DOES EXCHANGE RATE VOLATILITY DEPRESS TRADE FLOWS IN A SMALL OPEN ECONOMY? EVIDENCE FROM NEW ZEALAND[1]

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Abstract

This paper empirically investigates the impact of real exchange rate volatility on the real bilateral export flows of New Zealand by using quarterly data over 1991Q1-2007Q1 period. Cointegration and error-correction models are employed to obtain the estimates of the long run equilibrium and the short-run dynamics, respectively. We analysis the ignored potential structure breaks which might bias the results, and provide evidence that real exchange rate volatility has a significant negative effect on real exports in the long run, but a weak positive effect in the short run for New Zealand.

JEL Codes: C22, F31, F41

Key Words: Exchange Rate Volatility, Trade Flows, Cointegration, VECM

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1. Introduction

As we known, the breakdown of the Bretton Woods system of fixed exchange rates in 1973 brings us a new period of exchange rate floating system in economic history, meanwhile, it also brings us more widely fluctuated real and nominal exchange rate. One of the major economic issues that has received a great deal of attention by many researchers is the effects of exchange rate volatility on the trade volumes. According to published researches, the empirical literature provides a mixed conclusion. They use different measures of real or nominal exchange rate volatility to exam the effect of it on the volume or value of international aggregate, bilateral, or sectoral trade, for both developed and developing countries. Although most evidences argue that exchange rate volatility increases uncertainty and risk and therefore depresses the trade flows, some other studies suggest otherwise. The overall evidence is best characterized as mixed as the results are sensitive to the choices of sample period, model specification, measures of exchange rate volatility, and countries considered (developed vs. developing)[1].

The impact of exchange rate volatility on trade volume is ambiguous from a theoretical point of view (Broda and Romalis, 2003). The standard theoretical argument that exchange rate volatility may hinder the flow of international trade centered on the notion that exchange rate volatility represents uncertainty and will impose costs on risk averse commodity traders, such as Hooper and Kohlhagen (1978) illustrates in the theoretical model that exchange rate volatility might hamper trade. Contrary to this view, Broda and Romalis, (2003) develope a model of international trade in which international trade depresses real exchange rate volatility and exchange rate volatility impacts trade in products differently according to their degree of differentiation. Besides, Baum, Caglayan, and Ozkan (2004) find that the effect of exchange rate volatility on trade flows is nonlinear, depending on its interaction with the importing country's volatility of economic activity, and that it varies considerably over the set of country pairs considered.

Numerous empirical studies of developed countries reflect this ambiguity in the theoretical literature. Pick, Daniel H. (1990), Grier and Smallwood (2007), and Baum and Caglayan (2010) find no firm evidence for the relationship between exchange rate volatility and trade, whereas Chowdhury (1993), Dell'Ariccia (1999) provide evidences in support of the view that the volatility of exchange rates reduces the volume of international trade. On the other hand, Pickard (2003) find some evidences for a positive effect of exchange rate volatility on trade flows for some well-developed countries.

The same conflicting evidence for the relationship between exchange rate volatility and trade exists with regard to developing countries. While some studies such as by Caballero and Corbo (1989), Pick, Daniel H. (1990), Arize, Osang, and Slottje (2005), Grier and Smallwood (2007), find a significant negative relationship, the study by Bahmani-Oskooee (1991, 1993) shows that the significant negative relationship is just for some of the developing countries and not for the others, and Pickard, Joseph C. (2003) finds weak negative relationship between the two.

Some people point out that disaggregate data might tell us more about this ambiguous relationship between exchange rate volatility and trade volumes: McKenzie (1998) use both aggregate data and disaggregate data of Australia to show that the impact of exchange rate volatility does differ between traded good sectors. Broda and Romalis (2003) employe a large number of countries disaggregate data to show that commodities are less affected by exchange rate volatility than more highly differentiated products, while Dell'Ariccia (1999) points out that the sectors where the export activity requires large investments might indicate a more sensitive relation. Furthermore, Pick, Daniel H. (1990) gives the evidence that, at least for agriculture sector, there still exists a sensitive relation although people think the agriculture products as the necessary goods won't hold a sensation relation.

However, all those studies didn't investigate if economy scale matters for this relationship. In this paper, we are interested in if we can report any firm relationship between export flows and exchange rate volatility for a typical small open economies: New Zealand[2]. New Zealand as a typical small open economy has four characters: 1) Small. New Zealand is a small island country in the south-western Pacific Ocean comprising two main landmasses, and numerous smaller islands. The total land area, 268,021 square kilometers, is a little less than Italy and Japan, and a little more than the United Kingdom. It has a population of about 4.3 million which is around 1/30 of Japan, 1/15 of Italy and United Kingdom. and a GDP of about 115.624 billion in 2008 which is 1/40 of Japan, 1/21 of United Kingdom, and 1/17 of Italy. 2) Open. New Zealand is greatly depends on international trade, particularly in agricultural products. Exports account for around 24% of its output, which is a relatively high figure comparable to many smaller European countries. This makes New Zealand particularly vulnerable to international commodity prices and global economic slowdowns. According to economic freedom indices, New Zealand is also one of the most free market capitalist economies. 3) Developed. New Zealand has a relatively high standard of living with an estimated GDP per capita of $27,017 in 2008 (ranked 27 by IMF data source), comparable to Southern Europe. 4) The New Zealand dollar was floated since 4

March 1985. Its value is often strongly affected by currency trading, and it is among the 12 most-traded currencies. Since the small open economies are just price takers in international trades and their exchange rates are usually affected a lot by other big economies, we are concerned that if there is a firm significant negative relationship between exchange rate volatility and trade flows. If there is, they might have to keep their exchange rate volatility in a comparatively narrow range avoiding their trade flows getting hurt.

The approach here incorporates many of the recent developments in the literature. AMSD is used to measure the real exchange rate volatility. Special attention is given to the potential breakpoints in the New Zealand exports to Japan, United States, and United Kingdom. We employed both endogenous and exogenous breakpoint tests, including Chow test, the Quant-Andrews test, and the Perron structural break test, to find that 1994Q3, 1999Q4, and 2001Q4 are potential structural breaks for Japan, United States, and United Kingdom respectively. Finally, evidences are provided in subsamples that the long run equilibrium relationship between real export flows and real exchange rate volatility is significantly negative, and short run relationship is weakly positive. The rest of this paper is structured as follows. Section 2 presents the empirical model, variable definitions, and data source. Section 3 gives variable non-stationarity tests and cointegration analysis. Section 4 introduces the vector error correction model and discusses the empirical results. Conclusions are drawn in the last section.

