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## COINTEGRATION ANALYSIS OF PURCHASING POWER PARITY IN A SMALL COUNTRY CONTEXT

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# Cointegration Analysis of Purchasing Power Parity in a Small Country Context

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## ABSTRACT

We present an empirical analysis of a long run Purchasing Power Parity (PPP) for thirteen Asia-Pacific countries using cointegration techniques. Unlike standard unit root hypothesis tests, we specify the null as stationarity and the alternative as a unit root, as introduced by Kwiatkowski *et al* (1992). We find evidence in favour of a PPP relationship between the Solomon Islands and the US. Despite evidence of a cointegration relationship for a few other countries, the significance of the time trend variable violating a second necessary condition clearly rejects the absolute PPP claim, though there is some evidence of relative PPP. There is no evidence of a trans-Tasman PPP.

Keywords: Purchasing power parity, cointegration, long-run equilibrium relationship, unit roots, non-stationarity.

Journal of Economic Literature Classification: (C32, F41)

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## (I) Introduction

An important determination of an open economy's international competitiveness is given by relative movements in exchange rates and prices. The relationship between these two variables is best explained by the Purchasing Power Parity (PPP) theory. PPP theory argues that exchange rate movements reflect divergent rates of inflation. Traditionally, three models have been used to explain this equilibrium relationship, namely the laws of one price (LOP), absolute PPP and relative PPP. According to the LOP, assuming there are no transaction costs and trade barriers, the price of identical goods will be equalised across countries, when corrected for the exchange rate. Absolute PPP is an extension of the law of one price with the additional assumption of identical consumption patterns, according to which the price of the same basket of goods will be equalised across countries. Since the LOP involves only one commodity, while absolute PPP involves a basket of goods, the latter is supposedly weaker than the former. Although the LOP and absolute PPP are intuitively appealing, their usefulness in interpreting exchange rate movements is rather limited. Relative PPP, also regarded as a mild version of PPP, states that the rate of change in nominal exchange rates will be equal to the changes in the difference between domestic and foreign expected rates of inflation for the same basket of commodities, with similar assumptions as for absolute PPP. Stated differently, any deviation from the parity represents profitable commodity arbitrage opportunities which, if exploited, will tend to force the exchange rate towards price equilibrium for all three models. By assuming that (1) consumption patterns are similar across countries, (2) any problems of measuring the comparable price deflators are being solved and (3) there are no institutional impediments such as tariffs or quotas involved, a theoretical approach to both absolute and relative versions of the PPP suggests that it should hold in the long run for traded goods

There have been numerous empirical studies testing the validity of PPP; see, for example, Frenkel (1981), Adler and Lehman (1983) and Davutyan and Pippenger (1985). These tests do not take account of the fact that levels of spot exchange rates and prices (in both

countries) are typically non-stationary. However, it is possible that there exists a combination of the levels of spot exchange and prices which is stationary. In that case tests based on first differenced series lose long-run equilibrium information by 'over-differencing' the series. As a result, the use of conventional hypothesis tests (eg., t-test) becomes questionable and any inferences may be misleading.

However, recent studies [see eg. Corbae and Ouliaris (1988) and Taylor and Mc Mahon (1988)], recognising the fact that the exchange rate and relative price series are non-stationary, used cointegration techniques to test the validity of the PPP. These studies specify their null hypothesis as no cointegration and use standard Dickey-Fuller unit root tests. In this framework rejection of the unit root hypothesis is taken as evidence in favour of PPP and failure to reject the unit root is taken as evidence against PPP.

Even though the cointegration technique has advantages over the standard regression procedures in the context of testing the PPP, it has two main shortcomings. The first is the power of the Dickey-Fuller (DF) type unit root test. The DF test is based on the following regression:

$$y_t = \alpha + \delta t + \rho y_{t-1} + e_t.$$

It is well established for many economic time series that the standard unit root tests fail to reject the null of unit roots [see Nelson and Plosser (1982)]. The consensus is that most of the economic time series contain a unit root. The second drawback is related to the first, the way the null and alternative hypothesis is specified. In standard unit root hypothesis testing, the unit root is specified as the null and the alternative as a unit root. Because of the way this testing procedure is designed, the null is accepted most of the time unless there is strong evidence against it. In other words, the power of the standard unit root test is generally very low. Dejong *et al* (1989) ,for example, show that the power of the DF test is low against a stable autoregressive alternative with roots close to unity. Because of these two composite shortcomings, we will reverse our null and alternative hypothesis here when using cointegration techniques to test the validity of the PPP. Instead of DF tests, we use

the unit root test introduced by Kwiatkowski *et al* (1992), hereafter KPSS. This is particularly important for PPP tests when marginal decisions are often made. We therefore prefer this testing procedure to infer whether cointegration actually exists. The KPSS test statistic is given by:

$$\frac{\sum_{t=1}^{T} S_t^2}{S^2(l)}$$

where $S_t^2$ denotes the partial sum process of the residuals and $S^2(l)$ is a consistent estimator of $\sigma^2$, denoted by

$$T^{-1}\sum_{t=1}^{T} e^2_t + 2T^{-1}\sum_{s=1}^{l}\left[1 - \frac{S}{(1+l)}\right]\sum_{t=s+1}^{T} e_t e_{t-s}$$

where $l$ denotes the lag length. In this test, unlike the standard unit root testing specification, the null is specified as stationarity against the alternative of a unit root. However, for comparative purposes we will report DF test results as well.

Engle-Granger's (1987) two stage testing procedure is generally used to test for a cointegration relationship between two variables. If absolute PPP exists, one would expect the cointegrating vector to be equal to one. Because of this unit coefficient we could impose a restriction on the cointegration vector and analyse whether the residuals are I(0). As a result the Engle-Granger procedure is not suitable for testing the validity of the PPP. The residual series becomes:

$$u_t = y_t - x_t \qquad \text{.....(1)}$$

If the null of this series is specified as I(0), we could claim to have established a long run relationship between the exchange rate and relative price, and thus evidence in support of absolute PPP. On the other hand, if we reject the hypothesis of cointegration, we can still pursue a relative PPP analysis. Relative PPP theory asserts that movements in the nominal exchange rate and price levels adjust over time and keep the relationship between these relative prices within bounds. In a statistical sense the relative PPP hypothesis implies that

the movements in the real exchange rates between any two countries are stationary. As a result of this, shocks will only have temporary effects.

In this paper we examine the hypothesis of long run PPP. If the relative price series and nominal exchange rate series are individually integrated of different orders, a linear combination of any two will in general be integrated of the higher of the two orders. For example, if $y_t$ is I(1) and $x_t$ is I(0), the linear combination

$$u_t = y_t - \beta x_t \qquad \text{.....(2)}$$

will be I(1), regardless of $\beta$. However, if the two series are of the same order, e.g. I(1), there may exist a $\beta$ such that $u_t$ is I(0), i.e., there exist a linear combination which is of a lower order, I(0). In our analysis the linear combination of exchange rate series and relative price series is given by

$$\varepsilon_t = \text{Ex.Rate}_t - \beta\ \text{Rel.Price}_t \ . \qquad \text{.....(3)}$$

If the exchange rate and relative price series are cointegrated, this implies that they obey an equilibrium relationship in the long run, although they may diverge substantially from this equilibrium in the short run. On the other hand, if the linear combination is I(1), we have to take the first differences of both series to make the residual I(0), which may then be written as

$$v_t = \Delta\text{Ex.Rate}_t - \gamma\ \Delta\text{Rel.Price}_t \ . \qquad \text{.....(4)}$$

This is exactly the relative PPP. A long run equilibrium relationship like (2) is a necessary condition for PPP, but to establish a second condition we have to place restrictions on the cointegrating vector, i.e., $\beta = 1$. For equation (3) a similar restriction applies, i.e., $\gamma = 1$.

The testing procedures undertaken are as follows: First, we test the hypothesis that the nominal exchange rates and relative prices are I(0) series. If this hypothesis is not rejected, we can test for a cointegration relationship by testing whether the residuals from bivariate cointegrating regressions are I(0). More clearly, we test the null hypothesis that the residual series is stationary against the alternative that the series has a unit root, i.e., the null hypothesis is cointegration and the alternative hypothesis is non-cointegration. If the null is

not rejected, we could claim to have found a long run equilibrium relationship between exchange rates and relative prices in their levels. On the other hand, if we reject the hypothesis of I(0), we would establish there is no long run relationship between these two variables in levels exist. Then by taking the first differences of both of the series which are I(0), we test for a possible relative PPP relationship. Any regression in levels would then give spurious results. In this situation, we test whether $v_t$ is autocorrelated.

