IMF Working Paper

WP/99/120 INTERNATIONAL MONETARY FUND

Research Department

Measuring Misalignment: Purchasing Power Parity and East Asian Currencies in the 1990s

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September 1999

Abstract

The concept of purchasing power parity (PPP) is used to evaluate whether eight East Asian currencies were overvalued on the eve of the 1997 crises. The Johansen and Horvath-Watson cointegration test procedures are applied to bilateral and multilateral exchange rates, deflated using CPIs, producer price indices (PPIs), and price indices of export goods. The second deflator yields the greatest evidence of "stationarity." The study find's that the Malaysian, Philippines, and Thai currencies were overvalued, while the Korean and Indonesian were substantially undervalued. Mixed results were obtained for the others. Measures of the equilibrium rate based on time trends in CPI-deflated rates typically suggest larger overvaluations.

JEL Classification Numbers: F31, F41, F47

Keywords: exchange rate, purchasing power parity, overvaluation, cointegration

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[1]Visiting scholar, Research Department. The author thanks Janice Boucher Breuer, Yin-Wong Cheung, Hali Edison, Neil Ericsson, Ilan Goldfajn, Steve Kamin, Mark Stone, and seminar participants at the Federal Reserve Board and the IMF for valuable comments. All remaining errors are the sole responsibility of the author.

Contents

I. INTRODUCTION

In order to discern the causes of the 1997 East Asian currency crises, and project the future evolution of exchange rates in the East Asian region, one requires some operational measure of the equilibrium rate. In this paper I focus on a price-based measure of equilibrium, namely purchasing power parity (PPP). I first test for PPP, then use estimates of the equilibrium rate to calculate the degree of misalignment, and presumably overvaluation, on the eve of the 1997 currency crises.

There are a number of plausible and operationally useful definitions of equilibrium exchange rates. Three broad definitions (see Milesi-Ferretti and Razin, 1996, and Williamson, 1994) in use include:

1. Price based criteria, such as purchasing power parity and its variants.
2. Model based criteria, based on a formal model of nominal exchange rates.
3. Solvency and sustainability based criteria, which make reference to trends in the current account and the external debt to GDP ratio.

It turns out that the economic relevance of each criterion is inversely related to the difficulty of implementing it. Price based criteria are relatively easy to implement, but do not address the economically interesting question of whether a particular exchange rate is at an "optimal level," besides that defined by a no-arbitrage condition. On the other hand, the sustainability measures can make reference to an optimal level, but are very difficult to calculate as they require a fully-fleshed out macroeconomic model.[2] Moreover, in order to make a statement about optimality, such models need to take a stand on representative agent behavior. Given these difficulties, in this paper I set out to meet the rather more modest goals of implementing only the first criterion.

The paper proceeds in the following manner. In Section II, the price based measures are described and the tests for purchasing power parity undertaken. In Section III the calculations of equilibrium rates are reported. Section IV concludes.

To anticipate the results, I find that all the East Asian real exchange rates examined are mean reverting. This is a new finding, which opens the way to using the mean of the real exchange rate as an estimate of equilibrium.[3] According to this measure of equilibrium, the Malaysian ringgit, Thai baht and Philippine peso were overvalued on the eve of the 1997

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[2]For examples, see Bayoumi *et al.* (1994) and Driver and Wren-Lewis (1996).

[3]If the real exchange rate were found to be nonstationary, or integrated of order one, then one would need to search for other variables cointegrated with it. Chinn (1997) undertakes such an investigation for East Asian GDP deflator adjusted rates.

crisis. Surprisingly, the Indonesian rupiah does not show up as overvalued, while the Korean won shows up as undervalued even before the November currency crash.

II. Price Based Measures of the Equilibrium Rates

A. Theoretical Background to Purchasing Power Parity

The equilibrium exchange rate is often associated with an international version of the Law of One Price (LOP): abstracting from transport costs, identical goods in different countries have the same price, when expressed in common currency terms

$$s_t + p_t^{i*} = p_t^i \tag{1}$$

where s_t is the exchange rate in U.S. dollar/local currency unit (yen/local currency unit), p^i_t is the price of a U.S. (Japanese) widget, and p^{i*}_t is the price of a local widget in local currency units. An arbitrage argument is usually offered to explain why this condition should hold.

At this juncture, data limitations intrude. Typically, one does not have prices for identical goods; rather one observes price indices, p, for bundles of goods. These indices do not usually ascribe the same weights to each good, nor are the quality attributes of these goods the same, so that direct testing of LOP is not possible. What one can test is how well purchasing power parity (PPP) holds up to a constant κ which depends upon the base year of the price indices,

$$\begin{aligned} & s_t + p_t^* = p_t + \kappa \\ \Rightarrow \quad & q_t \equiv s_t - p_t + p_t^* - \kappa \end{aligned} \tag{2}$$

where q is the real exchange rate.

The consensus in the profession is that PPP does not hold continuously, so I will only concern myself with testing for long run PPP. Even relaxing this restriction, there is a possibility that PPP does not hold when one interprets the price index as one pertaining to a broad set of goods and services (see Breuer, 1994; Froot and Rogoff, 1995).[4] Since some of the items in a typical consumption or production bundle are not tradable and subject to competitive price pressures from international trade, this assertion is not implausible, and one might consider using a wholesale or producer price index (WPI or PPI), that covers goods considered to be highly tradable. On the other hand, since consumer bundles might be more

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[4]For a contrasting view, see the panel regression studies by Frankel and Rose (1996), MacDonald (1996), Oh (1996) and Wu (1996).

similar across countries than producer or wholesale bundles, consumer price indices (CPIs) may provide a more consistent measure of price levels and thus of real exchange rates.

I am agnostic on the issue of appropriate of deflator, so I consider both measures using the PPI as well as the CPI. Finally, if the countries of interest are exporting to primarily third country markets, then the export price index may be the more appropriate deflator. The key drawback of these data is that export unit value indices are notoriously subject to measurement error; moreover, the composition of the bundles of exports are likely to vary even more widely across countries than the corresponding PPI bundles, so the possibility of finding nonstationary real exchange rates is heightened.

At this point it is useful to define explicitly my usage of the terms PPP and equilibrium. I consider PPP a concept applicable to price indices, whereas other researchers consider tests applied to narrow price indices a test for the law of one price. I do not take a stand on which term is better; merely that some form of price equalization constitutes a definition of equilibrium. Further, the concept of equilibrium is *statistical* to the extent that there is no formal economic model of how price levels and exchange rates are driven to the conditional mean of the real exchange rate.

B. Methodology

The standard approach to testing for an equilibrium real exchange rate based on prices is to implement a unit root test, such as the following Augmented Dickey-Fuller (ADF) regression,

$$\Delta q_t = \gamma_0 + \Gamma q_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta q_{t-i} + \epsilon_t \qquad \textbf{(3)}$$

which yields an estimate of the rate of reversion toward PPP of $\Gamma < 0$. As is well known, such tests possess low power against local alternatives. Hence previous attempts to find mean reversion using univariate techniques have usually failed.

