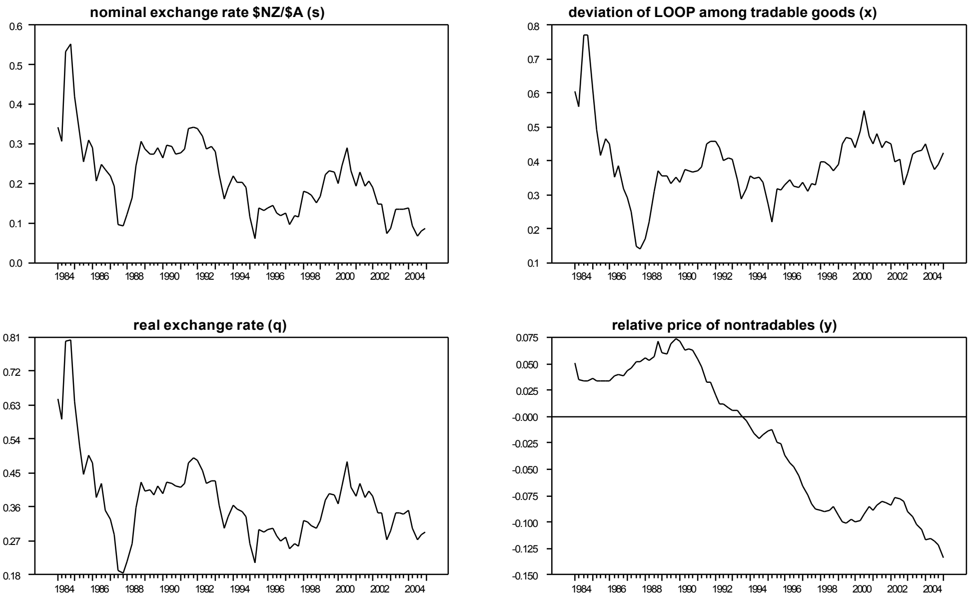
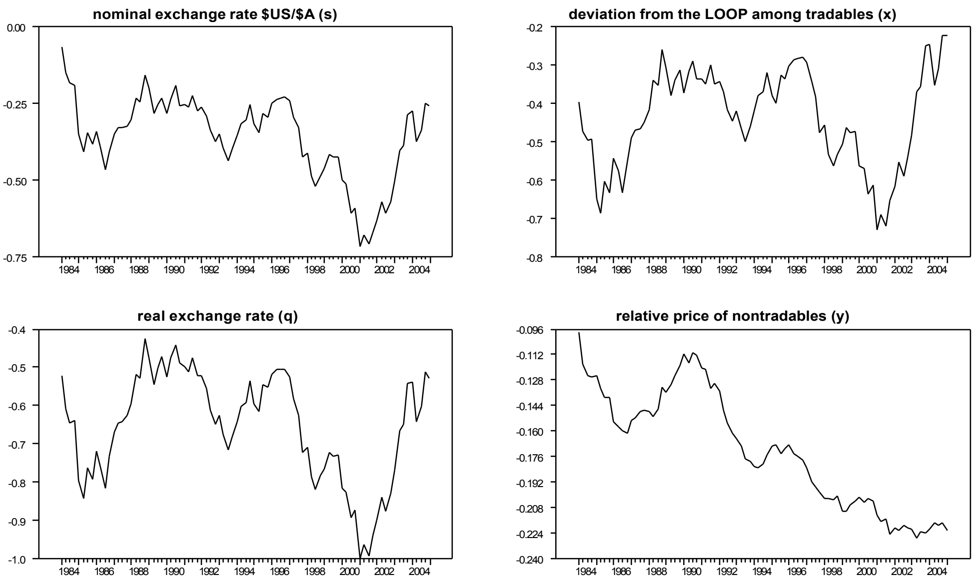


Figure 2: Components of Real Exchange Rates, Real and Nominal Exchange Rates (\$US/\$A)



Using these price indices obtained, series of the real exchange rate (q_t), the deviation from the law of one price among tradable goods (x_t) and the weighted relative price of nontradable to tradable goods across countries (y_t) are constructed for $NZ/$A and $US/$A exchange rates according to equations (2.4)-(2.6). The plots of these series and the nominal exchange rate (s_t) are displayed in Figure 1 and 2. The augmented Dicker-Fuller (Dickey and Fuller, 1979) test shows that both x_t and y_t are unit root processes. The finding that x_t has a unit root implies that the deviation from the law of one price among tradable goods is not transitory which runs counter to the assumptions of many theoretical models. The Engle-Granger test shows no cointegrating relationship among the two constituent components of the real exchange rate (x_t and y_t) and the nominal exchange rate (s_t).

In the next section, a structural vector autoregression model that characterises the behaviour of the components of the real exchange rate and nominal exchange rate is outlined.

3. A VAR Model

The model central of the analysis of this paper is adapted from the bivariate VAR model of Lastrapes (1992). The key feature of Lastrapes' (1992) model can be illustrated by considering a 2 x 1 vector of time series $\Delta z_t = [\Delta q_t \Delta s_t]'$, where Δ is the first difference operator. The exchange rate variables are expressed as logarithms of the foreign currency price of an Australian dollar (i.e. $US/$A or $NZ/$A). The variable q_t and s_t are assumed to be realisations of first-difference stationary or I(1) processes and hence by the multivariate form of Wold's decomposition, Δz_t will have a moving-average representation. Further, the vector $[q_t s_t]'$ is not cointegrated otherwise the moving-average representation of the vector Δz_t would be non-invertible and the Blanchard-Quah decomposition would be inapplicable.

