First draft
November 28, 2003

Disinflation and Deflation in Asia: A Panel Data Study

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Abstract

We estimate, using panel-data techniques, models for inflation and the output gap for ten Asian economies over the period 1990-2003. Inflation is driven by exchange rate changes, price developments in trading partners, the need for real rate depreciation after the Asian financial crisis, and the behaviour of output gaps. In turn, the output gaps are seen as depending on US real import demand and real interest rates. The hypothesis that the parameters are identical across economies can not be rejected, except for the exchange rate parameter in the inflation equation. Interestingly, inflation appears to have a large forward-looking component.

Key words: disinflation, deflation, Hong Kong, Asia, panel data.
JEL Numbers: C23, E31, E32, F42.

The views expressed are solely the authors' and not necessarily those of the HKMA. This paper is very much an extended version of an earlier, incomplete paper by Gerlach and Peng entitled *"Deflation in Hong Kong and Asia: Common patterns, common causes?"* We thank seminar participants at the IMF and the BIS for comments on that paper.

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1. Introduction

Following the Asian financial crises in 1997-98, a number of Asian economies have experienced deflation, defined as a prolonged fall in the economy-wide level of prices. While consumer prices in Japan, the internationally most noted case, fell by 2.5% between 1998 and 2002, prices in Hong Kong declined by about 12% during the same period. Furthermore, the Mainland of China ("China" hereafter) experienced declining prices 1998-99 and 2002, with the consumer price index falling by about 2% from its peak in 1997. Singapore also experienced a brief episode of falling prices in 1998 and in 2001-2002, as did Taiwan in the 2001-2003 period. In addition, many if not most other Asian economies have undergone subdued inflation in recent years. These episodes of deflation or unusually low inflation have also been associated with poor macroeconomic performance, as evidenced by reductions of the real growth rates and increasing unemployment rates across Asia. Real GDP declined in 1998 and 2001 respectively in Japan and recorded only modest growth in the rest of the past five years, while the unemployment rate rose by two percentage points during the period to 5.4% in 2002. Economic growth moderated in China from an average rate of 11% in 1993-97 to 7.5% in 1998-2002. Growth in the rest of Asia also slowed significantly, with increases in unemployment in most of these economies.

It is tempting to think of these episodes as reflecting country-specific developments. For instance, the deflation in Japan is sometimes viewed as partly resulting from a lack of progress with structural reform (Ahearne, Gagnon, Haltmaier and Kamin, 2002). The mild deflation in China is viewed mostly to be related to supply-side factors, including productivity gains, tariff reductions and other forms of trade liberalization, and lower commodity prices (IMF 2003). Moreover, the long process of declining prices in Hong Kong is seen by many as an integral, part of the economic adjustment under the currency board regime (Schellekens 2003). However, the fact that a number of economies in the Asian region are currently experiencing very low inflation suggests that the global, or at least regional, factors must have played a critical role in this episode. To understand better the sources and nature of the recent weakness of prices in Asia, it is therefore desirable to take a comparative perspective and seek to identify the common factors that may have impacted on the price setting in the region. This is the task we have set for the present paper. This is in many ways a complementary study to Disyatat (2003), which provides a careful and comprehensive survey of price developments in Asia and possible causes of deflationary pressures in recent years.[1]

The paper is structured as follows. Section II reviews the behavior of main macroeconomic variables using quarterly data from 1990:1 – 2003:1 for ten economies: China, Japan, Hong Kong, Indonesia, Korea, Malaysia, the Philippines, Singapore, Taiwan, and Thailand. We first study the behavior of inflation and the output gap, and note that they are strongly positively correlated both within and between economies (with the possible exception of China and Taiwan). This indicates that common aggregate demand and supply shocks may have contributed importantly to cyclical fluctuations in Asia. Next we turn to the behavior of nominal and real exchange rates and interest rates. The overview suggests that a decline in the equilibrium real exchange rate, which was required in part to strengthen the external payment position, probably put downward pressure on domestic prices, particularly in the economies where the room for nominal exchange rate adjustment is limited. Furthermore, high real interest rates tended to depress aggregate demand, increase output gaps and reduce the rate of inflation. We end this section by reviewing the behavior of US import demand and the behavior of non-oil commodity prices in international markets, both of which play an important role in determining the level of aggregate demand and the external inflation environment for Asian economies. These two variables appear to be positively correlated and declined during the low inflation periods following the Asian financial crisis and in the economic slowdown in 2001-02. Thus, both are likely to help explain the behavior of inflation in Asia.

Section III presents the quantitative analysis. Using a panel-data approach, we estimate a simple two-equation system comprising of an inflation equation, given by a Phillips-curve relationship, and an output gap equation, for the ten Asian economies. The models use the variables discussed in section II as regressors. While there are important differences in the behavior of inflation across economies, we identify some common factors, both internal and external, that appear to have played a role in price formation in Asia. In particular, we

[1] For other studies on deflation in Asia, see Morimoto, Hirata, and Kato (2003), and Fung, Ma, and McCauley (2003).

find that the need for real exchange rate depreciation and large output gaps have helped reduce inflation. Moreover, movements in US real import demand and domestic real interest rates have influenced the output gaps and thereby impacted on inflation. Section IV concludes.

2. Stylized facts

As a preliminary to the econometric analysis, we establish some stylized facts with respect to price movements and real economic activity in the ten Asian economies in our sample. These economies vary sharply in the macroeconomic framework and structure, in particular in terms of size and openness, suggesting that the inflation process may differ between them. Despite this, the starting point for our analysis is that these obvious differences may obscure much more fundamental similarities. In particular, these economies have all been exposed to several large common shocks. They were affected by the Asian financial crisis in 1997-98 and were to varying degrees exposed to the slowdown in the US economy in 2001. Moreover, economic linkages among the Asian economies have increased along with rising intra-regional trade and investment activity. These common shocks, combined with increased economic integration, may have impacted in similar ways, although to varying degrees, on the economies in our sample.

2.a Output gaps and inflation

Graph 1 contains data on output gaps (in bars) and inflation, measured using either the GDP deflator or the CPI, in the period 1990-2003. The inflation rate is measured by the four-quarter change of the logarithm of the price variable, while the output gap is calculated using the Hodrick-Prescott filter.[2] To facilitate comparison, the two largest (China and Japan) and smallest (Singapore and Hong Kong) economies are grouped together, while the other Asian economies form the second group.

[Insert Graph 1]

[2] The smoothing parameter (λ) is set equal to 1600.

The graph suggests that output in the Asian economies was generally above potential before the onset of the Asian financial crisis, reflecting the economic boom. Subsequently, these economies, except China and Taiwan, witnessed a sharp deterioration of economic growth, which led to the development of substantial negative output gaps in 1998-99. Output rose above potential again in 2000, but following the US and global slowdown that started in early 2001, several economies experienced a recession and a return to negative output gaps.

The plots show that both measures of inflation rates evolved in a similar way although movements in the GDP deflator recorded higher volatility. Following a temporary rise in inflation in those economies that witnessed a large depreciation in exchange rates during the Asian financial crisis (including Korea, Indonesia, Malaysia, Thailand and the Philippines), inflationary pressures subsequently abated across the region. In fact, in many economies the price levels started to fall in 1998 before recovering slightly in 2000. The temporary decrease in prices, along with the exchange rate adjustment, is arguably best seen as reflecting an adjustment of relative prices driven by a common regional shock, rather than as evidence of ongoing deflation. After the financial crisis, there were pressures across Asia to restore competitiveness and strengthen the precarious external payment position. The required decline in the relative price of non-tradables to tradables, coupled with weak commodity prices in the world market, led to a drop in the equilibrium level of prices relative to the rest of the world. This was achieved with a combination of nominal depreciation and declines in domestic prices. Since the downturn in 2001, there were renewed downward pressures on prices. The year-on-year changes in price levels were close to zero or even negative in many Asian economies.