The low power of such unit root tests may be due to the imposition of inappropriate common factor restrictions implicit in the ADF specification (Kremers, Ericsson and Dolado, 1992). In estimating an ADF on the real exchange rate, one forces the short run dynamics for the nominal exchange rate and both price levels to be the same. In principle, there is no reason to believe that this condition should hold. A more general specification implied by cointegration is:

$$
\begin{aligned}
\Delta s_t &= \Phi_1[\beta_1 s+\beta_2 p+\beta_3 p^*]_{t-1} + \sum_{i=1}^{k}\gamma_{1i}\Delta s_{t-i} + \sum_{i=1}^{k}\zeta_{1i}\Delta p_{t-1} + \sum_{1=i}^{k}\nu_{1i}\Delta p^*_{t-1} + \epsilon_{1t} \\
\Delta p_t &= \Phi_2[\beta_1 s+\beta_2 p+\beta_3 p^*]_{t-1} + \sum_{i=1}^{k}\gamma_{2i}\Delta s_{t-i} + \sum_{i=1}^{k}\zeta_{2i}\Delta p_{t-1} + \sum_{1=i}^{k}\nu_{2i}\Delta p^*_{t-1} + \epsilon_{2t} \\
\Delta p^*_t &= \Phi_3[\beta_1 s+\beta_2 p+\beta_3 p^*]_{t-1} + \sum_{i=1}^{k}\gamma_{3i}\Delta s_{t-i} + \sum_{i=1}^{k}\zeta_{3i}\Delta p_{t-1} + \sum_{1=i}^{k}\nu_{3i}\Delta p^*_{t-1} + \epsilon_{3t}
\end{aligned}
\qquad \textbf{(4)}
$$

Johansen (1988) and Johansen and Juselius (1990) describe the maximum likelihood method of estimating this vector error correction model (VECM) and for testing cointegration. A likelihood ratio test can be applied to the restriction that (β_1 β_2 β_3) takes on the value (1 -1 1). Cheung and Lai (1993b) are among the first to apply this approach; they find evidence for cointegration, but reject the unitary coefficient restriction implied by strict PPP.

Since one has prior information on the form of the cointegrating vector, a more powerful test of the null of no cointegration against the alternative of cointegration with a pre-specified cointegrating vector can be applied. Horvath and Watson (1995) tabulate the critical values for a Wald test on the joint null hypothesis that all Φ coefficients equal zero. Rejection of this null hypothesis implies cointegration because the variables, either singly or jointly, revert back to the conditional mean defined by the cointegrating vector. Edison, Gagnon and Melick (1997) apply this test and find mixed evidence for PPP for the G-7 currencies during the post-Bretton Woods .

C. Data

The countries of interest are Hong Kong-PRC, Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan, and Thailand. I generate the bilateral real exchange rates against both the U.S. dollar and the Japanese yen. Most series are from the IMF's *International Financial Statistics* database, and span the 1970.01–1998.03 period. The Taiwanese data are from Bank of China, *Financial Statistics*, various issues, as recorded in Federal Reserve Bank of San Francisco electronic database. The exchange rates are end-of-month data, expressed in U.S. dollar/local currency unit [inverse of *IFS* line *ae*]. Exchange rates against the yen are calculated by dividing by the U.S. dollar/yen rate.

For the broad based deflator, I use the CPI [*IFS* line 64]. For the "tradable" price based deflator, I use the PPI or WPI data reported in *IFS* line 63. The Indonesian PPI data exclude petroleum products [*IFS* line 63a], while the Hong Kong PPI data are quarterly, from the Hong Kong Department of Census and Statistics. The export price data are unit value indices [*IFS* line 74].

In principle, one should use trade weighted measures of the real exchange rate. The problem that one encounters is that the pattern of trade flows change substantially over the sample period and hence so too do the appropriate trade-weights. Nonetheless, I also examine the trade-weighted CPI deflated real exchange rates calculated by the IMF, and PPI deflated real exchange rates reported by Morgan Guaranty.[5] The bilateral (against U.S. dollar and yen) PPI-deflated exchange rates (rescaled to have a base of zero (in log terms) in 1990) are presented in Figures 1-8 for the East Asian currencies studied.

The time series patterns of the multilateral exchange rates do not differ greatly between those of the two bilateral exchange rates. In general the results from the multilateral rates will be some combination of the results from the bilateral rates. This outcome makes sense as the United States and Japan accounted for a large portion of these countries' imports and exports in 1996 (see Appendix I). As a digression, notice that there has been some reversion in the wake of the currency crashes of 1997, particularly for Korea, Thailand and Malaysia. Indonesia stands out as a notable exception.

Table 1 presents some summary statistics on trends in the various real exchange rate measures estimated from the regression

$$\Delta q_t = \delta + u_t \tag{5}$$

over the 1975.01–1996.12 sample period (except where indicated in the Table notes). There is no obvious difference in the drift estimates for the bilateral CPI-deflated dollar and yen series. The drift term estimates range from a depreciation of 0.0047/mo. (5.6 percent per year) of the Indonesian rupiah against the dollar, to an appreciation of 0.0009/mo. (1.1 percent per year) of the New Taiwan dollar against the U.S. dollar. The Hong Kong dollar drift estimates are not strictly comparable with the other estimates because the bilateral CPI series only begins in 1990. However the rate of appreciation over this period is remarkable–5.3 percent per year.

In contrast, the drift term for the PPI adjusted bilateral exchange rates are typically smaller (in absolute value) than their CPI-deflated counterparts. Furthermore, none of the drift estimates are statistically significant. These two results suggest that PPI's are a better measure of tradables prices than CPI's.

Interestingly, the real exchange rates defined using export price indices exhibit substantial drift terms. For the most part, the real exchange rates are depreciating against the dollar and yen. The only exception is the Singapore dollar. The presence of substantial, but imprecisely estimated, drift terms suggests that such price indices are subject to greater measurement error. In particular, the export bundles of these NICs have probably changed

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[5] The IMF series are described in Zanello and Desruelle (1997). The Morgan Guaranty series are the "broad" effective exchange rate indices, as described in *World Financial Markets* (1993). The Morgan Guaranty series are based on 1990 trade weights for the 1987–97 period, and 1980 weights for the preceding period.

