The Real Exchange Rate of New Zealand
and its Major Trading Partners:
A Variance Decomposition

“Submission of the MBus 590 project”

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1. Purpose

This paper examines the variability of New Zealand’s real exchange rate with that of its partner countries. What is the level of this variability, what does this variability comprise of, how does this variability change as the defined time horizon changes, and what can be said, if anything, about the past and expected future trend of the real exchange rate?

Furthermore, an explanation is given in this standing as to why this issue is important. Who gets affected by the results, why does it affect these groups, and what, if anything can be done about the consequences?

2. Conceptual Motivation

The real exchange rate is a non observable value which relates the real (inflation adjusted) purchasing power of one country’s currency (for a fixed basket of goods) relative to another. If for example country A’s real exchange rate rises relative to country B, country A’s currency can now purchase a greater proportion of the fixed basket of country B’s goods relative to the period before (e.g. 1 basket of country B’s goods before, 1.1 baskets now). Variability in the real exchange rate means that country A’s real purchasing power with regard to country B’s goods fluctuates over time.

So far as real exchange rate volatility is unwanted, any group with an interest in New Zealand’s bilateral exchange rates (and their variability’s) should care about a study into the level of this real exchange rate volatility (i.e. its variance), its composition (or determinants), and how these factors change as the time horizon in question changes. Not only this, any group with an interest in their future international purchasing power should also care about how the real exchange rate is expected to change for the future.

The level of real exchange rate volatility implicitly shows the level of real risk that an investor, trader, or other group with an interest (henceforth known as the “agent”) must bear in order to have an exposure to the foreign currency in question. Knowing
the real exchange rate volatility of all potential countries of interest allows an agent to compare the risk of investing in a particular country to the expected return that such a foreign investment will make. And ranking each country in terms of their variability's allows the agent an appropriate knowledge set for investing in the country for which he finds has the optimal risk and return trade off for himself.

The composition of this real exchange rate volatility is also of possible importance to an agent because it gives some guidance as to the drivers of real exchange rate volatility, as well as the ability to actively minimise these drivers. For example, if it is found that nominal exchange rate variance is the major driver of a country’s real exchange rate variance, then that country’s real exchange rate variance can be effectively reduced via a nominal exchange rate hedge. Knowledge of the composition of the real exchange rate variance allows positive action to be taken in order to reduce real variability, and it also gives an estimate of the likelihood of success from this positive action. These points are something an agent would likely wish to know before a decision to invest in a foreign country was to be made.

As discussed in the literature review forthcoming, it is possible that the level and composition of the real exchange rate variability may change as the time horizon in question changes. For example, whilst inflation may be a significant driver of real exchange rate variability over time horizons of several years, it may play a relatively smaller role in the composition of variability if we are focusing on periods of only several months. Any agent who has a predefined investment time horizon would have an interest only in details applicable to their length of time exposure. As the answers to the questions we ask may change dependant on the time horizon in question, we therefore address a broad range of investment time horizons for different agents who have different specific needs.

Finally, investigation is made with regard to the historical trend of the real exchange rate for the various different countries in question. Agents who invest do so for some future benefit. This means that they are interested in their future purchasing power. If for example a trend is present in the historical real exchange rate, it may also continue on into the future. An agent interested in their future purchasing power should therefore care about this trend.
We therefore have a conceptual motivation to analyse the level and determinants of New Zealand’s real exchange rate variability with its major trading partners, as well as a conceptual motivation to look at the historical trend of the real exchange rate. With regard to the term “major trading partners”, the context we take it in is that of the broadest sense, encompassing both major financial, as well as major physical trading partners. By addressing this issue in relation to these partner countries, we target those countries whose exchange rate both financial and physical traders have a definite particular interest in.

3. Who are the Agents?

As found by Goldberg and Klein (1997)\(^1\), real exchange rates are a significant determinant of regional trade and foreign direct investment. In the context of this report, this is real world evidence that groups do care and act upon changes in the real exchange rate.

But who are these groups? Who we define as our agent?

We define an agent as any group which has an interest in the future real exchange rate of New Zealand with any other country, be it a personal financial interest, or otherwise. Following this definition, the agent’s interest will also encompass the results of this report. Detailed below are groups which likely meet the criteria.

New Zealand investors and traders with an exposure abroad have an interest in the real exchange rate. Similarly, foreign investors and traders with an exposure to New Zealand also have an interest. With a shift in the real exchange rate, these groups’ future purchasing power is altered, be it via a change in the real value of their investment abroad, a real change in the value of their receivables or payables, or a change in demand for a trader’s products. As a result, these groups will have an interest in the future real exchange rate, so can be defined as an agent in this sense.

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\(^1\) Goldberg, L. Klein, M. W. Foreign Direct Investment, Trade, and Real Exchange Rate Linkages in Southeast Asia and Latin America, NBER Working Paper Series, 6344, NBER, Cambridge, Page 1, 1997
Multinational firms with operations in foreign countries will similarly be affected by real exchange rate changes. The real profitability of the company may be affected, as with the real value of their assets and liabilities abroad. As a result, multinational firms will be interested in the future path of the real exchange rate. Not only will they be interested via just their current situation however, future decision making may also change dependant on how the real exchange rate is viewed over this period. Whether they can successfully hedge their real exchange rate risk via a nominal exchange rate hedge will impact, for example, whether a company decides to invest abroad or not. Therefore, multinational firms can quite likely be viewed as an agent for the purposes of this report.

Central banks, such as the Reserve Bank of New Zealand, care about the welfare of the country that they monitor. As the real exchange rate can impact upon the welfare of all the citizens in that country via their international real purchasing power, central banks would likely have an interest in how the future real exchange rate acts so as to adjust their monetary policy appropriately. Therefore, central banks, along with the more financially aware members of the general public should care about this issue.

4. Theoretical Motivation

As discussed in the conceptual motivation, a change in the real exchange rate can affect the purchasing power of one country relative to another. This section is a discussion of the determination of the real exchange rate, with particular regard to the nominal spot rate and the inflation differential between countries; variables which implicitly lead to changes in the real exchange rate.

The real exchange rate can be defined as:

$$ E_t = S_t \frac{P_t}{P_t^{(F)}} $$

Where $E_t$ is the real exchange rate at time $t$, $S_t$ is the spot bilateral exchange rate (both rates being nominal Foreign Currency/Home currency), $P_t^{(F)}$ is the foreign price level, and $P_t$ is the home price level.
As identified algebraically from equation (1) by Click and Coval\(^2\) (Appendix A),

\[
\ln\left(\frac{E_{t+n}}{E_t}\right) \approx \ln\left(\frac{S_{t+n}}{S_t}\right) + (\Pi_{t,t+n} - \Pi_{t,t+n}^{(F)})
\]  

(2a)

where the inflation terms \(\Pi\) and \(\Pi^F\) are both expressed as percentages, approximated from the natural log price relative\(^3\) \(\ln(P_{t+n}/P_t)\).

From equation (2a), an approximation of the percentage change in the real exchange rate can be expressed as follows:

\[
\%\Delta E_{t,t+n} \approx \%\Delta S_{t,t+n} + (\Pi_{t,t+n} - \Pi_{t,t+n}^{(F)})
\]  

(2b)

Following this, the variance of percentage real exchange rate changes can then be expressed as\(^1\)

\[
\text{Var}(\%\Delta E_{t,t+n}) \approx \text{Var}(\%\Delta S_{t,t+n}) + \text{Var}(\Pi_{t,t+n} - \Pi_{t,t+n}^{(F)}) + 2\text{Cov}(\%\Delta S_{t,t+n}, \Pi_{t,t+n} - \Pi_{t,t+n}^{(F)})
\]  

(3)

From equation 3, we can see that the variability of the percentage change in the real exchange rate depends approximately upon the variability of the percentage change in the nominal spot rate, the variability of the inflation differential \((\Pi_{t,t+n} - \Pi_{t,t+n}^{(F)})\), and the covariance between the change in spot rate, and the inflation differential.

Click and Coval argue that for most developed countries, the variability of the inflation differential is low. The covariance between the percentage change in spot and the inflation differential for developed countries could also be considered low, Click and Coval stating that for developed countries “most of the variability in (nominal) spot rates is unrelated to inflation differentials”. It seems that the variability of these countries’ nominal spot rates are affected more by other factors such as changes in investor or trade preferences rather than inflation differentials, as these

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\(^2\) Click R W, Coval J D, Theory and practice international financial management, Prentice Hall, associated MS PowerPoint presentation, year unknown

\(^3\) Which is apparent when one takes natural logarithm of equation (2) and rearranges to form (3a). See proof in appendix A.
differentials are small, constant, and predictable over time. Therefore, we should expect that the variability of the percentage change in real exchange rates ($\text{Var}(\%\Delta E_{t\rightarrow t+n})$) for these countries should be mainly composed of the variance of the nominal spot rate, ($\text{Var}(\%\Delta S_{t\rightarrow t+n})$), as the other two factors are relatively insignificant. An agent, knowing this, can easily hedge away this nominal exchange rate variance, and at the same time effectively hedge away his real exchange rate risk.

For countries (usually developing) with large and highly variable inflation rates however, the variability of the inflation differential when compared to a developed country, ie $\text{Var}(\Pi_{t\rightarrow t+n} - \Pi^F_{t\rightarrow t+n})$, will typically be higher. As a result, an agent intending to invest in such countries needs to be aware of how inflation will act when determining the risk present within the real exchange rate variability. A nominal exchange rate hedge would not fully reduce his exposure to real exchange rate risk.