Graph 1 also suggests that positive output gaps are generally associated with higher inflation rates and vice versa. Furthermore, the fact that the output gaps moved in broadly similar ways across these economies may be linked to the commonality in inflation outcomes. However, the plots have little to say about differences between average inflation rates across economies. Such differences remained during the entire sample period, regardless of whether or not the economies had undergone a marked exchange rate depreciation as a consequence of the crisis. This suggests that while some common factors may explain variations in inflation over time, country-specific factors may account for differences in average inflation rates.

2.b Nominal and real effective exchange rates

As suggested above, the temporary rise in inflation in 1997-98 in many economies was largely related to episodes of exchange rate depreciation. It is therefore useful to consider the behavior of the exchange rates more closely. Graph 2 plots nominal and real effective exchange rates, which are defined so that a decrease represents a depreciation, and are normalized to 100 in 1995 to facilitate comparison.[3] Individual economies are arranged in the same fashion as before.

Graph 2 warrants several observations. First, both China and Hong Kong experienced appreciation of the real and nominal effective exchange rates at the peak of the crisis in 1998, in sharp contrast to the other Asian economies. This was no doubt due to the fact the renminbi and the Hong Kong dollar were tied to the US dollar, against which the other currencies in the region depreciated. Second, all economies, except China and Japan, have undergone varying degrees of real depreciation when compared with the pre-crisis levels. While real exchange rates might be driven far away from their equilibrium values, particularly under a floating exchange rate regime, the fact that eight of the ten economies experienced a sustained real depreciation is indicative of a decline in the equilibrium real exchange rates.

[Insert Graph 2]

The decline in the equilibrium exchange rates reflected probably a combination of factors. Many Asian economies suffered a weak balance of payment position immediately before and after the crisis. As such, these economies had a need for real depreciation in order to generate trade surpluses. Graph 3 displays the trade balance as a percentage of nominal GDP for the economies. With the exception of China and Japan, all the other economies recorded distinct improvements in the trade balance in the past five years, with persistent surpluses in most cases, notwithstanding some cyclical fluctuations. This is in contrast to

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[3] Data are collected from International Financial Statistics Monthly Release July 2003 by the IMF, the JP Morgan indices, Disyatat (2003) and from internal HKMA estimates.

the period before the crisis, where many Asian economies ran trade deficits. Moreover, the terms of trade for some economies have declined since 1998, possibly associated with the fall in prices of high-tech products in the global market (Graph 4).[4] In particular, in the cases of Korea and Thailand, the terms of trade have fallen markedly by over 20% since the crisis.

[Insert Graphs 3 and 4]

Given the nominal exchange rate, a real depreciation can only be achieved if the domestic inflation rate falls below that in the main trading partners. Thus, real exchange rate disequilibria can have significant effects on domestic inflation, particularly in economies with a fixed nominal exchange rate. Graph 5 presents the actual and a measure of "equilibrium" real effective exchange rates, and the gaps between them (in bars). While it is difficult to measure the equilibrium exchange rate, we use the simple, but not unreasonable, Hodrick-Prescott method to capture the trend level. We interpret this as an estimate of the equilibrium level under the assumption that any secular shift in the real rate is likely to reflect structural factors and thus be persistent. The trend real exchange rates, with the exception of China, have all depreciated, by between 5% in Hong Kong to around 20% in the Philippines, since 1997. In the wake of the Asian financial crisis, the actual real exchange rate depreciated beyond the estimated equilibrium level in many economies, exerting pressures on inflation rates to rise. By contrast, real exchange rate gaps were positive in China, Hong Kong and Singapore in the immediate aftermath of the crisis in 1997-1998. These put downward pressure on domestic prices, particularly in Hong Kong where the combination of a large real exchange rate gap, a fixed nominal exchange rate, and a highly open economy generated strong pressures for prices to decline.

[Insert Graph 5]

[4] The terms of trade is defined as a ratio between the unit value index of exports and that of imports.

2.c Nominal and real interest rates

Next we turn to domestic interest rates in the Asian economies. Graph 6 plots the three-month nominal and real interest rates across different economies.[5] Real interest rates generally rose sharply during the Asian financial crisis, and have subsequently tended to decline. In the case of Japan, at least as measured here, the real interest rate has risen mildly in recent years.

[Insert Graph 6]

The sharp rise in real interest rates was likely to have reduced inflation by triggering a contraction in aggregate demand and leading to the negative output gaps observed in 1998. While there are several possible channels through which real interest rates influence domestic demand, in the context of Asian economies, particularly Hong Kong, the most notable mechanism was through changes in asset prices.

2.d External factors

The fact that inflation and output gaps have moved in a broadly similar way across Asia suggests that common factors are important. Graph 7 displays the real demand for imports in the United States and (non-oil) commodity prices in international markets. Two aspects of the graph are of interest. First, the two series were positively correlated. Thus, commodity prices tended to be low in periods in which real US import demand was weak. Second, commodity prices fell sharply in the wake of the Asian financial crisis and following the decline of US import demand in 2001. These fluctuations in the demand for Asian goods and in commodity prices are likely to have impacted on inflation in the region. However, the size of the effect may vary between economies and likely depends on the extent to which the economy is open. We therefore explore this issue further in the empirical analysis below.

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[5] The real rates are computed as the nominal interest rates minus the rates of CPI inflation over the past four quarters.

[Insert Graph 7]

3. Model specification and estimation results

Having reviewed the behavior of the key macroeconomic time series, we next turn to the empirical work, which involves panel regression estimates of a two-equation model for inflation and output gaps for the ten economies studied above. The sample period spans from 1990Q1 to 2003Q1, entailing 53 quarterly observations. Given the size of the economic disturbances these economies have experienced and the limited number of observations, it is likely that if we estimate the equations for each economy individually, we will obtain large residuals, implying low significance of the estimated parameters. To raise power, it seems desirable to use a panel data approach, which leads to an (approximately) ten-fold increase in the sample size. A further motivation for the panel approach comes from the considerable commonality in inflation movements in the Asian economies, as noted above.

Of course, the panel approach comes at the cost of assuming that the parameters in the inflation and output gap equations are identical across economies (although economy-specific intercepts are included to allow for variations in average inflation rates across economies). Because there is no reason to believe that this should be the case, we examine the validity of these parametric restrictions in greater detail below.

3.a The model

The first building block is an inflation equation that can be written in the following general form:

$$(1) \quad \Delta p_{i,t} = \alpha_i + \beta_{i,1}\Delta p_{i,t-1} + \beta_{i,2}\Delta p_{i,t-2} + \gamma_i E_t \Delta p_{i,t+1} + \sum_{j=0}^{\tau} \lambda_{i,j} X_{i,t-j} + \varepsilon_{i,t} ,$$

where subscript *i* denotes economy *i*, and where $X_{i,t} = \left[\Delta e^{f}_{i,t} \quad y_{i,t} \quad q^{g}_{i,t} \quad \Delta p^{*}_{i,t}\right]$. More specifically, $\Delta p_{i,t}$ is the quarterly change in the consumer price index in economy *i* at time *t*, $\Delta e^{f}_{i,t}$ the quarterly change in the nominal effective exchange rate (NEER), $y_{i,t}$ the output gap, $q^{g}_{i,t}$ the real effective exchange rate ($q_{i,t}$) gap, and Δp^{*}_{t} the change in foreign prices.[6] All variables are expressed in logarithms. As noted above, the output gaps and the REER gaps are calculated using the Hodrick-Prescott filter. It should be noted from the outset that our panel estimates introduce the restriction that all coefficients, except α_i, are the same across economies. The validity of the restriction will be tested.