Figure 1: Hong Kong

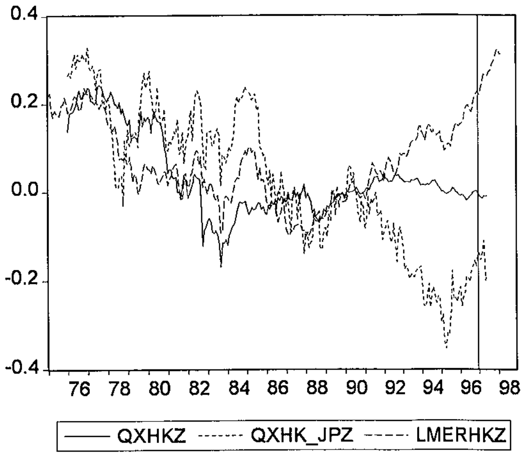


Figure 2: Indonesia

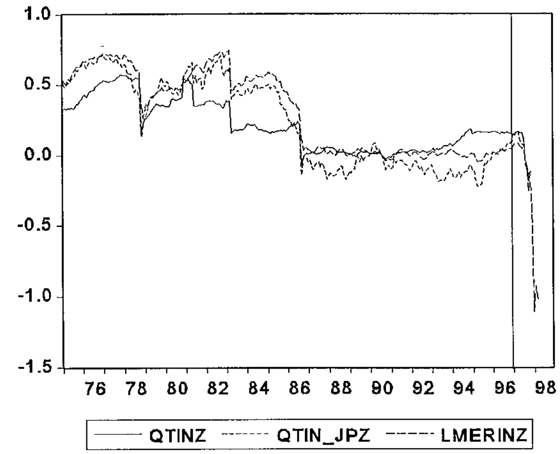


Figure 3: Malaysia

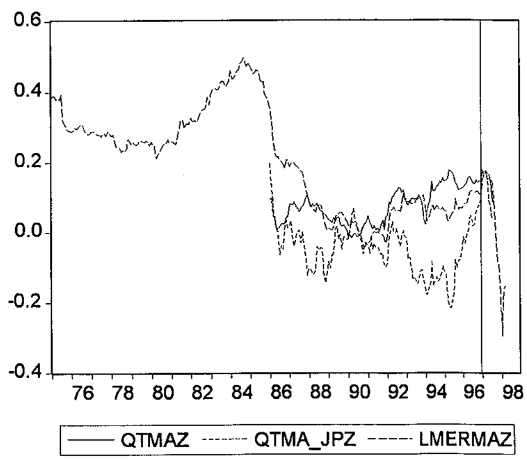


Figure 4: Korea

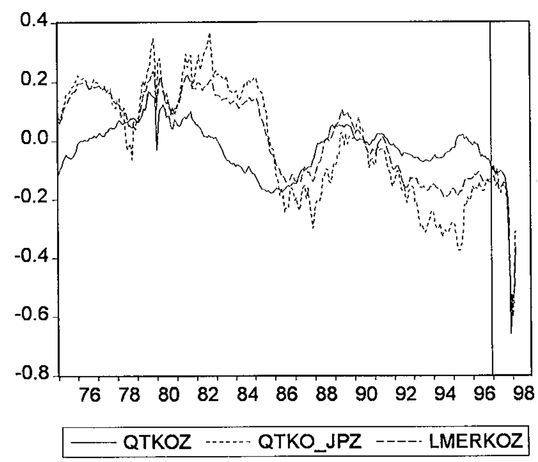


Figure 5: Singapore

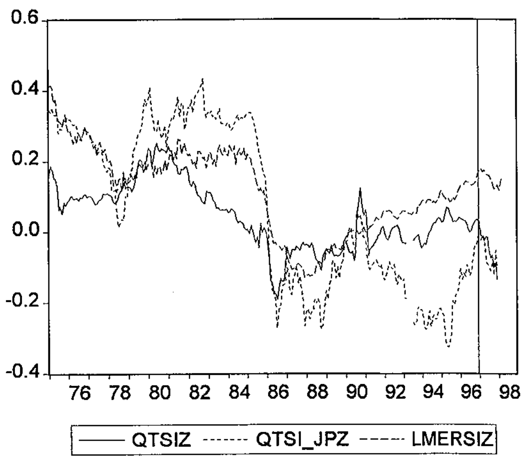


Figure 6: Philippines

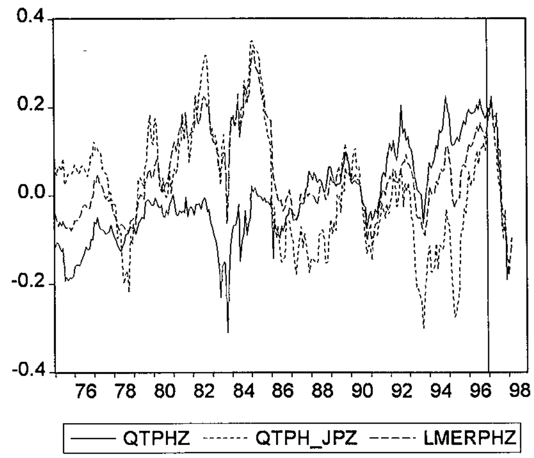


Figure 7: Thailand

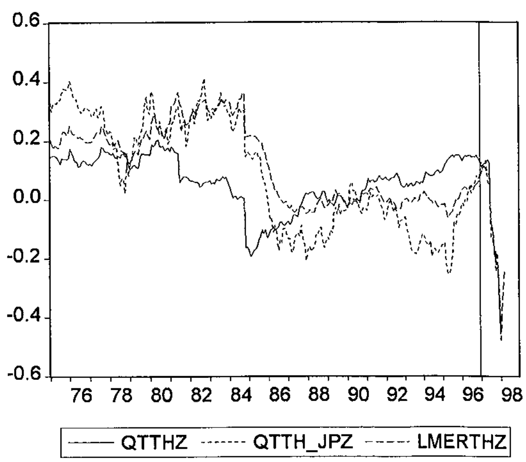
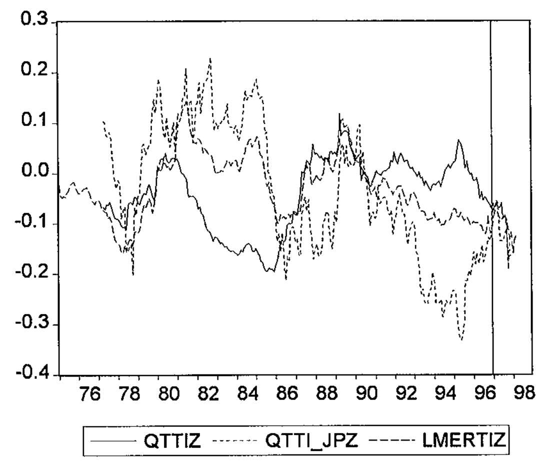


Figure 8: Taiwan



substantially over time, introducing drift in the price indices[6] (the Japanese yen/dollar rate is an exception; it is likely that the composition of the Japanese export bundle has changed less drastically over the sample period). Given the results reported above, the subsequent analysis will focus on the PPI deflated real exchange rates.

D. Empirical Results

Unit Root and Johansen Test Results

The ADF test was applied to all the real exchange rate series (results not reported). Only about four cases appeared to be stationary, a proportion about consistent with what would be expected to occur by chance.