2. Model Specification and Data Source

Following many previous empirical studies in this area, such as Chowdhury (1993), McKenzie (1998), Vergil (2001), Lee (2003), etc, we employ a simple traditional export demand function to investigate the long run equilibrium relationship between exchange rate volatility and trade flows[3]:

$$\ln X_t = c_1 + c_2 \ln Y_t^f + c_3 \ln P_t + c_4 \ln V_t + u_t \qquad (1)$$

Where X_t is real export volume (earlier studies suggest that export volume is a more appropriate measurement than value), Y_t^f is a measure of real foreign economic activity, P_t represents bilateral real exchange rate which measures the competitiveness of New Zealand exports in foreign markets, and V_t is the measure of exchange rate volatility. Coefficients c_2 is expected to be positive, since increases in real income of trading partners usually cause a greater volume of exports to those partners. The real exchange rate depreciation (an increase in P_t) may lead to an increase in exports due to the relative price effect, so Coefficient c_3 is supposed to be positive, too. However, as explained in the introduction, the relationship between the volatility of the real exchange rate and real exports is ambiguous, i.e. the sign of c_4 could either be positive or negative.

New Zealand has four major trading partners – Australia (20.5%), United States (13.1%), and Japan (10.3%), and United Kingdom (4.9%) [4]. Australia has had a free trade agreement with New Zealand since 1983, while theother three major partners have not reached a bilateral free trade agreement with New Zealand yet. In this paper, we will exam the real trade flows - real exchange rate relationship of New Zealand with all four. The reason for choosing 1991Q1 as the start date is that New Zealand has had important monetary policy change - adopted inflation targeting - since March 1990, and it would take a few months to show its affect on its exchange rate volatility[5]. Since then, there are no big policy issues affecting on its exchange rate volatility.

Thus, the sample period from 1991Q1-2007Q1 is chosen to minimize the specification problems stemming from the change in monetary policies of New Zealand.

All the data are obtained from the IMF's *International Financial Statistics*, except data of bilateral trade flows are from SourceOECD's *Quarterly Statistics of International Trade*. Nominal exports (in US dollars) of New Zealand to each trading partner were converted to New Zealand dollars and then deflated by the New Zealand export price index to define them in real volumes (not values), which is X_t in the model.

Country's GDP has been widely used as a proxy of economic activity. We convert quarterly nominal foreign country GDP to US dollars and deflate it by the U.S. consumer price index to define them in real terms, which is Y_t^f in the model. Australia is the only exception here. We deflate Australia's GDP (in Australia dollars) by Australia consumer price index directly since the biggest character of free trade agreement is that member countries don't have to use hard currency in their trade activities.

Bilateral real exchange rate (P_t) between New Zealand and its trading partners measures the competitiveness of New Zealand exports in foreign markets. Bilateral real exchange rates of New Zealand dollars against, for example, Australia, P^{AU}, is derived from quarterly nominal exchange rates for the New Zealand dollars against Australia's currency (NOM=(USD/NZD quote)/(USD/AUD quote)), a quarterly New Zealand consumer price index (NZCPI, 2005=100), and a quarterly foreign country consumer price index (AUCPI, 2005=100).

$$P^{AU} = (NOM*FRCPI)/NZCPI$$

Mckenzie (1999) summarizes 9 different statistical measures of exchange rate volatility which have been used in the literature. Two most frequently used measures are: 1) moving average standard deviation of the growth rate of the exchange rate (MASD); and 2) ARCH/GARCH. Just as Mckenzie (1998) states, “it is uncertainty in the exchange rate which constitutes volatility and measures of ‘changeableness’ fail to fully capture the uncertainty element embodied in changes in the exchange rate as they may be somewhat predictable”, so MASD is not necessarily appropriate. However, ARCH has its own limitation too. McClain et al. (1996) suggest that 300 observations is a threshold value for estimating a reliable ARCH model. Mckenzie (1998) admits that if ARCH is used in finite sample study, it will raise some other problems. In this paper, limited by data availability, MASD is a more appropriate measure of exchange rate volatility than ARCH. We use the MASD form of exchange rate volatility:

$$V_t = \left(\frac{1}{m} \sum_{i=1}^{m} \left(\ln P_{t+i-1} - \ln P_{t+i-2} \right)^2 \right)^{1/2} \tag{2}$$

where m is the order of the moving average and we set it equal to 4 here [6].

3. Cointegration Analysis

Before we employed the cointegration procedure developed in Johansen (1991) and Johansen and Juselius (1990), we need to identify the order of integration of individual variables in equation (1) first. We test the non-stationarity of those variable series by using the augmented Dickey-Fuller (ADF) test and the Phillips-Peron (PP) test, and find that, irrespective of country considered, the exchange rate volatility is stationary and the remaining variables included in this study are integrated of order one. The results of the ADF test with and without trend are summarized in Table 1a and Table 1b.

Secondly, we determine the lag length of individual variables for the VAR model by using the Akaike Information Criteria. The optimum lag length is two for level variables in Australia, UK, and US and one for Japan, which means we can only choose one lag for first-difference variables in the next section when we employ the error correction model. We set linear deterministic trend is allowed in a cointegration test, and assume there is interception but no trend in CE and VAR test. The Ljung-Box Q-statistics indicate that the residuals from each VAR model have a white noise process.

3.1 Without Breakpoint Test

If we are satisfied with the stationary results from the basic unit root test and go straight to the cointegration test, we will get Table 3a. It reports the results from the two common likelihood-ratio tests, the trace and the maximum eigenvalue (λ-max) tests, which are used to determine the number of cointegrating relations in non-stationary time series. For λ-max and trace statistics, the null hypothesis is that there are r or fewer cointegration vectors, whereas the alternative hypotheses are $r+1$ and at least $r+1$ cointegration vectors for the λ-max and trace statistics, respectively. According to the trace test results, under the assumption of allowing a deterministic trend with interception and no trend in CE and VAR test, the null hypothesis of $r = 0$ (no cointegration) is rejected in favor of the alternative hypothesis $r \geq 1$ at the 5% significant level. On the other hand, the null hypotheses of $r \leq 1$, $r \leq 2$ and $r \leq 3$ cannot be rejected in favor of the alternative hypotheses of $r \geq 2$, $r \geq 3$ and $r \geq 4$ at the 5% level of significance, respectively.

Maximum eigenvalue (λ-max) tests' results are mostly consistent with the trace tests' results at the 5% level of significance[7]. The null hypothesis of r = 0 is rejected in favor of r = 1 in Australia, the United States, and the United Kingdom, but not rejected in Japan. Furthermore, the null hypotheses of $r \leq 1$, $r \leq 2$ and $r \leq 3$ cannot be rejected (r = 1 is rejected for the UK) in favor of the alternative hypotheses of r = 2, r = 3 and r = 4, respectively. These results from the two tests indicate the presence of only one cointegrating relationship for Australia, the United States, and the United Kingdom at the 5% level of significance, and no significant cointegrating relationship for Japan at the 5% level of significance.

