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Under the skin of any international economist lies a deep-seated belief in some variant of the PPP theory of the exchange rate.

Dornbusch and Krugman, 1976

Real exchange rate behaviour is investigated for 11 Asian–Pacific countries between 1976 and 1990 using a modified version of principal components analysis. The standard principal component analysis is changed such that the results are independent of the numéraire currency. For the full-sample period the dominant Asian exchange rate movements are relative to Indonesia, Japan and the United States. Significant changes in the covariance structure have taken place since 1986. It appears that Asian–Pacific real exchange rate movements since September 1986 are dominated by Australia, Korea, New Zealand and Japan. This contradicts the popular notion of an emerging yen-block in the Asian–Pacific region.

I. INTRODUCTION

One of the stylized facts of the empirical exchange rate literature is that the behaviour of nominal as well as real exchange rate movements is close to a random walk. A more comforting empirical fact is that movements of real exchange rates for different currencies seem to share common sources of variation. For instance, one of the facts during the current floating period is that time series of real exchange rates against the US dollar are highly correlated. With respect to real exchange rates in the Asian–Pacific region very little empirical evidence is available. Nor is there, to our knowledge, any evidence on common sources of variation for exchange rate movements in this area. The latter is of special importance, for instance, to address the so-called issue of the emergence of a yen-block in the Asian–Pacific rim (see, e.g. Frankel, 1991).

The present study uses principal components analysis to answer two types of questions with respect to Asian–Pacific real exchange rates. First, can we attribute dominant movements in real exchange rates to a specific country or a group of countries? The answer to this question has implications for the discussion on the validity of long-run purchasing power parity (PPP). Between which currencies can one expect persistent deviations from PPP, and in which cases can we expect them to be less severe? The second type of questions relates to the main differences and similarities between different (sub)periods. The consequences of the Plaza meeting held in 1985 on the relations between real exchange rates in the Asian–Pacific region are investigated.

When these and related issues are discussed in the literature one almost always focuses on the United States. Moreover, when results for non-dollar currencies are presented, Asian–Pacific exchange rates are very seldom included. In contrast with most studies in the exchange rate literature, all countries are treated symmetrically. To this end, the standard principal components analysis is modified such that the set of principal components is unique and invariant to the (arbitrary) choice of the numéraire currency.[1]

The paper is organized as follows. In Section II the numéraire-free principal components transformation are derived. In Section III this technique is applied to Asian–Pacific real exchange rates between 11 countries for two different periods. In Section IV the relationships between the principal components analysis and the suggested explanations in the literature are discussed. Section V concludes the results.

[1] See Koedijk and Schotman (1989) for an application of this technique to exchange rates between 1957 and 1986.

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II. METHODOLOGY

The scale dependence problem has prevented principal component analysis from getting popular. Multiplying some variable by a non-zero scalar induces a non-trivial change in the component structure. If one variable is scaled such that it has a considerably larger variance than the other ones, it will generally dominate the first principal component. For this reason principal components are most often constructed from normalized variables, dividing all observations by their sample standard deviation. The only data input to the principal component analysis is the sample correlation matrix in that case.

In the analysis of exchange rates there is a second problem. The arbitrary choice of a numéraire currency affects the component structure. The correlation matrix of exchange rates *vis-à-vis* the dollar produces a different set of principal components than the correlation matrix of yen exchange rates, although they contain exactly the same amount of information.

The principal component analysis to overcome both problems is modified. The scale dependence disappears when one requires that the set of principal components is invariant with respect to the choice of numéraire currency. The cross-sectional relations between exchange rates provide useful prior information to obtain a unique scaling of the exchange rate data.

Consider an $n \times 1$ multivariate time series $\{x_t\}_{t=1}^{T}$ of logarithms of exchange rates expressed in a common numéraire currency. Observations on $\{x_t\}$ are stored in the $T \times n$ data matrix X. The $T \times n$ matrix Z of principal components is a transformation of the data matrix X, such that

(i) $Z = XQB$, with Q positive definite symmetric and B non-singular,

(ii) $Z'Z = \Lambda$, with Λ a diagonal matrix with elements $\lambda_1 \geqslant \lambda_2 \geqslant \ldots \geqslant \lambda_n \geqslant 0$,

(iii) $B'QB = I$, a normalization.

Condition (i) expresses that the transformation $X \rightarrow Z$ is linear. Q is a $n \times n$ scaling matrix and B is a $n \times n$ matrix containing the so-called factor loadings. The second condition requires that the components are orthogonal. Λ is a $n \times n$ diagonal matrix. The elements of Λ are in descending order of magnitude and determine the variance of the principal components. The first principal component (the first column of Z) has the largest variance. Condition (iii) is a normalization to set the scale of Z.