The empirical evidence is rather confused for both absolute and relative versions of the PPP. Krugman (1978) reports evidence against the absolute PPP, when neither prices nor exchange rates are treated as exogenous variables for the periods of the 1920s and 1970s. However, when endogeneity of prices and exchange rates is recognised, evidence is more favourable to PPP for the same data. Dornbusch (1980) uses a monetary approach, where prices are determined by domestic money supply and real money demand, and reports evidence against absolute PPP for the 1970s. Frenkel (1981a) finds contradictory results of PPP for these two different time periods. He reports a poor performance of both versions of the PPP in the 1970s and a relatively good performance of absolute PPP in the 1920s. Adler and Lehman (1983), using both monthly and yearly data for the 1970s and 1900s respectively, do not find support for relative PPP. Hakkio (1984) uses cross country tests to improve the efficiency of the absolute PPP estimates, which support PPP for the 1970s, but not the 1920s. Davuytan and Pippenger (1985) show that the 'collapse' of relative PPP in the 1970s was due to monetary shocks when they examined OECD countries for the 1920s and 1970s. Their explanation is that PPP did not fail but there was instead an increase in volatility of those factors that give rise to the deviation from PPP.

All these studies cited test the validity of the PPP hypothesis for large industrialised developed countries. In this paper we would like to extend this testing to thirteen 'small' Asia-Pacific countries, including a number of developing countries. In particular, we consider Australia, Fiji, Indonesia, Japan, Malaysia, New Zealand, Papua New Guinea, Philippines, Singapore, Solomon Islands, Sri Lanka, Thailand and Western Samoa. One

reason to include Japan is its economic dominance in the Asia-Pacific region. The period of study is from 1986:1 to 1994:12 and the data were obtained from EconData, derived from IFS-tapes. We use monthly seasonally unadjusted data of the CPI and end of the month exchange rates versus the US dollar. Since monthly CPI is not available for Australia, New Zealand and Papua New Guinea, we use quarterly data for these countries. Each country's exchange rate is defined as domestic currency units per unit of foreign currency. All prices and exchange rate series are converted to a common base period, January 1986. Relative price series for each country have been obtained by dividing the CPI of each country by US CPI and Japanese CPI, respectively. Plots of relative prices and exchange rates (in logarithmic form) for each country, against US dollar and Japanese yen, are given in Appendix A and B, respectively.

Statistics show that Japan's trade volume (see various issues of Year Book of International Trade Statistics) with other Asia-Pacific countries increased substantially over the past decade. One might expect then our set of currencies to be more integrated with the Japanese yen than with the US dollar and PPP to exist between the Japanese yen and these currencies. To investigate this relationship, we undertake similar testing procedures, as discussed above, between the Japanese yen and the remaining currencies.

Australia and New Zealand have a higher trade intensity between them than any other pair of countries in our study (see various issues of Year Book Australia). In addition, they have a trade agreement known as Closer Economic Relations (CER), established in 1983. Because of the 'closeness' between the two countries, we also test for the existence of a trans-Tasman PPP.

The paper is organised as follows: Section II pretests the (non)stationarity of exchange rates and relative prices. Section III presents tests of the absolute and relative PPP. In section IV we test whether a PPP prevails between Australia and New Zealand and finally section V offers some concluding remarks.

**(II) Tests for Nonstationarity**

**a) Exchange Rates**

In order to test for the order of integration of a series, we use the KPSS test. First, unit root tests were undertaken on exchange rates with a constant and a trend variable, when currencies are expressed in terms of the US dollar. Here, the null is stationarity and the alternative is non-stationarity. In all cases, we are able to reject the null hypothesis that nominal exchange rates (in levels) are I(0) series except for Thailand and Singapore. For comparative purposes, we also present the ADF test results in Table 1 under the column US. Only in one case is ADF rejected and in four cases KPSS is not rejected. Identical tests are undertaken when currencies are expressed in terms of Japanese yen and the results are presented, under the column Japan, in the same table. For six countries, we fail to reject the null of I(0). However, at 10% level of significance only in the case of 4 countries do we fail to reject the null of I(0). Based on these tests, we find that each of the nominal exchange rate series, whether expressed in terms of US dollar or in Japanese yen, generally appears to contain a single unit root.

**b) Relative Prices**

When we apply the same KPSS test to test the unit roots of relative price levels with constant and a trend (relative to the US), we are generally able to reject that the series is I(0) except for Solomon Islands, Sri Lanka and Western Samoa. Similar tests are conducted on the other set of relative prices (i.e., relative to Japan's CPI) and the results (see Table 2) show, we fail to reject the null of I(0) only in the case of Fiji and Thailand. So we conclude that the exchange rate and relative price series generally contain unit roots. For countries where exchange rate series and relative price series are integrated at different orders individually, a linear combination may not be I(0) which is obvious evidence of non-existence of PPP. However, we will continue to present the cointegration results for these countries.

**(III) Cointegration Test for Absolute and Relative PPP**

Since we are imposing theoretical restrictions on the cointegrating vector we will not use Engle-Granger's two step procedure in our analysis. If the residual series is I(0) we interpret this as a long run equilibrium relationship between exchange rate and relative prices, thus evidence for absolute PPP. Here the residual series is generated by simply taking the difference between exchange rate and relative price, i.e., by (1). Now we can apply the KPSS test to the residuals to test whether this series is I(0) or I(1). Here our null hypothesis is that the residual series is I(0) and the alternative is I(1). If we fail to reject the null we could establish a long run equilibrium relationship between exchange rates and prices at the levels. Here we interpret a long run equilibrium relationship as a cointegration relationship, and thus an existence of PPP.

On the other hand if the null hypothesis of I(0) residuals is rejected, we could claim to have no cointegration, hence no absolute PPP between exchange rates and relative prices. But there is a possibility that the two variables may be related in their first difference, i.e, relative PPP. In order to test this relationship, we analyse whether (4) is autocorrelated. If (3) is not autocorrelated, we will interpret this as evidence in favour of relative PPP. Plots in Appendix A and B show the possibility of a time trend as one of the regressors, so we should consider this as an explanatory variable. The KPSS test results on the residuals are presented in Table 3. We also present the ADF test results for comparative purposes. Appropriate lag lengths have been chosen using Akaike's information criteria (AIC). Applying the KPSS test, we are able to reject the null hypothesis of I(0) in all cases except for Solomon Islands and Papua New Guinea, i.e, we find a cointegrating relationship between the nominal exchange rate and relative price for Solomon Islands-US and Papua New Guinea-US as pairs. However, a modified t-test on the time trend turned out to be insignificant for Solomon Islands but not for Papua New Guinea. As a result we establish a long run cointegration relationship between Solomon Islands and US, thus evidence in favour of absolute PPP. This cointegration relationship is well supported the plot in Appendix A.

When applying a similar testing procedure to test PPP between Japan and the remaining countries, we establish a cointegration relationship between Japan and more than half of the countries in our sample (see Table 3). However, in all cases the time variable tends to be significant, which violates the PPP theory. As a result, in none of the remaining countries, do we establish an absolute PPP whether against US or Japan.

Even though we fail to find evidence for an absolute PPP, this does not necessarily reject the relative PPP relationship. In order to test this relationship, we may use (4) with the restriction of $\gamma = 1$. If $v_t$ is autocorrelated this is evidence against the existence of relative PPP whereas no autocorrelation is evidence in favour of relative PPP. We undertake a Ljung-Box test or modified Q test to examine whether $v_t$ is autocorrelated and the results are presented in Table 4. For countries with monthly and quarterly data we use a maximum of 12 and 4 lag lengths, respectively. For eight countries, $v_t$ is found to be autocorrelated with 12 lag lengths but for the rest no autocorrelation is found.

This indicates that there is a relative PPP between the US and eight countries. These results are generally supported by the plots in Appendix A. For the rest of the countries, we fail to find a relative PPP relationship. When identical tests are undertaken for the rest of the countries against Japan, we find the results are mixed (see Table 4). These results indicate evidence in support of relative PPP between Japan and six countries (see Appendix B).

Since relative PPP is evident for some countries, we would like to explore whether there is a relationship between PPP and the degree of openness of the economy, where it may be measured by the following formula:

$\frac{Trade}{Gross\ Domestic\ Product} \times 100$ as is used by the World Bank. Here *Trade* is total exports and imports of a country for a given period. Since this measurement considers only merchandise trade and does not include trade in services, it has its own limitations. A high degree of openness of an economy indicates fewer restrictions on imports and exports and vice versa and a potentially strong link between prices/trade/exchange rates. We categorise

Malaysia and Singapore in group one where the degree of openness[1] is high. The next group consists of Papua New Guinea, Philippines, Solomon Islands, Sri Lanka, Thailand and Western Samoa, where the degree of openness is moderate. Finally Australia, New Zealand, Japan and Indonesia are categorised in group three where the degree of openness is relatively low. Based on our PPP results, we are unable to establish a strong correlation between degree of openness and PPP relationship.