Equation (1) can be viewed as an open economy version of a Phillips-curve relationship for inflation. The inclusion of open-economy variables ($\Delta e^{f}_{i.t}$, $q^{g}_{i,t}$, and $\Delta p^{*}_{i,t}$) can be motivated by assuming a simple error-correction process in the REER to correct for deviations from the equilibrium level. That is,

$$\Delta q_{i,t} = \lambda_i q^{g}_{i,t-1}, \text{ where } -1 < \lambda_i < 0$$

Then,

$$\Delta p_{i,t} = -\Delta e^{f}_{i,t} + \Delta p^{*}_{i,t} + \lambda_i q^{g}_{i,t-1}$$

Thus, given changes in the NEER and foreign prices, a positive REER gap would reduce domestic prices due to competitive pressures. The relevant terms in Equation (1) can be derived by allowing for some inertia in the adjustment of inflation to changes in the NEER and foreign prices, and different constants to reflect secular trends in the equilibrium real exchange rates.

Recent research in macroeconomics has focused on exploring the relative importance of realized past and expected future inflation in determining current inflationary pressures. Empirical evidence presented by Galí and Gertler (1999) and Galí, Gertler, and Lopez-

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6 Data are taken mostly from International Financial Statistics (IFS) (July 2003 version) and CEIC. The effective exchange rates are from IFS, JP Morgan, the Bank of Thailand, and the Hong Kong Monetary Authority.

Salido (2001) on US and Euro-area data suggest that the forward-looking component is essential. On the other hand, Fuhrer (1997) and Roberts (2001) find that inflation is largely backward looking.[7] For this reason, we incorporate both backward- and forward-looking inflation terms as regressors. Thus, in the specification above, β_i captures the extent to which inflation is backward looking and γ_i the extent to which it is forward-looking.[8] Despite the difficulty in obtaining an appropriate measure of expectations, we favor inclusion of a forward-looking element for two reasons. First and as we discuss below, estimates of the backward-looking equation, for which we constrain γ_i to be zero, yield poorly behaved residuals, suggesting that the model does not fit the data well. Second, the financial crisis that many Asian economies underwent in 1997-1998 might have led to substantial changes in the inflation expectation formation process.

While survey data can be used to measure inflationary expectations, they are generally not available for Asian economies. We therefore follow a standard approach in the rational expectations literature and replace expected inflation with actual future inflation, but estimate the model using an instrumental variable (IV) technique to deal with the errors in variables problem.[9] The instruments must be correlated with the expected future inflation rate, yet uncorrelated with the disturbance term. However, under the assumption of rational expectations, any variable known in time *t* is a valid instrument.

In the estimations below, the time-series dimension, captured by the number of observations $(t = 1, 2,\ldots, 53)$, of the data exceeds, loosely speaking, the cross-sectional dimension, captured by the number of economies studied ($i = 1, 2,\ldots, 10$). This is in contrast to micro-panel studies that typically use large cross-sectional data sets with few observations over time. Pesaran, Shin and Smith (1999) and Arellano and Alvarez (2003) provide a general discussion on the appropriate estimation approach. When the time

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7 Galí and Gertler (1999), among others, rationalized the conflicting views through the forcing variable in the Phillips curve. They point out that a Phillips curve with marginal cost as a forcing variable is more consistent with the forward-looking framework and offers a more satisfactory description of inflation behavior than using the output gap. Because of data limitations, however, we are not able to compute unit labor costs for the economies in our sample. We therefore employ traditional output gaps.

8 Most empirical studies on inflation dynamics use a forward-looking specification combined with some lags of inflation. This is intended to account for rational expectations and the strong autoregressive component in inflation dynamics.

9 To see this, note that, by definition, $\pi = E\pi + v$, where v is an expectation error ($v \equiv \pi - E\pi$). Using π rather than $E\pi$ in the econometric analysis thus introduces a measurement error given by v.

dimension is large relative to the cross-sectional dimension, most empirical research on static panels adopts a seemingly unrelated regression (SUR) approach. It has the advantage of accounting for both heteroscedasticity and contemporaneous correlation of the residuals. However, the SUR method is inappropriate in the case of dynamic panels that involve expectation terms, since the measurement error arising from using actual future inflation as a proxy for expected inflation leads to inconsistent estimates. We therefore apply weighted two-stage least squares (2SLS) and three-stage least squares (3SLS) methods. As is discussed below, we find that the 3SLS method is more efficient, as theory suggests, with the estimated standard errors 10% smaller in general.[10]

Next we turn to the specification of the equation for the output gap. The previous section discusses the effects of domestic real interest rates and real US import demand on output gaps. To formalize this, consider the equation:

$$(2) \quad y_{i,t} = \delta_i + \kappa_{i,1} y_{i,t-1} + \kappa_{i,2} y_{i,t-2} + \theta_i \Delta d_{i,t}^{imp} + \mu_i r_{i,t} + v_{i,t}$$

where $\Delta d_{i,t+1}^{imp}$ denotes the growth rate of real US import demand and $r_{i,t}$ the domestic real interest rate, which we compute as the difference between the 3-month nominal interest rate and expected future inflation over 4 quarters. Since the expected inflation rate is not directly observable, we adopt the same method as in estimation of the inflation equation described above by using instrumental variable techniques.

3.b Heterogeneous effects of explanatory variables

Before estimating the model, which consists of equations (1) and (2), we turn to some econometric issues. The pooled estimates assume that the coefficients on the explanatory variables, except the intercepts, are identical for all economies. Given the vast differences of size, openness and structure of the economies studied, this assumption may not be valid. Since neglected heterogeneity across economies may lead to biased estimates and

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[10] An alternative estimation method for dynamic panels is GMM with lagged dependent and predetermined variables as instruments. Arellano and Alvarez (2003), Arellano and Honoré (2001), and Blundell and Bond (1998) discuss this estimator. We also perform GMM estimation using lagged variables (both in levels and in difference forms) as instruments. The estimated results are generally similar to the 3SLS methods, but they are somewhat sensitive to the choice of instruments.

misleading inference, we explore whether the assumption of identical parameters across economies imposes violence on the data.[11]

One implication of neglecting heterogeneity is the possibility of obtaining spurious nonlinear effects in the panel estimation, which in fact may be due to different linear relationship across economies. This suggests that tests for unequal coefficients can be based on tests for the presence of non-linearity in the estimated relationship. This approach is taken by Haque *et al.* (2000) and Pesaran *et al.* (1999) who propose to test for neglected heterogeneity by introducing a quadratic term for each regressor and testing whether it is significantly different from zero. If so, that particular variable may be subject to heterogeneity across sections. As is discussed further below, using this approach we find that changes in the NEER may have heterogeneous effects on inflation across the economies.

Another interesting issue to explore concerns whether there are asymmetric effects of output gaps on inflation. Asymmetry here refers to the possibility that a positive output gap may lead to a greater or smaller change of inflation than a negative one of the same absolute size.[12] We model the asymmetric effect with a kinked function with two linear segments.[13] Specifically, we employ a dummy variable that takes the value of unity for positive output gaps, and zero otherwise. The dummy variable is then interacted with the output gap and used as a regressor. The test for asymmetry is based on a standard t-test of the hypothesis that the interaction term is insignificant. To preview the estimation results, we do not find any evidence of asymmetric effects of the output gap on inflation.