Assume that Δz_t is explained by the following linear dynamic structural model:

$$\Delta z_t = A_0 \Delta z_t + A_1 \Delta z_{t-1} + \ldots + A_p \Delta z_{t-p} + u_t \qquad (3.1)$$

where $$A_0 = \begin{bmatrix} 0 & a_{02} \\ a_{03} & 0 \end{bmatrix}, \quad E u_t u_t' = \Omega = \begin{bmatrix} \omega_{11} & 0 \\ 0 & \omega_{22} \end{bmatrix},$$

and $A_1, \ldots, A_p$ are unrestricted parameter matrices. The zero restrictions in A_0 and Ω are convenient normalisations. The vector u_t contains two fundamental structural shocks, which will be given an economic interpretation below.

The data can recover only the unrestricted reduced form of the structural model (3.1):

$$\Delta z_t = (I - A_0)^{-1} A_1 \Delta z_{t-1} + \ldots + (I - A_0)^{-1} A_p \Delta z_{t-p} + (I - A_0)^{-1} u_t$$

$$= \Pi_1 \Delta z_{t-1} + \ldots + \Pi_p \Delta z_{t-p} + \varepsilon_t \qquad (3.2)$$

where $\Pi_i = (I - A_0)^{-1} A_i$, $\varepsilon_t = (I - A_0)^{-1} u_t$ and

$$E \varepsilon_t \varepsilon_t' = \Sigma = \begin{bmatrix} \sigma_{11} & \sigma_{12} \\ \sigma_{21} & \sigma_{22} \end{bmatrix}.$$

Without additional restrictions on the structural parameters, the only obtainable information from the reduced form is $\Pi_1, \ldots, \Pi_p, \Sigma,$ and the series of residuals ε_t. Nonetheless, if A_0 and Ω can be identified from the VAR estimates, we will be able to learn about the effects of the structural shocks u_t on Δz_t by using the following relationship which is derived from the structural model (3.1)

$$\Sigma = (I - A_0)^{-1}\Omega(I - A_0)^{-1'}, \tag{3.3}$$

Equation (3.3) above defines three equations and four unknows hence identification requires restrictions on A and Ω. Lastrapes (1992) follows the identification scheme of Blanchard and Quah (1989). It essentially involves the moving average representation which is obtained by inverting the reduced form model (3.2):

$$\Delta z_t = \begin{bmatrix} C_1(L) & C_2(L) \\ C_3(L) & C_4(L) \end{bmatrix} \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} = C(L)e_t \tag{3.4}$$

where: $C_i(L)$ for i = 1,.., 4 is an infinite-order lag polynomial. Equation (2.4) can be expressed in terms of levels of variables and the vector of structural shocks:

$$z_t = (1 - L)^{-1} C(L)(I - A_0)^{-1} u_t \tag{3.5}$$

It can be shown that the long-run effect of the structural shocks on z_t is:

$$\lim_{k\to\infty} \frac{\partial z_t}{\partial u_{t-k}} = C(1)(I - A_0)^{-1} \tag{3.6}$$

The expression (3.6) is central to the identifying restriction that is imposed in order that structural disturbances are recovered from the estimated reduced form VAR. The restrictions in (3.6) are derived from economic theory in particular the long-run neutrality of nominal shocks on the real exchange rate. Here u_{1t} and u_{2t} are assumed to be "real" exogenous shocks (for example shocks to technology, preferences) and "nominal" shocks (for example shocks to money demand and supply), respectively. The neutrality proposition requires that the matrix $C(1)(I - A_0)^{-1}$ is lower triangular which means that the long run effect of nominal shocks, u_{2t} on the real exchange rate, q_t is zero. This implies that $a_{02} = -[C_2(1)/C_1(1)]$. Effectively, this restriction eliminates an unknown parameter and allows the remaining structural parameters to be solved using equation (3.3). The resulting moving average representation (3.5) of the vector z_t containing real and nominal exchange rate series as functions of real and nominal shocks is then used to analyse the dynamic effects and the relative importance of these two types of shocks on real and nominal exchange rate fluctuations.

This prototype bivariate VAR model of real and nominal exchange rate is modified, in this study, such that the modified version allows us to assess empirically the theoretical proposition that movements in the real exchange rate are driven by productivity differentials through the relative price of nontradable goods. The modification is based on the decomposition of the real exchange rate, q_t into the deviation from the law of one price among tradable goods, x_t and the weighted relative price of nontradable to tradable goods across countries, y_t according to equations (2.4)-(2.6). That is, the empirical model by Lastrapes (1992) described above is adapted to include the tradable and nontradable components of the real exchange rate as separate variables together with the nominal exchange rate, thus forming a trivariate VAR model. Specifically under this modified model, Δq_t in the vector Δz_t is decomposed into Δy_t and Δx_t. In addition, three structural disturbances are identified, namely 'productivity shocks', 'deviation from the tradable Law of One Price (DLOOP) shocks' and 'nominal shocks' which are denoted by u_{pt}, u_{dt}, u_{nt} respectively. As such, this VAR system contains;

$$\Delta z_t = \begin{bmatrix} \Delta y_t \\ \Delta x_t \\ \Delta s_t \end{bmatrix} \quad \text{and} \quad u_t = \begin{bmatrix} u_{pt} \\ u_{dt} \\ u_{nt} \end{bmatrix}$$

In order that structural estimates and thereby disturbance series could be retrieved from the estimated reduced form, the following long-run identifying restrictions are imposed.