Usually the matrix Q is diagonal with elements $q_{ii} = 1/s_{ii}$, where s_{ii} is the sample variance of $\{x_{it}\}$. The transformation from X to Z is unique once Q has been specified, i.e. there exists only one matrix B satisfying conditions (i), (ii) and (iii),[2] see Leamer (1978, Appendix A, theorem 35). The principal components are computed by solving the eigenvalue problem

$$(Q^{1/2}X'XQ^{1/2})(Q^{1/2}B) = (Q^{1/2}B)\Lambda \tag{1}$$

where $Q^{1/2}Q^{1/2} = Q$. Equation 1 shows how the components depend on the choice of the scaling matrix $Q^{1/2}$. Q is not determined in the principal component analysis, but must be specified *a priori* by the user. Q is chosen such that the components Z are invariant to a change in the numéraire currency. To find a suitable matrix Q, one first looks at the effect of a change in the numéraire. Let x_{kj} be the logarithm of the (real) exchange rate of currency j against the numéraire currency k. Letting currency i be the numéraire instead of currency k amounts to the linear transformation:[3]

$$x_{ij} = x_{kj} - x_{ki}, \quad \text{for } j \neq k \tag{2}$$
$$x_{ik} = -x_{ki}.$$

The transformation can be written compactly in matrix notation as

$$x^1 = Px^0 \tag{3}$$

where P is the $n \times n$ matrix:

$$P = \begin{pmatrix} -1 & 0' \\ -\iota_{n-1} & I_{n-1} \end{pmatrix} \tag{4}$$

in which ι is a vector of ones (here of length $n-1$),[4] I is the identity matrix, x^0 is a $n \times 1$ vector of exchange rates in the original numéraire currency, and x^1 is the vector of exchange rates in the new numéraire currency (in this case currency 1). For notational convenience the order of exchange rates is rearranged such that currency 1 became the new numéraire. Transformation to another numéraire currency, say currency k, entails a permutation of the rows and columns of P. An important property of P is that it is unipotent, meaning that $P^2 = I$. Applying the same transformation twice yields the original exchange rates.

Let X_i and X_k be the $T \times n$ matrices of observations on log exchange rates expressed in currency i and k, respectively. A change of the numéraire implies that the data matrix X_i is postmultiplied by P' (after the necessary permutation of columns and rows in P', or of the columns in X_i and X_k). The principal components, Z, are invariant to this change of numéraire if

$$X_iQB_i = Z = X_kQB_k. \tag{5}$$

Using the data transformation matrix P in Equation 4 and

[2] B is unique apart from sign, if all elements of Λ are different, which is henceforth assumed.

[3] Note that the same transformation applies to first differences of log exchange rates, and to all relative variables, such as inflation and interest rate differentials between countries. The numéraire-free principal components transformation is thus more generally applicable.

[4] For notational convenience the subscripts on ι and I will be suppressed when there can be no confusion about their appropriate dimensions.

the fact that P is unipotent one can write

$$X_i Q B_i = X_k (P'QP) P B_i \tag{6}$$

Hence, comparing Equations 5 and 6 the principal components are invariant to the change in the numéraire if Q can be constructed such that $Q = P'QP$, and if the factor loadings are related by $B_k = PB_i$. Moreover, these conditions must hold for all possible numéraire currencies, i.e. all permutations of the transformation matrix P. Partitioning Q^{-1} and expanding the condition $Q = P'QP$ yields

$$\begin{aligned} Q^{-1} &= \begin{pmatrix} q^{11} & q^{12} \\ q^{21} & Q^{22} \end{pmatrix} \\ &= \begin{pmatrix} -1 & 0' \\ -\iota & I \end{pmatrix} \begin{pmatrix} q^{11} & q^{12} \\ q^{21} & Q^{22} \end{pmatrix} \begin{pmatrix} -1 & -\iota' \\ 0 & I \end{pmatrix} \\ &= \begin{pmatrix} q^{11} & q^{11}\iota' - q^{12} \\ q^{11}\iota - q^{21} & q^{11}\iota\iota' - q^{21}\iota' - \iota q^{12} + Q^{22} \end{pmatrix} \end{aligned} \tag{7}$$

where q^{11} is a scalar, q^{12} and q^{21} are $n-1$ vectors, Q^{22} is a $(n-1 \times n-1)$ matrix. From Equation 7 the restrictions obtained are

$$q^{21} = \frac{q^{11}}{2}\iota \quad \text{and} \quad q^{12} = \frac{q^{11}}{2}\iota'. \tag{8}$$