The differing examples presented above illustrate the need to identify the composition of real exchange rate variability for the different countries of interest. In knowing this, an agent can therefore determine beforehand his ability to hedge away real exchange rate risk, as well as the likelihood of success of his actions.

From this theory, we can therefore identify for NZ and its partner countries

i. The level of variance of the percentage change in the directly unobservable real exchange rate for each foreign country, $\text{Var}(\%\Delta E_{t\rightarrow t+n})$, via a summation of the observable terms on the right hand side of equation 3.

ii. The rank of each foreign country in terms of their real exchange rate variability.

iii. The size of the components of $\text{Var}(\%\Delta E_{t\rightarrow t+n})$, as per the right hand side of equation 3.

iv. Whether these rankings or component sizes change significantly as the defined time horizon changes.
Investors and consumers will be interested in these questions because they relate directly to the purchasing power of their funds in foreign countries. The more variable the real exchange rate is, the more difficult it is for them to predict the value of their future foreign consumption, or the value of their future foreign funds. Therefore, they will have an interest in the results which follow.

5. Previous Research

There has been much research on real exchange rates, and purchasing power parity (PPP, effectively meaning the real exchange rate is stationary, and has no trend). For example, according to Papell (2002)⁴, “The behaviour of real exchange rates over the post-1973 floating exchange rate period is one of the most extensively studied empirical topics in international economics. The most frequently asked question is whether long-run purchasing power parity holds over this period, posed statistically as whether unit roots in real exchange rates can be rejected. Despite the large amount of research on this topic, we do not have a definitive answer to the most basic issues. Is the real exchange rate mean reverting, or does it have a unit root (stochastic trend)?”

Monadjemi⁵ (2000) follows the unit root approach above, and for six OECD countries decomposes the variance of real exchange rates into the same parts as this project proposes in equation 3. He finds that the nominal exchange rate is “a far more important variable in explaining the variations of the real exchange rate than the domestic price level”. His paper considers only the long run however, searching for a cointegrating result over two decades of OECD data. As this paper intends to distinguish the effect of differing time horizons, it makes it practically more applicable than Monadjemi’s.

One point to note regarding the time horizon (investment horizon) focused upon is that it does indeed matter with respect to the empirical results. Previous research, such

⁴ Papell, D. 2002, The Panel Purchasing Power Parity Puzzle, University of Houston website (http://www.uh.edu/~d papell/Puzzle.pdf)
as that by Antweiler (2005)\textsuperscript{6} suggests that absolute PPP (i.e. zero, or low real exchange rate variability) is more likely to hold over longer time horizons, from 3 to 10 years. Lothian (1998)\textsuperscript{7} attributes this to the idea that “the PPP relationship generally is regarded as having much greater relevance over the long run than over the short run. Over shorter time horizons, the effects of shocks can be quite substantial; in the long run, however, they appear to dissipate greatly.” Therefore, the questions posed will be focused upon using different time horizons, differing from the short term (1 month) to the long term (48 months), in order to identify whether or not our results differ per horizon. Conceptually, this is appealing because investors do indeed have different investment horizon lengths, so require details specific to their investment length.

Luo (2003)\textsuperscript{8} tests for a PPP relationship between the New Zealand dollar and four other major currencies. In doing so, he is identifying whether the real exchange rates of New Zealand with these countries have unit roots or not, and whether or not they have a deterministic trend. However, his dataset begins from the period post 1985, which includes the structural break of the RBNZ 1989 act. Therefore, extrapolating his real exchange rate trend results into the future may well be inappropriate.

Whilst several other foreign studies have incorporated NZ into their PPP and real exchange rate studies, no comprehensive study into the variance of the real exchange rate several time horizons could be found, for NZ, or any other country. Therefore, this study is not a replication of something already known to exist.

\textsuperscript{6} Werner Antweiler, Sauder School of Business webpage, University of British Columbia, http://fx.sauder.ubc.ca/PPP.html

\textsuperscript{7} Lothian, J. 1998, Movements in Exchange Rates and Relative Price Levels in the Netherlands and Britain over the Past Four Centuries Graduate School of Business, Fordham University http://www.eh.net/Clio/Conferences/ASSA/Jan_99/lothian.shtml

\textsuperscript{8} Luo, R. 2003. On the Purchasing Power Parity Puzzle: The Case of New Zealand, Auckland University of Technology
6. Methodology

The methodology used in this paper is as follows.

i) From the obtained CPI series, the natural log series of the relative values are calculated using SAS, i.e. \( \ln(\text{CPI}_t / \text{CPI}_{t-n}) \) and \( \ln(\text{CPI}_t^{(F)} / \text{CPI}_{t-n}^{(F)}) \) for both New Zealand and the foreign country respectively, where \( n \) is equal to the time horizon period being focused upon in months (i.e. \( n = 1,3,6,12,24,48 \)). \( \ln(\text{CPI}_t / \text{CPI}_{t-n}) \) and \( \ln(\text{CPI}_t^{(F)} / \text{CPI}_{t-n}^{(F)}) \) are approximations of \( \prod_{t,t+n} \) and \( \prod_{t,t+n}^{F} \) respectively.

ii) The inflation differential \( \prod_{t,t+n} - \prod_{t,t+n}^{F} \) is calculated by subtracting the log price ratios i.e. \( \ln(\text{CPI}_t / \text{CPI}_{t-n}) - \ln(\text{CPI}_t^{(F)} / \text{CPI}_{t-n}^{(F)}) \)

iii) \( \ln(\text{S}_t / \text{S}_{t-n}) \) is also calculated using the obtained exchange rate series, where \( \ln(\text{S}_t / \text{S}_{t-n}) \) is approximately equal to \( \% \Delta \text{S}_{t,t+n} \) over the time horizon \( n \).

iv) The variance of the inflation differential and the variance of the percentage change in nominal spot rate are calculated using SAS, as with the covariance between the two. Everything on the right hand side of equation 3 is now produced. Both the variance and covariance values are scaled by the time horizon, \( n \), to produce variance/covariance per month.

v) The variance of the percentage change in the real exchange rate (\( \text{Var}(\% \Delta \text{E}_{t,t+n}) \)) is now calculated from equation 3, from the variables in step iv). Each country can now be ranked in terms their real exchange rate variance. Note that the real exchange rate variance is also displayed scaled by the time horizon, \( n \), so as to show the real exchange rate variance per month.

vi) Analysis of the calculated series in iv) and v) can now occur, i.e. whether rankings significantly change over different time horizons (determined by a visual examination of the ranking lists over different time horizons), or whether the composition of real exchange looks to change.
vii) The historical trend and stationarity of the real exchange rate can be analysed using the Augmented Dickey Fuller Test procedure, as described below.

6a. Augmented Dickey Fuller Test procedure

In this paper we apply the augmented Dickey-Fuller test (ADF) as recommended by Granger and Engle (1987). The test (for stationarity) is the t statistic on $\rho$ in the following regression $\Delta = (1-L)^K Z_t = \alpha_0 + \alpha_1 t + \rho Z_{t-1} + \sum_{i=0}^{K} \beta_i \Delta Z_{t-i} + \epsilon_t$

(5)

where $Z_t$ is the series under consideration and $K$ is large enough to ensure that $\epsilon_t$ is white noise. In practice we do not know the appropriate order of the autoregression, $K$. In our implementation of the ADF test we follow the suggestion of Engle and Yoo (1987) and use the Akaike (1974) information criterion (AIC) to determine the optimal specification of equation 5. This criterion is defined by

$$AIC(q) = N \ln(SSR/N) + 2q$$

(6)

Where $N$ is the number of observations to which the model is fitted, SSR is the sum of squared residuals and $q$ is the number of parameters, equal to $K+1$. By this method the appropriate order of the model is determined by computing equation 6 over a selected grid of values of $K$ and finding that value of $K$ at which the AIC attains its minimum. The distribution of the ADF statistic is non-standard and, accordingly, we use the critical values tabulated by Engle and Yoo.

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10 Granger, C. and Engle, R. Co-integration and error correction: representation, estimation, and testing, *Econometrica*, 55, 251-76
If the t statistic on $\rho$ is not significant, i.e. $H_0: \rho = 0$, then at least one unit root exists. If $H_a: \rho < 0$ is found to hold, then the real exchange rate in question is stationary.

A test for a deterministic historical time trend is done via the t statistic on $\alpha_2$. If $\alpha_2$ is not found to be significant, i.e. $\alpha_2 = 0$, then the real exchange rate in question does not have a deterministic trend. If $\alpha_2$ is found to be significantly different from zero, i.e. $H_a: \alpha_2 \neq 0$, then the historical real exchange rate has a deterministic trend over time.

For prediction purposes, it may be helpful to know whether any particular real exchange rate was trend stationary, level stationary, or non stationary. If no unit root is found, i.e. $\rho < 0$, and the historical exchange rate also has no deterministic trend, i.e. $\alpha_2 = 0$, then the historical exchange rate is defined as mean reverting. Knowing that the exchange rate reverts to a particular mean, for example, may provide some insight as to the behaviour of real exchange rates in the future.