The cointegrating vector, which is normalized with respect to real exports, is given in Table 4a. Surprisingly, a positive sign of c_4 shows up for all of the trading partner countries of New Zealand except for Australia, which means increasing real exchange rate volatility will increase the real export flows to those three countries. Additionally, c_2 has an unexpected negative sign for Japan and the United States and c_3 has an unexpected negative sign in Japan, the United States, and the United Kingdom. All of these unexpected results are telling us something is wrong, and we need to go further with breakpoint tests before the cointegration test for the individual variables.

3.2 With Breakpoint Tests

Inspection of the export volume series graphs reaffirms our concern. In figure 1a, we didn't see any clue that breakpoints exist in export flows to Australia or in Australia's GDP, and the results from the Chow test, the Quandt-Andrews test, and the Perron test also improve this non-breakpoint conclusion.

In figure 1b, export flows to Japan seem to have a break around 1994Q3. Before 1994Q3, the log value of real export volume is around the level of 14.75, but after 1994Q3 it jumps to a level of around 14.9. When we check the graph of Japan's GDP, we find a potential break at the same time. An upward sloping GDP curve before 1994Q3 becomes a downward sloping GDP curve afterwards. The Chow test for 1994Q3 gets an F statistic of 10.9: reject the null of no breakpoint at the 1% level of significance. Maximum LR F-statistic and Maximum Wald F-statistic in the Quandt-Andrews test exogenously get consistent results of breakpoint in 1994 Q3. This breakpoint is further proven in the Perron test as a one-time permanent change in a trend stationary series. Japan's real estate bubble started in 1985 and collapsed in 1994. Since the early 1990's, and especially since its "financial bubble" collapsed in 1994, Japan has to a certain extent begun to accept that it has to make special efforts to open its economy to international competition and embark on structural reforms for its own good and for the benefit of the international community. The scope of import promotion measures was expanded in the Government Actions for Import Promotion of March 1994. These policies have led to the implementation of taxation and financing measures that promote imports, supporting efforts made by foreign companies and governments to increase exports to Japan, and the improvement of the import promotion infrastructure[8].

In figure 1c for the United States, we didn't see any obvious jump in export flows, but we see a slow level-transfer from 1996 to 2001. Before 1996, the log value of export flows was around 14.5, while after 2001 it transfers to the level of 15.2. Meanwhile, there seems a short flat line from 2000Q1 to 2001Q2 in the US GDP curve. Hence, we should test several points ranged between these potential break periods. Chow test's null hypothesis is rejected in 2001Q4 by F statistics 7.45 at the 1% level of significance. The Quandt-Andrews test doesn't get a consistent breakpoint from Maximum LR F-statistic and Maximum Wald F-statistic exogenously. The Perron test's results confirm that 2001Q4 is a one-time change in the united root process. This one-time change reminds us what happened near 2001Q4 in the United States: 9/11 attacks in New York City. It brought the city's GDP down by $27.3 billion for the last three months of 2001 and all of 2002. 430,000 jobs and $2.8 billion in wages were lost in the three months following the 9/11 attacks. The breakpoint test results show that the 9/11 attacks do not only impact on the United States' GDP, but also on its import pattern and its trade account.

In figure 1d of the United Kingdom, those potential breaks are around 1992 and 2000 in both the export flows curve and the GDP curve. Although the Chow test and the Quandt-Andrews test fail to show consistent breakpoint results, the Perron test finds 1999 Q4 is a structural breakpoint in the trend stationary export flows to the United Kingdom[9]. This breakpoint happened at the time that United Kingdom decided not to enter euro zone. Prior to that, United Kingdom was the destination for over half of all New Zealand's exports. Today, New Zealand's trade and other links have spread and diversified enormously. New Zealand's pattern of international trade changed significantly since then. Table 2 summarizes the significant results of the Chow test, the Quandt-Andrews test, and the Perron test for the above potential breakpoints[10].

According to the breakpoint tests' results reported in Table 2, we split previous samples of Japan, the United States, and the United Kingdom into two sub-samples for each country. For Japan, we have two sub-samples: 1991Q1 to 1994Q2 and 1994Q3 to 2007Q1. For the United States, we have sub-samples: 1991Q1 to 2001Q3 and 2001Q4 to 2007Q1. For the United Kingdom, we have sub-samples: 1991Q4 to 1999Q3 and 1999Q4 to 2007Q1. We test the non-stationarity of those variable series by using the augmented Dickey-Fuller (ADF) test and the Phillips-Peron (PP) test, and find that,

As we expected, cointegration test results have significantly improved as reported in Table 3b and Table 4b. The trace and the maximum eigenvalue (λ-max) tests in Table 3b consistently show that there is one cointegration relationship among real export volumes, real GDP, real exchange rate, and real exchange rate volatility in all four of New Zealand's trading partner countries. In Table 4b, normalized cointegration equations present the significant negative long-run equilibrium relationship at the 5% level between real export flows and real exchange rate volatility in Australia, Japan, and the United States, and a weak negative relationship in the United Kingdom. The values of c_4 are close between sub-samples within each country, which means the relationship between real export flows and real exchange rate volatility does not change before and after the breakpoint. For example, in the United States, the coefficient of c_4 is 0.1 in both sub-samples, which means a point one percent increase in exchange rate volatility will cause a one percent increase in home country real export to that foreign country in the long run, whether the exchange rate volatility increases before or after the breakpoint in 2001Q4. All the signs of c_2 and c_3 for each country are consistent with our expectations, expect in the United States in sub-sample 2001Q4 to 2007Q1. The relationship between real export flows and real exchange rate are not as significant as the relationship between real export flows and real GDP. 83% of the coefficients of real GDP are significant at the 1% level, while only 33.3% of coefficients of real export flows significant at the 1% level and 66.6% are not significant even at the 10% level. All these results, reported in Table 4b, provide very strong evidence that exchange rate volatility has a negative and significant long-run effect on real export flows.

4.5 Vector Error-Correction Model

Based on the long run equilibrium relationship we find above, a VECM can be developed below[18]:

$$\Delta \ln X_t = c + \alpha ECT_{t-1} + \phi_i \sum_{i=1}^{k} \Delta \ln X_{t-i} + \beta_i \sum_{i=0}^{k} \Delta \ln Y_{t-i}^{f} + \lambda_i \sum_{i=0}^{k} \Delta \ln P_{t-i} + \gamma_i \sum_{i=0}^{k} \Delta \ln V_{t-i} + \varepsilon_t \qquad (3)$$

where ECT_{t-1} is the lagged error correction term and is the residual from the cointegrating regression equation (1), so it is a I(0) process. ECT captures the adjustment toward the long-run equilibrium. The coefficient α represents the proportion of the disequilibrium in real exports in one period corrected in the next period. The equation (3) is estimated with a general specified lag structure for all the variables in the equation (1), a constant term and one-lagged error-correction term. The lag length for the VAR models is one, determined by using the likelihood ratio test.