All non-diagonal elements in the first row and column of Q^{-1} must be equal and half the diagonal element. Since this must also hold if columns and rows 1 and j ($j = 2, \ldots, n$) are interchanged, the restrictions in Equation 8 must hold for all columns and rows. Hence, the matrix Q^{-1} has the structure

$$Q^{-1} = \theta(I_n + \iota_n \iota_n') \tag{9}$$

where θ is an arbitrary scalar.[5] Using the matrix inversion lemma this implies that

$$\begin{aligned} Q &= \frac{1}{\theta}\left(I - \frac{1}{n+1}\iota\iota'\right) \\ &= [\theta^{-1/2}(I - \alpha\iota\iota')]^2 = (Q^{1/2})^2 \end{aligned} \tag{10}$$

for $\alpha = [1 - (n+1)^{-1/2}]/n$.[6] It remains to be verified that $B_k = PB_i$ relates the new factor loadings to the old factor loadings. To prove this, condition (ii) is needed in the definition of the principal components. The factor loadings are uniquely determined by the requirement that the principal components are orthogonal with decreasing variances that appear on the diagonal of the Λ:

$$\begin{aligned} \Lambda_i &= B_i' Q X_i' X_i Q B_i \\ &= (B_i'P')(P'QP)(PX_i'X_iP')(P'QP)(PB_i) \\ &= (B_i'P'Q^{1/2})(Q^{1/2}X_k'X_kQ^{1/2})(Q^{1/2}PB_i). \end{aligned} \tag{11}$$

But B_k and Λ_k are also uniquely determined in

$$\Lambda_k = B_k' Q X_k' X_k Q B_k = (B_k'Q^{1/2})(Q^{1/2}X_k'X_kQ^{1/2})(Q^{1/2}B_k). \tag{12}$$

Conditions (11) and (12) define the same eigenvalue problem, since $(Q^{1/2}PB_i)$ and $Q^{1/2}B_k$ are both required to be orthogonal matrices in condition (iii) of the definition of the principal components. Therefore, $B_k = PB_i$, and $\Lambda_k = \Lambda_i$. This completes the proof that there exists a unique set of numéraire free principal components.

If all n components are extracted from the original series the transformation is non-singular and no information in the data is lost. The amount of variation in the data explained by the first K components is expressed by the goodness-of-fit statistic (see Anderson, 1984):

$$R^2(K) = \frac{\text{total variance of first } K \text{ components}}{\text{total variance of transformed data}} \tag{13}$$

$$= \frac{\mathrm{tr}(Z(K)'Z(K))}{\mathrm{tr}[Q^{1/2}X'XQ^{1/2}]} = \frac{\sum_{i=1}^{K} \lambda_i}{\sum_{i=1}^{n} \lambda_i}$$

where $\lambda_1 > \lambda_2 > \ldots > \lambda_n$ are the eigenvalues of $(Q^{1/2}X'XQ^{1/2})$, and $Z(K)$ is the $T \times K$ matrix of the first K principal components of the transformed data $XQ^{1/2}$.

For the interpretation of the components our interest is in the correlation between component i and a time series of real exchange rate x_{ij}. Since the principal components are orthogonal, the total amount of variation in x_{ij} explained by the first K components is the sum of the squared correlations:

$$R_{ij}^2(K) = \sum_{l=1}^{K} r_{ij}^2(l) \tag{14}$$

where $r_{ij}^2(l)$ is the squared correlation between x_{ij} and component l.

The principal component analysis is largely descriptive and only allows for identification of groups of countries with similar real exchange rate patterns. Formal testing is as yet infeasible. In the present analysis, focus is made on a comparison of individual correlations $r_{ij}^2(l)$ with the overall fit measured by $\lambda_l/\sum_{i=1}^{n}\lambda_i$, therefore. A focus is made on the correlations $r_{ij}^2(l)$ exceeding the average fit $\lambda_l/\sum_{i=1}^{n}\lambda_i$; these are printed in bold in the Appendix tables. If a number of real exchange rates is highly – that is, above average – correlated with some principal component, this component is identified with that group.

[5]In a maximum likelihood derivation of the principal components θ has the interpretation of a variance. The choice of θ does not affect the factor loadings; it only serves as a scalar scaling parameter for all time series of principal components.

[6]Another solution is $\alpha = [1 + (n+1)^{-1/2}]/n$. The choice of α is not important, since the principal components depend on Q, not $Q^{1/2}$.