Firstly, only productivity shocks can exert a long-run effect on the relative price of nontradable to tradable goods across countries (y_t). This restriction is justified by the first proposition in the Samuelson-Balassa hypothesis that productivity differentials explain the movements in relative prices of nontradable goods. This is reinforced by the empirical findings of Asea and Mendoza (1994) which shows that relative labour productivity differentials explain the relative prices of nontradable goods in the long run.

Secondly, the long-run level of x_t which is interpreted as the deviation from the law of one price among tradable goods could be influenced by real productivity shocks and another type of real shock labelled as the deviation from tradable LOOP price shocks. Nominal shocks have no impact on the long-run level of x_t. The deviation from the tradable LOOP will later be shown to contain a unit root which implies that it is subject to both permanent and transitory disturbances unless it is a random walk. Here it is assumed that real shocks with permanent impacts on the deviation from the tradable LOOP comprise productivity shocks and tradable LOOP shocks while shocks that have transitory impacts that do not extend to the long run are nominal shocks. This restriction also stems from the notion of the long-run nominal neutrality as x_t can be interpreted as the real exchange rate based on the relative price of tradable goods across countries. Finally, the nominal exchange rates can be affected by all three shocks in the long run.

As structural parameters and disturbances are identified through the long-run identification scheme described above, an analysis of impulse responses will permit us to learn about dynamic effects of productivity shocks, shocks to tradable Law of One Price and nominal shocks on each component of the real exchange rate and the nominal exchange rate. The question of interest is through which channel various shocks primarily influence the real exchange rate, i.e. the tradable or nontradable components. Furthermore, a variance decomposition analysis will allow us to investigate the nature of shocks that are attributable to fluctuations in the real exchange rate, each of its constituent components and the nominal exchange rate. Essentially, these analyses will allow us to examine an extent to which the theoretical proposition that the relative price of nontradable to tradable goods across countries determines movements in the real exchange rate holds in the data.

Recall from section 2 that the unit root and cointegration tests on the data show that z_t is a vector of independent unit root series. Hence a stationary system in first-difference is specified and the Blanchard and Quah (1989) decomposition approach is applied. A reduced-form VAR model is estimated where a GST dummy is included as an exogenous variable to take into account the introduction of GST in 2000. The number of lags chosen to be included in each equation is four[3]. The innovation accounting result of the structural VAR analysis is presented in the next section.

4. Results

4.1 Impulse responses

With the identifying restrictions described above, the impulse response functions of each series to three structural shocks and their one-standard error confidence bounds[4] are generated and shown in Figures 3 to 5 for $NZ/$A exchange rate and in Figures 6 to 8 for $US/$A exchange rate. Since the real exchange rate in our VAR model is decomposed into the tradable component of the real exchange rate (x_t) and the relative price of nontradables (y_t), the total response of the real exchange rate (q_t) to each shock is given by the sum of impulse

[3] Results are not substantially sensitive to choice of lag length between 3, 4 and 5.

[4] One-standard errors for the impulse responses are approximated using 1000 bootstrap replications following the procedure described in Runkle (1987). It is noted that one-standard error confidence bounds around the impulse responses are large except for the responses constrained by the long-run identification restrictions. Because large confidence bounds around impulse responses are typical of VAR models, this paper focuses on the point estimates of the impulse responses and their interpretation.

responses of the x_t and y_t components to the shock. An additional graph showing the aggregate responses of the real exchange rate (q_t) to each shock is appended to each figure.