Our test results are based on each country's CPI. Instead of CPI, one could use alternative price indices such as Producer Price Index (PPI) or Whole Sale Price Index (WPI). Though we do not pursue this exercise here, we plotted CPI against WPI/PPI[2] for each country to check whether we can possibly expect different cointegration results when we replace CPI by an alternative price index (see plots in Appendix C). Only Indonesia, Sri Lanka and Thailand exhibit very close movements between the two indices, whereas in other countries they move apart. So one would not expect a cointegration relationship between exchange rates and alternative price indices in these three countries, but for the others these alternative price indices may actually be useful in establishing cointegration.

[1] For most of the developing countries this is readily available from World Bank Book and for the rest of the countries the measure was computed. For all countries, the mid sample period (June 1990) measure of openness was considered.

[2] . For Fiji, Papua New Guinea, Solomon Islands and Western Samoa either PPI or WPI is not available. PPI for Malaysia is incomplete.

**(IV) Trans -Tasman PPP**

To test the PPP between Australia and New Zealand with quarterly data, the cross exchange rate between the NZ and Australian dollar was derived from their respective US dollar quotations. In addition, we also compute relative prices by dividing NZ prices by Australian prices. Before undertaking a test for PPP, the KPSS test for stationarity as in Section II shows that both exchange rate and relative price series are not I(0). The same testing procedure as in Section III is applied to test for a relationship between the relative price and exchange rate. Using AIC, we retain one lag length for each variable. When the KPSS test is applied to the residuals, we are able to reject the null hypothesis of cointegration, and hence reject a long run equilibrium relationship or absolute PPP. However, we still can test the relative PPP using (4). Using a Ljung-Box test for autocorrelation, we find that $v_t$ is autocorrelated with four lag lengths, hence a trans-Tasman relative PPP hypothesis is rejected. This result is further confirmed by the plot (see Appendix E) between the exchange rate and relative price which appear to drift apart.

## (V) Conclusion

This paper applies cointegration techniques to test for the existence of the PPP in thirteen Asia-Pacific countries. Unlike standard unit root hypothesis testing, we specify our null hypothesis as cointegration and the alternative as non-cointegration. Only for the Solomon Islands-US pair, do we find a cointegrating relationship with an insignificant trend variable, and thus evidence in favour of absolute Purchasing Power Parity. For the other countries, the empirical evidence does not support absolute PPP: nominal exchange rates and relative prices are not cointegrated, either against the US dollar or the Japanese yen, for the sample period examined. Although a cointegrating relationship is established for a few countries against Japan, the significance of the time trend rejects the validity of absolute PPP. If we interpret cointegration as evidence of a long run equilibrium relationship, our results show that relative prices and nominal exchange rates tend to drift apart without bound. However, we do find evidence in support of relative PPP between eight countries and the USA. We also find a relative PPP relationship between Japan and six countries. For the remaining countries, we fail to find either form of PPP relationship between them and the US or Japan. There is also evidence that a high degree of openness of an economy fails to indicate a PPP relationship and vice versa. Therefore, our results support previous studies which generally reject a PPP relationship in absolute form. We also fail to find a PPP relationship between Australia and New Zealand. Future research obviously requires a longer sampling period where PPP is sometimes found to hold. In addition, the degree of openness might be considered as an explanatory variable.

**Table 1.**

**Tests for Unit Roots in the Exchange Rates**

| | US | | Japan | |
|---|---|---|---|---|
| **Country** | **ADF[1]** | **KPSS[2]** | **ADF** | **KPSS** |
| Australia | -2.44 | 0.213 | -1.40 | 0.237 |
| Fiji | -1.74 | 0.328 | -2.08 | 0.186 |
| Indonesia | -1.09 | 0.191 | -3.58* | 0.167 |
| Japan | -2.39 | 0.400 | -- | -- |
| Malaysia | -2.48 | 0.162 | -2.83 | 0.105** |
| New Zealand | -0.15 | 0.128** | -1.92 | 0.222 |
| Papua New Guinea | -1.24 | 0.376 | -4.67* | 0.218 |
| Philippines | -2.31 | 0.296 | -2.91 | 0.062** |
| Singapore | -3.06 | 0.078 | -2.20 | 0.129** |
| Solomon Islands | -4.13* | 0.144** | -3.17 | 0.110** |
| Sri Lanka | -1.79 | 0.142** | -2.91 | 0.112** |
| Thailand | -3.30 | 0.085** | -2.42 | 0.131** |
| Western Samoa | -2.14 | 0.202 | -2.18 | 0.508 |

1. Ho is that the nominal exchange rate series is I(1).Critical value for the ADF test at the 5% level of significance is -3.45. For Australia, New Zealand and Papua New Guinea the critical value is -3.60.

2. Ho is that the nominal exchange rate series is I(0). Critical value for the KPSS test at the 5% level of significance is 0.146.

* Indicates Ho (ADF) is rejected at the 5% level of significance.

** Indicates Ho (KPSS) is not rejected at the 5% level of significance.

**Table 2.**

**Tests for Unit Roots in Relative Prices[2]**

| | US | | Japan | |
|---|---|---|---|---|
| **Country** | **ADF[1]** | **KPSS[2]** | **ADF[1]** | **KPSS[2]** |
| Australia | -2.32 | 0.310 | -2.54 | 0.308 |
| Fiji | -1.40 | 0.543 | -1.33 | 0.114** |
| Indonesia | -2.78 | 0.247 | -3.15 | 0.274 |
| Japan | -2.53 | 0.746 | -- | -- |
| Malaysia | -0.10 | 0.320 | -1.26 | 0.227 |
| New Zealand | -8.01* | 0.246 | -6.57* | 0.271 |
| Papua New Guinea | -1.78 | 0.202 | -1.00 | 0.223 |
| Philippines | -2.28 | 0.180 | -1.76 | 0.350 |
| Singapore | -1.07 | 0.859 | -0.96 | 0.509 |
| Solomon Islands | -4.32* | 0.111** | -2.34 | 0.178 |
| Sri Lanka | -2.41 | 0.112** | -1.06 | 0.148 |
| Thailand | -1.18 | 0.505 | -2.73 | 0.125** |
| Western Samoa | -2.88 | 0.066** | -2.35 | 0.167 |

1. Ho is that the relative price series is I(1).Critical value as in Table1 note.

2. Ho is that the relative price series is I(0). Critical value as in Table 1 note.

* , ** as in Table 1.

**Table 3.**

**Cointegration Test for absolute PPP**

| | US | | Japan | |
|---|---|---|---|---|
| **Country** | **ADF[1]** | **KPSS[2]** | **ADF** | **KPSS** |
| Australia | -2.61 | 0.258 | -1.48 | 0.271 |
| Fiji | -2.21 | 0.479 | -2.66 | 0.315 |
| Indonesia | -4.18 | 0.361 | -3.64* | 0.098** |
| Japan | -2.20 | 0.378 | -- | -- |
| Malaysia | -1.14 | 0.746 | -3.23 | 0.096** |
| New Zealand | -0.37 | 0.170 | -6.40* | 0.272 |
| Papua New Guinea | -1.85 | 0.124** | -0.54 | 0.251 |
| Philippines | -1.84 | 0.362 | -2.88 | 0.080** |
| Singapore | -2.84 | 0.401 | -2.46 | 0.122** |
| Solomon Islands | -2.25 | 0.069** | -2.62 | 0.127** |
| Sri Lanka | -2.84 | 0.339 | -2.57 | 0.129** |
| Thailand | -2.11 | 0.423 | -2.35 | 0.128** |
| Western Samoa | -2.59 | 0.203 | -2.32 | 0.150** |

1. Ho is that the cointegrating regression residuals are I(1) series. Critical value for the ADF statistic at 5% level of significance is -3.45.
   For Australia, New Zealand and Papua New Guinea the critical value at 5% level of significance is -3.60.

2. Ho is that the cointegration regression residuals are I(0) series. Critical value for the KPSS statistic at 5% level of significance is 0.146.

* Indicates Ho (ADF) is rejected at the 5% level of significance.
** Indicates Ho (KPSS) is not rejected at the 5% level of significance.