Table 1. *Asian–Pacific real exchange rates (1976:1–1990:3)*

Countries	[a]μ	[b]σ	Min	Max	[c]ρ
AU	0.095	0.133	−0.070	0.414	0.920
HK	1.900	0.126	1.700	2.155	0.940
IN	6.863	0.362	6.309	7.366	0.944
JP	5.241	0.186	4.875	5.559	0.917
MA	0.848	0.140	0.636	1.112	0.948
NZ	0.419	0.158	0.169	0.817	0.915
PH	2.879	0.141	2.678	3.145	0.910
SI	0.706	0.073	0.574	0.820	0.921
KR	6.572	0.116	6.374	6.794	0.966
TH	3.138	0.110	2.981	3.315	0.940

Notes: a. Mean of the series.
b. Standard deviation (degrees of freedom is 59).
c. First-order serial correlation coefficient.
AU = Australia, HK = Hong Kong, IN = Indonesia, JP = Japan, MA = Malaysia, NZ = New Zealand, PH = Philippines, SI = Singapore, KR = South-Korea, TH = Thailand.

III. PARTITIONING ASIAN–PACIFIC EXCHANGE RATES

The following 11 countries were selected for the principal component analysis, Australia (AU), Hong Kong (HK), Indonesia (IN), Japan (JP), Malaysia (MA), New Zealand (NZ), Philippines (PH), Singapore (SI), South Korea (KR), Thailand (TH) and the United States (US). For all currencies nominal exchange rates and prices on a quarterly basis were taken from the IFS data bank over the sample period 1976:1 to 1990:3. All variables are transformed to logarithms. Real exchange rates against the US dollar were constructed as $x = e - p + p^{US}$, where e is the log nominal exchange rate, p is the log of the domestic consumer price index and p^{US} denotes the log of the US consumer price index. Table 1 presents some simple statistics of the real exchange rates used here. Note that the first-order serial correlation coefficient is close to one, indicating that mean-reversion takes considerable time to materialize. Further, except for Indonesia, standard deviations do not differ much across countries.

The main concern is to find empirical regularities in the behaviour of Asian–Pacific real exchange rates between 1976 and 1990. An investigation is made of how the results depend on choice of sample period by comparing for the full-sample period 1976–90 with the subperiod 1986–90. For the use of the reader, the exchange rate regimes in the Pacific region are summarized in Table 2.

Asian–Pacific real exchange rates: the period 1976:1–1990:3

First the sample 1976:1 to 1990:3 is considered, which covers the full period for the Asian–Pacific exchange rates. A summary of the results of the principal component analysis is reported in Table A1 of the appendix. The first part of the table gives some overall statistics of the principal components: the variance of the individual components and the goodness of fit. It takes only three components to explain more than 90% of the total variance. The interpretation of the principal components relies on the correlation between real exchange rates and the first three components. Parts a–d of the table report the squared correlations between the first three components and the corresponding underlying real exchange rates versus each of the benchmark countries in turn. In the present study the Australian dollar, the Hong Kong dollar, the Indonesian rupiah and the Japanese yen are taken as the benchmark currencies. Individual correlations exceeding the average fit of the principal component under consideration are printed in bold characters and are the main focus of discussion.

Table 2. *Current Asian–Pacific exchange rate regimes*

Australian dollar:	Free floating
Hong Kong dollar:	Pegged to US dollar
Indonesian rupiah:	Managed floating
Japanese yen:	Free floating
Malaysian ringgit:	Pegged to basket of currencies
New Zealand dollar:	Free floating
Philippine dollar:	Free floating
Singapore dollar:	Managed floating
Korean won:	Managed floating
Thailand baht:	Pegged to basket of currencies
USA dollar:	Free floating

Source: *AMEX Bank Review* (June 1991).

The first principal component which captures 77% of all real exchange rate movements can be identified as an Indonesian phenomenon. This is exemplified in the first row of part c of the table: the correlations between the first principal component and the real exchange rate *vis-à-vis* Indonesia are very high for each of the countries. The second component, which captures 9% of all real exchange rate movements is identified as a United States phenomenon. The third component which explains 6% of the total variance is a Japanese phenomenon as is illustrated in the third row of part d of Table A1: in 8 out of 11 entries, the correlation of the third principal component with real exchange rates relative to the Japanese yen is exceeding the average.

The dominance of the Indonesian component which captures 77% of all real exchange rate movements is entirely due to three massive devaluations the Indonesian currency experienced between 1978 and 1986. Indonesia's fortunes have for years depended on the price of oil. Whenever there was a major decline in the price of oil like in 1983 and 1986, the Indonesian Government reacted promptly by devalueing the exchange rate. In 1983 the Indonesian rupiah was devalued by 27.6% and in September 1986 by 31%. The large devaluations were not followed by a similar rise in the domestic price level.[7]

[7]For a full account of Indonesian inflation experience see Dornbusch and Fischer (1991).