Figure 3: Impulse Response Functions of $NZ/$A to Productivity Shocks

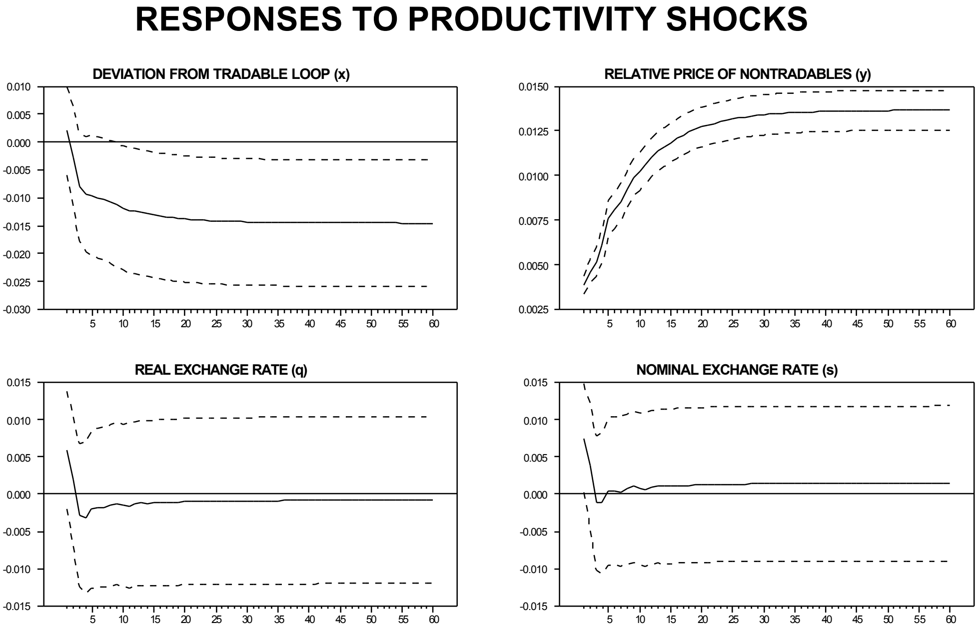


Figure 4: Impulse Response Functions of $NZ/$A to DLOOP shocks

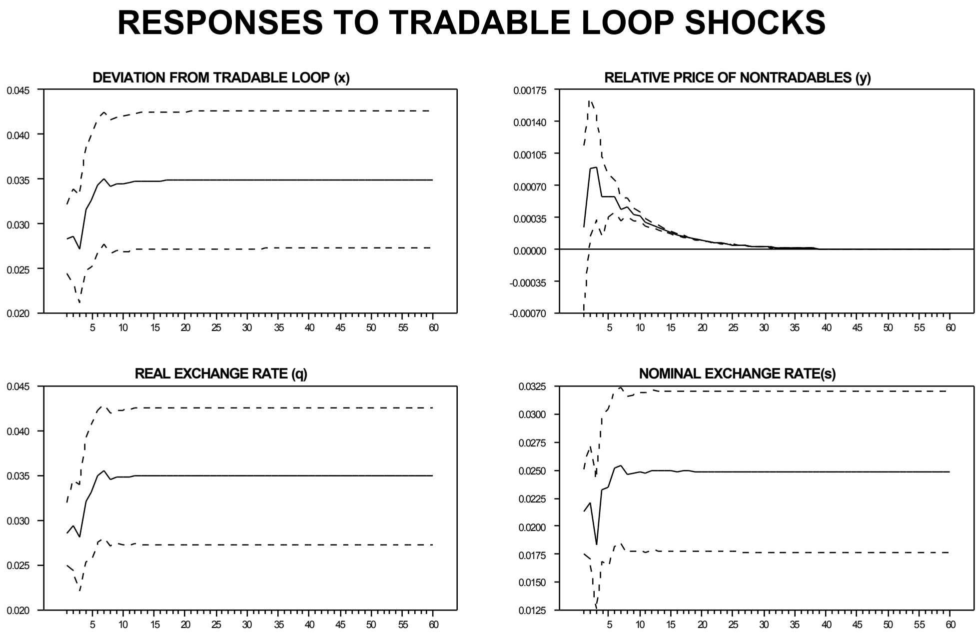


Figure 5: Impulse Response Functions of $NZ/$A to Nominal Shocks

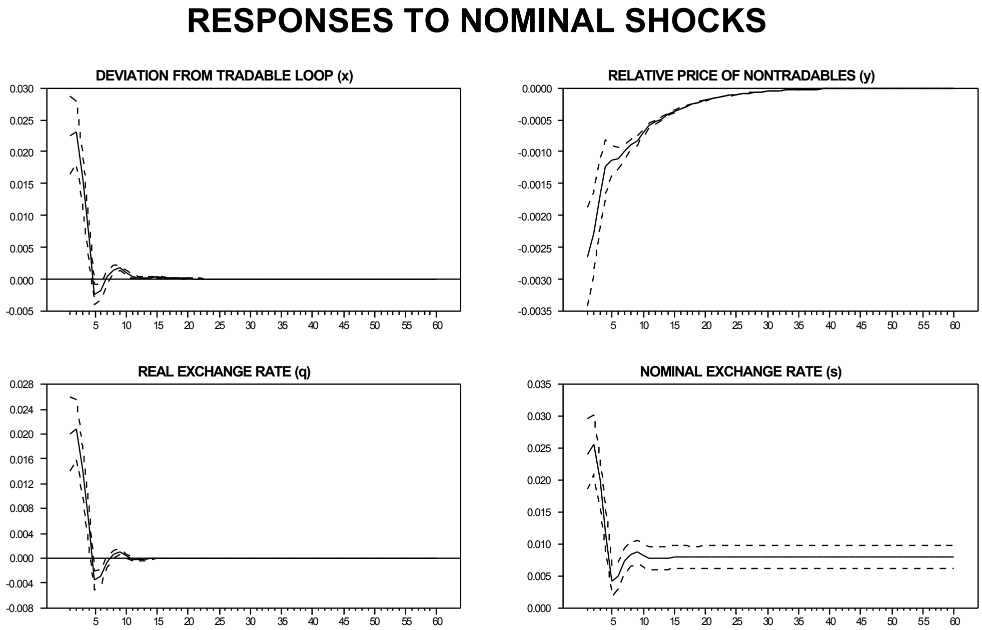


Figure 6: Impulse Response Functions of $US/$A to Productivity Shocks

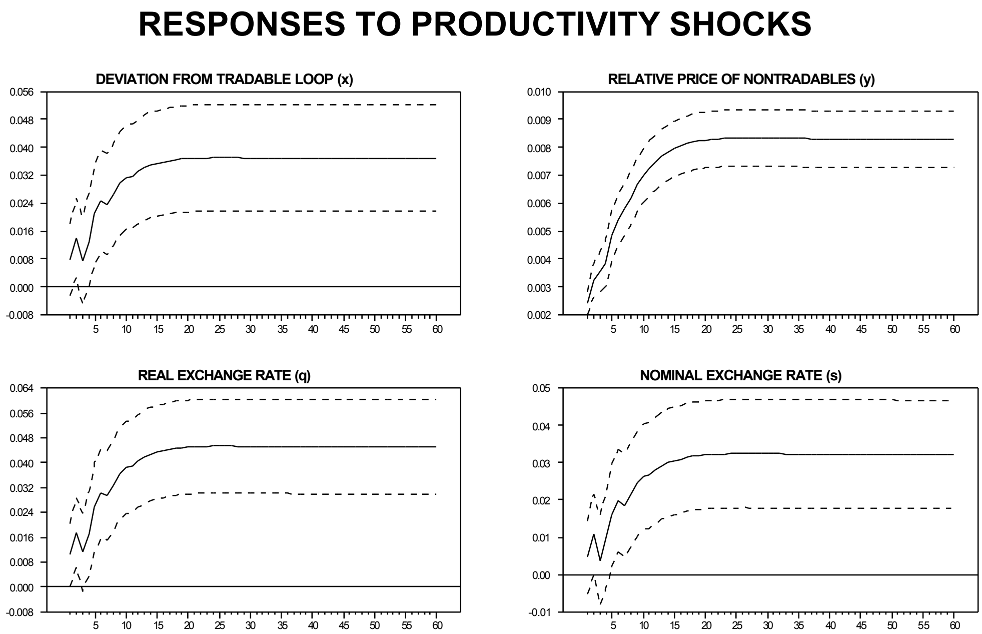


Figure 7: Impulse Response Functions of US/$A to DLOOP Shocks

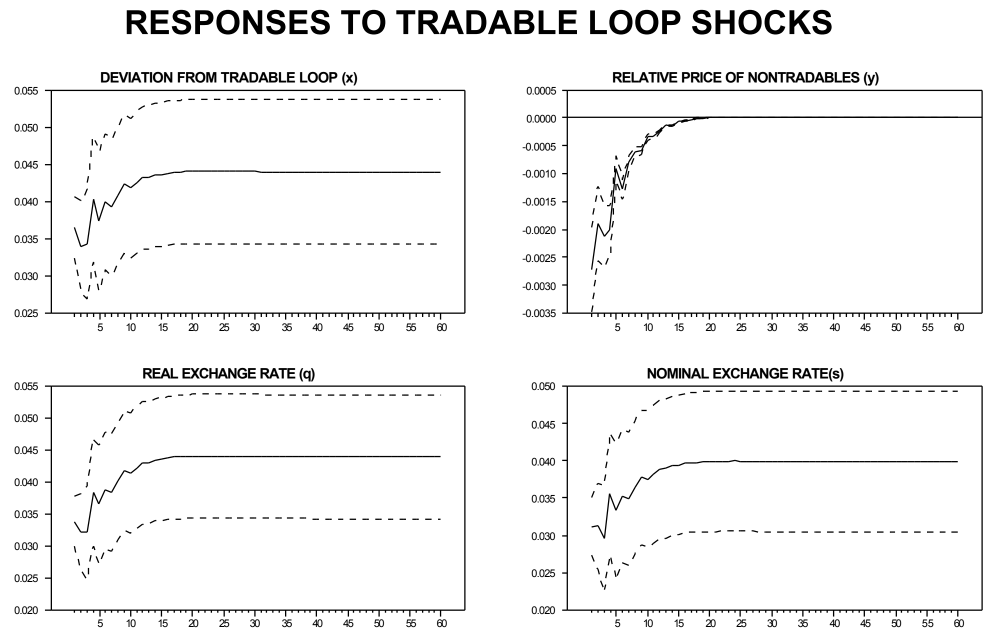
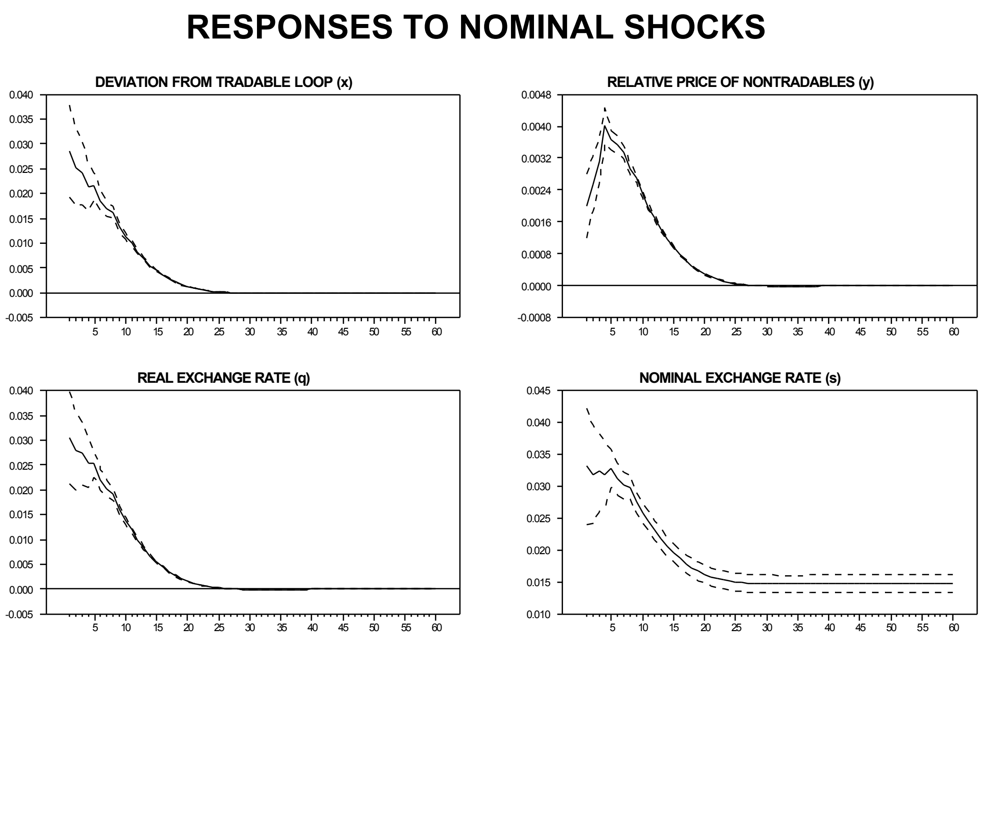


Figure 8: Impulse Response Functions of US/$A to Nominal Shocks



The impulse responses generated by the extended VAR model presented in this study provides a greater insight into how real and nominal exchange rates respond to real and nominal shocks in addition to what can be learnt from the original Lastrapes' (1992) model. Two types of real shocks are identified. The first type of real shock labelled as 'productivity shock' is interpreted as a shock that raises the productivity in the Australian tradable goods sector relative to the nontradable goods sector, holding relative foreign productivity constant. According to the Balassa-Samuelson hypothesis, such a productivity shock leads to a rise in the relative price of nontradable to tradable goods in Australia and thus a real appreciation of the Australian dollar, provided that the law of one price among tradable goods holds. Another type of real shocks that the VAR model identifies is labelled as `tradable LOOP shocks'.