The estimation results of the VECM are summarized in Table 5. R^2 is not high here due to the reason that regression is based on the first differences in variables. Since there is only one CI vector, our VECM looks just like the single ECM. The error correction term's coefficient for Australia, Japan, the United States, and the United Kingdom are all negative and statistically significant at the 1% level as expected. It indicates that if exchange rate volatility increased (decreased) and made the home real export deviate upward (downward) from the long run equilibrium in the last period, i.e. when X_{t-1} > (<) X^e, then the home real export will fall down (go up) in this period, i.e. ΔX_t < (>) 0, in order to get itself back to its long run equilibrium. This dynamics makes X_t converge towards its long run equilibrium. For example, the absolute value of α is 0.12 for Australia, which means 12% of the home real export adjustment occurs in one quarter for Australia. α is so called the adjustment speed of Australia's real export flows. In the same way, Japan's adjustment speed is 0.96, United States is 0.24/1.42 (sub-sample 1/sub-sample 2), and United Kingdom is 1.31/0.85 (sub-sample 1/sub-sample 2). Their adjustment speed are all much faster than Australia's adjustment speed.

Besides the dynamics of error correction term, we are also interested that how the current change of home real export, i.e. ΔX_t, responses to the change of exchange rate volatility V_t happened in the last period, i.e. ΔV_{t-1}. The table 5 shows that the coefficients of ΔV_{t-1} are positive but insignificant (except Japan is significant at the 10% level). Its value for Australia, Japan, the United States, and the United Kingdom are all under 0.1. This small short run effect has an opposite direction to the long run effect which is a little surprising. It shows that increases in exchange rate volatility could possibly simulate the trade flows in the short run because the risk raises the expected marginal utility of export revenue, but in the long run, it will significantly depress the export volume.

Finally, most of the coefficients of ΔY_{t-1} are insignificantly negative except Australia's and the sub-sample 2 of United Kingdom's are insignificantly positive. The coefficients of ΔP_{t-1} have positive sign in Japan, the United States, and the sub-sample 2 of United Kingdom while negative sign in Australia and sub-sample 1 of United Kingdom. However, none of them are significant. Hence, we conclude that the last period changes of trading partner's real GDP and bilateral real exchange do not have a significant short run effect on New Zealand's current period change of export volume.

5. Summary and Conclusions

This paper analyzes the dynamic relationship between real exchange rate volatility and the volume of real export in a small open economy, New Zealand, by employing the error-correction model. The model is estimated for New Zealand and its trade partners: Australia, Japan, the United States, and the United Kingdom over 1991Q1 to 2007Q1 sample period. We use moving average standard deviation of the percentage change in the real exchange rate as a proxy of exchange rate volatility. Some potential breakpoints are found by employing the exogenous breakpoint tests: the Chow test and the Perron Test, and the endogenous breakpoint test: the Quandt-Andrews test. After we split the original samples of four countries into sub-samples by potential breakpoints, the cointegration test results of long run equilibrium relationship among real export flows, foreign income, real exchange rate, and real exchange rate volatility have significantly improved.

Our results concerning the effects of exchange rate volatility on real exports suggest that the long-run relationship between New Zealand's real exports and its bilateral real exchange rate volatility is negative and statistically significant, but the short-run impact of the exchange rate volatility is insignificantly positive. Utilization of forward exchange markets to fully hedge exchange rate risk may have made exchange rate volatility less of a factor in explaining real export changes to these countries in the short-run, but still keep it as an important factor in the long run equilibrium. On the other hand, foreign income uncertainty has a more pervasively significant influence on trade than real exchange rate uncertainty no matter in the short run or in the long run.

Notes:

1. Surveys of the literature can be found in Cote (1994), McKenzie (1999), and Clark, Tamirisa, and Wei (2004), and Ozturk, Ilhan (2006).

2. McKenzie (1998) once investigated the trade between Australia and New Zealand, but he used the OLS method and quarterly data from 1988-1995.

3. Some other studies use gravity model or include other variables, such distance, openness, etc. into their models.

4. Data is of New Zealand (2006) from Wikipedia. China (5.4%) is the fourth biggest export partner of New Zealand. But, since the exchange rate policy of China is not floating in our exam period, we exclude China in our study.

5. New Zealand announced to start inflation targeting since July 1989, but it actually hadn't adopted it until March 1990.

6. The main results are robust irrespective of the value of m (m=6 and m=8).

7. If the results of the two test statistics are not consistent, go with the trace statistics.

8. More information about Japan's trade expansion policy in 1994 could be found at http://www.wto.org/english/tratop_e/tpr_e/tp5_e.htm

9. We cannot test the potential breakpoint around 1992 due to limited observations before 1992.

10. I also test the sub-samples split by point 1997 Q2 and 1998 Q1 for the United States, and 1996Q2 for the United Kingdom, but no significant long run equilibrium in those sub-samples can be found.