With respect to the partitioning of the Asian–Pacific real exchange rates, a tentative conclusion would be that movements on the real exchange rates are dominated by three major components and that the 11 countries can roughly be divided into four groups:

1. Indonesia
2. United States
3. Japan
4. Australia, Hong Kong, Korea, Malaysia, New Zealand, Philippines, Singapore and Thailand.

Figure 1 shows the first principal component together with the Indonesian/US real exchange rate.[8,9] The first thing to note in this figure is the large swing in the first component. Compare this component with the real exchange rate of Indonesia. The large devaluations in 1978, 1983 and 1986 can also be seen in the first principal component.

Recently, it has been argued that significant changes in the dominant relations between real exchange rates have taken place since the mid-1980s. In order to investigate this conjecture, the same exercise on the subperiod 1986:3–1990:3 was performed.

Real exchange rates after the Plaza agreement, 1986:3–1990:3

In this section the dominant movements between the 11 Asian–Pacific currencies between September 1986 and September 1990 are investigated. Frankel (1990) reports on changes in the dominant relations between exchange rates in the mid-1980s: 'An obvious point from which to date the switch is 22 September 1985, when Finance Ministers and Central Bank Governors from the G-5 countries met at the Plaza Hotel in New York and agreed to bring the dollar down'. It was decided to start this subperiod in the third quarter of 1986 to exclude the devaluation of the Indonesian rupiah in 1986:2.

The results for the principal components for the period 1986:3–1990:3 are in Table A2 of the Appendix. An important difference between the correlations in Tables A1 and A2 is the disappearance of the Indonesian component. The first component for this period captures 64.5% of all movements and can be identified as an Australian/South Korean phenomenon, as is exemplified in the high correlations of the first principal component with real exchange rates relative to the Australian dollar (part a of Table A2) and to the South Korean won (not shown in tables). The second principal component which now captures 24% of all exchange rate movements can be identified as a New Zealand phenomenon and to a lesser extent as a Japanese phenomenon. The third principal component now captures 6% of all movements and is without any doubt a Japanese phenomenon. The partitioning presented here seems to be in conflict with the popular notion that a yen-block has emerged in the Asian–Pacific region in recent years: a major part of all real exchange rate movements is related to Australia, South Korea and New Zealand and not directly to Japan.

Figure 2 shows the first principal component for the period 1986:3–1990:3 and the Australian real exchange rate (deviations from its mean over the period 1986:3–1990:3). The thing to notice is the decline of the first component over