**Table 4**

**Test for relative PPP**

**Ljung-Box Q test for autocorrelation of $v_t$[1]**

| | US | Japan |
|---|---|---|
| **Country** | **Q-Statistic** | **Q-statistic** |
| Australia | 1.97 | 1.80 |
| Fiji | 55.2* | 20.5* |
| Indonesia | 21.5* | 8.98 |
| Japan | 18.6* | -- |
| Malaysia | 23.9* | 18.8* |
| New Zealand | 8.90* | 13.1* |
| Papua New Guinea | 0.95 | 19.2* |
| Philippines | 18.8* | 6.80 |
| Singapore | 14.7 | 19.4* |
| Solomon Islands | 9.00 | 12.6 |
| Sri Lanka | 6.40 | 6.80 |
| Thailand | 18.7* | 12.3 |
| Western Samoa | 32.1* | 19.2* |

1. Ho is that $v_t$ is autocorrelated .

Critical value for the Ljung-Box Q test statistic at the 10% level of significance with 12 degrees of freedom is 18.55.

For Australia, New Zealand and Papua New Guinea the critical value for the Q test statistic at the 10% level of significance with 4 degrees of freedom is 7.78.

* Indicates Ho is rejected.

**BIBLIOGRAPHY**

Adler, M. and Lehman, B.(1983) Deviations from purchasing power parity in the long run, *Journal of Finance*, 38, 1471-87.

Corbae, D. and Ouliaris, S. (1988) Cointegration and tests of purchasing power parity, *The Review of Economic and Statistics*, 70, 508-11.

Davutyan, N. and Pippenger, J. (1985) Purchasing power parity did not collapse during 1970s, *American Economic Review*, 75, 1151-58.

Dickey, D.A. and Fuller, W.A. (1979) Distribution of the estimators for autoregressive time series with a unit root, *Journal of the American Statistical Association*, 74, 427-31.

Dickey, D.A and Fuller, W.A. (1981) The likelihood ratio statistics for autoregressive time series with a unit root, *Econometrica,* 49 1057-72.

Dornbusch, R. (1980) Exchange rate economics: where do we stand?, *Brookings Papers on Economic Activity,* 1, 143-85.

Engle, R. F and Granger, C. W. J (1987) Cointegration and error correction: representation and estimation and testing, *Econometrica,* S5, 251-76.

Frenkel, J. A. (1981a) The collapse of the purchasing power parities during the 1970s, *European Economic Review,* 16, 145-65.

Frenkel, J. A. (1981b) Flexible exchange rates, prices and the role of news: lessons from the 1970s, *Journal of Political Economy*, 89, 665-705.

Hakkio, C.(1984) A re-examination of purchasing power parity: a multi-country, multi period study, *Journal of International Economics*, 17, 265-77.

Krugman, P. R. (1978) Purchasing power parity and exchange rates: Another look at the evidence, *Journal of International Economics*, 8, 397-407.

Kwiatkowski, D., Phillips, P.C.B., Schmidt, P., and Shin, Y. (1992) Testing the null hypothesis of stationarity against the alternative of unit root, *Journal of Econometrics*, 54, 159-178.

Shin, Y. (1994) A residual-based test of the null of cointegration against the alternative of no cointegration, *Econometric Theory*, 10, 91-109.

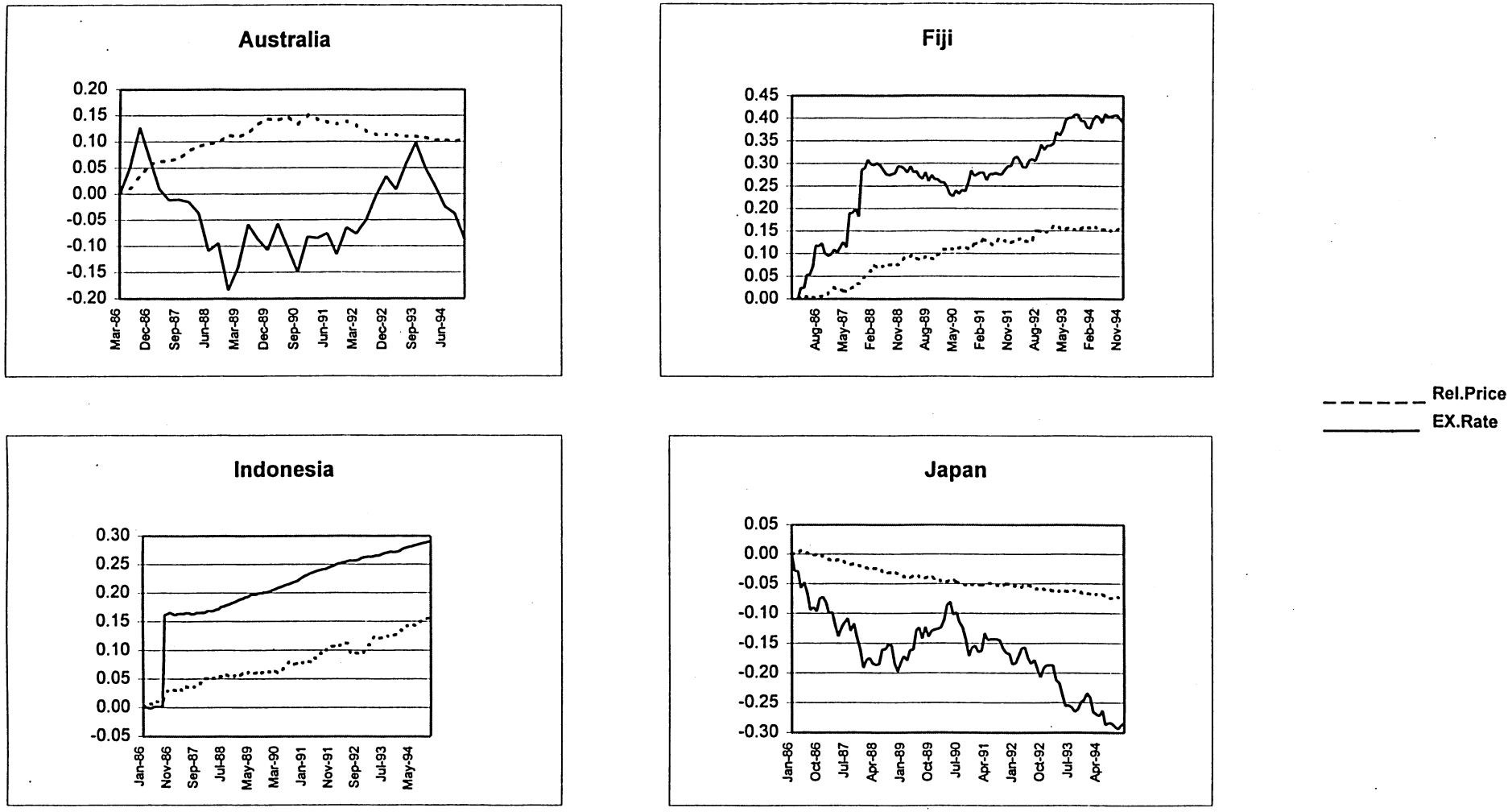
Taylor, M. P. and Mc Mahon, P.C. (1988) Long run purchasing power parity in the 1920s, *European Economic Review*, 32,179-97.

The World Bank Publication (1995) Trends in developing economies, A World Bank Book, Washington.

Year Book of International Trade Statistics (1980-1995) Trade by country, United Nations Publications, New York.

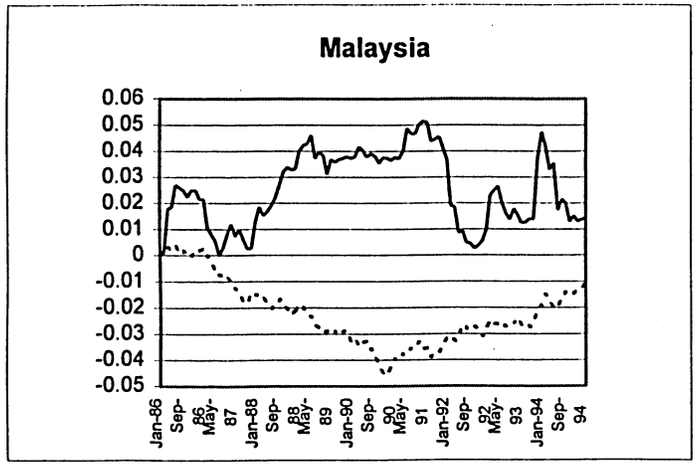
Australian Bureau of Statistics (1985-1992) Year Book of Australia, Volumes 69-75.