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Figure 1a

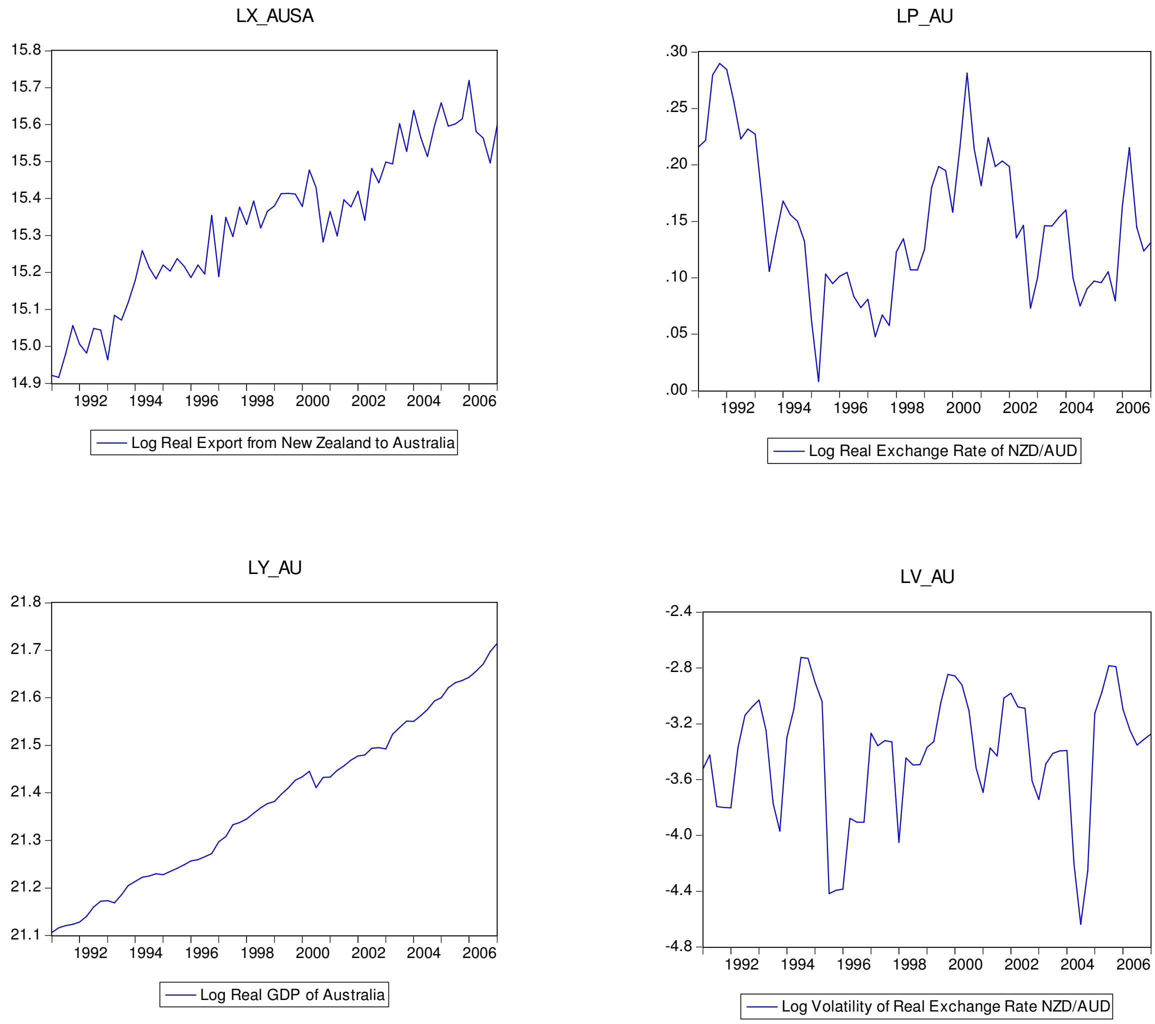

LX_AUSA
15.8
15.7
15.6
15.5
15.4
15.3
15.2
15.1
15.0
14.9
1992 1994 1996 1998 2000 2002 2004 2006
Log Real Export from New Zealand to Australia
LP_AU
.30
.25
.20
.15
.10
.05
.00
1992 1994 1996 1998 2000 2002 2004 2006
Log Real Exchange Rate of NZD/AUD
LY_AU
21.8
21.7
21.6
21.5
21.4
21.3
21.2
21.1
1992 1994 1996 1998 2000 2002 2004 2006
Log Real GDP of Australia
LV_AU
-2.4
-2.8
-3.2
-3.6
-4.0
-4.4
-4.8
1992 1994 1996 1998 2000 2002 2004 2006
Log Volatility of Real Exchange Rate NZD/AUD

Figure 1b

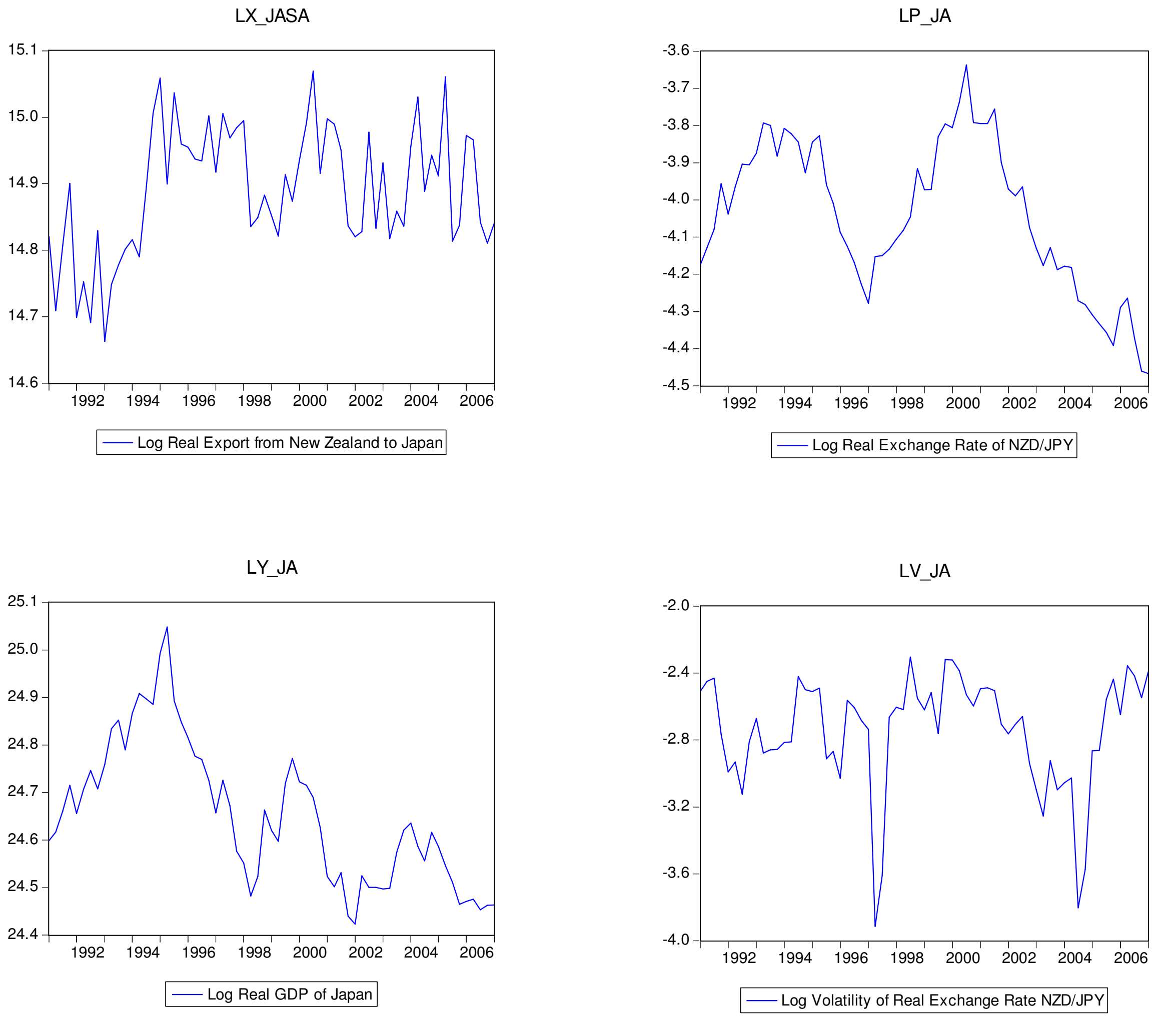
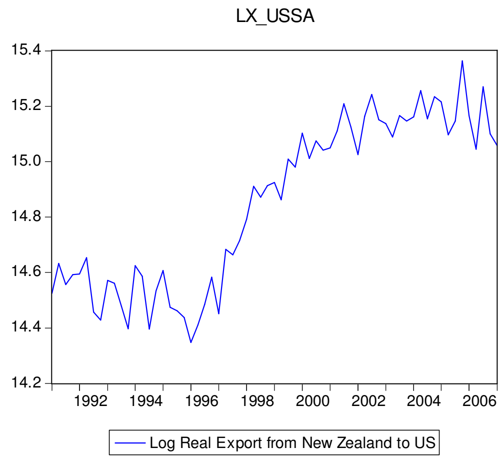