If $\rho = 0$, then at least one unit root exists. Whilst further tests could be run to determine the exact number of unit roots, for the purposes of this report, this is not required. We test for stationarity in order to give some insight as to the predictability of the future real exchange rate. If we find that the real exchange rate is stationary (i.e. has no unit root), then we know that this series has a constant mean or is stationary around a deterministic trend, and also has a constant variance. If this is found to be the case, then predicting future values of the real exchange rate will be much simpler than if it does not have a constant mean, or does not have a constant variance (i.e. does not have a stochastic trend, when one or more unit roots are found). In essence, we are most interested in the case whereby no unit root is found. An agent, knowing some exchange rate series are stationary, and some are not, will have gained more information for his risk/return decision making when it comes to compare country to country investments, which is the entire point of this report. Choosing to invest in a country with a stationary real exchange rate means data from the past is much more useful in determining how the real exchange rate will act for the future (e.g. does it mean revert?). Therefore, the question of whether there is one or more unit roots is of lesser interest to us, we are more worried about the case of stationarity or not.
7. Data

Data for the inflation rates of all countries has been obtained from the Cleveland Federal Reserve website. Monthly CPI rates are used for all countries, beginning from the first quarter of 1992 (just after the beginning of NZ inflation targeting, and the beginning of a new long term trend) to the present (to keep the inflation policy consistent throughout). New Zealand and Australia only produce quarterly inflation data series however, so in order to prevent a loss of high frequency data from the other countries, monthly data rates have been interpolated from the NZ and AU quarterly figures, as per Luo (2003). In order to ensure that interpolation has not affected the results adversely, variance measures were also taken upon the unaltered quarterly data. The resulting variance values were very similar to that of the interpolated monthly data (see appendix B).

Monthly exchange rate data has also been collected from the U.S. Federal Reserve H10 release available from their website.

New Zealand’s top major trading partners (import and export volumes) as determined by Statistics New Zealand in 2004 have been obtained. Major financial trading partners have also been identified from the New Zealand balance of payments (specifically, investment from the capital account), obtained through Statistics New Zealand. From these rankings, the following major partners have been included in this study: China, Korea, Taiwan, Malaysia, Singapore, Canada, US, UK, Australia, Japan, and Thailand.

13 http://www.clevelandfed.org/research/inflation/world-Inflation/index.cfm
15 www.federalreserve.gov/releases/H10/hist/
8. Results

As per the methodology, the directly observable variables on the right hand side of equation 3 were calculated and summed to calculate the variance of the percentage change in the real exchange rate, \( \text{Var}(\% \Delta E_{t,t+n}) \), for differing time horizons of \( n \). An example of the results for the given countries is shown below in Figure 1, where an investment time horizon of 1 month is used.

![Figure 1: Variance of the % Change in the Real Exchange Rate](image)

From figure 1, we can see that clear rankings exist in terms of the countries variance of the percentage change in the real exchange rate. China has the highest \( \text{Var}(\% \Delta E_{t,t+n}) \), at 0.0025 per month, while Australia has the least, at about a \( \frac{1}{10} \)th of China’s. If real exchange rate risk was the only thing that an investor was worried about, China would be the worst country to invest in as deemed by these results.

As identified before however, a change in the investment time horizon may alter the results and rankings of the countries significantly. Shown overleaf in figure 2 is the real exchange rate variance \( \text{Var}(\% \Delta E_{t,t+n}) \) of countries when the investment time horizon in question becomes 3 months.
Figure 2: Variance of the % Change in the Real Exchange Rate
(Per month variance, for a 3 month time horizon investment)

Again we see that Australia has the lowest real exchange rate variance over our sample time frame. However, China's real exchange rate variance is no longer the highest; it seems Korea has taken the lead regarding this. Many other rankings have also changed as the time horizon has been changed from 1 to 3 months.

The importance of this is obvious when taken in relation to an agent whose investment time horizon may be fixed for a set number of months. An agent investing for 1 month may pick a different country to invest in if he were instead investing for 3 months, as the relative risk between countries over different time horizons changes. This becomes even more apparent when the results of an investment time horizon of 48 months are shown, as per figure 3 overleaf.
With an investment time horizon of 48 months, we can see a clear contrast between the shorter time horizons of 1 and 3 months, and that of the longer 48 month period. The difference between the most variable countries and the least variable countries (excluding Australia) has decreased, caused mainly by an increase in risk by the majority of the lower end countries. The stark exception is Australia, whose lowest risk position now stands out even more clearly than before. Also, the US now has the second highest real exchange rate risk, whereas when a one month time horizon was used, it had the second lowest risk. Clearly, the rankings have been altered significantly focusing upon the long term; even more so than when the time horizon changed between 1 month and 3 months.

It is clear then that an investor must focus upon his own particular time horizon when interpreting any results, as applying results generally could lead an investor to very inaccurate conclusions. To illustrate this issue fully, figure 4 overleaf shows the ranking positions of the countries as the time horizon in question changes.
As can be seen from figure 4, Australia clearly has the lowest real exchange rate variance over all time horizons in question. As for the other countries, it can be seen that whilst the earlier time horizons of 1 and 6 months have fairly flat and stable rankings between countries as time passes between these horizons, between the 6 and 24 month time horizons, these rankings begin to change substantially. For a short term investor who is uncertain of his investment length, but knows that 6 months of investing is his maximum, he can be fairly certain that trusting the rankings from either of the 1 month, 3 month or the 6 month time horizon is relatively safe, regardless of the exact time length he invests for.

On the other hand, this means an investor who is uncertain of his investment length, but knows it will be somewhere between 6 to 24 months will have difficulty in applying any ranking system such as the one described for the short term agent above. A slight unexpected increase in investment length may mean the optimal country choice in terms of the risk/return trade off is no longer the country this uncertain investor picked in the first place. We see therefore that there is a substantial difficulty in making an optimal decision beforehand if ones investment time horizon is not fixed from the onset.
From the 24 to 48 month investment time horizon, the rankings flatten and stabilize out again, adding some certainty to the decision making processes of the uncertain investor between this time span.

In sum, we see that in terms of real exchange rate variance rankings, the time horizon in question does matter. Making an optimal choice in terms of risk and return means an agent must attempt to clarify his investment time horizon before proceeding with a choice of investment country. The more uncertain an agent is about his investment time horizon, the more likely his country choice is to be based around inaccurate data, and this is especially so if his investment lies between a 6 to 24 month time frame. Either way however, knowing the real exchange rate risk of countries over different time horizons aids to an agent’s risk/return decision making for investment into a foreign country.

Regarding the composition of the real exchange rate variance over any time horizon length in particular, we can see from chart group 1a, 1b, and 2 below that the variance of the percentage change in nominal spot rate, $\text{Var}(\%\Delta S_{t,t+n})$, comprises most of the variance of the percentage change in the real exchange rate, $\text{Var}(\%\Delta E_{t,t+n})$ (with a notable exception of China, in chart group 2).\(^{18}\) In terms of how this relates to the agent, this is likely excellent news as if one is able to hedge the nominal spot rate risk (fairly easy to do using currency derivatives such as forwards or options), then they will have effectively reduced the majority of their real exchange rate risk at the same time. In effect, a nominal currency hedge reduces $\text{Var}(\%\Delta S_{t,t+n})$ to zero, and since we have just found that $\text{Var}(\%\Delta S_{t,t+n})$, is often the major component of $\text{Var}(\%\Delta E_{t,t+n})$, then effectively, $\text{Var}(\%\Delta E_{t,t+n})$ will also be reduced to near zero (barring the other effects from equation 3). The chart groups 1, 1b, and 2 below show us however that each country is different with regard to the exact percentage of nominal exchange rate variance that comprises the real. And not only this, the exact percentage changes as the time horizon in question changes.

\(^{18}\) For information on how to read this 100% stacked bar chart type, please refer to appendix C
Chart Group 1a

Legend

- \(2 \times \text{Cov}(\% \text{Chg nom spot, } \% \text{Chg inf diff})\)
- \(\text{Var}(\% \text{change inf diff})\)
- \(\text{Var}(\% \text{change nominal spot})\)

For Australia, Japan, UK, and US, the charts show the time horizon with percentage changes over different time periods.
Chart Group 1b

Legend

- 2 x Cov (% Chg non spot, % Chg inf diff)
- Var (% change inf diff)
- Var (% change nominal spot)

Singapore

Malaysia

Taiwan

Canada
From the changing columns in the chart groups above over different time horizons, we can identify that the time horizon does indeed matter in terms of the composition of the variance in the real exchange rate. Focusing on the extreme example of China in chart group 2 above, we can see that for investors of a 1 month time horizon, the majority of their variance in the real exchange rate ($\text{Var}(\%\Delta E_{t,1m})$) comes from the variance in the nominal exchange rate, $\text{Var}(\%\Delta S_{t,1m})$. An investor of a 1 month time
horizon can therefore hedge successfully the majority of his real exchange rate risk by hedging away the nominal spot rate risk, $\text{Var}(\%\Delta S_{t,t+n})$. As the agents investment time horizon in China increases however, the nominal spot rate variance begins to play an increasingly smaller role in the composition of real exchange rate risk. By the time the investment time horizon reaches 48 months for China, the nominal spot rate variance contributes then to less than half of the real exchange rate variance. An agent intent on hedging away his real exchange rate risk should therefore be wary of investing in China over a long investment period.

And whilst the results of other countries are not quite as dramatic as China’s, agents must still be aware that the size and composition of the real exchange rate variance can and will change as the time horizon in question changes. As each country faces different compositions with respect to their real exchange rate risk, agents must be able to compare and contrast the chart groups above in making their risk/return investment decisions for investing in countries, as well as for their final investment time horizon. The composition of the real exchange rate is an important input as to how successful in real terms a nominal exchange rate hedge will be.