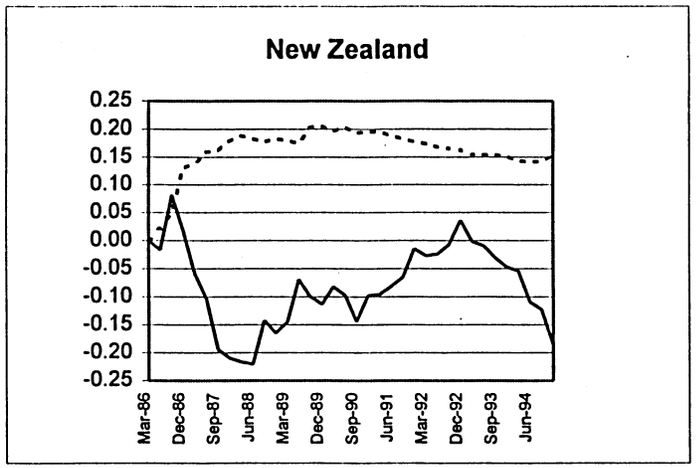
## Figure A1: Relative Price Vs Exchange Rate (US Dollar Base)

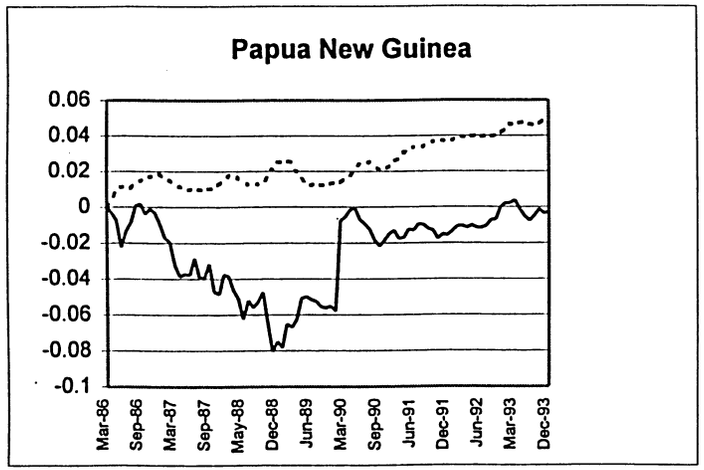


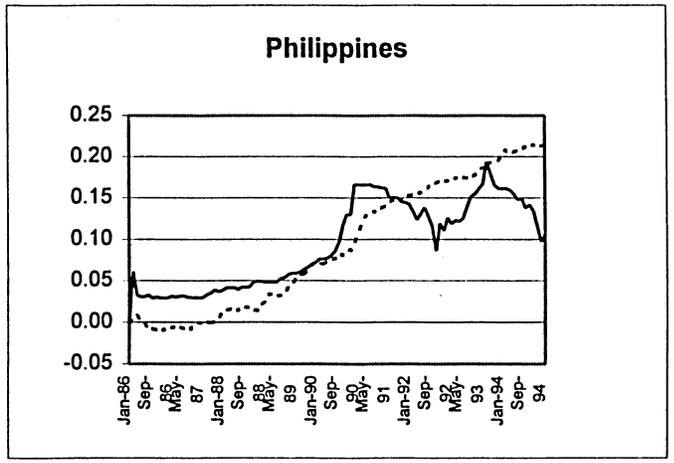

Footnotes : Exchange rates and Relative prices are in logarithmic form.
Downward movements of exchange rate indicate an apppreciation in the domestic currency against the US $ .
For Australia, New Zealand and Papua New Guinea data is quarterly.

## Figure A2 : Relative Price Vs Exchange Rate (US Dollar Base)



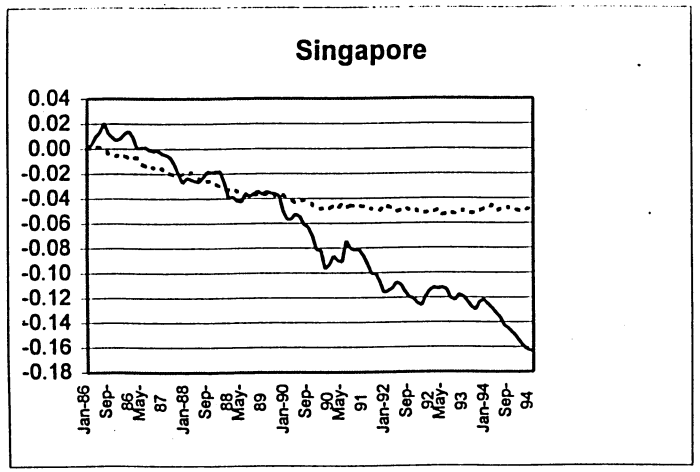



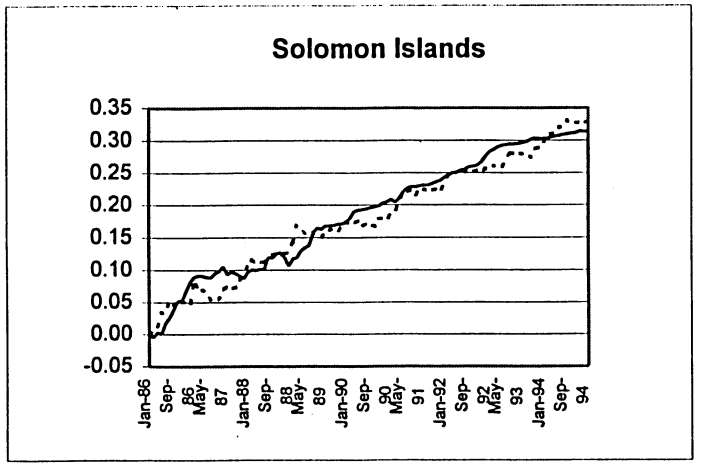



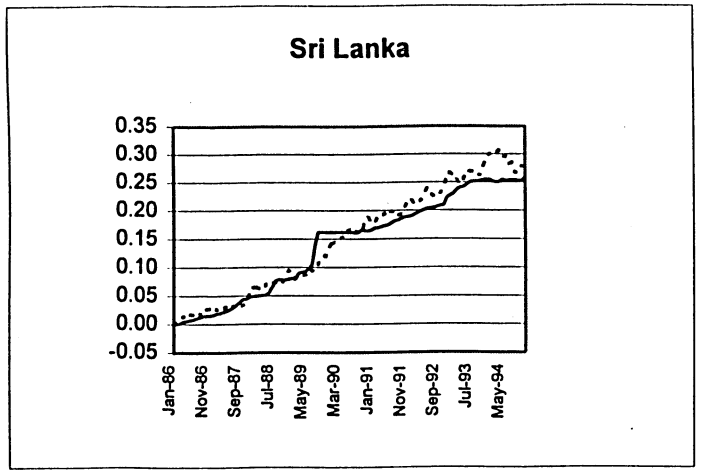

Rel.Price
EX.Rate

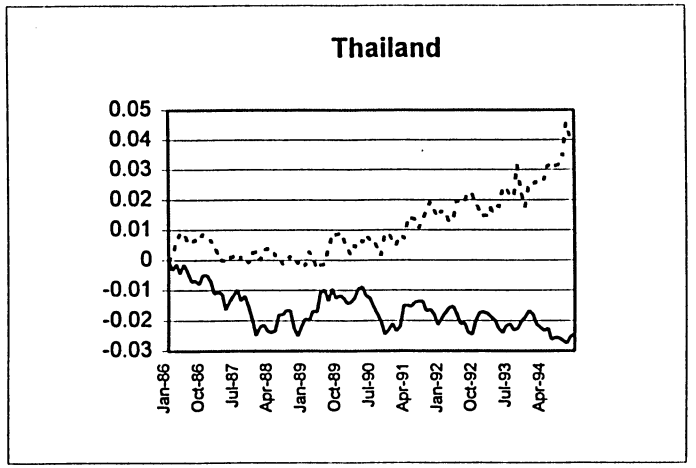
Footnotes : As in Figure 1.

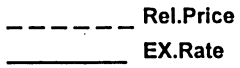
## Figure A3 : Relative Price Vs Exchange Rate (US Dollar Base)



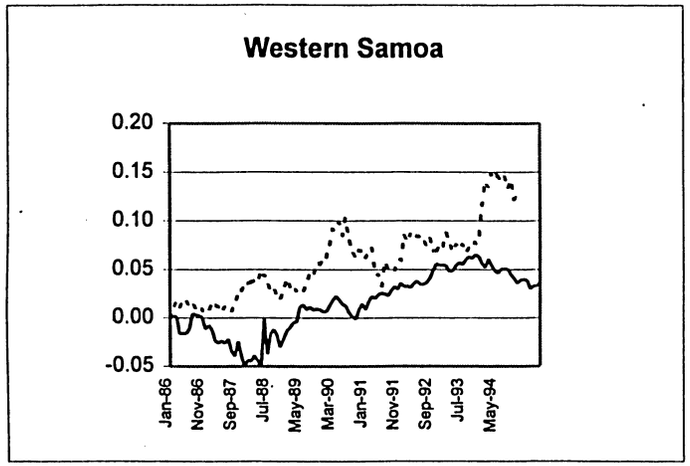




Footnotes: As in Figure 1.