The dynamic effects of productivity shocks on the exchange rate are shown in Figure 3 and 6. Figure 3 shows that a productivity shock raises the relative price of nontradable goods to tradable goods (y_t) in Australia relative to New Zealand as suggested by the Balassa-Samuelson hypothesis. However, a productivity shock results in a negative effect on the deviation from the tradable LOOP (x_t). Recall that $x_t = s_t + p_t^T - p_t^{T*}$. The negative impact results from the fact that the positive impact of the productivity shock on the nominal $NZ/$A exchange rate (s_t) is outweighed by the negative impact on the price of tradable goods (p_t^T)as the result of a rise in tradable sector productivity. In the short run, i.e. 1 to 2 quarter horizons, the overall impact of productivity shocks on the real exchange rate is positive, but the negative impact on the x_t component dominates the positive impact on the y_t component as the forecast horizon increases, resulting in a long run real depreciation of the Australian dollar against the New Zealand dollar.

By contrast, Figure 6 shows that a productivity shock has a positive impact on the nominal $US/$A exchange rate (s_t), the relative price of nontradable to tradable goods between Australia and the U.S. (y_t) as well as the deviation from the law of one price among tradable goods (x_t), which translate into both short-run and long-run real appreciation of the Australian dollar against the U.S. dollar. The magnitude of the response of the x_t component to a productivity shock is far greater than that of the y_t component of the real exchange rate.

Despite some differences, a common result found in both $NZ/$A and $US/$A cases is that a productivity shock leads to a sizeable and persistent impact on the deviation from the tradable LOOP (x_t). This violates the key assumption underlying the Balassa-Samuelson hypothesis that arbitrage activities bring about an adjustment of the tradable goods price to shocks to restore any disparities from the law of one price. In addition, for both real exchange rates, it is also observed that the impact of productivity shocks on the real exchange rate seems to principally occur through its tradable component. This finding is consistent with results obtained in Engel (1999) where a different empirical approached is used.

The impulse responses of $NZ/$A and $US/$A exchange rates to another type of real shocks identified in our VAR model, i.e. deviation from tradable LOOP shocks, are shown in Figure 4 and 7, respectively. It is found that a deviation from tradable LOOP shock results in real and nominal appreciation of the Australian dollar against the New Zealand dollar as well as the U.S. dollar. The impact of a tradable LOOP shock on the relative price of nontradable goods (y_t) between Australia and New Zealand is positive. However, the relative price of nontradable goods (y_t) between Australia and the U.S. decreases in response to a tradable LOOP shock. As also found for productivity shocks, the magnitudes of impulse responses of the y_t components of both exchange rates to tradable LOOP shocks are almost negligible relative to the magnitudes of impulse responses of the x_t component. Consequently, the patterns and magnitudes of the impulse responses of each real exchange rate (q_t) to tradable shocks follow closely the impulse responses of its tradable component (x_t). This finding thus suggests that the key channel through which tradable LOOP shocks influence the real Australian exchange rate is also its tradable component (x_t).

Similar observations are found for the case of responses to nom inal shocks. Figure 5 reveals that the effect of a nominal shock on the real $NZ/$A exchange rate predominantly occurs through the tradable component (x_t) of the real exchange rate as indicated by similar patterns and magnitudes of the impulse response of the x_t component and the impulse response of the real exchange rate (q_t). While a nominal shock leads to a rise in the deviation from the law of one price among tradable goods (x_t), it results in a decrease in the relative price of nontradable goods between Australia and New Zealand (y_t). However, the magnitude of the negative response of the component is 100 times smaller than the positive response of the component, resulting in an overall positive effect. This result is reconcilable with the finding obtained using Engel's (1999) approach that movements in the real exchange rate are driven by movements in the deviation from the law of one price among tradable goods (x_t).

Similarly, Figure 8 provides deeper insights into how nominal shocks affect the real $US/$A exchange rate in the short run than the original model of Lastrapes' (1992) would have allowed. It is observed that the pattern and magnitude of the impulse response to a nominal shock of the real $US/$A exchange rate follow closely the impulse response of the deviation from tradable LOOP (x_t). Hence, it can also be surmised that a primary channel through which a nominal shock impacts the real $US/$A exchange rate is its tradable component (x_t).

Overall, most striking of the results is that all three shocks influence the real exchange rate primarily through its tradable component (x_t) rather than through the relative price of nontradable goods (y_t). This is consistent with the empirical results obtained by Engel (1999) for the U.S. real exchange rate relative to major OECD countries. That is, the relative price of nontradable to tradable goods across countries is not an important driver of real exchange rate movements as traditional theoretical views posit.

4.2 Forecast Error Variance decompositions

An alternative way of interpreting the results is by examining the relative importance of each structural shock to the forecast error variance of each component of the real exchange rate. By doing so, it can be assessed whether the primary sources of fluctuations in each component of the real exchange rate are attributable to productivity, tradable LOOP or nominal shocks. Table 1 and Table 2 show the variance decomposition results from the VAR models of the $NZ/$A and $US/$A exchange rates, respectively.