The results of applying the Johansen procedure are reported in Table 2. Panel 2.1 presents the CPI results. Excepting Indonesia, there is evidence of cointegration, even using the finite sample critical values (Cheung and Lai, 1993a). However, there are quite a few perversely signed and statistically significant coefficients. For instance according to the Johansen estimates, for each 1 percent rise in the Hong Kong CPI, the Hong Kong dollar appreciates by 0.14 percent; a 1 percent rise in the US CPI *de*preciates the Hong Kong dollar against the U.S. dollar.

Skipping to the export price deflated exchange rate results in panel 2.3, one finds that the U.S. export price index either enters in with incorrect sign, or with correct sign and a significant difference from the anticipated unitary coefficient (excepting the Philippine peso).

On the other hand, the PPI based results in panel 2.2 indicate some support for the PPP hypothesis in two cases: the Korean won and the Singapore dollar. While the Philippine peso and the Taiwan dollar also fit into the model qualitatively, the null hypothesis of unitary coefficients on the US PPI is rejected. The results of applying the Johansen procedure to the yen based rates are similarly mixed and consequently are not reported.

Horvath-Watson Cointegration Test Results

Table 3 reports the results of applying the Horvath Watson procedure for the U.S. dollar, the Japanese yen, and the trade weighted exchange rates (TWXR). The export price deflated rates can be dispensed with immediately, as only the Thai baht shows up as stationary. Turning to the PPI based results, one finds that the Wald test statistic rejects the no-cointegration constraint for the trade weighted Hong Kong dollar, the rupiah, won and

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[6]Ito, Isard and Symansky (1996) argue that machine exports have increased substantially for these East Asian countries, thus contributing to real exchange rate appreciation as measured using standard deflators which include nontradables.

baht (against the U.S. dollar) and the ringgit and Philippine peso (against the Japanese yen). Among the currencies of the East Asian NICs, only the Singapore and Taiwanese stand out as nonstationary. However, the latter currency, deflated by the CPI, does appear to be stationary, on a bilateral basis against either the U.S. dollar or the yen. Hence, only the Singapore dollar appears nonstationary on all counts (although the Singapore dollar *does* fulfill the PPP conditions according to the Johansen results described earlier).

Some other interesting results are obtained. First, the PPI-deflated won/yen rate does not mean-revert, which is surprising given the apparently close link between the Korean and Japanese economies. Second, the trade weighted indices do not typically evidence mean reversion, with the exception of the PPI deflated Hong Kong dollar and the Malaysian ringgit. This finding may obtain because of the shifts in the trade weights used in calculating the Morgan-Guaranty series.[7]

Considering all the CPI- and PPI-deflated rates (against the dollar, yen and multilateral), evidence of mean reversion is found for all the region's currencies. Therefore, the results reported above are more favorable to the PPP hypothesis than those obtained in previous studies of the East Asian currencies. Phylaktis and Kassimatis (1994), and Fukuda and Kano (1997) find mean stationarity in PPI deflated bilateral exchange rates of the won, and peso against the dollar, and the ringgit against the yen. Lee (1999) finds mean reversion for the PPI deflated rupiah, won, ringgit, peso and Singapore dollar (expressed against the U.S. dollar) over longer samples spanning both the pre- and post-Bretton Woods periods.[8]

III. Estimated Equilibrium Rates

A. Baseline Results

Based on the Horvath-Watson and Johansen test results, mean stationarity of the PPI deflated rate is found for the rupiah, won, baht and Singapore dollar (against the U.S. dollar),

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[7]Since Morgan Guaranty does not report the nominal trade weighted indices corresponding to the real indices, it is not possible to estimate directly the implied error correction model. Furthermore, without the weights, it is not possible to construct the rest-of-world price level. I proxy the nominal rate with the IMF nominal trade weighted exchange rate, and the rest-of-world PPI with the corresponding IMF rest-of-world CPI. To the extent that both of these (the nominal exchange rate and the rest-of-world CPI) enter in as first difference terms, the effect on the results should be second order.

[8]Bahmani-Oskooee (1993), Tang and Buitong (1994), Baharamshah and Ariff (1997) and Chou and Shih (1995) find evidence of cointegration for several currencies, but reject the symmetry and proportionality conditions that are required for mean reversion in real exchange rates.

the ringgit and peso (against the yen), and the Hong Kong dollar and ringgit on a multilateral basis. Finally, the CPI deflated New Taiwan dollar is mean stationary against both the U.S. dollar and the yen (although the Horvath-Watson test indicates stronger rejection of the no cointegration null when using the yen bilateral rate). Then one can assess misalignments, keeping these results in mind.

The real exchange rates are centered using a regression of the real rate on a constant, to allow for the base year effect. In some previous studies, the predicted real rate has been allowed to move with a linear deterministic trend (*e.g.*, one of the detrended series in Goldfajn and Valdes, 1999). To compare my results against this alternative measure, I also calculate an alternative estimate of the equilibrium rate which allows for a trend in the CPI-deflated exchange rate.

$$q_t^{CPI} = \mu_0 + \mu_1\tau + v_t \tag{6}$$

where τ is a time trend.

For illustrative purposes, the equilibrium dollar rates and actual levels are plotted in Figures 9-16. The over- and undervaluation calculations for 1997.05 and the two year period preceding that are presented in Table 4, with entries in bold face denoting cases where the cointegration tests indicate that the calculated deviations are meaningful. The PPI-based results indicate a May 1997 undervaluation of the Indonesian rupiah (6 percent), won (9 percent) and Singapore dollar (6 percent), and overvaluation for the Malaysian ringgit, Philippine peso and Thai baht (8 percent, 19 percent and 7 percent respectively). But of these last three, only the last one is a valid measure according to the cointegration tests. By way of comparison, the CPI w/trend measures imply larger overvaluations of 17 percent, 24 percent and 13 percent, respectively. Moreover, this latter calculation implies that the Indonesian rupiah was also overvalued by 30 percent (as opposed to the 5 percent implied undervaluation I obtain using PPIs).[9] Even though the CPI based estimates accord more closely with some popular accounts, the PPI based estimates are to be preferred on econometric grounds. Hence, one puzzle contained in these calculations is why the misalignments are so modest in magnitude (or even negative).

The foregoing discussion has only a few instances of economically significant overvaluations.This mystery of the missing overvaluation is compounded when one turns to the statistical significance of the deviations.To investigate whether the deviations from mean were statistically significant, I calculated the ± 2 standard error bands around the predicted equilibrium-PPP values. Because of serial correlation in the real exchange rate series, robust

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[9]Two anomalous implications of the CPI-based measures are that the Singapore dollar is substantially overvalued (13 percent), while the Japanese yen is undervalued (16 percent) at this time.