LX_JASA
15.1
15.0
14.9
14.8
14.7
14.6
1992 1994 1996 1998 2000 2002 2004 2006
Log Real Export from New Zealand to Japan
LP_JA
-3.6
-3.7
-3.8
-3.9
-4.0
-4.1
-4.2
-4.3
-4.4
-4.5
1992 1994 1996 1998 2000 2002 2004 2006
Log Real Exchange Rate of NZD/JPY
LY_JA
25.1
25.0
24.9
24.8
24.7
24.6
24.5
24.4
1992 1994 1996 1998 2000 2002 2004 2006
Log Real GDP of Japan
LV_JA
-2.0
-2.4
-2.8
-3.2
-3.6
-4.0
1992 1994 1996 1998 2000 2002 2004 2006
Log Volatility of Real Exchange Rate NZD/JPY

Figure 1c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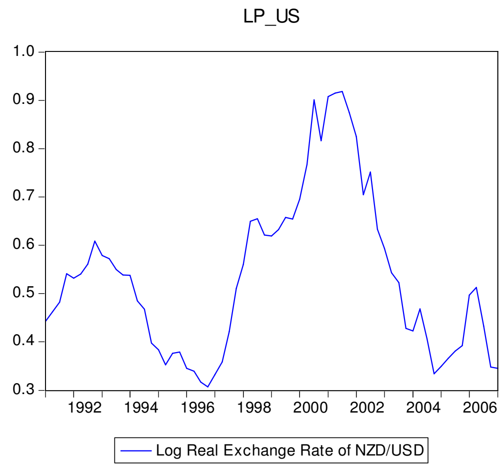
15.4
15.2
15.0
14.8
14.6
14.4
14.2
1992
1994
1996
1998
2000
2002
2004
2006
Log Real Export from New Zealand to US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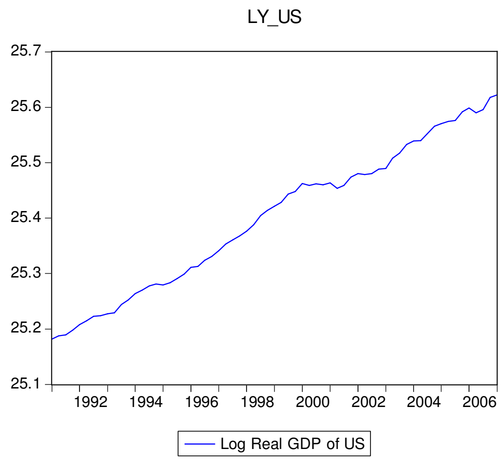
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
1992
1994
1996
1998
2000
2002
2004
2006
Log Real Exchange Rate of NZD/USD


LY_US
25.7
25.6
25.5
25.4
25.3
25.2
25.1
1992
1994
1996
1998
2000
2002
2004
2006
Log Real GDP of US

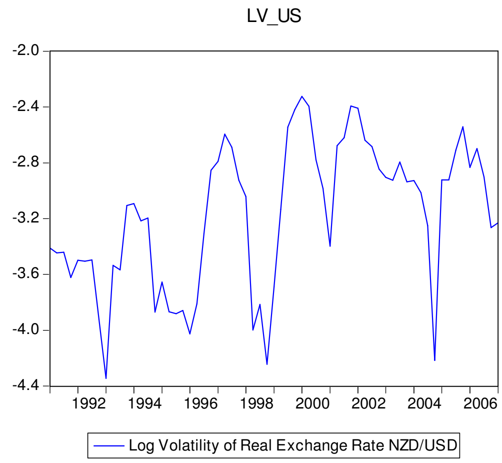

LV_US
-2.0
-2.4
-2.8
-3.2
-3.6
-4.0
-4.4
1992
1994
1996
1998
2000
2002
2004
2006
Log Volatility of Real Exchange Rate NZD/USD