One final point to note regarding the composition of the real exchange rate variance is that for the countries in chart group 2 (China, Thailand, and Korea), it is actually possible to over-hedge nominal exchange rate variance in trying to reduce real exchange rate variance. As these countries uniquely have a negative covariance term, a full spot rate hedge (i.e. reducing the component $\text{Var}(\%\Delta S_{t,t+n})$ to zero, making disappear it from the chart groups above) may cause the real exchange rate variance ($\text{Var}(\%\Delta E_{t,t+n})$) to become negative (interpreted as variance, but of movements in the opposite direction for the real exchange rate compared to the nominal spot rate). For example, with a time horizon of 1 month investing in China, whilst a full nominal spot rate hedge would be very close to eliminating the majority of real exchange rate risk (as the remaining percentages from $\text{Var}(\Pi_{t,t+n} - \Pi_{F_{t,t+n}})$ and $2\text{Cov}(\%\Delta S_{t,t+n}, \Pi_{t,t+n} - \Pi_{F_{t,t+n}})$ sum to near zero), for a time horizon of 48 months, it can be seen graphically (China’s chart, chart group 2) that this will be too large a hedge (as the remaining percentages sum to a negative number). Again this shows that agents must be fully aware of the particular characteristics of each country they choose to invest in if they intend to properly set their risk exposure to the optimal levels. And indeed, the
information presented in the chart groups above does allow awareness into each country's unique details in particular.

Finally, we can examine the unit root tests regarding the possible future behaviour of real exchange rates for each country of interest. Figure 5 below shows the real exchange rate behaviour of New Zealand with its major trading partners over the period from January 1982 to March 2005 (January 1992 is the base level, set at 100).

From figure 5, we can identify clearly that the real exchange rates of New Zealand with its trading partners all move together in a similar “wave like” fashion. Without going into why this is the case (for example, explaining how the New Zealand economy has acted over this time period), one might expect that the unit root testing would return similar results for all countries in question, as their behaviours all seem to follow the same pattern. And as expected from looking at the graph above, we find similar results from which unfortunately, there is difficulty in drawing any useful conclusions.
Table 1: Unit Root Testing

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<tr>
<th>Country</th>
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<th>Time Trend</th>
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<td>yes</td>
</tr>
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</tr>
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<td>yes (+ve)</td>
<td>no</td>
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<td>Singapore</td>
<td>yes (+ve)</td>
<td>no</td>
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</tr>
<tr>
<td>Korea</td>
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<tr>
<td>Australia</td>
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</tbody>
</table>

Table 1 above shows the descriptive results of the unit root testing. Of the 11 partner countries being tested, only Singapore was found not to have any unit roots. The remainder of the countries were deemed to be either random walks, random walks with positive drift (i.e. with an intercept), or having a unit root (random walk) as well as a number of autoregressive terms (see Appendix D). Possibly, though not necessary for the scope of this study, it may have been found that there may have been even more than one unit root for some of the series.

Yet from the real exchange rate movements from figure 5, the description of “random walk” for each individual series does not seem to intuitively hold. Whilst some of the series from figure 5 seem to fluctuate nearer to the base level of 100 (the countries without a drift term) whilst the others fluctuate at a level slightly higher than the 100 base (the countries with a positive drift term), as was identified earlier, the individual series all seem to move together in pattern. And this pattern can only be observed after looking over a 10 to the entire 13 year period. If indeed each series individually followed a random walk, then we would not expect such co-movement as we see in the data. Possibly, the unit root tests were unable to deem this 13 year trend as significant as each series in question had not continued on to show this trend for long enough. Therefore, the unit root results which we have found may have been altered by the lack of the trending data available in our regressions.

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19 For more detailed results, See Appendix D.
And another area of unease for us is that whilst each model being selected for our analysis was determined by the data as the most appropriate, a very obvious divergence in the number of significant autoregressive lags (ranging from 0 to 9) was present in the final regression models used. How this happened when the actual data the models were being produced from looked to be so similar (again, Figure 5) leaves a definite cause for concern as to whether enough data was available to produce the final models that we did.

As such, confirming the result that 10 of the 11 partner countries have non stationary exchange rates over the period January 1992 to March 2005 seems much to do with the small sample size and time frame we are dealing with rather than the long term exchange rates actually having the characteristics of true non stationary exchange rate series (though indeed, non stationary they may actually be). Having only 159 months to use as our dataset may have limited the tests to accept the null hypothesis, such that 10 of the 11 real exchange rates have at least one unit root. If there were a longer time span without structural breaks for which to test our hypothesis on, the results may have come out differently to how they have actually returned. The wave like pattern followed by all of the countries may have continued on, fluctuating around the base level of 100. Over time, this may have lead to accepting the stationarity of the real exchange rates, with the wave fluctuating around a constant mean, and having a constant variance (as expected by the economic theory of long run purchasing power parity).

So with regard to the rationale behind unit root testing in providing a mechanism to add to the predictive power of agents, it is interpreted from the results that using a small dataset such as this will provide little information as to how the real exchange rate will act in the future. The unit root testing in this report has found unit roots for 10 of the 11 countries in question, which in theory suggests there is a randomness about real exchange rates which cannot accurately be predicted. From the longer term wave like pattern which is clearly noticeable from the data however, other methods such as predicting the behaviour of the exchange rate's underlying factors (for example, the performance of the New Zealand economy), or waiting until a conclusion can be drawn about the wave like pattern of the real exchange rates, may indeed work as a method for predicting real exchange rates for the future. The
"randomness" via the unit root(s) which were found may indeed disappear if one lets the data continue on as it has. How long one has to wait for conclusions to be drawn, however, is another question.

9. Conclusion

This report is an investigation into the real exchange rate of New Zealand and its major trading partners. It was conceptualised from the idea that agents who have or intend to have an investment exposure to foreign countries should have an interest in the real exchange rate as well. Not only this, it was conceptualised on the fact that agents do have different investment needs, and also, different risk and return characteristics. As such, the purpose of this report was to give to these agents information which could apply to them, so that optimal investment choices could be made irrespective of whatever their investment needs may have initially been.

Firstly, rankings of countries in terms of their real exchange rate variances were provided. It was identified that these rankings change significantly as the defined time horizon in question changes. Taken from this was the idea that it is most important for an investor to make country to country investment decisions with a fixed time horizon in place from the onset of his decision making. In fixing his time horizon, the agent is able to use real exchange rate data which is most relevant to his decision making needs. In case an agent was unable to fix his time horizon from the onset, it was identified that if an agent attempted to remain a short term investor (less than 6 months), or attempted to remain a long term investor (24 to 48 months), then the data would remain stable enough to make a near optimal decision using any particular time horizon datasets within these bands. For an uncertain investor investing in the 6 to 24 month band however, the rankings fluctuate enough so that an optimal decision based off any particular data point in time is difficult to make.

It was also identified that the composition of the variance in the real exchange rate changes significantly between country to country, and also, from time horizon to time horizon. Whilst it was found that the real exchange rate variance for almost all of the
countries was comprised mainly of nominal exchange rate variance (a successful hedging of a majority of real exchange rate risk via nominal exchange rate hedge is therefore possible), the exact composition of the real exchange rate variance is different on a country by country basis. Agents who intend to hedge their real exchange rate risk need to care about this composition, for it is only the nominal spot rate variance for which they can easily hedge directly. If nominal spot rate risk is the major component of the real exchange rate risk, then a successful real exchange rate hedge is possible. How important hedging is to the investing agent determines how important the composition of the real exchange rate is to them.

Also of note was the fact that some countries have a positive covariance term, whilst some countries instead have a negative covariance term. Regarding successful hedging, this further emphasises the point that an agent must be particularly aware of how the composition of his particular investment country behaves. A negative covariance term implies that over hedging of the real exchange rate is possible. Agents should be aware of this before they begin making their hedging decision making.

And again, the agent must be aware of his own investment time horizon before making his decisions based on the composition of the real exchange rate. The amount of real exchange rate risk that can be hedged via a nominal means changes as the time horizon in question changes. Knowing how the composition changes over time allows an agent to make an optimal investment choice based on his own investment time horizon, or allows the agent a range of data so as to choose the optimal investment time horizon for his risk / return needs.

Finally, the real exchange rates of New Zealand and its major trading partners were examined via unit root testing. The intention was to determine how the real exchange rates had acted in the past, so as to give some possible predictive value for how they would behave in the future. The rationale behind the need for unit root testing was that agents care about their international future purchasing power. If any results could be drawn about the behaviour of the real exchange rate (e.g. whether the real exchange rate has a positive trend, or, whether it is mean reverting), they would surely be welcome by agents intending to invest for the future. Unfortunately however, little
could be drawn from the results produced from the data. Although the unit root testing suggested non stationary real exchange rate series for 10 of the 11 countries, this report is unwilling to interpret this as there being little predictive power for future real exchange rates, due to the small sample sizes at hand inherent with the limited “structural break free” time period we have.