Figure 9: Indonesia Actual and Predicted

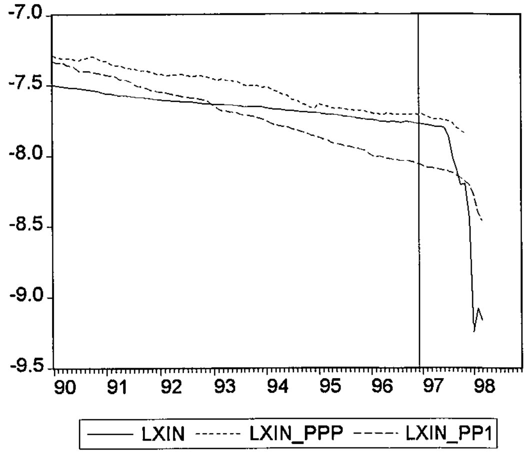


Figure 10: Malaysia Actual and Predicted

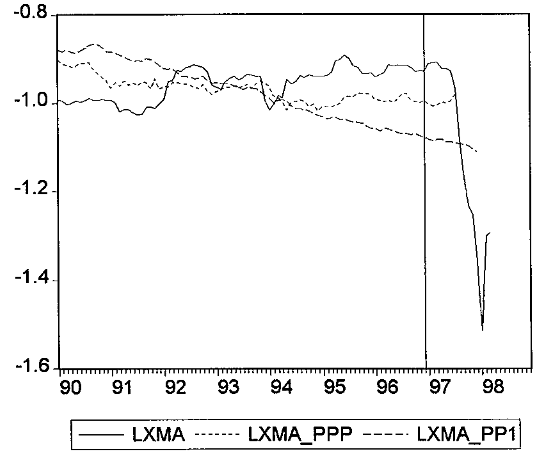


Figure 11: Philippine Actual and Predicted

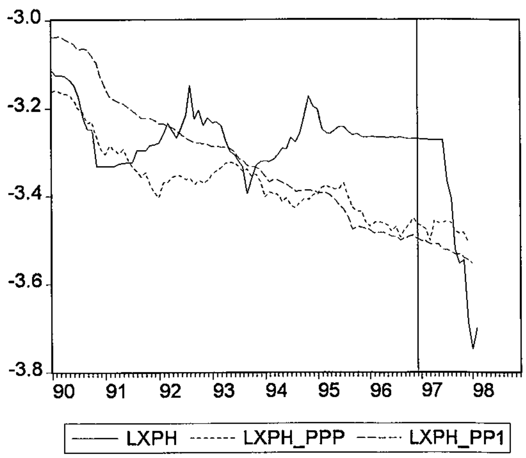


Figure 12: Singapore Actual and Predicted

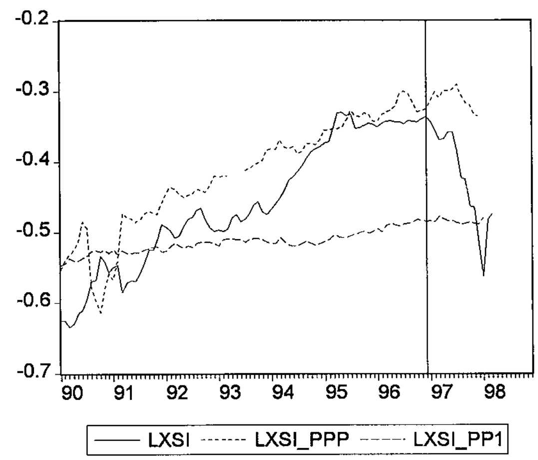


Figure 13: Hong Kong Actual and Predicted

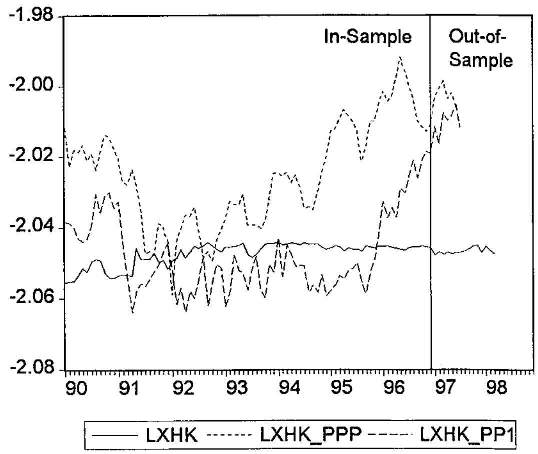


Figure 14: Korea Actual and Predicted

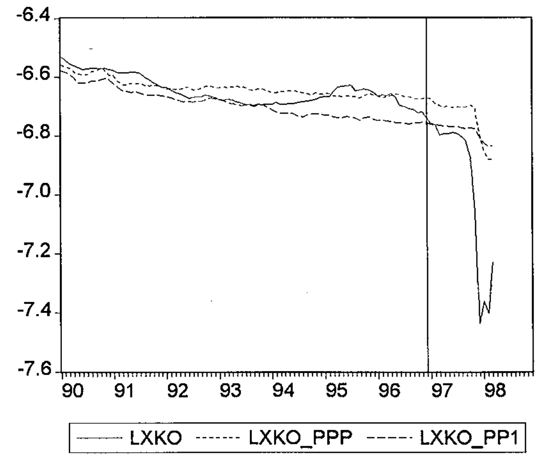


Figure 15: Thai Actual and Predicted

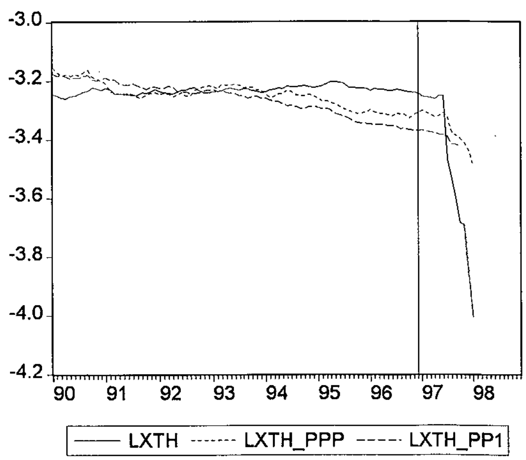
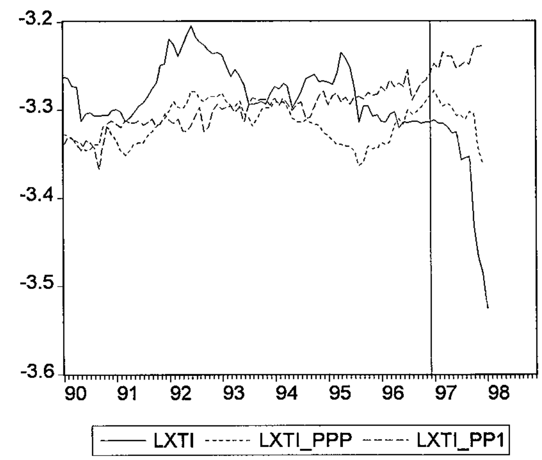


Figure 16: Taiwan Actual and Predicted



standard errors were calculated using the suggested truncation lag suggested by Newey and West). None of the relevant U.S. dollar based exchange rates (including the baht) were near the boundaries of the band. However, the yen based Philippine peso did exceed the ±2 s.e. band.