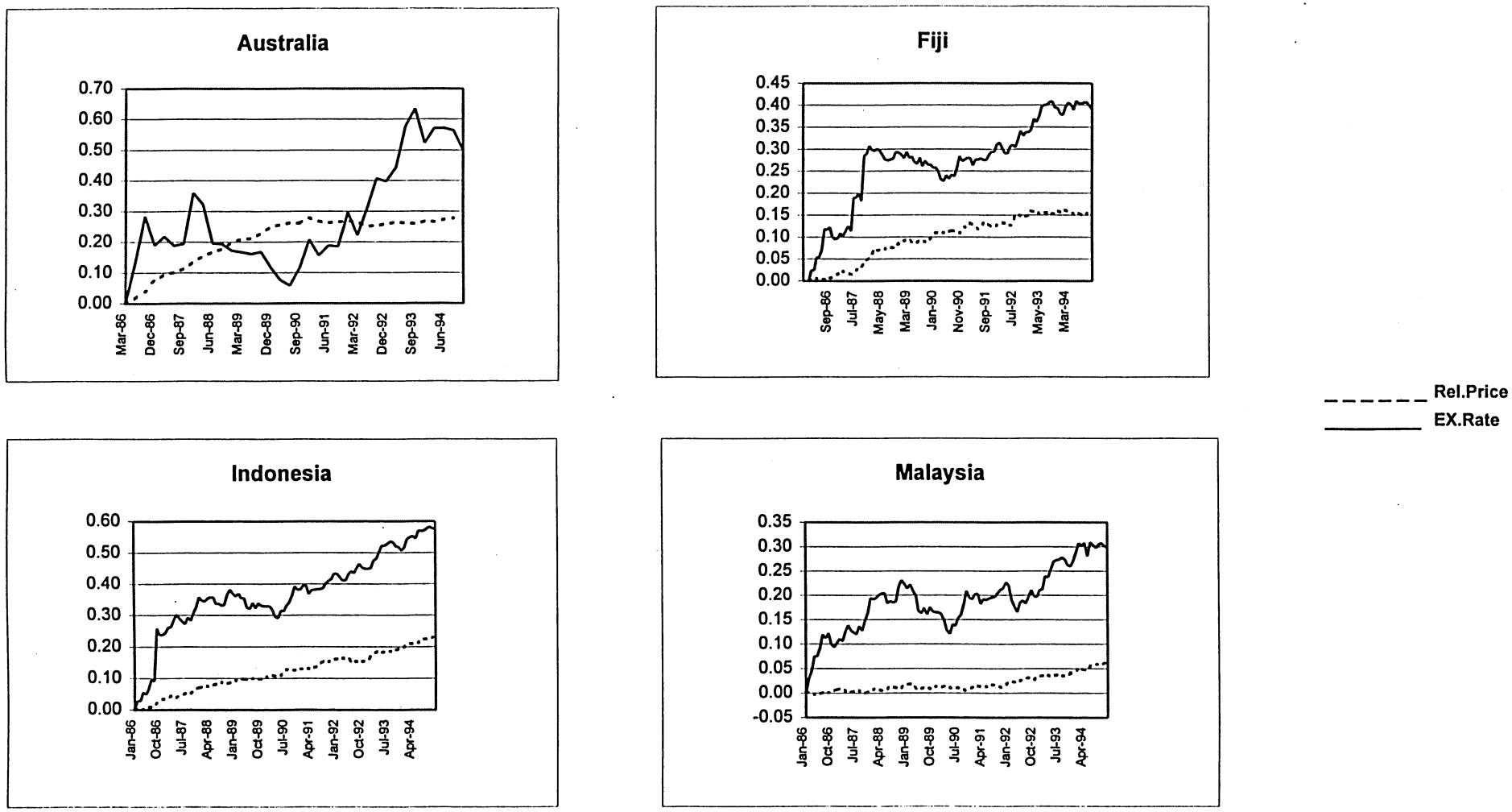
## Figure A4 : Relative Price Vs Exchange Rate (US Dollar Base)




Footnotes: As in figure 1.

Appendix B

## Figure B1: Relative Price Vs Exchange Rate (Japanese Yen base)

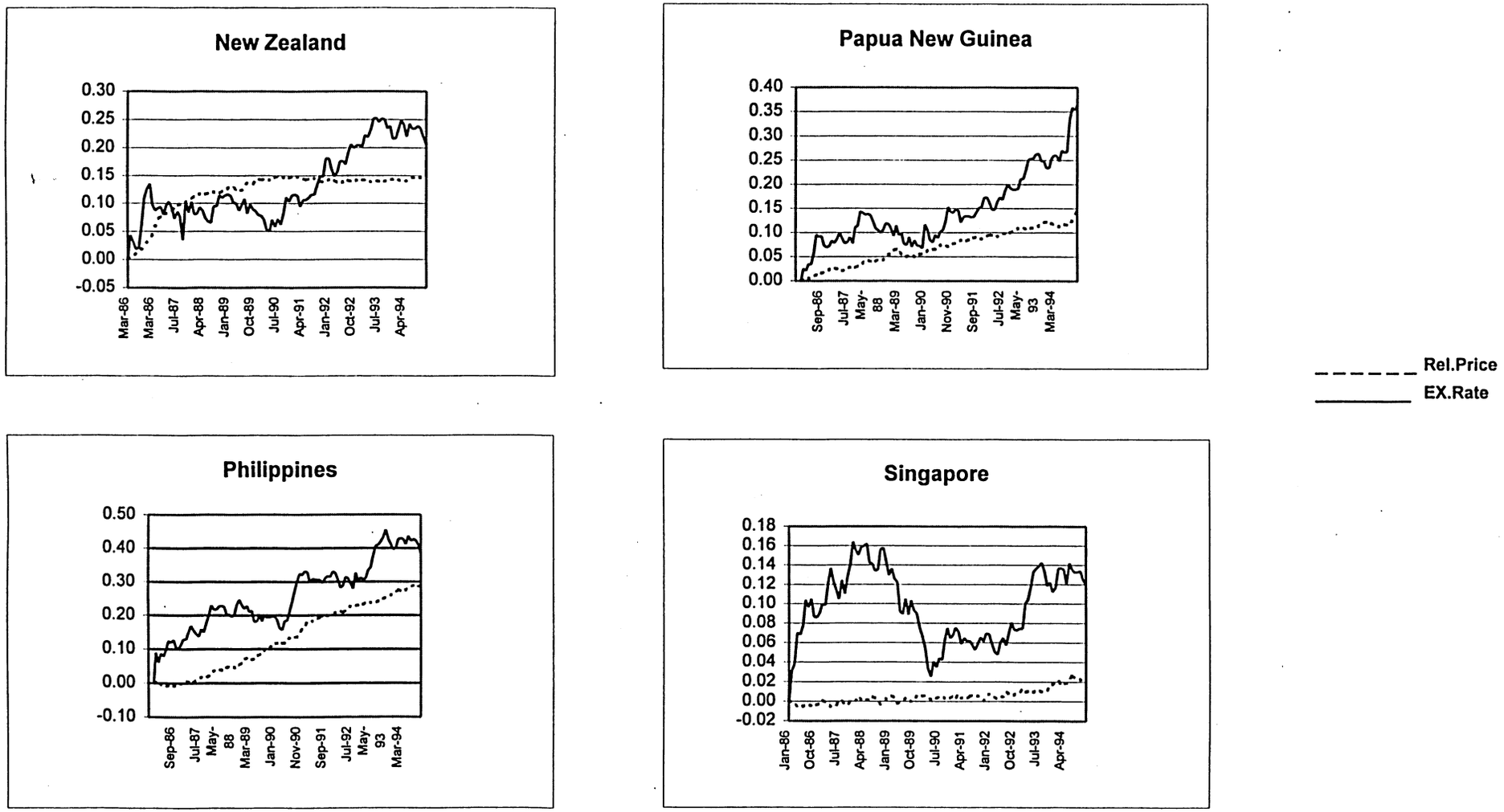



Footnotes: Exchange Rates and Relative Prices are in logarithmic form.

Downward movements in exchange rate indicate an appreciation in the domestic currency against the Japanese Yen.

For Australia,New Zealand and Papua New Guinea data is quarterly.