In sum, whilst the goal of this report was to provide specific information to agents intending on investing abroad, the main conclusion drawn from the findings is that in order to use any data optimally for investment, an agent must have a clear risk and return function in mind, and also, preferably have his investment “rules” such as investment time horizon set out in place from the onset of his activities. Only this way can an agent apply the data presented in this report most effectively.
10. References


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Capital account source for identification of major investment partners, Statistics NZ Webpage:
Appendix
Appendix A

Equation 2a proof

\[ E_i = S_i \frac{P^t_i}{P^F_i} \quad E_{t+n} = S_{t+n} \frac{P^{t+n}_i}{P^{F}_{t+n}} \]

\[ \frac{E_{t+n}}{E_i} = \frac{S_{t+n} \frac{P^{t+n}_i}{P^{F}_{t+n}}}{S_i \frac{P^t_i}{P^F_i}} \]

\[ \frac{E_{t+n}}{E_i} = \frac{S_{t+n} \frac{P^{t+n}_i}{P^{F}_{t+n}} \times P^F_i}{S_i \frac{P^t_i}{P^F_i} \times P^F_i} \]

\[ \ln \frac{E_{t+n}}{E_i} = \ln \left[ \frac{S_{t+n} \frac{P^{t+n}_i}{P^{F}_{t+n}} \times P^F_i}{S_i \frac{P^t_i}{P^F_i} \times P^F_i} \right] \]

\[ \ln \left( \frac{E_{t+n}}{E_i} \right) = \ln \left( \frac{S_{t+n}}{S_i} \right) + \ln \left( \frac{P^{t+n}_i}{P^t_i} \right) + \ln \left( \frac{P^F_i}{P^{F}_{t+n}} \right) \]

\[ \ln \left( \frac{E_{t+n}}{E_i} \right) = \ln \left( \frac{S_{t+n}}{S_i} \right) + \ln \left( \frac{P^{t+n}_i}{P^t_i} \right) - \ln \left( \frac{P^{F}_{t+n}}{P^F_i} \right) \]

\[ \ln \left( \frac{P^{t+n}_i}{P^t_i} \right) \approx \text{home inflation rate from } t \text{ to } t + n, \quad \Pi_{t,t+n} \]

\[ \ln \left( \frac{P^{F}_{t+n}}{P^F_i} \right) \approx \text{foreign inflation rate from } t \text{ to } t + n, \quad \Pi^{(F)}_{t,t+n} \]

\[ \ln \left( \frac{E_{t+n}}{E_i} \right) = \ln \left( \frac{S_{t+n}}{S_i} \right) + (\Pi_{t,t+n} - \Pi^{(F)}_{t,t+n}) \]  \hspace{1cm} (Equation 2a)

Q.E.D
### Appendix B

Comparison between interpolated (monthly) / non interpolated (quarterly) results

#### TABLE 2: VARIANCE OF % CHANGE IN REAL EXCHANGE RATE (MONTHLY)

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<th>Horizon</th>
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#### TABLE 3: VARIANCE OF % CHANGE IN REAL EXCHANGE RATE (QUARTERLY)

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### TABLE 4: COVARIANCE OF SPOT AND INFLATION DIFFERENTIAL (MONTHLY)

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### TABLE 5: COVARIANCE OF SPOT AND INFLATION DIFFERENTIAL (QUARTERLY)

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<td>0.00003</td>
<td>0.00004</td>
<td>0.00005</td>
<td>0.00010</td>
<td>0.00009</td>
</tr>
<tr>
<td>THAILAND</td>
<td>-0.00006</td>
<td>-0.00008</td>
<td>-0.00011</td>
<td>-0.00010</td>
<td>-0.00013</td>
</tr>
<tr>
<td>Horizon</td>
<td>3</td>
<td>6</td>
<td>12</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>CHINA</td>
<td>0.00018</td>
<td>0.00029</td>
<td>0.00054</td>
<td>0.00116</td>
<td>0.00164</td>
</tr>
<tr>
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<td>0.00004</td>
<td>0.00004</td>
<td>0.00003</td>
<td>0.00004</td>
<td>0.00004</td>
</tr>
<tr>
<td>TAIWAN</td>
<td>0.00005</td>
<td>0.00003</td>
<td>0.00003</td>
<td>0.00004</td>
<td>0.00005</td>
</tr>
<tr>
<td>MALAYSIA</td>
<td>0.00002</td>
<td>0.00002</td>
<td>0.00003</td>
<td>0.00004</td>
<td>0.00005</td>
</tr>
<tr>
<td>SINGAPORE</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.00002</td>
<td>0.00002</td>
<td>0.00002</td>
</tr>
<tr>
<td>CANADA</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.00001</td>
</tr>
<tr>
<td>US</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.00001</td>
</tr>
<tr>
<td>UK</td>
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<td>0.00001</td>
<td>0.00001</td>
<td>0.00001</td>
</tr>
<tr>
<td>AUSTRALIA</td>
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<td>0.00001</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.00001</td>
</tr>
<tr>
<td>JAPAN</td>
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<td>0.00002</td>
<td>0.00002</td>
<td>0.00002</td>
<td>0.00002</td>
</tr>
<tr>
<td>THAILAND</td>
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<td>0.00004</td>
<td>0.00006</td>
<td>0.00010</td>
<td>0.00016</td>
</tr>
</tbody>
</table>

Table 6: Variance of Inflation Differential (Monthly)

<table>
<thead>
<tr>
<th>Horizon</th>
<th>3</th>
<th>6</th>
<th>12</th>
<th>24</th>
<th>48</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHINA</td>
<td>0.00017</td>
<td>0.00027</td>
<td>0.00054</td>
<td>0.00116</td>
<td>0.00161</td>
</tr>
<tr>
<td>KOREA</td>
<td>0.00005</td>
<td>0.00003</td>
<td>0.00003</td>
<td>0.00004</td>
<td>0.00004</td>
</tr>
<tr>
<td>TAIWAN</td>
<td>0.00006</td>
<td>0.00005</td>
<td>0.00003</td>
<td>0.00004</td>
<td>0.00005</td>
</tr>
<tr>
<td>MALAYSIA</td>
<td>0.00002</td>
<td>0.00003</td>
<td>0.00003</td>
<td>0.00004</td>
<td>0.00005</td>
</tr>
<tr>
<td>SINGAPORE</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.00002</td>
<td>0.00002</td>
<td>0.00002</td>
</tr>
<tr>
<td>CANADA</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.00001</td>
</tr>
<tr>
<td>US</td>
<td>0.00002</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.00001</td>
</tr>
<tr>
<td>UK</td>
<td>0.00002</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.00001</td>
<td>0.00001</td>
</tr>
<tr>
<td>AUSTRALIA</td>
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<td>0.00001</td>
<td>0.00001</td>
<td>0.00001</td>
</tr>
<tr>
<td>JAPAN</td>
<td>0.00001</td>
<td>0.00002</td>
<td>0.00002</td>
<td>0.00003</td>
<td>0.00002</td>
</tr>
<tr>
<td>THAILAND</td>
<td>0.00004</td>
<td>0.00005</td>
<td>0.00006</td>
<td>0.00010</td>
<td>0.00017</td>
</tr>
</tbody>
</table>

Table 7: Variance of Inflation Differential (Quarterly)
<table>
<thead>
<tr>
<th></th>
<th>Horizon</th>
<th>3</th>
<th>6</th>
<th>12</th>
<th>24</th>
<th>48</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHINA</strong></td>
<td></td>
<td>0.00278</td>
<td>0.00296</td>
<td>0.00383</td>
<td>0.00538</td>
<td>0.00465</td>
</tr>
<tr>
<td><strong>KOREA</strong></td>
<td></td>
<td>0.00310</td>
<td>0.00249</td>
<td>0.00173</td>
<td>0.00197</td>
<td>0.00182</td>
</tr>
<tr>
<td><strong>TAIWAN</strong></td>
<td></td>
<td>0.00083</td>
<td>0.00079</td>
<td>0.00109</td>
<td>0.00183</td>
<td>0.00176</td>
</tr>
<tr>
<td><strong>MALAYSIA</strong></td>
<td></td>
<td>0.00130</td>
<td>0.00130</td>
<td>0.00130</td>
<td>0.00179</td>
<td>0.00117</td>
</tr>
<tr>
<td><strong>SINGAPORE</strong></td>
<td></td>
<td>0.00065</td>
<td>0.00065</td>
<td>0.00079</td>
<td>0.00126</td>
<td>0.00096</td>
</tr>
<tr>
<td><strong>CANADA</strong></td>
<td></td>
<td>0.00067</td>
<td>0.00072</td>
<td>0.00095</td>
<td>0.00143</td>
<td>0.00141</td>
</tr>
<tr>
<td><strong>US</strong></td>
<td></td>
<td>0.00082</td>
<td>0.00099</td>
<td>0.00140</td>
<td>0.00228</td>
<td>0.00189</td>
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<tr>
<td><strong>UK</strong></td>
<td></td>
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<td>0.00090</td>
<td>0.00098</td>
<td>0.00126</td>
<td>0.00130</td>
</tr>
<tr>
<td><strong>AUSTRALIA</strong></td>
<td></td>
<td>0.00032</td>
<td>0.00030</td>
<td>0.00027</td>
<td>0.00025</td>
<td>0.00026</td>
</tr>
<tr>
<td><strong>JAPAN</strong></td>
<td></td>
<td>0.00129</td>
<td>0.00133</td>
<td>0.00150</td>
<td>0.00216</td>
<td>0.00175</td>
</tr>
<tr>
<td><strong>THAILAND</strong></td>
<td></td>
<td>0.00171</td>
<td>0.00199</td>
<td>0.00158</td>
<td>0.00144</td>
<td>0.00130</td>
</tr>
</tbody>
</table>

| **CHINA**          |         | 0.00303 | 0.00323 | 0.00391 | 0.00540 | 0.00477 |
| **KOREA**          |         | 0.00197 | 0.00232 | 0.00172 | 0.00199 | 0.00180 |
| **TAIWAN**         |         | 0.00083 | 0.00085 | 0.00109 | 0.00186 | 0.00190 |
| **MALAYSIA**       |         | 0.00109 | 0.00114 | 0.00112 | 0.00170 | 0.00123 |
| **SINGAPORE**      |         | 0.00062 | 0.00067 | 0.00078 | 0.00129 | 0.00108 |
| **CANADA**         |         | 0.00068 | 0.00073 | 0.00092 | 0.00140 | 0.00146 |
| **US**             |         | 0.00077 | 0.00100 | 0.00142 | 0.00230 | 0.00202 |
| **UK**             |         | 0.00083 | 0.00097 | 0.00100 | 0.00126 | 0.00130 |
| **AUSTRALIA**      |         | 0.00034 | 0.00033 | 0.00029 | 0.00024 | 0.00026 |
| **JAPAN**          |         | 0.00115 | 0.00128 | 0.00150 | 0.00218 | 0.00183 |
| **THAILAND**       |         | 0.00143 | 0.00170 | 0.00143 | 0.00134 | 0.00127 |
Appendix C

How to read the chart group graphs

The 100% stacked column chart takes the absolute value of the components in question, i.e. $\text{Var}(\% \Delta S_{t,t+n})$, $\text{Var}(\Pi_{t,n} - \Pi^f_{t,n})$, and $2 * \text{Cov}(\% \Delta S_{t,t+n}, \Pi_{t,n} - \Pi^f_{t,n})$, and sums them to a value which is equal to 100%.