Considering the average deviations over the two years preceding the crisis does not directly resolve the mystery, as the pattern of overvaluations remains much the same as before. However, this finding is interesting in its own right; it suggests a relatively slow reversion to PPP over this period. Moreover, if the *duration* of the overvaluation matters as much as the magnitude, then one may have a partial solution to the mystery of why these modest overvaluations subsequently evolved into such severe depreciations. A prolonged period of overvaluation surely has qualitatively different effects on an open economy than a short-lived one (as suggested by the contemporaneous trade deficits suffered by most of these countries). Thailand, the Philippines and Malaysia experienced about 3 ½ years of overvaluation before the currency crises of 1997. Indonesia also joins this group if the equilibrium rate is estimated from the 1986-96 period (see below).

B. Robustness Checks

Given our uncertainty regarding all types of PPP calculations, it makes sense to undertake some robustness checks against the use of different sample periods and of alternative currencies. I recalculated the equilibrium values, using the 1986.01–1996.12 period instead of the 1975.01–1996.12. If the real exchange rate series were truly mean stationary, changing the sample period should not matter very much. In fact, the estimates do not change significantly, except for the Indonesian rupiah. In this case, the rupiah is about 9 percent overvalued as of 1997.05, as well as for the two year period preceding that.

Table 5 presents the overvaluation calculations for the yen rates. These PPI-based results are at some variance with the previous results. They indicate that as of May 1997, all the East Asian currencies were undervalued except the Malaysian ringgit and Philippine peso. These two currencies are exactly the ones that, according to the statistical tests, are mean reverting. Hence, one can take the 14 percent overvaluation of the ringgit and the 10 percent overvaluation of the Philippine peso as valid indicators. Finally, since the *CPI*-deflated New Taiwan dollar is stationary against the yen, it makes sense to calculate the deviation for this measure: -0.053672, or a 5 percent undervaluation. On the other hand, the CPI-based estimates yield very high *over*valuations—as high as 29 percent for the Thai baht and 46 percent for the Indonesian rupiah! While I consider these estimates implausibly high, Ito (1997) has argued that the Thai, Indonesian and Malaysian *de facto* dollar pegs combined with the dollar appreciation over the past two years caused overvaluation and the subsequent difficulties; these CPI-based estimates support this view.

However, interpretation of the Hong Kong calculation is problematic, since Morgan Guaranty uses a retail price index as a proxy for the PPI. Over the 1990-98 period, the retail price index has moved more in tandem with the CPI and PPI, prompting concerns about the robustness of this particular conclusion.[10] These two are the series for which it is valid to calculate the deviations from mean, although for completeness' sake, I have reported the other deviations.

Why do these calculations for the yen and the trade-weighted rates yield such counter-intuitive results? For the yen rates, it may be relevant that, with the exception of Indonesia,[11] the United States accounted for a larger share of these countries' exports than did Japan. If the sensitivity of trade flows is on the export side, then one might place greater importance on the U.S. dollar based calculations of overvaluation. To the extent that the United States constitutes the single largest export market for most of these countries (see Appendix Table 1), then the trade-weighted indices suffer from a similar deficiency.

IV. Conclusions

This paper has tested for mean reversion in real exchange rates in the East Asian region, as a prelude to implementing a price-based approach to assessing East Asian currency misalignment. As is typically the case, univariate techniques fail to detect mean reversion in either the CPI or PPI deflated real exchange rates. Multivariate cointegration techniques yield more evidence of mean reversion in particularly PPI deflated rates.

Using the PPI based estimates yields overvaluation estimates consistent with the view of overvaluation for Thailand, the Philippines and Malaysia. On the other hand, several countries that suffered precipitous declines in their currency values—Korea and Indonesia (the latter, keeping in mind the caveat about the appropriate reference period)—were apparently undervalued. Indeed, the finding of Korean undervaluation is consistent across both dollar and yen bilateral rates.

In this study, the validity of the PPP criterion is not merely asserted, as is often the case; rather it is justified by the finding of real exchange rate stationarity, when real exchange rates are defined using a price index of tradable goods. Although the implied over- and undervaluations are more consistent with common priors, the use of CPI-based real exchange rates is *not* validated by the econometric tests implemented in the paper, with the exception of

[10]Over this period the RPI rose 25 percent relative to the PPI. Unfortunately, a long span of PPI data is not available, so that formal testing for the stationarity of a true Hong Kong PPI-deflated series is not possible. However, visual inspection of PPI and real unit labor cost deflated series indicate much less pronounced appreciation over the 1990s, adding further evidence against the overvaluation view.

[11]The fact that Indonesia devotes a larger share of its exports to Japan is attributable to Japan's dependence of imported oil.

the new Taiwan dollar. In particular, the multilateral CPI-deflated real exchange rate is never found to be stationary; this suggests that the popular method of assuming trend stationarity in such a variable is likely to lead to inappropriate inferences.

It is important to observe that the measures of overvaluation implemented in this paper do not address some of the other popular explanations for the crisis. For instance, journalistic accounts make reference to the currency values relative to the currencies of export-competing countries such as India and Vietnam. Huh and Kasa (1997) argue that the most important country in this regard is China, which is omitted in all the calculations reported above. I reserve the implications of this argument for future research.[12]

[12]Although Liu, *et al.* (1998) and Fernald, *et al.* have disputed the importance of China's exchange rate in precipitating the 1997 crises.