3.c Estimates of inflation equation

Next we turn to the estimates of the inflation equation. Tables 1 and 2 display the estimation results of the benchmark model with both backward-looking and forward-

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[11] The neglected slope heterogeneity generates serial correlation in the disturbances and more seriously, a correlation between the regressors and the error terms. Haque et al. (2000) discuss the potential problems that arise if the slope heterogeneity is ignored.

[12] Clark, Laxton and Rose (1995) discuss this in the case of OECD economies, and Razzak (1997) considers the case of the New Zealand economy.

[13] Other approaches to test for asymmetric effects include quadratic functions and Box-Cox transformations. See Razzak (1997).

looking specifications. We perform both 2SLS and 3SLS estimates for comparison. For each specification and each estimation method, we tabulate in Panel A the parameter estimates, their standard errors and p-values of a hypothesis test that they are zero, and in Panel B unit-root tests on the residuals for each economy.[14] The presence of unit roots may indicate various estimation problems, including autocorrelation, neglected heterogeneity, and equation misspecification. The last part in each table (Panel C and D) shows the stability test results.

The benchmark model

Both 2SLS and 3SLS yield similar coefficient estimates (Panel A) and unit-root test results (Panel B) for a given specification. However, the estimated standard errors are generally smaller when 3SLS is used. Therefore, we focus on the 3SLS estimates in the subsequent discussion.

Next, we compare the results between the two specifications of the inflation equation. The estimates indicate that the backward-looking model does not fit the Asian economies well. Examination of the residuals suggests the presence of unit roots in the cases of China and Hong Kong (Panel B in Table 1). The presence of unit roots may be due to specification errors. Specifically, the backward-looking equation assumes a relatively stable economic structure so that the expected future rate of inflation is similar to recently observed inflation rates. However, this may not be appropriate in the context of the Asian economies we study here since inflation underwent discrete changes following the financial crisis in 1997-98. By contrast, the residuals from the forward-looking equation are stationary and thus appear to be better behaved.

The estimation results in Table 2 on the forward-looking equation suggest that the output gaps, REER gaps and movements in the NEER, and foreign prices are significant determinants of inflation. All estimated coefficients have the expected signs: a decrease (i.e. depreciation) of the NEER, a rise in foreign prices, or a fall of REER below equilibrium will raise inflation, as does an increase in the output gap. At the same time,

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[14] Phillips and Moon (2000) survey the literature on panel unit root test. Boumahdi and Thomas (1991) and Breitung and Meyer (1994) illustrate the use of various modified Dickey-Fuller tests in applied work.

inflation exhibits strong inertia, as evidenced by the significant coefficients on its first and second lags. Expected future inflation also is significant and has a coefficient of 0.53 (3SLS estimate). The sum of the coefficients on lagged and expected future inflation rates is around 0.94 when the parameters are freely estimated. We therefore impose the restriction that the coefficients sum to unity.[15]

A special note is warranted for the foreign price variable used in the model. We first tried international non-oil commodity prices and oil prices respectively, but they were insignificant. We then used a weighted average of the consumer price indices of the main trading partners of the individual economies, with the weights being the same as those used in computing the effective exchange rates. Thus, foreign prices facing the individual economies are somewhat different depending upon their trade patterns. These foreign price variables turn out to be significant and of a correct sign. This suggests that the Asian economies are affected more by price developments in their main trading partners than general movements in international commodity prices. This is perhaps not surprising as increased trade and investment activities within the region would help transmit shocks originating in one economy or a subset of economies to the rest of the region.

Stability

An immediate question that arises concerns whether the equations are stable in the estimation period. From the previous graphs, we note that many variables, including inflation and the output gaps, exhibit large, discrete jumps during the Asian financial crisis. Since this was associated with a large depreciation of many currencies and changes in the exchange rate regime in some Asian economies, it seems likely that the behavior of inflation changed as a consequence. To test for such a structural change, we perform a Chow breakpoint test in the 3SLS estimation by comparing the sum of squared residuals in the entire sample from 1990:1 to 2003:1 with the sum of squared residuals from two sub-samples that span from 1990:1 to 1997:2, and 1997:3 to 2003:1 respectively.[16] Panel C in

[15] The p-value of a Wald test of the hypothesis that the coefficients sum to unity is 0.09. This restriction is usually imposed to ensure that the long-run Phillips curve is vertical.

[16] The restricted sum of squared residuals is always greater than the unrestricted one in the least square estimation. This may not be true when the estimation is obtained by iterations to convergence in the present case. Therefore, the sum of squared residuals is taken from the 3SLS method without iterations. The same conclusion holds in weighted 2SLS and SUR methods.

Tables 1 and 2 shows instability in the backward-looking specification, with an F-statistic of 13.4 compared to the critical value around 1.67. By contrast, the forward-looking model passes the same test for stability with an F-statistic of 1.57.

The Chow breakpoint test, however, is silent on whether the instability comes from the slope coefficients or intercepts, or both. To explore this, we include an intercept dummy that take the value of unity for the period from 1997:3 to 2003:1 and zero otherwise, and also interact the dummy with explanatory variables (one for each explanatory variable). Panel D in Tables 1 and 2 provides p-values and Chi-squared statistics for the null hypothesis that the coefficients on dummy variables are equal to zero. The p-values on the interacting dummies in the backward-looking equation are essentially zero, pointing to instability in the slope coefficients. On the other hand, we do not find any evidence of instability in the forward-looking equation. This confirms the conclusion from the Chow breakpoint test.

Tests of homogeneity

The pooled estimates in the benchmark model implicitly impose homogeneity of the relationship across economies. As discussed above, we follow Haque *et al* (2000) and introduce quadratic terms to test for omitted heterogeneous effects. Table 3 displays the results with additional quadratic terms on output gaps, REER gaps, and changes in the NEER and foreign prices respectively. Only the squared change of the NEER is significant, suggesting possible economy-specific effects of NEER changes on inflation.[17]

Furthermore, although our results suggest that the effect of the output gap on inflation is the same across economies, this effect may be asymmetric. In particular, it is possible that a positive output gap exerts a larger or smaller impact than a negative output gap of an equal size. To explore this hypothesis, we introduce a dummy variable that is unity when the output gap is positive and zero otherwise, and interact it with the output gap. However, the estimation results in Table 3 do not suggest evidence of such asymmetric effects.

[17] We also introduce a quadratic term of lagged and expected inflation terms to test the implied homogeneity restriction. After imposing the restriction that these coefficients sum to unity, a joint test of the hypothesis that the coefficients on the quadratic inflation terms are zero is not rejected.

Table 4 presents the final model for inflation where economy-specific coefficients on NEER changes are included, and the sum of the parameters on lagged and expected inflation are restricted to be unity. Comparing these results with those of the benchmark model in Table 2 in which no heterogeneous effects are allowed, several interesting differences are worth noting. Firstly, while the coefficients on lagged and expected future inflation rates do not change materially, those on the output gap, the REER gap, and changes in foreign prices are somewhat smaller. This holds regardless of whether 2SLS or 3SLS are used to estimate the model. Secondly, after we relax the homogeneity restriction on changes of NEERs, we observe a range of coefficients across economies from (0.01) for Japan to (-0.08) for Korea, compared to the pooled estimate of -0.03 in Table 2. This generally supports the previous test that the NEER coefficients are indeed different across economies. Although the coefficients for most economies are of a correct sign, surprisingly they are no longer significant at the 5% level, with the exception of those for Indonesia and Korea. The coefficient for Thailand comes close next with a p-value of 0.16. One possible explanation is that these three economies were most exposed to the Asian financial crisis which led to sharp depreciation of their currencies and banking crisis. Thus, the sharp depreciation of the exchange rates, combined with concerns about a loss of monetary control, conceivably had a significant impact on domestic prices in these economies.