Figure 1d

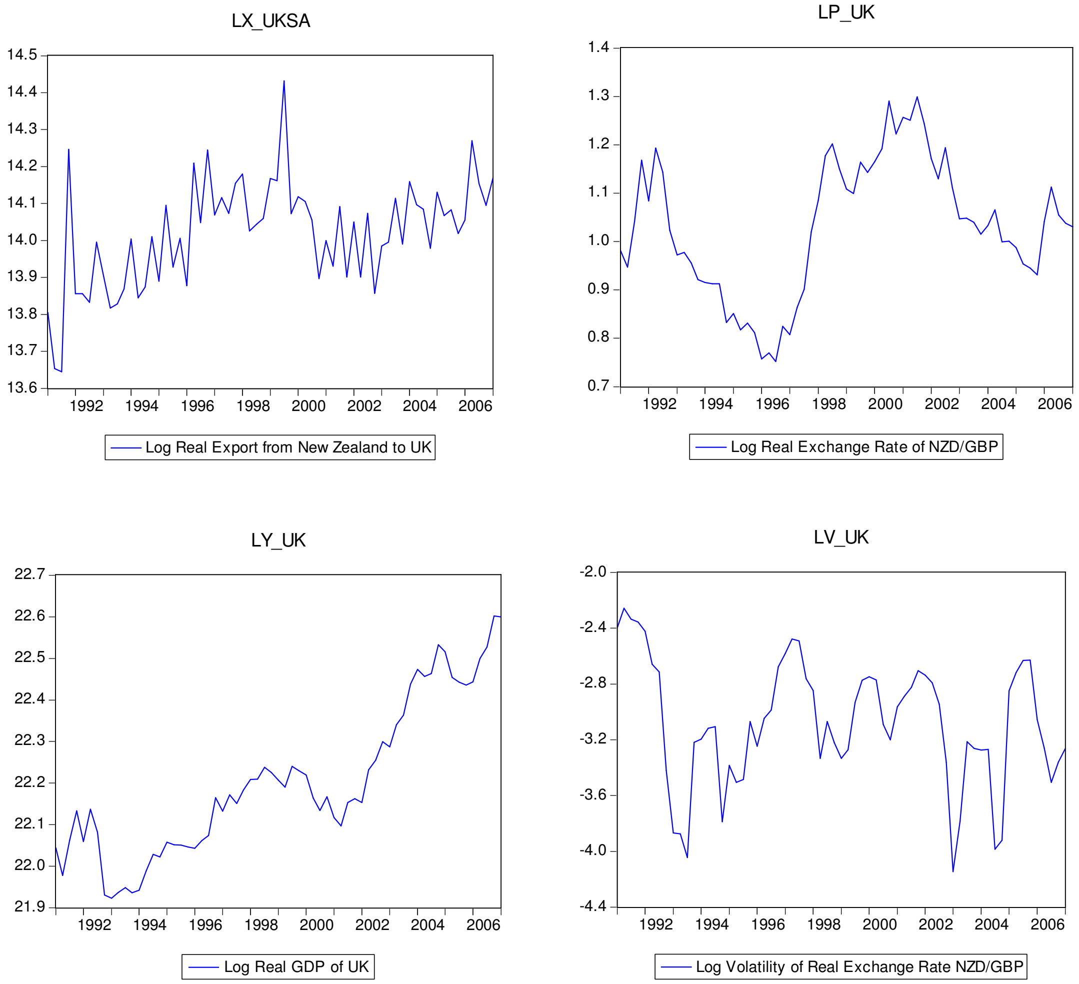

LX_UKSA
14.5
14.4
14.3
14.2
14.1
14.0
13.9
13.8
13.7
13.6
1992 1994 1996 1998 2000 2002 2004 2006
Log Real Export from New Zealand to UK
LP_UK
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
1992 1994 1996 1998 2000 2002 2004 2006
Log Real Exchange Rate of NZD/GBP
LY_UK
22.7
22.6
22.5
22.4
22.3
22.2
22.1
22.0
21.9
1992 1994 1996 1998 2000 2002 2004 2006
Log Real GDP of UK
LV_UK
-2.0
-2.4
-2.8
-3.2
-3.6
-4.0
-4.4
1992 1994 1996 1998 2000 2002 2004 2006
Log Volatility of Real Exchange Rate NZD/GBP

Table 1a: ADF Unit Root Test Results (intercept, without trend)

ADF Test	Australia	Japan	US	UK
$\ln X_t$	-1.70	-2.63*	-0.62	-3.78***
$\ln Y_t$	1.27	-0.91	-0.33	0.3
$\ln P_t$	-2.42	-0.40	-1.67	-1.75
$\ln V_t$	-4.96***	-3.15**	-3.68***	-4.00***
$\Delta\ln X_t$	-7.07***	-7.40***	-6.40***	-9.78***
$\Delta\ln Y_t$	-5.28***	-3.66***	-4.71***	-3.82***
$\Delta\ln P_t$	-5.36***	-3.96***	-3.29**	-4.33***
$\Delta\ln V_t$	-5.61***	-5.14***	-4.50***	-4.82***

Notes: All tests are specified with two lags. According to Mackinnon (1996) critical value, * shows rejection of the null hypothesis of a unit root at the 10% level, ** shows 5% level, and *** shows 1% level. The symbol Δ is the first difference.

Table 1b: ADF Unit Root Test Results (intercept, with trend)

ADF Test	Australia	Japan	US	UK
$\ln X_t$	-2.85	-2.49	-1.38	-3.99**
$\ln Y_t$	-1.61	-2.43	-2.06	-2.13
$\ln P_t$	-2.25	-1.44	-1.58	-1.84
$\ln V_t$	-4.95***	-3.07	-4.6***	-3.94**
$\Delta\ln X_t$	-7.14***	-7.39***	-6.35***	-9.63***
$\Delta\ln Y_t$	-5.54***	-3.63**	-4.66***	-4.13***
$\Delta\ln P_t$	-5.45***	-4.11**	-3.3*	-4.30***
$\Delta\ln V_t$	-5.57***	-5.12***	-4.46***	-4.80***

Notes: All tests are specified with two lags. According to Mackinnon (1996) critical value, * shows rejection of the null hypothesis of a unit root at the 10% level, ** shows 5% level, and *** shows 1% level. The symbol Δ is the first difference.

Table 2: Breakpoint Tests Results

Country	Chow Test	Quandt-Andrews Test		Perron Test			
	F-statistic	Max LR	Max Wald	$x_t = a_0 + a_1 D_L + a_2 D_P + a_3 t + a_4 x_{t-1} + \sum_{i=1}^{k} \beta_i \Delta x_{t-i} + e_t$			
				H_0: a_1	$a_2 \neq 0$	$a_3 = 0$	$a_4 = 1$
				H_1: $a_1 \neq 0$	a_2	a_3	$a_4 < 1$
AU	–	–	–	–			
JA	**1994Q3**	**1994Q3**		**1994Q3**			
	10.9048 (0.0001)	10.9048 (0.0656)	28.3644 (0.0000)	0.1988 (0.0003)	-0.0637 (0.4355)	-0.0016 (0.0314)	0.0413 |-58.28|>|-22.95|(cv)
US	**2001Q4**	**2001Q4**		**2001Q4**			
	7.4475 (0.0013)	1997Q2 12.1983 (0.0382)	1998Q1 63.5507 (0.0000)	-0.0909 (0.0431)	0.0359 (0.7012)	0.0035 (0.7012)	0.8956 |-7.13|<|-23.79| (cv)
UK	**1999Q4**	**1999Q4**		**1999Q4**			
	0.2729 (0.7622)	1996Q2 12.7597 (0.0301)	1996Q2 19.7591 (0.0013)	-0.2259 (0.0006)	0.1672 (0.2030)	0.0078 (0.0003)	0.0631 |-58.28|>|-23.45|(cv)

Note: Critical value at the 1% level of significance are calculated by Perron. P-values are in parentheses.