Table 1. Monthly Drift Terms of Real Exchange Rates
1975.01–1996.12

	CPI			PPI			Export Prices	
	TWXR[d/]	$	¥	TWXR	$	¥	$	¥
HK	0.0016†	0.0044***[a/]	0.0034	0.0000	-0.0000[b/]	-0.0004[b/]	-0.0005[c/]	-0.0016[c/]
	(0.0011)	(0.0006)	(0.0036)	(0.0172)	(0.0001)	(0.0040)	(0.0010)	(0.0023)
IN	-0.0024	-0.0029	-0.0047*	-0.0019	-0.0006	-0.0015	-0.0095	-0.0100
	(0.0021)	(0.0024)	(0.0029)	(0.0019)	(0.0023)	(0.0027)	(0.0067)	(0.0070)
KO	-0.0003	0.0009	-0.0009	-0.0008	0.0003	-0.0006	-0.0036**	-0.0051
	(0.0010)	(0.0009)	(0.0022)	(0.0009)	(0.0010)	(0.0021)	(0.0017)	(0.0037)
MA	-0.0011†	-0.0015*	-0.0034*	-0.0010	0.0004	-0.0008	-0.0030	-0.0031
	(0.0008)	(0.0009)	(0.0019)	(0.0009)	(0.0013)	(0.0027)	(0.0033)	(0.0037)
PH	0.0003	0.0002	-0.0017	0.0007	0.0011	0.0002	-0.0039	-0.0043
	(0.0020)	(0.0018)	(0.0029)	(0.0016)	(0.0017)	(0.0027)	(0.0055)	(0.0059)
SI	0.0006	-0.0003	-0.0021	-0.0009	-0.0005	-0.0012	0.0013	0.0007
	(0.0006)	(0.0009)	(0.0018)	(0.0010)	(0.0012)	(0.0019)	(0.0020)	(0.0027)
TH	-0.0001	-0.0004	-0.0023	-0.0006	-0.0001	-0.0010	-0.0006	-0.0005
	(0.0011)	(0.0009)	(0.0020)	(0.0010)	(0.0010)	(0.0019)	(0.0018)	(0.0028)
TI	0.0009	0.0009	-0.0005	-0.0004	-0.0000	-0.0009	--	--
	(0.0011)	(0.0010)	(0.0023)	(0.0008)	(0.0008)	(0.0021)		
JP	0.0021†	0.0018	--	0.0004	0.0009	--	0.0003	--
	(0.0017)	(0.0021)		(0.0013)	(0.0020)		(0.0023)	

Notes: TWXR is the trade-weighted exchange rate. Regression coefficients from OLS. †{*}(**)[***] indicates significance at the 20 percent {10 percent}(5 percent)[1 percent] MSL.

[a/] Sample period 1990.01 to 1996.12.
[b/] Sample period 1991.1 to 1996.4 converted to monthly basis.
[c/] Sample period 1985.01 to 1996.12.
[D] Sample period 1979.1 to 1996.12.

Table 2. Johansen Cointegration Results

Panel 2.1: CPI

	HK	IN	JP	KO	MA	PH	SI	TH	TI
k	1	1	1	1	1	1	1	1	1
#[#]	1[0]	0[0]	2[2]	2[2]	1[1]	1[1]	1[1]	1[1]	2[2]
c	1.006	-5.942	-29.885	5.135	3.405	2.940	13.148	2.337	8.033
β_1	1	1	1	1	1	1	1	1	1
β_2	0.362*** (0.164)	1.535 (4.038)	-7.930 (3.296)	0.940 (1.337)	0.829*** (0.347)	-0.572 (0.762)	0.257 (1.236)	1.130*** (0.305)	-1.886* (0.531)
β_3	-0.136*** (0.059)	1.482 (2.154)	15.505** (7.278)	-0.633* (0.902)	-1.363*** (0.539)	0.560 (0.377)	-3.019 (2.645)	-0.937*** (0.287)	0.847 (0.707)
LnLik	959.8	1538.2	1676.7	1900.9	1957.5	1640.0	1928.4	1916.1	1636.8
Smpl	90.01 -96.12	75.01 -96.12	75.01 -96.12	75.01 -96.12	75.01 -96.12	75.01 -96.12	75.01 -96.12	75.01 -96.12	75.01 -96.12
N	82	264	264	264	264	264	264	264	264

Table 2. Johansen Cointegration Results (continued)

Panel 2.2: PPI

	HK	IN	JP	KO	MA	PH	SI	TH	TI
k	--	1	1	1	1	1	1	1	1
#[#]	--	0[0]	0[0]	1[1]	0[0]	2[2]	1[1]	1[1]	1[0]
c	--	21.862	3.335	6.998	-0.269	4.669	1.519	2.124	6.116
β_1	--	1	1	1	1	1	1	1	1
β_2	--	-5.131 (5.335)	-1.924*** (0.130)	-0.996 (0.444)	1.684*** (0.838)	-1.299*** (0.112)	-1.071 (0.126)	0.382*** (0.293)	-1.651* (0.184)
β_3	--	1.908 (1.070)	2.253*** (0.276)	0.870* (0.268)	-1.405*** (0.645)	0.964 (0.031)	0.856 (0.163)	-0.148*** (0.233)	1.029 (0.250)
LnLik	--	1154.2	1597.8	1664.2	956.9	1256.2	1499.3	1632.0	1585.5
Smpl	90.01 -96.12	75.01 -96.12	75.01 -96.12	75.01 -96.12	75.01 -96.12	75.01 -96.12	75.01 -96.12	75.01 -96.12	75.01 -96.12
N	--	264	264	264	264	264	264	264	264

Table 2. Johansen Cointegration Results (concluded)

Panel 2.3: Export Price Indices

	HK	IN	JP	KO	MA	PH	SI	TH	TI
k	1	1	1	7	1	1	3	1	--
#[#]	2[2]	1[1]	1[1]	0[0]	1[1]	1[1]	1[1]	1[1]	--
c	7.231	-2.029	-2.188	-8.770	1.321	1.761	12.104	2.634	--
β_1	1	1	1	1	1	1	1	1	--
β_2	-8.153 (14.198)	2.866*** (0.104)	-1.468*** (0.130)	2.562** (1.630)	0.132*** (0.048)	-0.835 (0.259)	-1.998*** (0.279)	-0.387** (0.349)	--
β_3	7.138 (11.560)	-0.804 (0.078)	2.042 (0.228)	0.749 (0.684)	-0.214 (0.040)	1.127 (0.097)	-0.525 (0.238)	0.507 (0.227)	--
LnLik	1470.1	501.2	1072.2	683.6	868.0	595.1	1128.7	1132.2	--
Smpl	90.01 -96.12	75.01 -96.12	75.01 -96.12	75.01 -96.12	75.01 -96.12	75.01 -96.12	75.01 -96.12	75.01 -96.12	--
N	256	237	264	76	207	204	212	249	--

Notes: k is lag in VECM specification. #[#] is the number of cointegrating vectors according to a likelihood ratio test on the maximal eigenvalue statistic, using asymptotic [finite sample] critical values. Finite sample critical values from Cheung and Lai (1993). β_i are cointegrating vector coefficients. *(**)[***] denotes significance at the 10 percent(5 percent)[1 percent] MSL for the null hypothesis of $\beta_2 = -1$ or $\beta_3 = 1$. LnLik is the log likelihood statistic, smpl is ample, N is number of observations.