If all the components are positive, then the resulting chart is simple to read.

<table>
<thead>
<tr>
<th>Table 10: Fruit Basket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apples</td>
</tr>
<tr>
<td>Oranges</td>
</tr>
<tr>
<td>Total # fruit</td>
</tr>
</tbody>
</table>

**Figure 6**

Example 1

In the case of example 1 above (Table 10 and Figure 6), the sum of the absolute value of all the components of the fruit basket (i.e. Apples and Oranges) is equal to 100%, i.e. $50 + 50 = 100 = 100%$. From the chart, we can see that apples make up 50% of 100, and Oranges make up 50% of 100.

When a negative number is introduced into the components, the chart can be used to identify the value of the components in question (e.g. the number of red apples in a
basket, and the number of apples eaten out of the basket), and also the sum of the individual components (i.e. the number of apples left in the basket after eating).

### Table 11: Fruit Basket

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Red apples</td>
<td>100</td>
</tr>
<tr>
<td>Eaten apples</td>
<td>-100</td>
</tr>
<tr>
<td>Total # Apples</td>
<td>0</td>
</tr>
</tbody>
</table>

**Figure 7**

In example 2 above (Table 11 and Figure 7), the sum of the absolute value of all the components of the fruit basket (i.e. apples and eaten apples) is equal to 100%, i.e. $100 + 100 = 200 = 100\%$. We can see from the chart that apples make up 50% of the total absolute value, i.e. 50% of 200 = 100. We can also see from the above chart that eaten apples is represented by a value of -50%, i.e. a negative percentage. This value is interpreted as being 50% of the sum of the absolute values, i.e. 50% of 200, but negative, i.e. $-(50\% \text{ of } 200) = -100$

The sum of the fruit basket is equal to a sum of the percentages in the graph above, multiplied by the sum of the absolute values, i.e. $[(50\% + -50\%) \times 200] = 0 \times 200 = 0$.

A final more complex example, example 3 is given below (Table 12 and Figure 8).
Table 12: Fruit Basket

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Red apples</td>
<td>50</td>
</tr>
<tr>
<td>Green apples</td>
<td>50</td>
</tr>
<tr>
<td>Eaten apples</td>
<td>-50</td>
</tr>
<tr>
<td>Total # apples</td>
<td>50</td>
</tr>
</tbody>
</table>

The sum of the absolute value of the components in example 3 is \( = 50 + 50 + 50 = 150 \). From figure 20 above, the number of red apples = 33.3\% \times 150 = 50. The number of green apples = 33.3\% \times 150 = 50. As for the number of eaten apples, this value is interpreted as \(-(33.3 \times 150) = -(50) = -50\).

The total number of fruit left in the fruit basket is equal to a sum of the percentages in the graph above, multiplied by the sum of the absolute values, i.e. \([(33.3\% + 33.3\% + (-33.3\%) \times 150] = 33.3\% \times 150 = 50\).

Following these steps should enable one to interpret the graphs in chart group 1a, 1b, and 2, for which analogously, the number of fruit in the basket is equal to the variance of the \% change in the real exchange rate, i.e. \( \text{Var}(\%\Delta E_{t+t^1}) \).
Appendix D

Unit Root Test Results for SAS code part 2. For reasons of space, only each country’s most valid model is presented below. The Code used to produce these results are shown in Appendix E.

China

| Variable  | Parameter Estimate | Standard Error | t Value | Pr > |t| |
|-----------|--------------------|----------------|---------|------|---|
| RERCHNL1  | -0.00317           | 0.00343        | -0.93   | 0.3555 |

Korea

| Variable  | Parameter Estimate | Standard Error | t Value | Pr > |t| |
|-----------|--------------------|----------------|---------|------|---|
| RERKOREL1| -0.00373           | 0.00405        | -0.92   | 0.3583 |
| ARKORE2   | 0.12135            | 0.08303        | 1.46    | 0.1461 |
| ARKORE3   | 0.02147            | 0.08198        | 0.26    | 0.7938 |
| ARKORE4   | -0.23783           | 0.08184        | -2.91   | 0.0043 |
| ARKORE5   | -0.07189           | 0.08417        | -0.85   | 0.3943 |
| ARKORE6   | -0.04942           | 0.08410        | -0.59   | 0.5577 |
| ARKORE7   | -0.04512           | 0.08183        | -0.55   | 0.5822 |
| ARKORE8   | -0.20000           | 0.08186        | -2.44   | 0.0158 |
| ARKORE9   | 0.14882            | 0.08293        | 1.79    | 0.0749 |

Taiwan

| Parameter Estimates | Parameter Estimate | Standard Error | t Value | Pr > |t| |
|---------------------|--------------------|----------------|---------|------|---|
| Intercept           | 0.46272            | 0.21811        | 2.12    | 0.0355 |
| RERTAIWL1           | -0.03283           | 0.01349        | -2.43   | 0.0161 |
| ARTAIW2             | 0.13092            | 0.07906        | 1.76    | 0.0809 |
| ARTAIW3             | -0.14819           | 0.07905        | -1.87   | 0.0627 |
### Malaysia

| Variable    | DF | Parameter Estimate | Standard Error | t Value | Pr > |t| |
|-------------|----|--------------------|----------------|---------|------|---|
| Intercept   | 1  | 0.07041            | 0.02723        | 2.59    | 0.0106 |
| RERMALAL1   | 1  | -0.04737           | 0.01655        | -2.86   | 0.0048 |

### Singapore

| Variable    | DF | Parameter Estimate | Standard Error | t Value | Pr > |t| |
|-------------|----|--------------------|----------------|---------|------|---|
| Intercept   | 1  | 0.04042            | 0.01393        | 2.90    | 0.0043 |
| RERSINGL1   | 1  | -0.04668           | 0.01494        | -3.12   | 0.0021 |
| ARSING2     | 1  | 0.10330            | 0.07791        | 1.33    | 0.1869 |
| ARSING3     | 1  | -0.15153           | 0.07802        | -1.94   | 0.0540 |

### Canada

| Variable    | DF | Parameter Estimate | Standard Error | t Value | Pr > |t| |
|-------------|----|--------------------|----------------|---------|------|---|
| RERCANAL1   | 1  | -0.00197           | 0.00230        | -0.93   | 0.3513 |
| ARCANA2     | 1  | -0.00578           | 0.08006        | -0.07   | 0.9426 |
| ARCANA3     | 1  | -0.06550           | 0.07988        | -0.82   | 0.4136 |
| ARCANA4     | 1  | 0.10418            | 0.07989        | 2.05    | 0.0416 |

### US

| Variable    | DF | Parameter Estimate | Standard Error | t Value | Pr > |t| |
|-------------|----|--------------------|----------------|---------|------|---|
| RERUSL1     | 1  | -0.00133           | 0.00170        | -0.78   | 0.4378 |
| ARUS2       | 1  | 0.19069            | 0.07550        | 4.38    | <.0001 |
### UK

#### Parameter Estimates

| Variable  | DF | Parameter Estimate | Standard Error | t Value | Pr > |t| |
|-----------|----|--------------------|----------------|---------|------|---|
| RERUKL1   | 1  | -0.00091356        | 0.00197        | -0.46   | 0.6430 |
| ARUK2     | 1  | 0.24575            | 0.08073        | 3.04    | 0.0028 |
| ARUK3     | 1  | -0.15393           | 0.08260        | -1.86   | 0.0643 |
| ARUK4     | 1  | 0.12385            | 0.08136        | 1.52    | 0.1301 |

### Australia

#### Parameter Estimates

| Variable  | DF | Parameter Estimate | Standard Error | t Value | Pr > |t| |
|-----------|----|--------------------|----------------|---------|------|---|
| RERAUSTL1 | 1  | -0.00099391        | 0.00119        | -0.83   | 0.4055 |
| ARAUST2   | 1  | 0.38950            | 0.07891        | 4.94    | <.0001 |
| ARAUST3   | 1  | -0.25931           | 0.08343        | -3.11   | 0.0023 |
| ARAUST4   | 1  | 0.17898            | 0.08349        | 2.14    | 0.0337 |
| ARAUST5   | 1  | -0.22799           | 0.07864        | -2.90   | 0.0043 |

### Japan

#### Parameter Estimates

| Variable  | DF | Parameter Estimate | Standard Error | t Value | Pr > |t| |
|-----------|----|--------------------|----------------|---------|------|---|
| Intercept | 1  | 2.00749            | 0.93667        | 2.14    | 0.0337 |
| RERJAPAL1 | 1  | -0.03011           | 0.01316        | -2.29   | 0.0235 |
| ARJAPA2   | 1  | 0.36150            | 0.07368        | 4.91    | <.0001 |