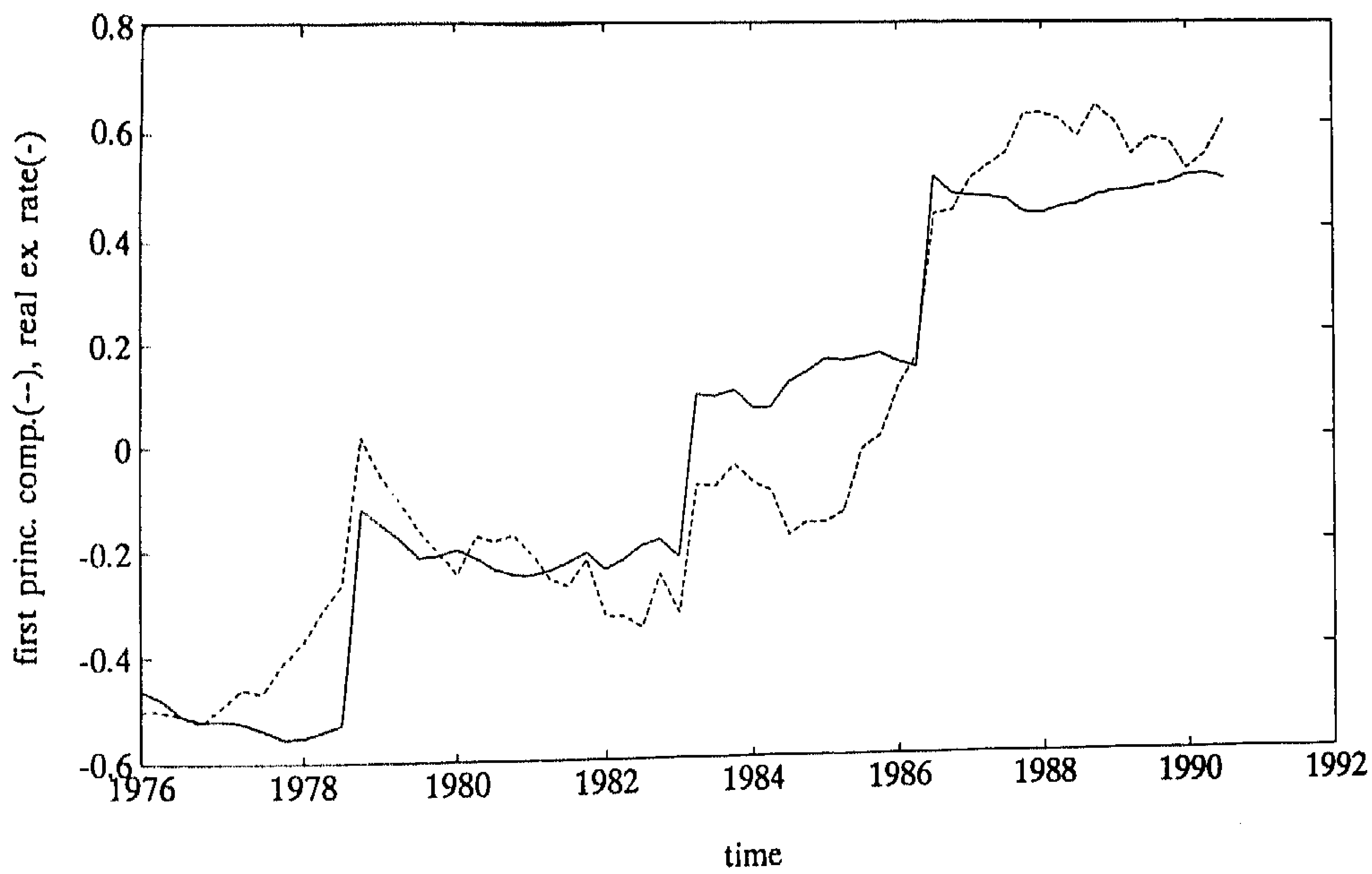

Fig. 1. *Indonesian real exchange rate (——) and first component (------)*

[8]Note that the choice of the numéraire country is an arbitrary one, since a numéraire-free principal components method is used.
[9]The series of the real exchange rate is plotted as the deviation of the real rate from its mean over the period 1976:1–1990:3.

the whole period. Compare this with the real exchange rate of Australia. The real exchange rate experience of Australia and New Zealand during the last few years may be partly caused by the deflationary policies that were pursued in order to tackle the inflation rates of the mid-1980s in these countries.

An important conclusion that can be derived from a comparison of Tables A1 and A2 is that the dominant relations between real exchange rates have not been constant over time. During the first part of the sample period the large devaluations of the Indonesian rupiah dominate the picture, in the second period 1986:3–1991:1, real exchange rate movements relative to Australia, Korea, New Zealand and Japan have become much more important.

IV. DISCUSSION OF RESULTS

In the co-integration literature Stock and Watson (1987) demonstrate how principal component analysis is connected to tests for the number of unit roots in a multivariate time series and the estimation of co-integrating vectors. These links enable a further interpretation of the principal component analysis presented here, and of tests of long-run PPP.[10]

The long-run PPP hypothesis is the fundamental equilibrium relation for the level of real exchange rates, and as such PPP is a crucial building block of models of exchange rate determination. While the data overwhelmingly reject instantaneous PPP, long-run PPP is still much debated. In testing long-run PPP one looks for evidence that real exchange rates return toward equilibrium values over time. The hypothesis of long-run PPP is violated if real exchange rates follow a random walk and thus contain a unit root.

The intimate relation between long-run PPP and the partitioning of real exchange rates using principal components analysis raises several interesting questions with regard to the determination of real exchange rates. Why do some countries exhibit similar real exchange rate behaviour, while others do not? An explanation would be that the countries that belong to the same group are closely connected through trade. Hence, any persistent movements in their real exchange rate will disappear by goods arbitrage, and PPP can be expected to hold closely. The harder questions arise when PPP breaks down. What is the important difference between two countries if their real exchange rate is highly correlated with the dominant principal components? The literature, which has concentrated on putting forward explanations for the major currencies like US dollar, German mark, Japanese yen and British pound, distinguishes two sets of explanations.[11] The first stresses real factors to account for movements in the expected long-run equilibrium real exchange rate. Work by Marston (1986) and Krugman and Baldwin (1987) suggests that the movements in the real dollar/yen exchange rate can be accounted for by the large difference in