Table 3. Horvath-Watson Test Results for U.S. Dollar, Yen and Trade-Weighted Exchange Rates

Panel 3.1: CPI

	HK[1]	IN	JP	KO	MA	PH	SI	TH	TI
US$									
k	1	1	12	12	11	11	12	1	1
W	**9.790***	**17.913*****	4.484	**14.323*****	5.121	1.456	2.277	**18.523*****	**10.544***
¥									
k	1	12	--	12	12	12	12	12	12
W	3.941	9.309†	--	**13.005****	4.104	8.674	6.202	4.936	**16.914*****
TWXR									
k	1	1	1	1	1	1	1	1	1
W	7.414	4.569	8.372	4.059	1.322	2.356	2.061	1.408	9.198†

Panel 3.2: PPI

	HK[1]	IN	JP	KO	MA	PH	SI	TH	TI
US$									
k	--	1	12	12	2	12	12	5	4
W	--	**10.544***	3.497	**13.742****	2.649	4.036	7.095	**12.050****	4.368
¥									
k	--	12	--	11	1	2	3	2	6
W	--	4.640	--	3.465	**12.413****	**9.867***	2.919	7.346	2.267
TWXR									
k	1	1	1	1	1	1	1	1	1
W	**10.098***	2.990	7.066	5.918	**10.318***	8.674	0.111	1.403	1.835

Panel 3.3: Export Price Indices

	HK[1]	IN	JP	KO	MA	PH	SI	TH	TI
US$									
k	12	11	12	1	4	12	1	1	--
W	9.630†	5.366	3.926	3.926	7.690	8.374	3.337	**22.270*****	--
¥									
k	1	11	--	1	1	2	2	1	--
W	6.198	3.838	--	5.110	0.762	4.705	3.323	2.644	--

[1]Hong Kong trade weighted PPI deflated series uses a retail price index (RPI) for Hong Kong prices (see the Data Appendix). The sample periods vary in length. Bilateral CPI samples are 1990.01-96.12; the trade weighted CPI sample is 1989.01-96.12. The RPI/PPI deflated trade weighted sample is 1975.01-96.12.

Notes:*(**)[***] is significance at the 10 percent(5 percent)[1 percent] MSL. † indicates borderline significance. k is the number of first difference lags included in the VECM (selected by Schwartz Information Criterion, for lags up to 12). W is the Wald statistic. Critical values are 9.72 (11.62)[15.41], from Horvath and Watson (1995). TWXR denotes trade weighted exchange rate (PPI deflated series from Morgan Guaranty, CPI deflated series from IMF).

Table 4. Deviations from PPP as Predicted by PPI-Deflated and CPI-Deflated (w/trend) Real Rates Against U.S. dollar

Panel 4.1: 1997.05

$$Dev_t = q_t - \hat{q}_t$$

	HK	IN	JP	KO	MA	PH	SI	TH	TI
PPI	-0.046	**-0.056**	0.089	**-0.093**	0.079	0.189	**-0.059**	**0.070**	-0.029
CPI	-0.039	0.303	-0.160	-0.024	0.167	0.237	0.126	0.133	-0.087

Panel 4.2: 1995.06-1997.05

$$Dev_{t,t-23} = \sum_{i=1}^{23} (q_{t-i} - \hat{q}_{t-i})$$

	HK	IN	JP	KO	MA	PH	SI	TH	TI
PPI	-0.040	**-0.055**	0.155	**-0.024**	0.072	0.189	**-0.025**	**0.077**	0.010
CPI	-0.015	0.259	-0.053	0.057	0.145	0.218	0.145	0.120	-0.038

Notes: Local currency overvaluations (+) or undervaluation (-) relative to U.S. dollar, calculated as actual log real exchange rate minus predicted log real rate. "PPI" indicates that the predicted value is the mean of the the log PPI deflated series. "CPI" indicates that the predicted value is from a regression of log CPI deflated series on a constant and time trend.

Table 5. Deviations from PPP as Predicted by PPI-Deflated and CPI-Deflated (w/trend) Real Rates against Yen

Panel 5.1: 1997.05

$$Dev_t = q_t - \hat{q}_t$$

	HK	IN	KO	MA	PH	SI	TH	TI
PPI	-0.225	-0.145	-0.182	**0.136**	**0.100**	-0.150	-0.019	-0.099
CPI	0.202	0.463	0.136	0.327	0.397	0.286	0.293	0.074

Panel 5.2: 1995.06-1997.05

$$Dev_{t,t-23} = \sum_{i=1}^{23} (q_{t-i} - \hat{q}_{t-i})$$

	HK	IN	KO	MA	PH	SI	TH	TI
PPI	-0.225	-0.210	-0.178	0.064	**0.035**	-0.182	-0.078	-0.125
CPI	0.104	0.312	0.110	0.198	0.271	0.197	0.173	0.0162

Notes: Local currency overvaluations (+) or undervaluation (-) relative to ¥, calculated as actual log real exchange rate minus predicted log real rate. "PPI" indicates that the predicted value is the mean of the the log PPI deflated series. "CPI" indicates that the predicted value is from a regression of log CPI deflated series on a constant and time trend.

Table 6. Deviations from PPP as Predicted by PPI-Deflated and CPI-Deflated (w/trend) Real Multilateral Rates

Panel 6.1: 1997.05

$$Dev_t = q_t - \hat{q}_t$$

	HK	IN	JP	KO	MA	PH	SI	TH	TI
PPI	**0.204**	-0.252	0.006	-0.184	**-0.041**	0.097	0.044	-0.034	-0.061
CPI	0.052	0.313	-0.302	-0.082	0.222	0.105	0.110	0.154	-0.087

Panel 6.2: 1995.06-1997.05

	HK	IN	JP	KO	MA	PH	SI	TH	TI
PPI	**0.122**	-0.280	0.068	-0.162	**-0.098**	0.072	0.015	-0.082	-0.069
CPI	0.015	0.283	-0.284	-0.067	0.182	0.116	0.101	0.130	-0.094

Notes: Local currency overvaluations (+) or undervaluation (-) relative to trade-weighted basket of foreign currencies, calculated as actual log real exchange rate minus predicted log real rate. "PPI" indicates that the predicted value is the mean of the the log PPI deflated series. "CPI" indicates that the predicted value is from a regression of log CPI deflated series on a constant and time trend.

Data Appendix

The data are from IMF, *International Financial Statistics*, November 1997 CD-ROM, and updated using economic data sharing system at the IMF, April 1998. Data for Taiwan: Bank of China, *Financial Statistics*, various issues, as recorded in Federal Reserve Bank of San Francisco electronic database.

□ Exchange rates, IFS line ae, in U.S. dollar/national currency unit, end of period.

□ Consumer price index, *IFS* line 64, 1990 = 100.

□ Producer price index, *IFS* line 63, 1990 = 100. Indonesian data excludes petroleum prices (line 63a). Hong Kong data is quarterly, starting from 1991.1 (Source: Hong Kong Department of Census and Statistics, personal communication from Winnie Tam).

□ Export price index, *IFS* line 74, 1990 = 100..

□ "Broad" trade-weighted real exchange rates (PPI-deflated). 1990=100, 1990 trade weights. (Source: JP Morgan, http://www.jpmorgan.com).The Hong Kong series is deflated by a Hong Kong retail price index.

□ "Broad" trade-weighted real exchange rates (CPI-deflated). 1990=100, 1990 trade weights used for 1987–98; 1980 trade weights used for earlier period. (Source: IMF Information Notices System).

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