### Thailand

#### Parameter Estimates

| Variable  | DF | Parameter Estimate | Standard Error | t Value | Pr > |t| |
|-----------|----|--------------------|----------------|---------|------|---|
| Intercept | 1  | 0.74713            | 0.34903        | 2.14    | 0.0340 |
| RERTHAIL1 | 1  | -0.05272           | 0.02240        | -2.35   | 0.0200 |
| ARTHAI2   | 1  | -0.23789           | 0.08096        | -3.18   | 0.0018 |
| ARTHAI3   | 1  | -0.25263           | 0.08324        | -3.04   | 0.0029 |
| ARTHAI4   | 1  | 0.13405            | 0.08539        | 1.57    | 0.1187 |
| ARTHAI5   | 1  | -0.07844           | 0.08484        | -0.92   | 0.3568 |
| ARTHAI6   | 1  | 0.06827            | 0.08440        | 0.81    | 0.4199 |
| ARTHAI7   | 1  | -0.04056           | 0.08176        | -0.50   | 0.6206 |
| ARTHAI8   | 1  | -0.17986           | 0.07966        | -2.26   | 0.0255 |

### Appendix E

**SAS CODE (PART 1)**

*Identifying the optimal number of lags*

```sas
proc import out=work.realER
datafile="S:XXXXXXXrealER.xls"
dbms=excel replace;
```

43
getnames=yes;
run;

proc Arima data=dat1;
Identify var=RERCHIN stationarity =
(adf=(0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20));
estimate p=1;
estimate p=2;
estimate p=3;
estimate p=4;
estimate p=5;
estimate p=6;
estimate p=7;
estimate p=8;
estimate p=9;
estimate p=10;
estimate p=11;
estimate p=12;
estimate p=13;
estimate p=14;
estimate p=15;
estimate p=16;
estimate p=17;
estimate p=18;
estimate p=19;
estimate p=20;
run;

proc Arima data=dat2;
Identify var=RERKORE stationarity =
(adf=(0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20));
estimate p=1;
estimate p=2;
estimate p=3;
estimate p=4;
estimate p=5;
estimate p=6;
estimate p=7;
estimate p=8;
estimate p=9;
estimate p=10;
estimate p=11;
estimate p=12;
estimate p=13;
estimate p=14;
estimate p=15;
estimate p=16;
estimate p=17;
estimate p=18;
estimate p=19;
estimate p=20;
run;

proc Arima data=dat3;
Identify var=RERTAIW stationarity =
(adf=(0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20));
estimate p=1;
estimate p=2;
estimate p=3;
estimate p=4;
estimate p=5;
estimate p=6;
estimate p=7;
estimate p=8;
estimate p=9;
estimate p=10;
estimate p=11;
estimate p=12;
estimate p=13;
estimate p=14;
estimate p=15;
estimate p=16;
estimate p=17;
estimate p=18;
estimate p=19;
estimate p=20;
run;

proc Arima data=dat4;
Identify var=RERMALA stationarity =
(adf=(0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20));
estimate p=1;
estimate p=2;
estimate p=3;
estimate p=4;
estimate p=5;
estimate p=6;
estimate p=7;
estimate p=8;
estimate p=9;
estimate p=10;
estimate p=11;
estimate p=12;
estimate p=13;
estimate p=14;
estimate p=15;
estimate p=16;
estimate p=17;
estimate p=18;
estimate p=19;
estimate p=20;
run;

proc Arima data=dat5;
Identify var=RERSING stationarity =
(adf=(0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20));
estimate p=1;
estimate p=2;
estimate p=3;
estimate p=4;
estimate p=5;
estimate p=6;
estimate p=7;
estimate p=8;
estimate p=9;
estimate p=10;
estimate p=11;
estimate p=12;
estimate p=13;
estimate p=14;
estimate p=15;
estimate p=16;
estimate p=17;
estimate p=18;
estimate p=19;
estimate p=20;
run;
estimate p=17;
estimate p=18;
estimate p=19;
estimate p=20;
run;
proc Arima data=dat6;
identify var=RERCANA stationarity =
(adf=(0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20));
estimate p=1;
estimate p=2;
estimate p=3;
estimate p=4;
estimate p=5;
estimate p=6;
estimate p=7;
estimate p=8;
estimate p=9;
estimate p=10;
estimate p=11;
estimate p=12;
estimate p=13;
estimate p=14;
estimate p=15;
estimate p=16;
estimate p=17;
estimate p=18;
estimate p=19;
estimate p=20;
run;

proc Arima data=dat7;
identify var=RERUS stationarity =
(adf=(0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20));
estimate p=1;
estimate p=2;
estimate p=3;
estimate p=4;
estimate p=5;
estimate p=6;
estimate p=7;
estimate p=8;
estimate p=9;
estimate p=10;
estimate p=11;
estimate p=12;
estimate p=13;
estimate p=14;
estimate p=15;
estimate p=16;
estimate p=17;
estimate p=18;
estimate p=19;
estimate p=20;
run;

proc Arima data=dat8;
identify var=RERUK stationarity =
(adf=(0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20));
estimate p=1;
estimate p=2;
estimate p=3;
estimate p=4;
estimate p=5;
estimate p=6;
estimate p=7;
estimate p=8;
estimate p=9;
estimate p=10;
estimate p=11;
estimate p=12;
estimate p=13;
estimate p=14;
estimate p=15;
estimate p=16;
estimate p=17;
estimate p=18;
estimate p=19;
estimate p=20;
run;

proc Arima data=dat9;
Identify var=RERAUST stationarity =
(adf=(0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20));
estimate p=1;
estimate p=2;
estimate p=3;
estimate p=4;
estimate p=5;
estimate p=6;
estimate p=7;
estimate p=8;
estimate p=9;
estimate p=10;
estimate p=11;
estimate p=12;
estimate p=13;
estimate p=14;
estimate p=15;
estimate p=16;
estimate p=17;
estimate p=18;
estimate p=19;
estimate p=20;
run;

proc Arima data=dat10;
Identify var=RERJAPA stationarity =
(adf=(0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20));
estimate p=1;
estimate p=2;
estimate p=3;
estimate p=4;
estimate p=5;
estimate p=6;
estimate p=7;
estimate p=8;
estimate p=9;
estimate p=10;
estimate p=11;
estimate p=12;
estimate p=13;
estimate p=14;
estimate p=15;  
estimate p=16;  
estimate p=17;  
estimate p=18;  
estimate p=19;  
estimate p=20;  
run;

proc Arima data=datll;  
Identify var=RERTHAI stationarity =  
{adf=(0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20)};  
estimate p=1;  
estimate p=2;  
estimate p=3;  
estimate p=4;  
estimate p=5;  
estimate p=6;  
estimate p=7;  
estimate p=8;  
estimate p=9;  
estimate p=10;  
estimate p=11;  
estimate p=12;  
estimate p=13;  
estimate p=14;  
estimate p=15;  
estimate p=16;  
estimate p=17;  
estimate p=18;  
estimate p=19;  
estimate p=20;  
run;

SAS CODE (PART 2)

Unit Root Testing

proc import out=work.datl  
datafile="E:\realR.xls"  
dbms=excel2000 replace;  
getnames=yes;  
run;

data datl;  
set RERCHINL1=lag1(RERCHIN);  
de1RERCHIN=RERCHIN-RERCHINL1;  
Run;

proc reg data=datl;  
model de1RERCHIN=RERCHINL1 /noint;  
output out=outl p=yhatl r=residl;  
run;

proc gplot data=outl;  
plot residl*yhatl;  
symbol v=circle h=0.1;  
run;
proc reg data=datl;
model delRERCHIN=RERCHINL1;
output out=out2 p=yhat2 r=resid2;
run;

proc gplot data=out2;
plot resid2*yhat2;
symbol v=circle h=0.1;
run;

proc reg data=datl;
model delRERCHIN= Time RERCHINL1;
output out=out3 p=yhat3 r=resid3;
run;

proc gplot data=out3;
plot resid3*yhat3;
symbol v=circle h=0.1;
run;

data datl;
set;
RERKORELl=lag1(RERKORE);
delRERKORE=RERKORE-RERKORELl;
ARKORE2=lag1(delRERKORE);
ARKORE3=lag2(delRERKORE);
ARKORE4=lag3(delRERKORE);
ARKORE5=lag4(delRERKORE);
ARKORE6=lag5(delRERKORE);
ARKORE7=lag6(delRERKORE);
ARKORE8=lag7(delRERKORE);
ARKORE9=lag8(delRERKORE);
run;

proc reg data=datl;
model delRERKORE=RERKOREL1 ARKORE2 ARKORE3 ARKORE4 ARKORE5 ARKORE6 ARKORE7 ARKORE8 ARKORE9 /noint;
output out=out4 p=yhat4 r=resid4;
run;

proc gplot data=out4;
plot resid4*yhat4;
symbol v=circle h=0.1;
run;

proc reg data=datl;
model delRERKORE=RERKOREL1 ARKORE2 ARKORE3 ARKORE4 ARKORE5 ARKORE6 ARKORE7 ARKORE8 ARKORE9;
output out=out5 p=yhat5 r=resid5;
run;

proc gplot data=out5;
plot resid5*yhat5;
symbol v=circle h=0.1;
run;

proc reg data=datl;
model delRERKORE= Time RERKOREL1 ARKORE2 ARKORE3 ARKORE4 ARKORE5 ARKORE6 ARKORE7 ARKORE8 ARKORE9;
output out=out6 p=yhat6 r=resid6;
run;

proc gplot data=out6;
plot resid6*yhat6;
symbol v=circle h=0.1;
run;