The top panel of Table 1 shows that the variation in the nontradable component of the real $NZ/$A exchange rate (y_t) is principally accounted for by productivity shocks at all horizons. However, nominal shocks play a non-trivial role up to the four-quarter forecast horizon. Approximately 32% of the one-quarter forecast error variance is accounted for by nominal shocks. As shown from the middle panel of Table 1, much of the variation in the tradable component of the real $NZ/$A exchange rate (x_t) is accounted for by the deviation from tradable LOOP shocks at any horizon. It is noteworthy that nominal shocks explain a slightly higher proportion of the forecast error variance of the x_t component than they do the variance of the y_t component of the real NZ/$A exchange rate. For instance, nominal shocks explain 27% of the variance of the x_t component of the real exchange rate but only 14% of the variance of the y_t component at the four-quarter horizon. Tradable LOOP shocks are also found to be very important in accounting for the variability in the nominal $NZ/$A exchange rate as shown in the bottom panel of Table 1.

In general, similar trends are observed from the variance decomposition results of the $US/$A exchange rates shown in Table 2. However, differences do occur, most notably nominal shocks do not seem to explain a larger proportion of the variance of the tradable component (x_t) than the variance of the nontradable component (y_t) of the real $US/$A exchange rate as in the case of the $NZ/$A real exchange rate. Productivity shocks also appear to play a larger role in accounting for the forecast error variance of the x_t component of the real $US/$A exchange rate at long horizons as compared to the $NZ/$A exchange rates. For example, at the 10-year horizon, 36% of the variance of the x_t component of the $US/$A real exchange rate is explained by productivity shocks whereas only 12% of the variance of the x_t component of the $NZ/$A real exchange rate is attributable to productivity shocks. Nevertheless, tradable LOOP shocks are found to play the most prominent role in explaining the variation in the x_t components of Australian real exchange rates as well as nominal exchange rates against both the U.S. and New Zealand dollars.

Table 1: Variance Decomposition of components of the real exchange rate ($NZ/$A)

Variance Decomposition of the nontradable component (y_t)

	Percentage of Variance due to		
horizon	*productivity shock*	*tradable LOOP shock*	*nominal shock*
1	67.81	0.25	31.93
4	84.34	1.68	13.98
8	94.09	0.76	5.15
12	96.90	0.42	2.68
16	98.07	0.26	1.67
20	98.65	0.18	1.16
24	98.98	0.14	0.88
28	99.19	0.11	0.70
32	99.33	0.09	0.57
36	99.43	0.08	0.49
40	99.51	0.07	0.42

Variance Decomposition of the tradable component (x_t)

	Percentage of Variance due to		
horizon	*productivity shock*	*tradable LOOP shock*	*nominal shock*
1	0.31	60.89	38.80
4	3.35	69.19	27.46
8	5.80	80.65	13.55
12	7.48	83.69	8.83
16	8.72	84.79	6.49
20	9.66	85.22	5.12
24	10.39	85.40	4.21
28	10.96	85.46	3.58
32	11.40	85.49	3.11
36	11.77	85.49	2.75
40	12.06	85.48	2.46

Variance Decomposition of the nominal exchange rate (s_t)

	Percentage of Variance due to		
horizon	*productivity shock*	*tradable LOOP shock*	*nominal shock*
1	5.12	41.74	53.14
4	2.01	49.70	48.29
8	1.19	67.88	30.92
12	0.86	74.69	24.45
16	0.70	78.46	20.84
20	0.61	80.78	18.61
24	0.55	82.35	17.10
28	0.51	83.48	16.01
32	0.48	84.34	15.18
36	0.46	85.01	14.53
40	0.45	85.55	14.00

Table 2: Variance Decomposition of components of the real exchange rate ($US/$A)

Variance Decomposition of the nontradable component (y_t)

	Percentage of Variance due to		
horizon	*productivity shock*	*tradable LOOP shock*	*nominal shock*
1	34.08	42.74	23.17
4	44.00	19.51	36.49
8	61.62	8.39	29.99
12	74.76	4.76	20.48
16	82.64	3.16	14.20
20	87.16	2.32	10.52
24	89.89	1.83	8.28
28	91.67	1.50	6.82
32	92.92	1.28	5.80
36	93.84	1.11	5.05
40	94.55	0.98	4.47

Variance Decomposition of tradable component (x_t)

	Percentage of Variance due to		
horizon	*productivity shock*	*tradable LOOP shock*	*nominal shock*
1	2.76	60.51	36.73
4	5.94	63.93	30.13
8	15.43	63.33	21.24
12	22.69	62.79	14.52
16	27.54	62.00	10.46
20	30.65	61.33	8.03
24	32.69	60.83	6.49
28	34.08	60.48	5.44
32	35.09	60.23	4.68
36	35.84	60.05	4.12
40	36.42	59.91	3.67

Variance Decomposition of the nominal exchange rate (s_t)

	Percentage of Variance due to		
horizon	*productivity shock*	*tradable LOOP shock*	*nominal shock*
1	1.00	46.46	52.54
4	2.77	48.10	49.13
8	9.00	48.09	42.91
12	14.93	49.60	35.48
16	19.58	50.84	29.58
20	22.94	51.76	25.30
24	25.32	52.42	22.26
28	27.03	52.92	20.06
32	28.29	53.30	18.42
36	29.25	53.59	17.16
40	30.01	53.83	16.16

The structural VAR model presented in this study allows us to gain an additional insight into the variance decomposition of the real exchange rate beyond what can be learnt from the model by Lastrapes' (1992). That is, the relative contribution of real shocks to the volatility of the real exchange rate can be disentangled into contributions of 'productivity shocks' and 'tradable LOOP shocks'. Table 3 shows the percentage of the variation in the real $NZ/$A and $US/$A exchange rate that is explained by 'productivity shocks', 'tradable LOOP shocks' and 'nominal shocks'.