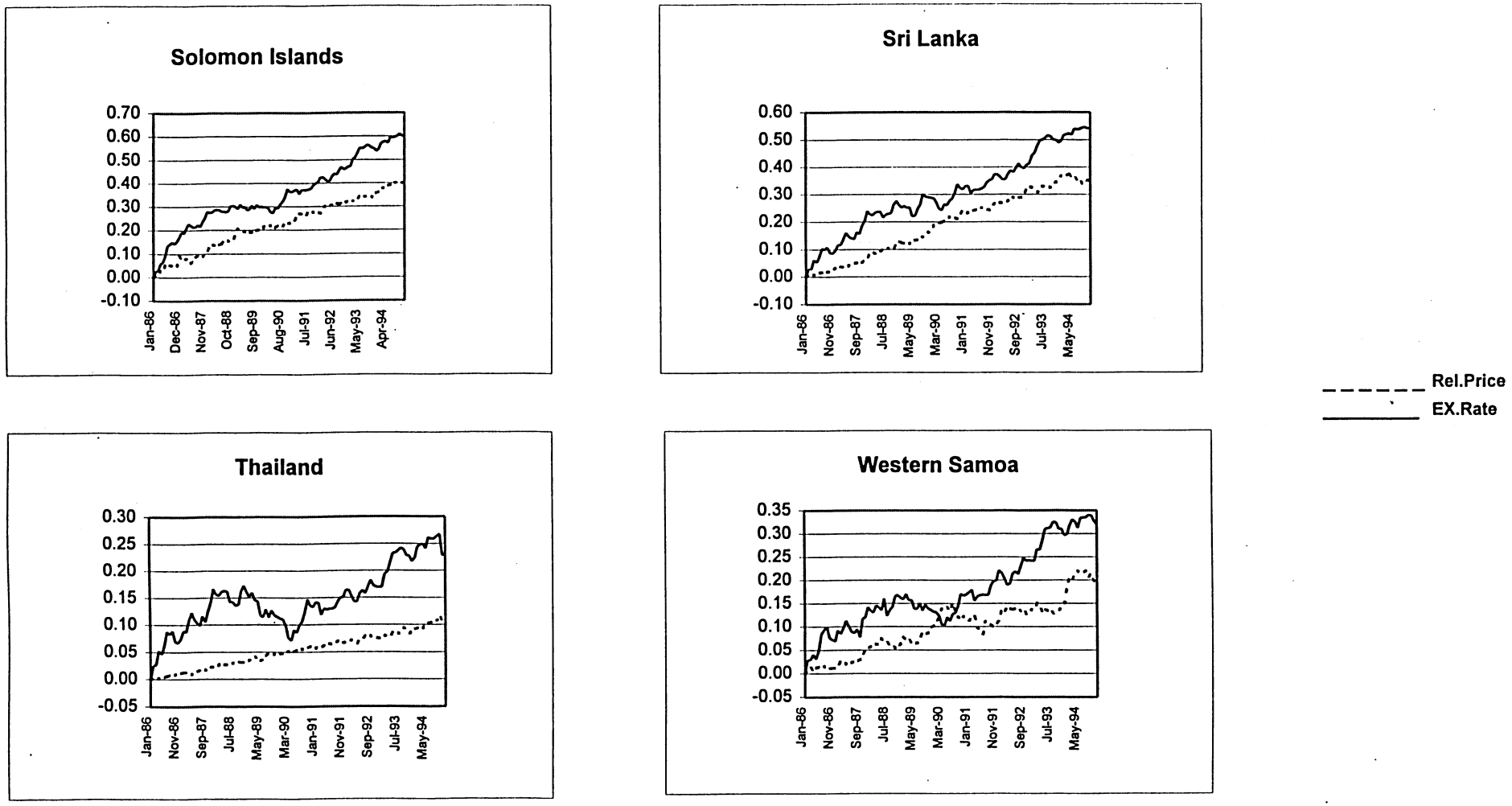
## Figure B2: Relative Price Vs Exchange Rate (Japanese Yen base)




Footnotes: As in Figure 1.