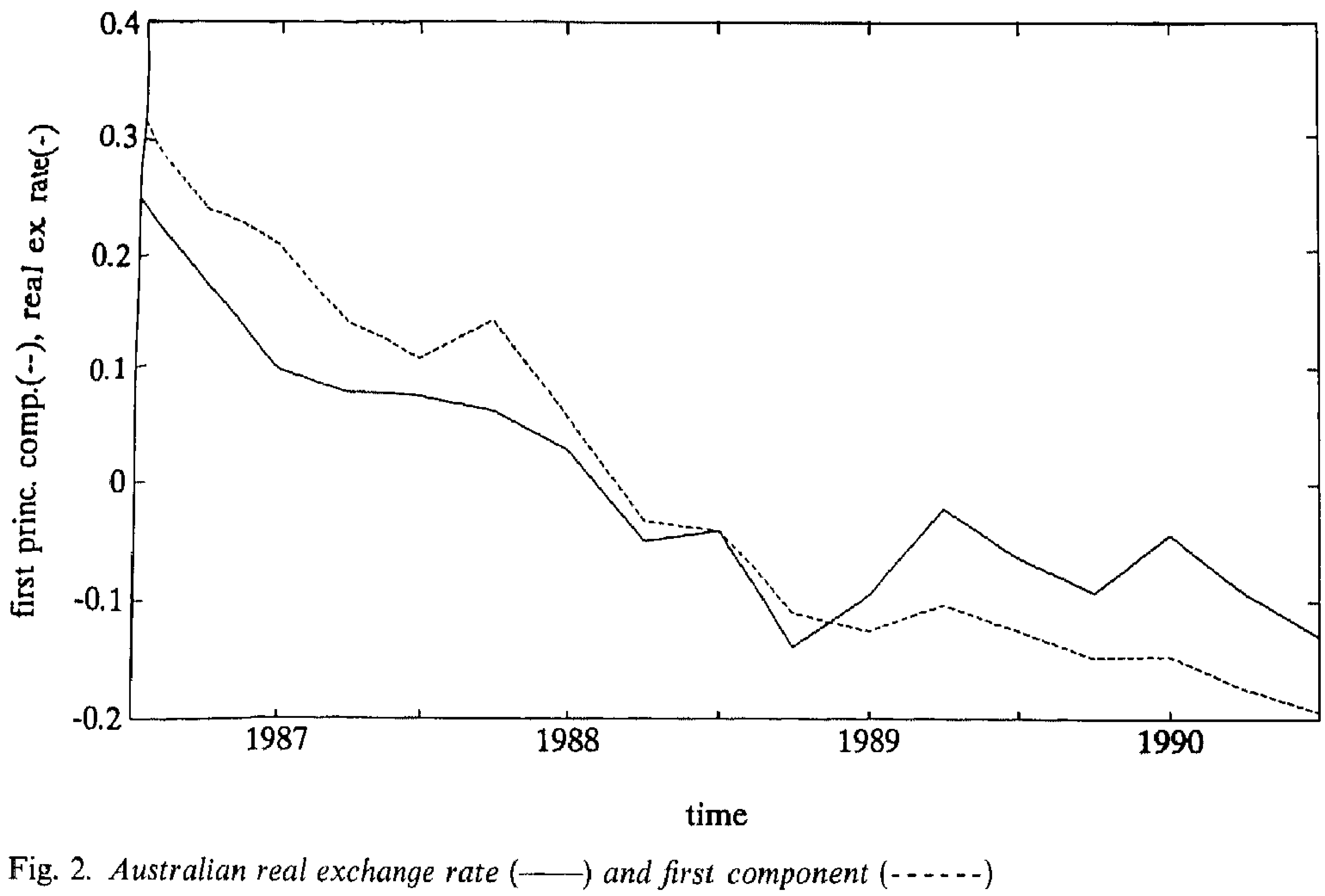

Fig. 2. *Australian real exchange rate (——) and first component (------)*

[10]Hakkio and Rush (1991) show that co-integration tests applied to short samples have low power in the case of high serial correlation in the data. Another study by Diebold *et al.* (1991) stresses the same point. In other words, co-integration is a long-run property of the data.
[11]Recently, it has been suggested by Frankel (1990) that the exchange rate policy played an important role in the case of the Japanese yen and the South Korean won.

productivity growth in the tradeable goods sectors in the United States and Japan.[12]

The other explanation looks at monetary factors. Real exchange rates deviate from long-run equilibrium because monetary policy between countries is systematically different, resulting in persistent inflation or real interest rate differentials. The inflation or money growth explanation is advanced in Lothian (1987). A strong real appreciation accompanied by high interest rates and relatively high inflation rates suggests that the monetary explanation was especially relevant for Australia and New Zealand in recent years.

V. CONCLUSIONS

The relations between all possible bilateral real exchange rates for 11 Asian–Pacific countries using quarterly data for the period 1976:1–1990:3 are investigated. To extract the dominant movements in real exchange rates, the standard principal component analysis was modified such that the principal components are invariant with respect to the choice of a numéraire currency. Note that this method is applicable to all relative variables, such as inflation and interest differentials between countries.