data datl;
set;
RERTAIWL1=lag1(RERTAIW);
delRERTAIW=RERTAIW-RERTAIWL1;
ARTAIW2=lag1(delRERTAIW);
ARTAIW3=lag2(delRERTAIW);
run;

proc reg data=datl;
model delRERTAIW=RERTAIWL1 ARTAIW2 ARTAIW3 /noint;
output out=out7 p=yhat7 r=resid7;
run;

proc gplot data=out7;
plot resid7*yhat7;
symbol v=circle h=0.1;
run;

proc reg data=datl;
model delRERTAIW=RERTAIWL1 ARTAIW2 ARTAIW3;
output out=out8 p=yhat8 r=resid8;
run;

proc gplot data=out8;
plot resid8*yhat8;
symbol v=circle h=0.1;
run;

proc reg data=datl;
model delRERTAIW=Time RERTAIWL1 ARTAIW2 ARTAIW3;
output out=out9 p=yhat9 r=resid9;
run;

proc gplot data=out9;
plot resid9*yhat9;
symbol v=circle h=0.1;
run;

data datl;
set;
RERMALAL1=lag1(RERMALA);
delRERMALA=RERMALA-RERMALAL1;
run;

proc reg data=datl;
model delRERMALA=RERMALAL1 /noint;
output out=out10 p=yhat10 r=resid10;
run;

proc gplot data=out10;
plot resid10*yhat10;
symbol v=circle h=0.1;
run;

proc reg data=dat1;
model delRERMAL=RERMALAL1;
output out=out11 p=yhat11 r=resid11;
run;

proc gplot data=out11;
plot resid11*yhat11;
symbol v=circle h=0.1;
run;

proc reg data=dat1;
model delRERMAL=Time RERMALAL1;
output out=out12 p=yhat12 r=resid12;
run;

proc gplot data=out12;
plot resid12*yhat12;
symbol v=circle h=0.1;
run;

data dat1;
set;
RERSINGL1=lag1(RERSING);
delRERSING=RERSING-RERSINGL1;
ARSING2=lag1(delRERSING);
ARSING3=lag2(delRERSING);
run;

proc reg data=dat1;
model delRERSING=RERSINGL1 ARSING2 ARSING3 /noint;
output out=out13 p=yhat13 r=resid13;
run;

proc gplot data=out13;
plot resid13*yhat13;
symbol v=circle h=0.1;
run;

proc reg data=dat1;
model delRERSING=RERSINGL1 ARSING2 ARSING3;
output out=out14 p=yhat14 r=resid14;
run;

proc gplot data=out14;
plot resid14*yhat14;
symbol v=circle h=0.1;
run;

proc reg data=dat1;
model delRERSING= Time RERSINGL1 ARSING2 ARSING3;
output out=out15 p=yhat15 r=resid15;
run;

proc gplot data=out15;
plot resid15*yhat15;
symbol v=circle h=0.1;
run;

data dat1;
set;
RERCANAL1=lag1(RERCANA);
delRERCANA=RERCANA-RERCANAL1;
ARCANA2=lag1(delRERCANA);
ARCANA3=lag2(delRERCANA);
ARCANA4=lag3(delRERCANA); 
run;

proc reg data=dat1;
model delRERCANA=RERCANAL1 ARCANA2 ARCANA3 ARCANA4 /noint;
output out=out16 p=yhat16 r=resid16;
run;

proc gplot data=out16;
plot resid16*yhat16;
symbol v=circle h=0.1;
run;

proc reg data=dat1;
model delRERCANA=RERCANAL1 ARCANA2 ARCANA3 ARCANA4;
output out=out17 p=yhat17 r=resid17;
run;

proc gplot data=out17;
plot resid17*yhat17;
symbol v=circle h=0.1;
run;

proc reg data=dat1;
model delRERCANA= Time RERCANAL1 ARCANA2 ARCANA3 ARCANA4;
output out=out18 p=yhat18 r=resid18;
run;

proc gplot data=out18;
plot resid18*yhat18;
symbol v=circle h=0.1;
run;

data dat1;
set;
RERUSL1=lag1(RERUS);
delRERUS=RERUS-RERUSL1;
ARUS2=lag1(delRERUS);
run;

proc reg data=dat1;
model delRERUS=RERUSL1 ARUS2 /noint;
output out=out19 p=yhat19 r=resid19;
run;

proc gplot data=out19;
plot resid19*yhat19;
symbol v=circle h=0.1;
run;

proc reg data=dat1;
model delRERUS=RERUSL1 ARUS2;
output out=out20 p=yhat20 r=resid20;
run;

proc gplot data=out20;
plot resid20*yhat20;
symbol v=circle h=0.1;
run;

proc reg data=datl;
model de1RERUS= Time RERUSL1 ARUS2;
output out=out21 p=yhat21 r=resid21;
run;

proc gplot data=out21;
plot resid21*yhat21;
symbol v=circle h=0.1;
run;

data datl;
set;
RERUKL1=lag1(RERUK);
delRERUK=RERUK-RERUKL1;
ARUK2=lag1(delRERUK);
ARUK3=lag2(delRERUK);
ARUK4=lag3(delRERUK);
run;

proc reg data=datl;
model delRERUK=RERUKL1 ARUK2 ARUK3 ARUK4 /noint;
output out=out22 p=yhat22 r=resid22;
run;

proc gplot data=out22;
plot resid22*yhat22;
symbol v=circle h=0.1;
run;

proc reg data=datl;
model delRERUK=RERUKL1 ARUK2 ARUK3 ARUK4;
output out=out23 p=yhat23 r=resid23;
run;

proc gplot data=out23;
plot resid23*yhat23;
symbol v=circle h=0.1;
run;

proc reg data=datl;
model delRERUK= Time RERUKL1 ARUK2 ARUK3 ARUK4;
output out=out24 p=yhat24 r=resid24;
run;

proc gplot data=out24;
plot resid24*yhat24;
symbol v=circle h=0.1;
run;

data datl;
set;
RERAUSTL1=lag1(RERAUST);
delRERAUST=RERAUST-RERAUSTL1;
ARAUSTR2=lag1(delRERAUST);

ARAUST3=lag2(delRERAUST);
ARAUST4=lag3(delRERAUST);
ARAUST5=lag4(delRERAUST);
run;

proc reg data=datl;
model delRERAUST=RERAUSTL1 ARAUST2 ARAUST3 ARAUST4 ARAUST5 /noiht;
output out=out25 p=yhat25 r=resid25;
run;
proc gplot data=out25;
plot resid25*yhat25;
symbol v=circle h=0.1;
run;
proc reg data=datl;
model delRERAUST=RERAUSTL1 ARAUST2 ARAUST3 ARAUST4 ARAUST5;
output out=out26 p=yhat26 r=resid26;
run;
proc gplot data=out26;
plot resid26*yhat26;
symbol v=circle h=0.1;
run;
proc reg data=datl;
model delRERAUST= Time RERAUSTL1 ARAUST2 ARAUST3 ARAUST4 ARAUST5;
output out=out27 p=yhat27 r=resid27;
run;
proc gplot data=out27;
plot resid27*yhat27;
symbol v=circle h=0.1;
run;
data datl;
set;
RERJAPAL1=lag1(RERJAPA);
delRERJAPA=RERJAPA-RERJAPAL1;
ARJAPA2=lag1(delRERJAPA);
run;
proc reg data=datl;
model delRERJAPA= RERJAPAL1 ARJAPA2 /noiht;
output out=out28 p=yhat28 r=resid28;
run;
proc gplot data=out28;
plot resid28*yhat28;
symbol v=circle h=0.1;
run;
proc reg data=datl;
model delRERJAPA= RERJAPAL1 ARJAPA2;
output out=out29 p=yhat29 r=resid29;
run;
proc gplot data=out29;
plot resid29*yhat29;
symbol v=circle h=0.1;
run;

proc reg data=dat1;
model delRERJAPA= Time RERJAPAL1 ARJAPA2;
output out=out30 p=yhat30 r=resid30;
run;

proc gplot data=out30;
plot resid30*yhat30;
symbol v=circle h=0.1;
run;

data dat1;
set;
RERTHAIL1=lag1(RERTHAI);
delRERTHAI=RERTHAI-RERTHAIL1;
ARTHAI2=lag2(delRERTHAI);
ARTHAI3=lag3(delRERTHAI);
ARTHAI4=lag4(delRERTHAI);
ARTHAI5=lag5(delRERTHAI);
ARTHAI7=lag6(delRERTHAI);
ARTHAI8=lag7(delRERTHAI);
run;

proc reg data=dat1;
model delRERTHAI=RERTHAIL1 ARTHAI2 ARTHAI3 ARTHAI4 ARTHAI5 ARTHAI6 ARTHAI7 ARTHAI8 /noint;
output out=out31 p=yhat31 r=resid31;
run;

proc gplot data=out31;
plot resid31*yhat31;
symbol v=circle h=0.1;
run;

proc reg data=dat1;
model delRERTHAI=RERTHAIL1 ARTHAI2 ARTHAI3 ARTHAI4 ARTHAI5 ARTHAI6 ARTHAI7 ARTHAI8;
output out=out32 p=yhat32 r=resid32;
run;

proc gplot data=out32;
plot resid32*yhat32;
symbol v=circle h=0.1;
run;

proc reg data=dat1;
model delRERTHAI= Time RERTHAIL1 ARTHAI2 ARTHAI3 ARTHAI4 ARTHAI5 ARTHAI6 ARTHAI7 ARTHAI8;
output out=out33 p=yhat33 r=resid33;
run;

proc gplot data=out33;
plot resid33*yhat33;
symbol v=circle h=0.1;
run;