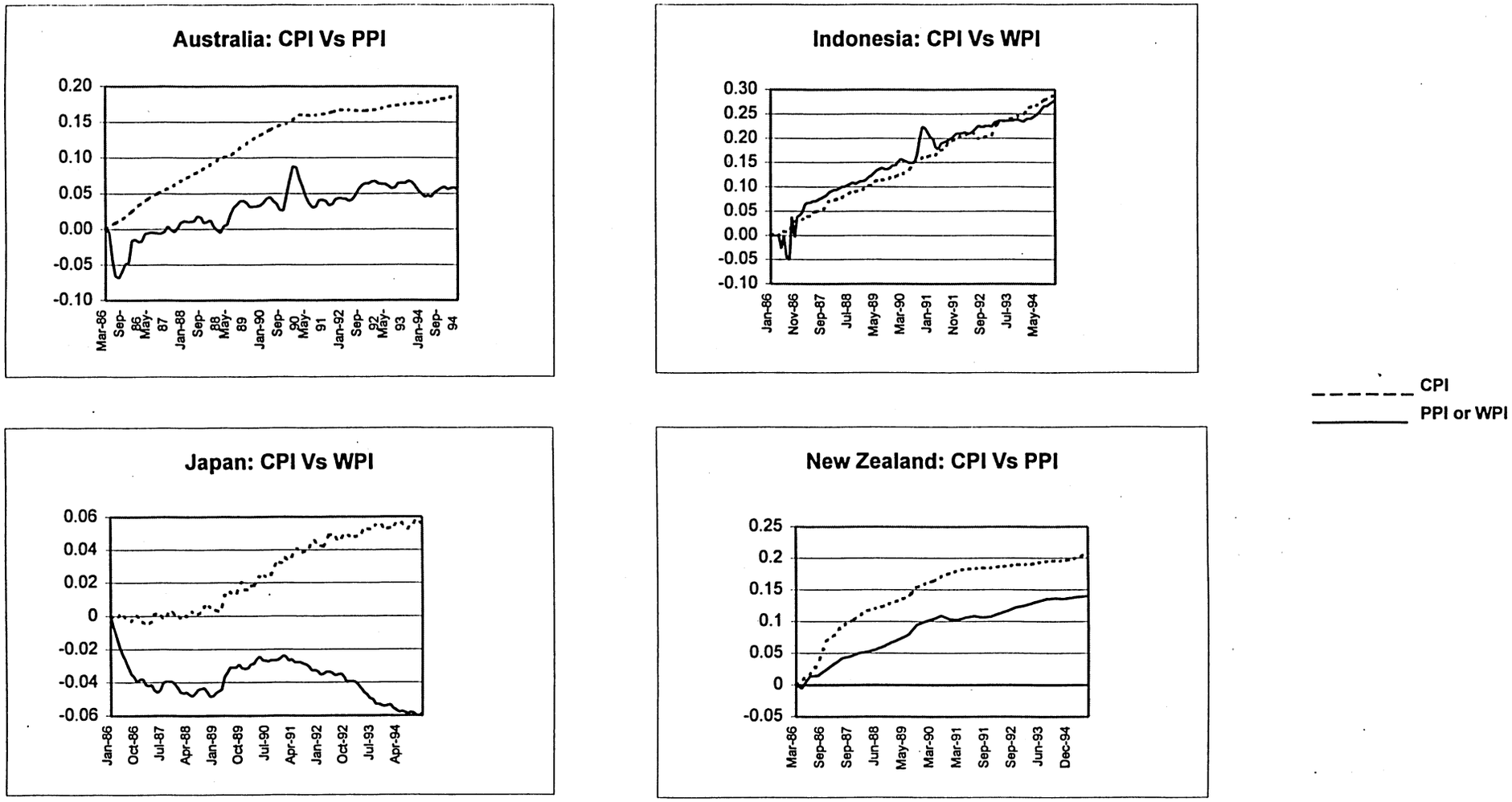
Appendix B

## Figure B3: Relative Price Vs Exchange Rate (Japanese Yen base)



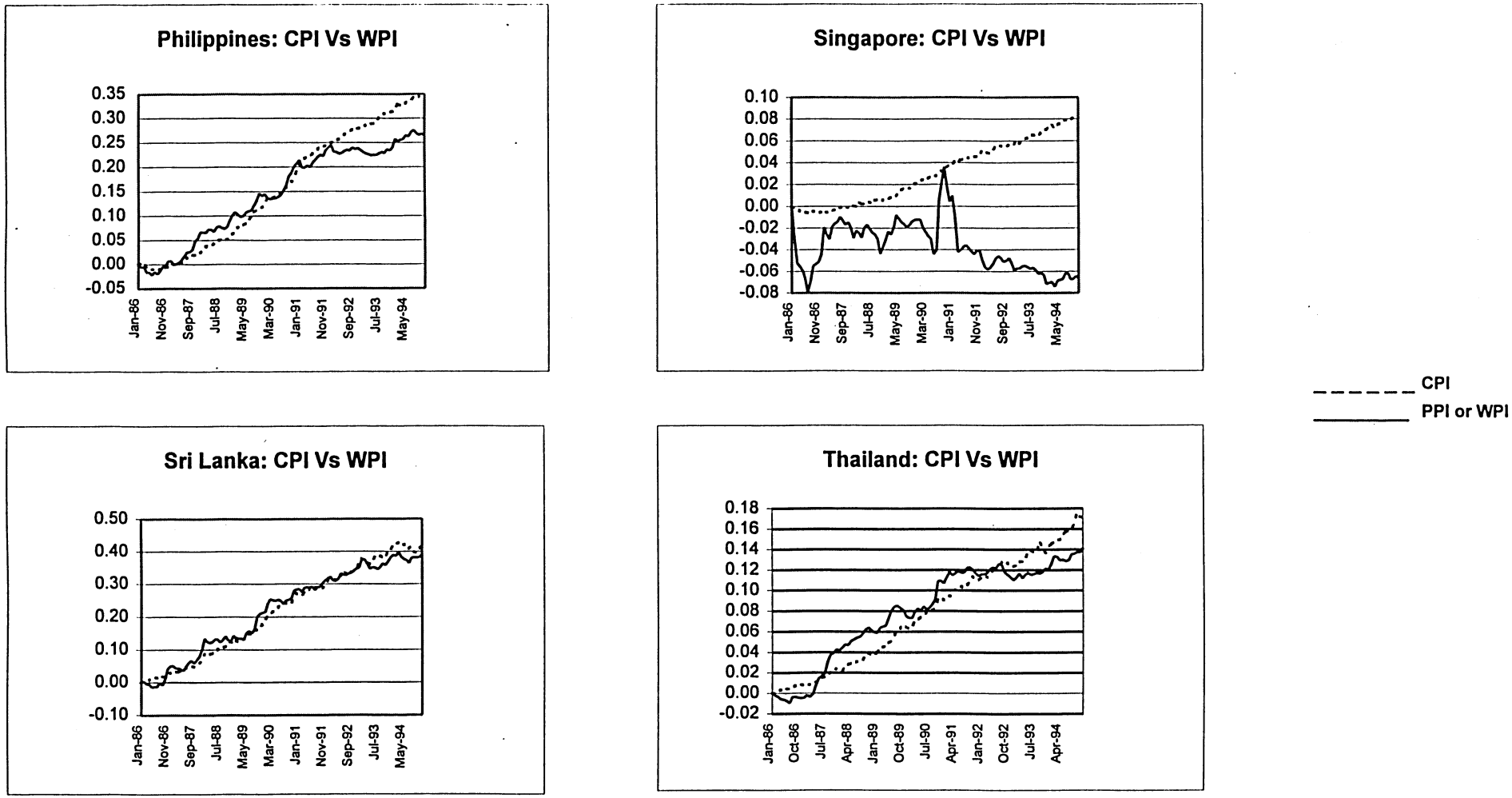

Footnotes: As in Figure 1.

## Figure C1: CPI Vs PPI or WPI




Footnotes: CPI and PPI/WPI are in logarithmic form.
For Australia and New Zealand data is quarterly.

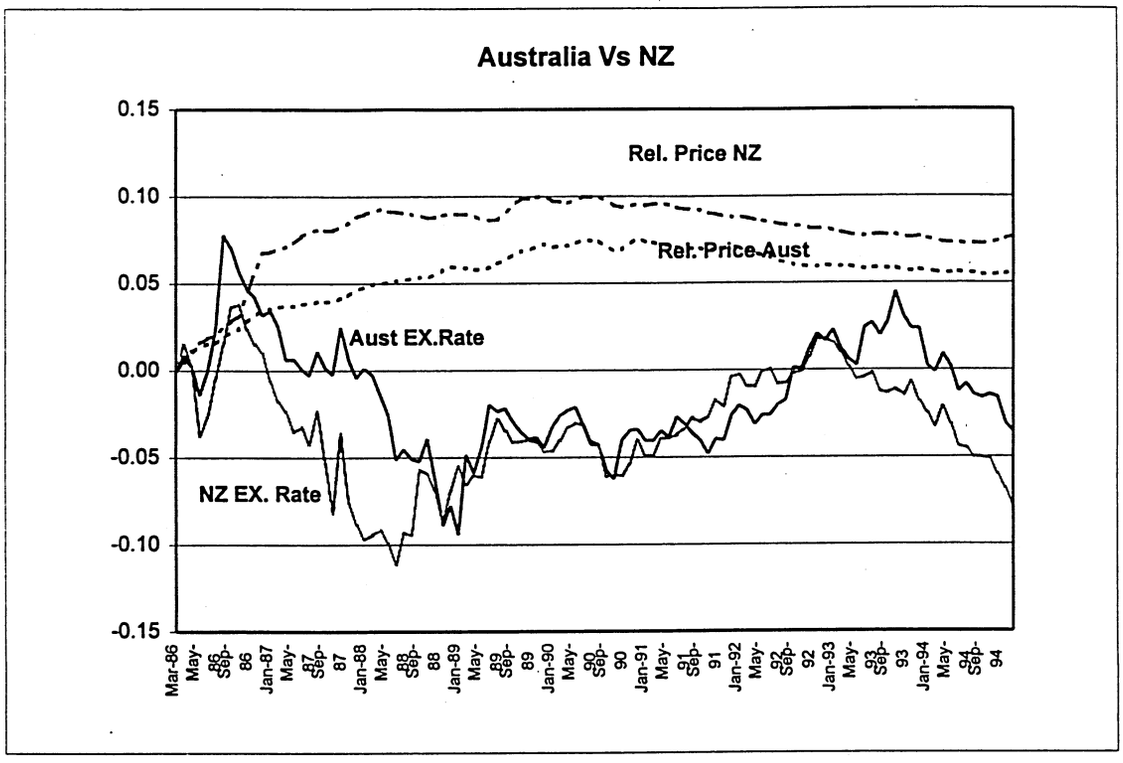
## Figure C2: CPI Vs PPI or WPI



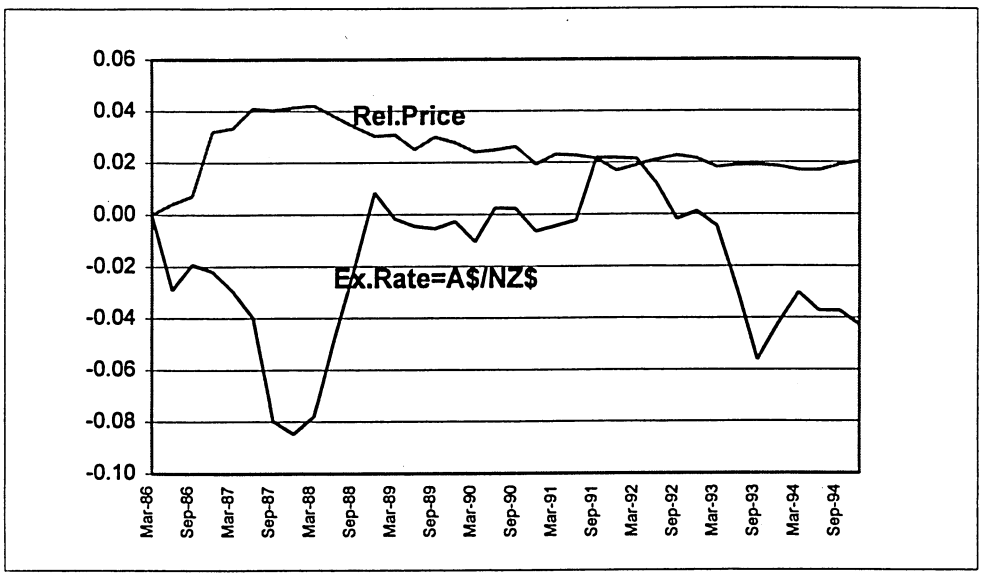

Footnotes : As in Figure 1.

Appendix D

## Australia Vs NZ: Relative Prices and Exchange Rates (US Dollar Base)



## Trans-Tasman: Relative Price Vs Exchange Rate (Quarterly)




Foot Notes: Relative Price and Exchange rate are in logarithmic form
Exchange rate is defined as one Aust.dollar in terms of NZ dollars