The impact of changes of the NEER on inflation may vary according to the degree of openness of the different economies considered. In particular, changes in the NEER may elicit larger effects on inflation in small, open economies such as Hong Kong and Singapore that rely heavily on external trade than in larger and more closed economies. We examine this potential heterogeneity by interacting changes in the NEER with a measure of the degree of openness in the different economies.[18] However, the estimated coefficient on the interaction term is not significant at the 5% level.[19]

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[18] Two measures of openness are tried. One is the average of total external trade as a percentage of nominal GDP over the sample period, and the other is the average imports as a percentage of GDP (retained imports for local use in the case of Hong Kong and Singapore).

[19] The p-value is 0.90 in the case of 2SLS and 0.63 in the case of 3SLS.

Summary

Our estimates suggest that a forward-looking specification performs better than a backward-looking equation. The nominal exchange effective rates, price developments in the main trading partners, deviations of the real effective exchange rate from its equilibrium level and the output gaps are found to influence inflation in the Asian economies. Interestingly, we find that changes in NEERs have heterogeneous effects across economies. The estimates do not suggest an asymmetric effect of output gaps on inflation.

3.d Estimates of the output gap equation

Having reviewed the results for the inflation equation in some detail, we next turn to the equation for the output gap.

The benchmark model

We perform a similar exercise on the output gap equation. Table 5 shows the estimates, unit-root and stability test results using both 2SLS and 3SLS methods. Both the first and second lags of output gaps are significant. Since the first autoregressive parameter is larger than unity and the second is negative but smaller than one in absolute value, the output gap displays a hump-shaped behavior in response to disturbances. The external and internal factors discussed earlier are significant. First, the coefficient on real interest rates is negative as expected. This suggests that one reason why real economic activity fell sharply as a consequence of the Asian financial crisis was the large increase in the real interest rates. Secondly, the weakness in real US import demand during the recession that started in 2001 is likely to have contributed to poor growth in the Asian economies. In particular, a one percent decline in real US import demand is estimated to bring about 0.07% fall in output relative to potential in the short run.

Stability and homogeneity

Next, we test for instability in the output gap equation. Most economies experienced a large, positive output gap in the early 1990s. This is in contrast to the sluggish output growth after the financial crisis. We perform a Chow breakpoint test in the 3SLS estimation by comparing the sum of squared residuals in the entire sample from 1990:1 to

2003:1 with the sum of squared residuals from two sub-samples that span from 1990:1 to 1997:2, and 1997:3 to 2003:1 respectively. The results listed in Table 5 (Panel C) suggest instability, with F-statistic of 4.86 compared to a critical value around 1.65.

Next, we use the dummy variable method to examine the source of the instability. The procedure is the same as in the inflation equation. The dummies are assigned the value of unity for the period from 1997:3 to 2003:1, and zero otherwise. We include an intercept dummy, and dummies interacting with explanatory variables (for each explanatory variable). The chi-squared statistics and p-values from the Wald test on the joint significance are shown in Panel D in Tables 5. The estimates suggest that instability comes from the intercept dummies, while the interaction dummies are not significant with a p-value 0.16. Given the results, we drop the interacting dummies but keep the intercept dummies, and estimate the equation again. Table 6 shows the results, with all the intercepts and dummy coefficients omitted. The estimates are close to those of the benchmark model.

The panel estimation implicitly assume that the coefficients are identical across economies. To explore the validity of this restriction, we introduce quadratic terms for each regressor to test for non-linear effects. Table 7 displays the results. The quadratic terms on domestic real interest rates and real US import demand are not significant, indicating that the homogeneous restriction across economies cannot be rejected at the 5% level. On the other hand, there seem to be non-linear effects in the lagged terms of the output gaps, as evidenced by the significance of the first lag of the quadratic terms in 3SLS estimates. This suggests that the Asian economies may follow different dynamics in the output gap movements. Table 8 shows the results after relaxing the homogeneous restriction on the first lag of the output gap. Estimates of the coefficients on real interest rates and real US import demand are similar to those in the benchmark model. The estimates of the coefficients on the first lagged output gap are clustered around 1, except for Japan, and possibly Korea, Taiwan and China. This suggests that the “northeast” Asian economies of China, Japan, Korea and Taiwan may have a different dynamics in the output gaps than the rest of the group. One possible explanation is that Korea and Taiwan are more affected by developments in Japan than other Asian economies, and together they have a rather different economic structure. China is also distinct in terms of size, the structure of the economy, and the policy framework, and escaped the Asian financial crisis relatively unhurt.

Summary

Changes in domestic real interest rates and external demand as represented by US import growth are found to affect output gaps in the Asian economies. There seem to be some differences in the dynamics of the output gaps between the northeast and southeast Asian economies. An examination of the residuals suggests that they in general are less well-behaved for China and Japan than the other economies. China and Japan are relatively less open economies and have been affected various domestic factors that are not captured by the model. The model also fits less well for the Asian financial crisis period. This is perhaps not surprising because the rises in interest rates were only one consequence of the Asia financial crisis that depressed economic growth. The credit crunch associated with the banking crisis in these economies and sharp declines in asset prices (beyond the extent justified by the rise in interest rates) were important factors that contributed to a contraction in output, but are not captured by our model. Another factor that has influenced economic growth in the Asian economies is fiscal policy, which has had an expansionary stance in many of these economies in recent years. However, it is difficult to measure fiscal policy stance empirically, particularly at the quarterly frequency, and thus it is not included in the model.

4. Conclusion

Inflation has declined significantly across Asia in the past five years, with a number of the economies experiencing persistent or sporadic deflationary pressures. This paper examines inflation dynamics in the Asian region using a panel-data approach. In particular, it considers whether and how common or "regional" factors may have contributed to the considerable similarities in inflation outcome across Asian economies. A number of preliminary conclusions are drawn from the empirical results. Firstly, common "regional" factors that have reduced inflation rates include the need for a depreciation of the real exchange rate following, and the very high real interest rates observed during, the Asian financial crisis. The former resulted from a need to run trade surpluses to repair the precarious external payments position, and in some economies also reflected a deterioration of the terms of trade. This required real depreciation exerted downward pressures on domestic prices, particularly in China and Hong Kong that have had a relatively stable nominal exchange rate. The high real interest rates contributed to negative output gaps in most Asian economies, which in turn depressed domestic prices.

Secondly, movements in foreign prices have affected inflation in the Asian economies. Interestingly, a trade-weighted average of consumer price indices in the individual economies' main trading partners are found to be significant in explaining domestic price inflation, in contrast to general indicators of international commodity prices. This suggests that inflation is more affected by price developments in other economies in the region, probably reflecting the increasing intra-region trade and investment activities. Thirdly, growth in US import demand is found to be a significant force influencing economic performance, and price developments in Asia through the impact on output gaps. This probably reflects the fact that the US remains the largest market for Asia in terms of the final demand.

Finally, it should be noted that there are important differences between these economies in terms of size, openness, the macroeconomic policy framework, and shocks experienced. Naturally, the model of this paper, which tries to study the common factors affecting the region, is not rich enough to account for differences in the underlying forces that drive price movements. In particular, price declines in China are likely also related to rapid liberalization and positive supply-side developments that raise the potential output, while in the case of Japan it may, in part be attributable to weaknesses in the financial sector that in turn have tended to restrict aggregate demand. Moreover, the Asian financial crisis impacted on the Asian economies through other channels, including credit crunches and sharp asset price declines that are not adequately captured by the model.