Application of the numéraire-invariant principal components technique and our interpretation of the descriptive evidence suggests that the chosen set of countries might be partitioned in four groups. Countries within the same group share the same (long-run) real exchange rate characteristics. For the sample 1976:1–1990:3, Indonesia, the United States and Japan are the leading countries, suggesting that deviations from PPP between these countries are most severe. In addition to presenting full-sample results, results are provided for the subperiod 1986:3–1990:3 since it has been suggested in the literature that a significant regime switch in exchange rate policy making took place around that time following the Plaza Accord. The covariance structure of dominant relations between Asian–Pacific real exchange has been found to change considerably. Dominant movements in the Asian–Pacific rim are now much more related to Australia, South Korea, New Zealand and Japan. Since a major part of all movements is not related to Japan during this period, the hypothesis of an emerging yen-block is not supported by the real exchange rate data.

APPENDIX

Table A1. *Partitioning Asian–Pacific real exchange rates, 1976:1–1990:3*

Component	1	2	3	Cumulated (1–3)
Variance	0.1464	0.0179	0.0112	
Fit (%)	77.5	9.5	6.0	93.0

	AU	HK	IN	JP	KR	MA	NZ	PH	SI	TH	US
a. *Australia is benchmark country*											
1	—	10	**92**	71	24	29	73	22	0	16	13
2	—	5	0	0	7	**38**	3	**16**	**71**	**47**	**67**
3	—	14	6	25	1	21	5	4	14	10	9
1–3	—	29	98	96	32	88	81	42	85	73	89
b. *Hong Kong is benchmark country*											
1	10	—	**93**	**84**	43	20	**78**	17	6	2	33
2	5	—	1	0	0	**37**	6	**16**	**54**	32	**53**
3	**14**	—	3	**13**	**18**	**9**	0	0	0	0	1
1–3	29	—	97	97	61	66	84	33	60	34	87
c. *Indonesia is benchmark country*											
1	**92**	**93**	—	**99**	**92**	**81**	**98**	**84**	**90**	**88**	**88**
2	0	1	—	0	1	**15**	0	5	8	7	**11**
3	**6**	3	—	1	6	0	1	4	2	3	1
1–3	98	97	—	100	99	96	99	93	100	98	100
d. *Japan is benchmark country*											
1	71	**84**	**99**	—	63	**88**	30	**83**	**78**	**82**	55
2	0	0	0	—	0	7	9	2	8	4	**27**
3	**25**	**13**	1	—	**36**	3	**42**	**11**	**13**	**11**	**15**
1–3	96	97	100	—	99	98	81	96	99	97	97

Note: Numbers in bold are larger than the fit from the principal components analysis.

[12]See also Stockman (1983) for a theoretical framework and some empirical evidence based on real factors.

Table A2. *Partitioning Asian–Pacific real exchange rates, 1986:3–1990:3*

Component	1	2	3	Cumulated (1–3)
Variance	0.0246	0.0092	0.0023	
Fit (%)	64.5	24.0	6.0	93.5

	AU	HK	IN	JP	KR	MA	NZ	PH	SI	TH	US
a. *Australia is benchmark country*											
1	—	59	**95**	**81**	2	**98**	23	**83**	**82**	**93**	**92**
2	—	**27**	0	11	**24**	0	**53**	6	7	3	5
3	—	2	0	5	**11**	1	**14**	0	1	0	0
1–3	—	88	95	97	37	99	90	89	90	96	97
b. *Hong Kong is benchmark country*											
1	59	—	**65**	33	**75**	**89**	3	52	59	**78**	**85**
2	**27**	—	**27**	**54**	6	8	**92**	6	20	17	8
3	2	—	1	**12**	**11**	0	4	1	0	1	0
1–3	88	—	93	99	92	97	99	59	79	96	93
c. *Indonesia is benchmark country*											
1	**95**	**65**	—	4	**94**	**91**	49	22	43	17	9
2	0	**27**	—	**60**	2	1	**42**	**37**	**20**	**39**	**78**
3	0	1	—	**31**	2	3	**7**	0	1	0	0
1–3	95	93	—	95	98	95	98	59	64	56	87
d. *Japan is benchmark country*											
1	**81**	33	4	—	**77**	20	62	10	21	8	5
2	11	**54**	**60**	—	20	**45**	3	**64**	**58**	**70**	**73**
3	5	**12**	**31**	—	1	**31**	**35**	**16**	**19**	**22**	**20**
1–3	97	99	95	—	98	96	100	90	98	100	98

Note: Numbers in bold are larger than the fit from the principal components analysis.

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