Table 3: Variance Decomposition of the real exchange rates

Variance Decomposition of q_t($NZ/$A)

	Percentage of Variance due to		
horizon	*productivity shock*	*tradable LOOP shock*	*nominal shock*
1	2.78	65.32	31.90
4	1.23	75.93	22.84
8	0.74	87.85	11.41
12	0.54	91.92	7.53
16	0.44	93.95	5.61
20	0.37	95.16	4.47
24	0.32	95.96	3.72
28	0.28	96.54	3.18
32	0.25	96.96	2.78
36	0.23	97.30	2.47
40	0.22	97.56	2.22

Variance Decomposition of q_t($US/$A)

	Percentage of Variance due to		
horizon	*productivity shock*	*tradable LOOP shock*	*nominal shock*
1	4.80	52.57	42.62
4	9.55	54.43	36.02
8	21.71	53.20	25.09
12	30.53	52.58	16.89
16	36.21	51.79	11.99
20	39.76	51.14	9.10
24	42.05	50.65	7.30
28	43.59	50.31	6.09
32	44.70	50.08	5.23
36	45.52	49.90	4.58
40	46.16	49.77	4.08

It is asserted from Table 3 that the deviation from tradable LOOP shock plays a more important role than the productivity shock in explaining the volatility of the real $NZ/$A exchange rate both in the short and long run. At the four-quarter horizon, 1% and 76% of forecast error variance of the real $NZ/$A exchange rate is explained by productivity shocks and tradable LOOP shocks respectively. For the real $US/$A exchange rate, tradable LOOP shocks play a far more important role than productivity shocks up to around the 20-quarter forecast horizon. However, at longer forecast horizons, productivity shocks are nearly as important as the deviation from tradable LOOP shocks in accounting for the variation in the real $US/$A exchange rate.

The finding that the tradable LOOP shock is the primary source of fluctuations in the real Australian exchange rate both in the short and the long run and that the productivity shock plays a less important role especially in the case of the $NZ/$A real exchange rate reinforces the finding of Engel (1999) and hence provides evidence against theoretical models of real exchange rate determination that ignore the importance of the deviation from the law of one price among tradable goods.

5. Conclusion

This paper investigates sources of fluctuations in the real Australian exchange rates. Particularly, it tests whether the relative prices of nontradable to tradable goods across countries drives movements in the real exchange rate as theoretical models posit. The original contribution of this study to the current literature on sources of real exchange rate fluctuations is the use of a VAR framework to reconcile the groundbreaking results of Engel's (1999) that the relative price of nontradable goods has little importance in determining real exchange rate movements, contrary to the traditional view embodied in the Balassa-Samuelson (1964) hypothesis. This is done by extending the bivariate VAR model by Lastrapes (1992) to decompose the real exchange rate into the deviation from the law of one price among tradable goods and the relative price of nontradable goods and include them separately in the VAR model. The analysis of the resulting trivariate VAR model shows that the chief channel through which both types of real shocks and nominal shocks influence the real exchange rate is the tradable component of the real exchange rate. Furthermore, unanticipated productivity factors are found to form the primary source of both short-run and long-run fluctuations in the nontradable component of the real exchange rate. The variation in the tradable component of the real exchange rate is largely accounted for by real shocks that are labelled as `tradable LOOP' shocks at all horizons. In aggregate, tradable LOOP shocks are found to be a major source of fluctuations in real Australian exchange rates against the New Zealand and the U.S. dollar.

It is important to note that only one identification procedure is used to identify shocks from the structural VAR model. Hence, it might be useful to see how sensitive our findings are to other identification assumptions.

Appendix

The U.S.: The approach of Engel (1999) is followed to construct the U.S. tradable and nontradable price indices. Seasonally unadjusted monthly data from January 1984 to March 2005 on consumer prices are used. The share that nontraded goods take in the overall index is taken from Engel (1999)'s estimate of 0.4590.

Australia: An estimate of the share that nontraded goods take in the price index, α is determined by the following formula:

$$\hat{a} = \frac{1}{T}\sum_{t=1}^{T}\frac{services \quad consumption \quad \exp ditures_t}{total \quad consumption \quad \exp enditure_t}.$$

Services consumption expenditure includes rent and other dwelling services; transport services; communications; recreation and culture; education services; hotel, cafes and restaurants; and insurance and other financial services. These data items are under the 'Household final consumption expenditure: Chain volume measures' from the ABS: time series statistics. The estimate of the share that nontraded goods take in the price index is 0.4935.

New Zealand: The CPI-tradable and CPI-nontradable indeices for 1988Q4-2005Q1 are taken directly from the Reserve Bank of New Zealand's website. The data prior to 1988Q4 is unavailable and is calculated using the following formula:

CPI-tradable = $w_{T,1988Q4}$ * CPI-all items

CPI-nontradable = $w_{NT,1988Q4}$ * CPI-all items

where

$w_{T,1988Q4}$ = (CPI-tradables at 1988Q4)/ (CPI-all items at 1988Q4)

$w_{NT,1988Q4}$ = (CPI-nontradables at 1988Q4)/ (CPI-all items at 1988Q4).

Statistics New Zealand reports an estimate of the share of nontraded goods in the price index to be 0.5560. See 'Consumers Price Index Tradable and Non-tradable series' September 2004 quarter, Statistics New Zealand.

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