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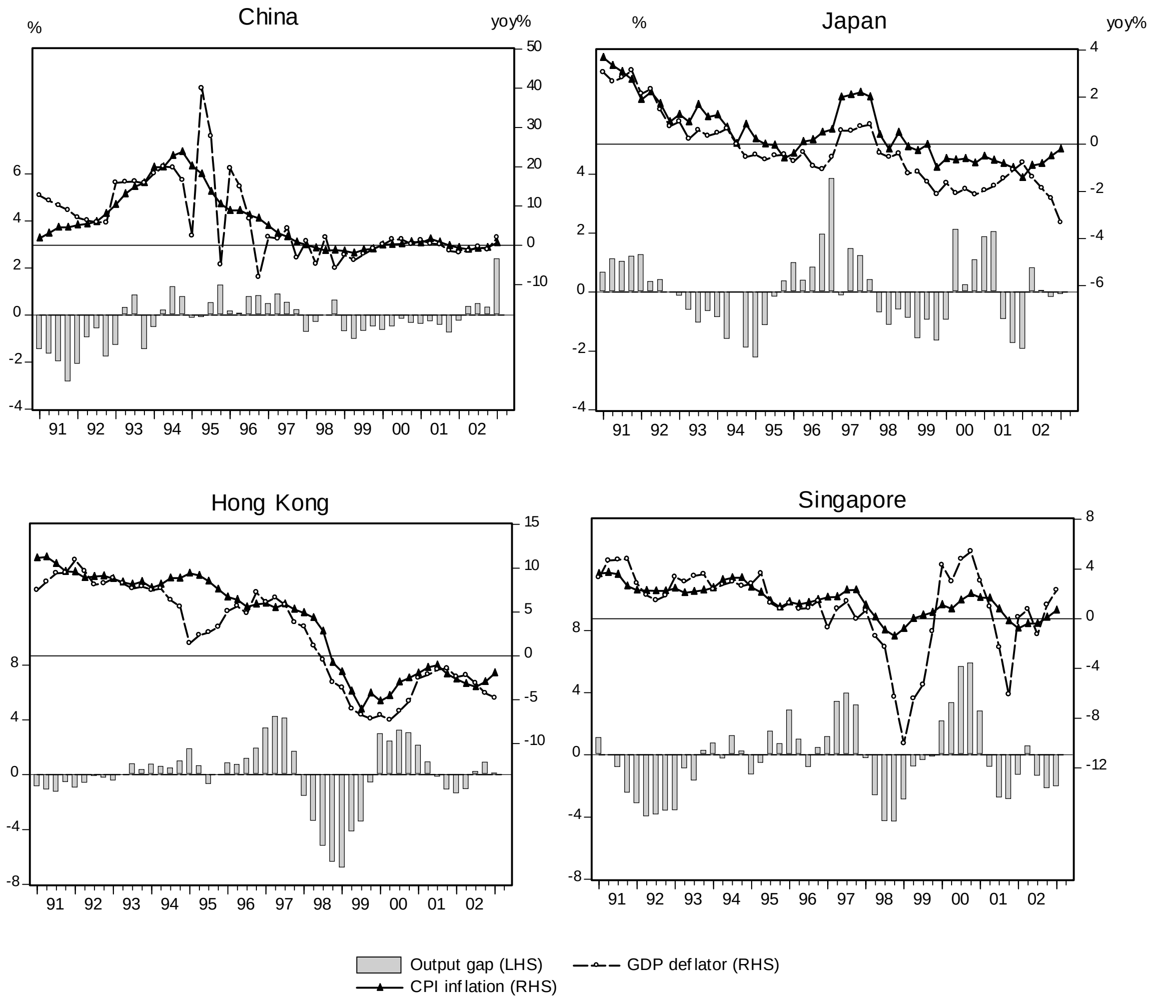
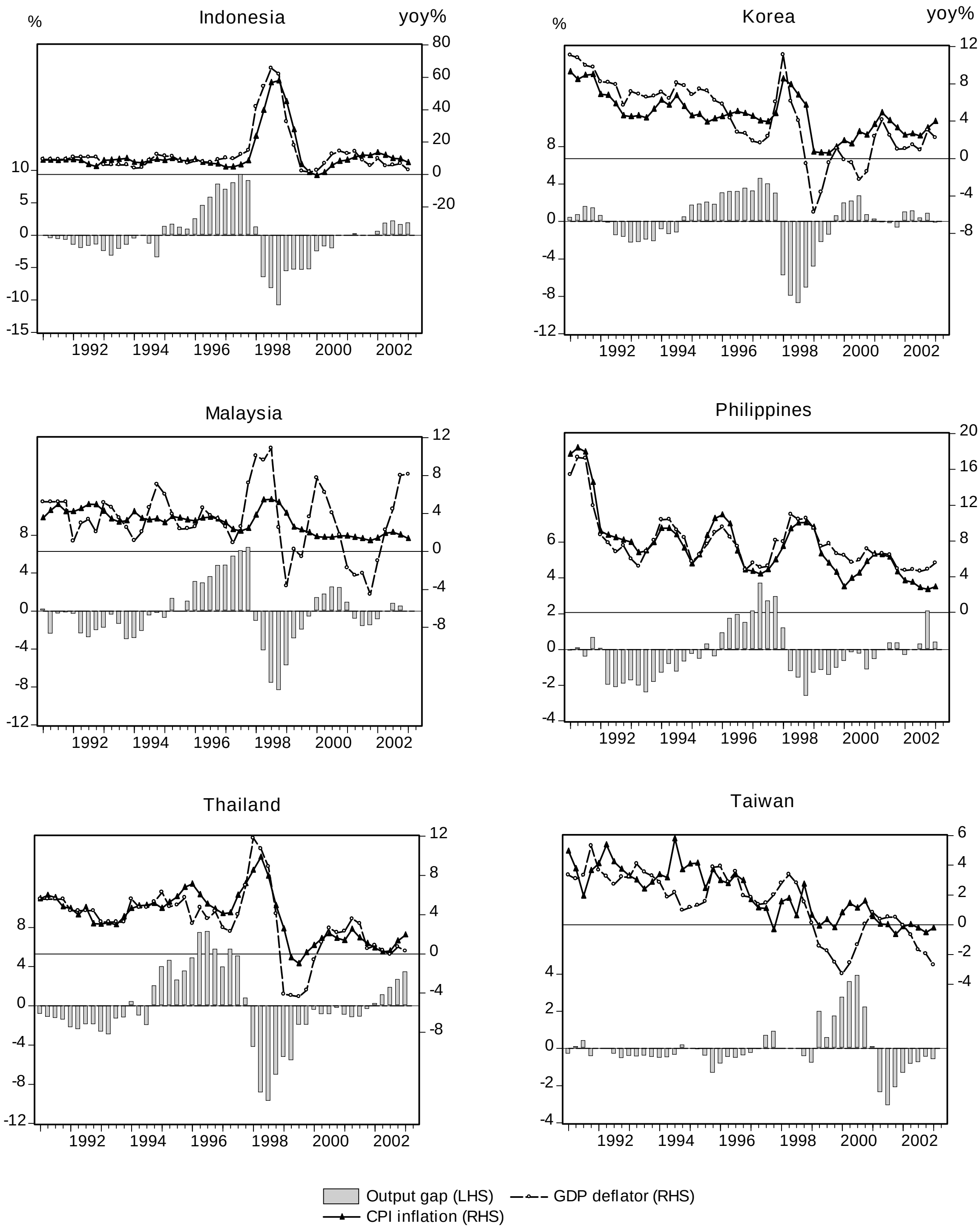
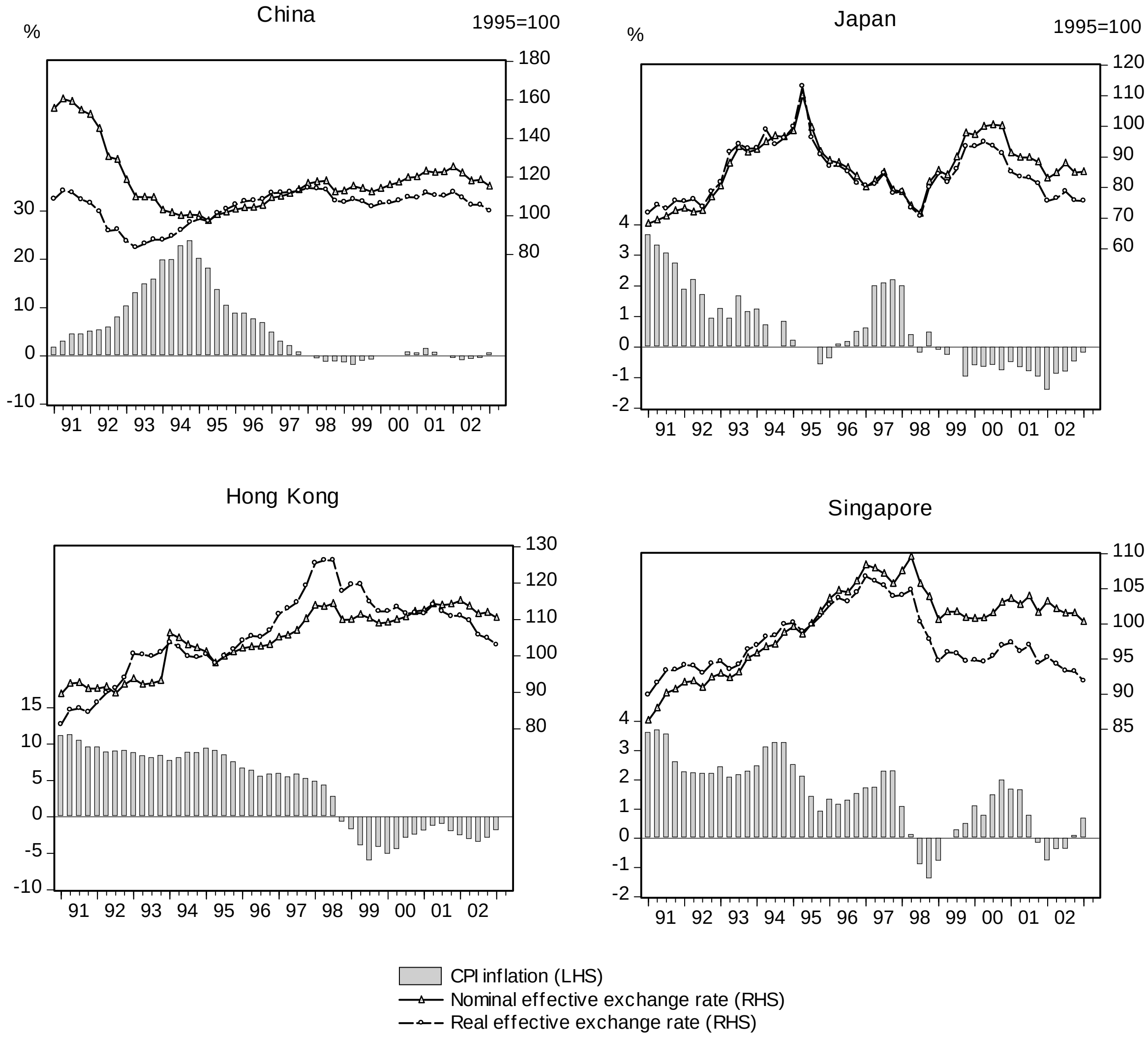
Graph 1. Inflation and Output Gaps