Table 3a: Johanson Cointegration Test Results

	λ-max Statistics				**Trace Statistics**			
	H_0: r = 0	r ≤ 1	r ≤ 2	r ≤ 3	r = 0	r ≤ 1	r ≤ 2	r ≤ 3
Country	H_1: r = 1	r = 2	r = 3	r = 4	r ≥ 1	r ≥ 2	r ≥ 3	r ≥ 4
Australia	**27.44**	20.37	7.79	0.74	**56.33**	28.89	8.52	0.74
Japan	25.45	11.18	4.47	1.84	42.94	17.49	6.31	1.84
US	**35.84**	13.70	3.90	0.09	**53.53**	17.69	3.99	0.09
UK	**29.25**	**22.99**	3.91	0.09	**56.24**	26.99	4.00	0.09
CV (5%)	27.58	21.13	14.26	3.84	47.86	29.80	15.49	3.84

Notes: r denotes the number of cointegrating vectors. Bold numbers are bigger than the critical value at 5% level of significance (MacKinnon-Haug-Michelis (1999)).

Table 3b: Johanson Cointegration Test Results

		λ-max Statistics				**Trace Statistics**			
Country	H_0:	r = 0	r ≤ 1	r ≤ 2	r ≤ 3	r = 0	r ≤ 1	r ≤ 2	r ≤ 3
	H_1:	r = 1	r = 2	r = 3	r = 4	r ≥ 1	r ≥ 2	r ≥ 3	r ≥ 4
Australia	91Q1-07Q1	**27.44**	20.37	7.79	0.74	**56.33**	28.89	8.52	0.74
Japan	91Q1-94Q2	Insufficient Number of observations							
	94Q3-07Q1	**34.93**	11.92	7.19	0.80	**54.84**	19.91	7.99	0.80
US	91Q1-01Q3	27.46	15.33	4.91	3.41	**51.11**	23.66	8.33	3.42
	01Q4-07Q1	**32.89**	16.49	5.97	0.04	**55.39**	22.49	6.01	0.04
UK	91Q4-99Q3	**34.21**	14.55	4.68	2.28	**55.72**	21.51	6.96	2.28
	99Q4-07Q1	**28.87**	14.01	8.18	0.01	**51.06**	22.20	8.19	0.01
CV (5%)		27.58	21.13	14.26	3.84	47.86	29.80	15.49	3.84

Notes: r denotes the number of cointegrating vectors. Bold numbers are bigger than critical value at 5% level of significance (MacKinnon-Haug-Michelis (1999)).

Table 4a: Estimates of the Cointegrating Relationships

Country	Normalized Cointegrating Vector
Australia	$\ln X_t = -9.03 + \mathbf{1.09} \ln Y_t^f + 0.05 \ln P_t - \mathbf{0.30} \ln V_t$ (0.15) (0.39) (0.06)
Japan	$\ln X_t = 15.49 - 0.02 \ln Y_t^f - 0.03 \ln P_t + 0.08 \ln V_t$ (0.11) (0.09) (0.05)
US	$\ln X_t = 227.6 - \mathbf{7.64} \ln Y_t^f - \mathbf{4.10} \ln P_t + \mathbf{5.21} \ln V_t$ (2.82) (1.88) (0.82)
UK	$\ln X_t = 6.86 + \mathbf{0.36} \ln Y_t^f - 0.24 \ln P_t + \mathbf{0.21} \ln V_t$ (0.12) (0.15) (0.06)

Note: Standard errors are in parentheses. Bolded numbers are significant at the 5% level (1% level of significance included).

Table 4b: Estimates of the Cointegrating Relationships

Country		Normalized Cointegrating Vector
Australia		$\ln X_t = -9.03\ \mathbf{+\ 1.09}\ \ln Y_t^f + 0.05\ \ln P_t\ \mathbf{-\ 0.30}\ \ln V_t$
		(0.15) (0.39) (0.06)
Japan	91Q1-94Q2	Insufficient Number of observations
	94Q3-07Q1	$\ln X_t = 10.90\ \mathbf{+\ 0.16}\ \ln Y_t^f + 0.04\ \ln P_t\ \mathbf{-\ 0.06}\ \ln V_t$
		(0.06) (0.05) (0.025)
US	91Q1-01Q3	$\ln X_t = -16.57\ \mathbf{+\ 1.20}\ \ln Y_t^f\ \mathbf{+\ 0.89}\ \ln P_t\ \mathbf{-\ 0.10}\ \ln V_t$
		(0.24) (0.13) (0.04)
	01Q4-07Q1	$\ln X_t = 15.87 - 0.04\ \ln Y_t^f + 0.05\ \ln P_t\ \mathbf{-\ 0.10}\ \ln V_t$
		(0.24) (0.08) (0.03)
UK	91Q4-99Q3	$\ln X_t = -11.30 + \mathbf{1.15}\ \ln Y_t^f\ \mathbf{-\ 0.19}\ \ln P_t - 0.04\ \ln V_t$
		(0.14) (0.08) (0.03)
	99Q4-07Q1	$\ln X_t = 4.44 + \mathbf{0.42}\ \ln Y_t^f + 0.17\ \ln P_t - 0.03\ \ln V_t$
		(0.20) (0.28) (0.04)

Note: Standard errors are in parentheses. Bolded numbers are significant at the 5% level (1% level of significance included).

Table 5: Vector Error Correction Model Results

Country	ECT_{t-1}	ΔlnX_{t-1}	ΔlnY_{t-1}	ΔlnP_{t-1}	ΔlnV_{t-1}	C	Summary Statistics
Australia	**-0.12**	**-0.54**	1.31	-0.09	0.04	0.003	R^2=0.48, AIC= -2.71
91Q1-07Q1	[-1.75]	[-3.90]	[1.48]	[-0.46]	[1.58]	[0.18]	
Japan	Insufficient Number of observations						
91Q1-94Q2							
Japan	**-0.96**	0.04	-0.23	0.02	**0.05**	-0.00	R^2=0.51, AIC= -2.43
94Q3-07Q1	[-4.97]	[0.29]	[-0.92]	[0.07]	[1.72]	[-0.09]	
US	-0.24	-0.19	-0.9	0.42	0.03	0.02	R^2=0.18, AIC= -1.69
91Q1-01Q3	[-1.47]	[-1.06]	[-0.31]	[1.17]	[0.68]	[0.70]	
US	**-1.42**	0.34	-4.06	0.07	0.04	0.03	R^2=0.61, AIC= -1.92
01Q4-07Q1	[-3.12]	[1.15]	[-1.34]	[0.17]	[0.66]	[1.01]	
UK	**-1.31**	0.025	-0.57	-0.04	0.09	0.03	R^2=0.62, AIC= -1.20
91Q4-99Q3	[-4.40]	[0.13]	[-0.68]	[-0.07]	[1.15]	[1.39]	
UK	**-0.85**	**-0.33**	0.17	0.46	0.04	-0.01	R^2=0.48, AIC= -2.13
99Q4-07Q1	[-4.80]	[-2.60]	[0.47]	[1.39]	[0.88]	[-0.73]	

Note: Australia is summarized from the output including two lags since none of those second lags has a significant coefficient. *t* statistics are in [ ].