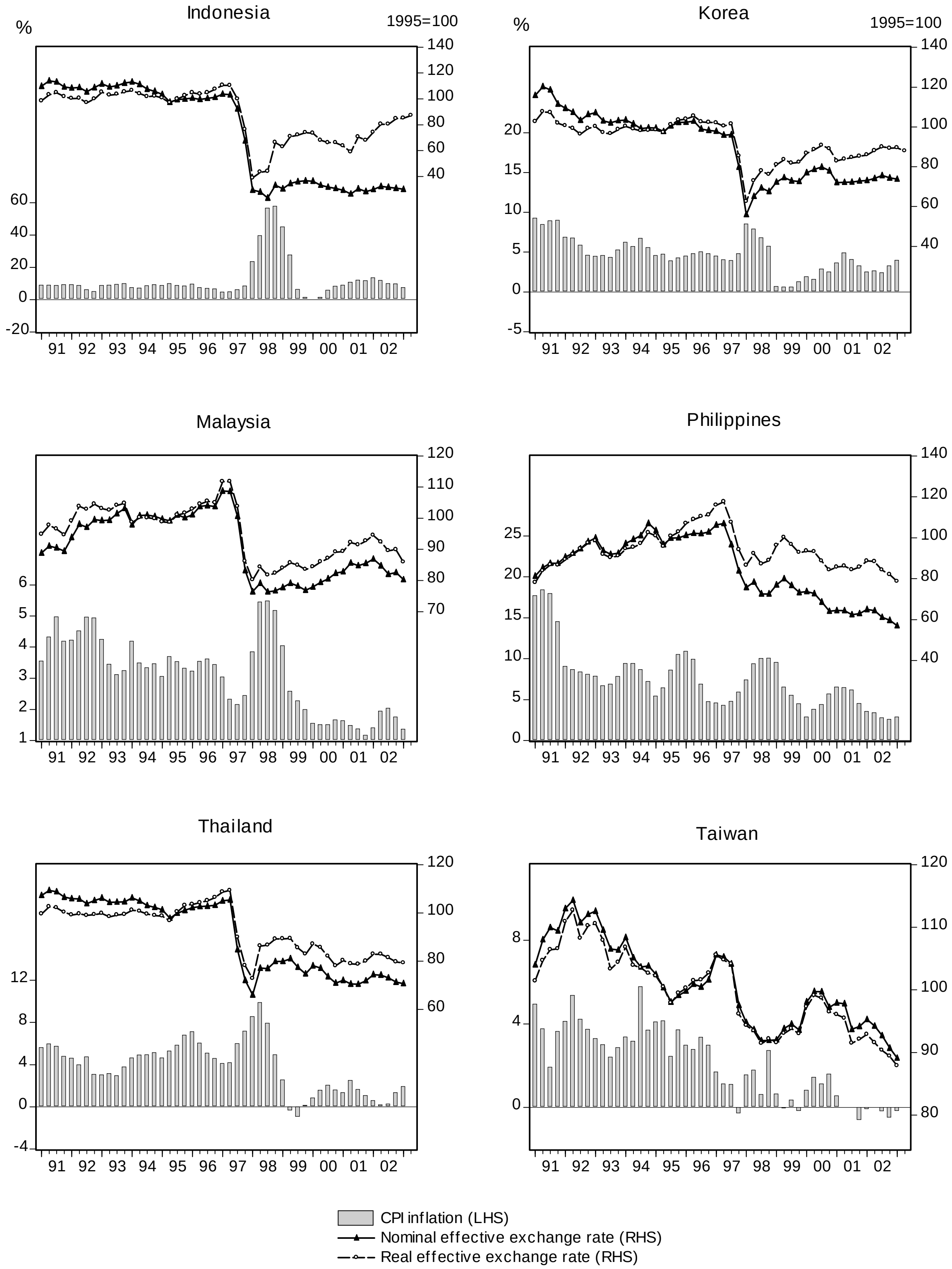
Graph 1. Inflation and Output Gaps (Continued)



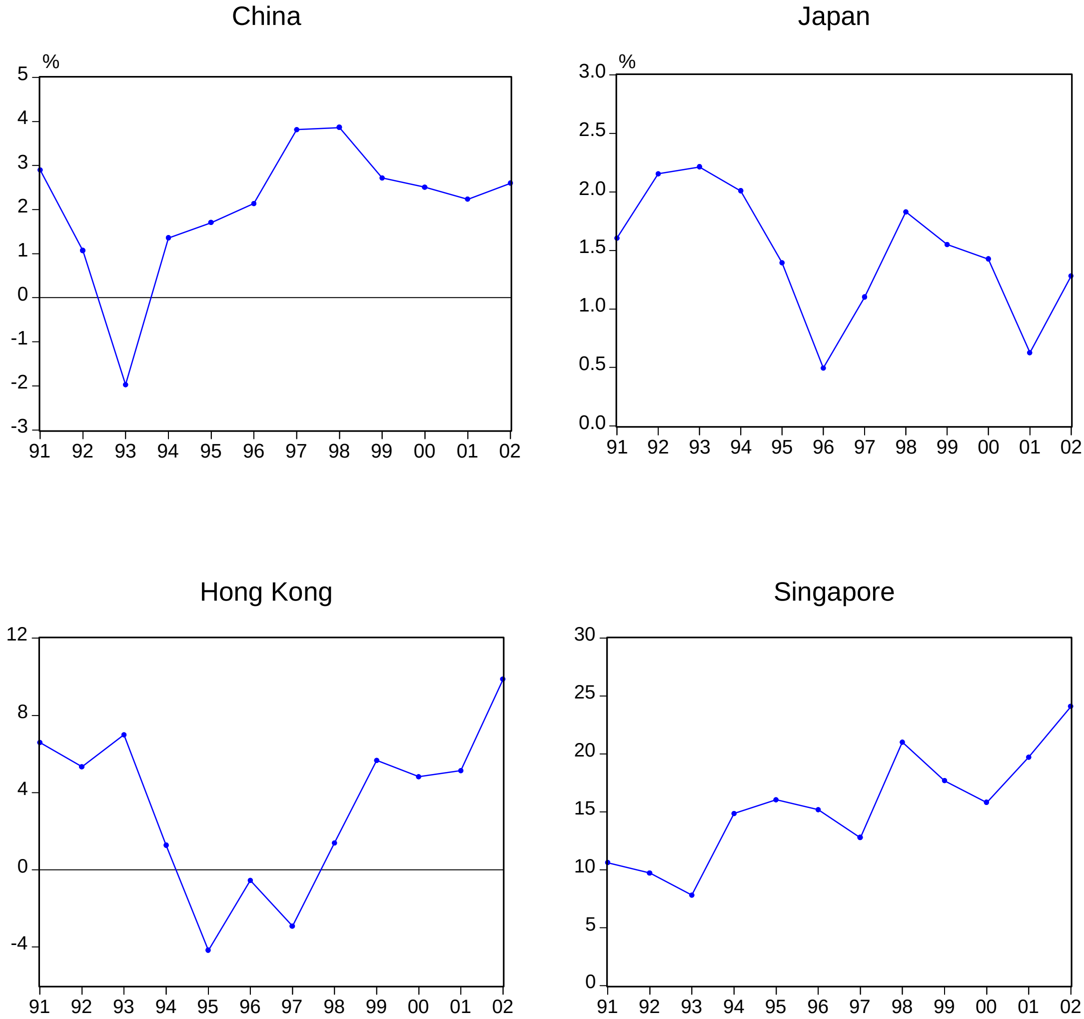
Graph 2. Nominal and Real Effective Exchange Rates



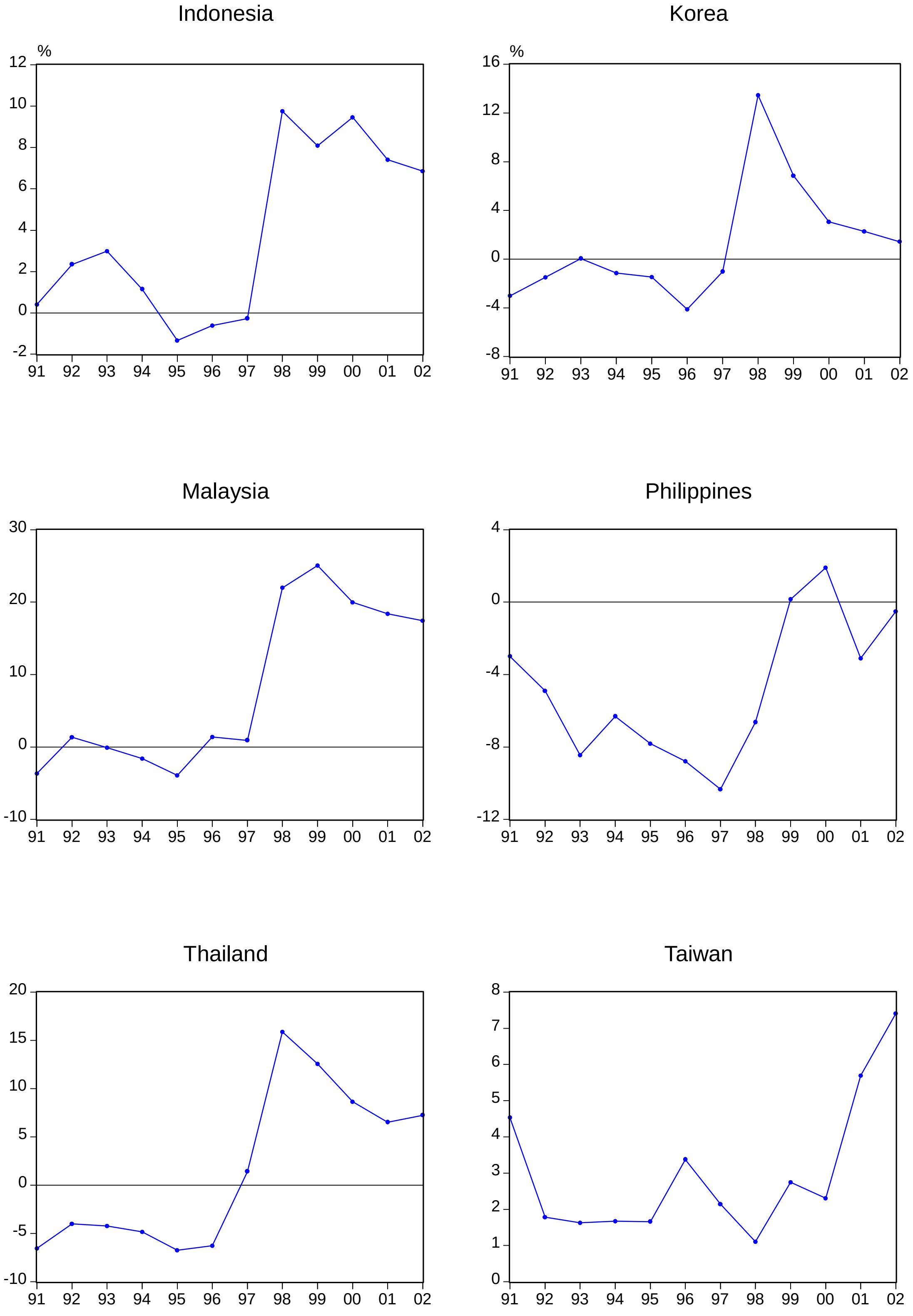
Graph 2. Nominal and Real Effective Exchange Rates (Continued)



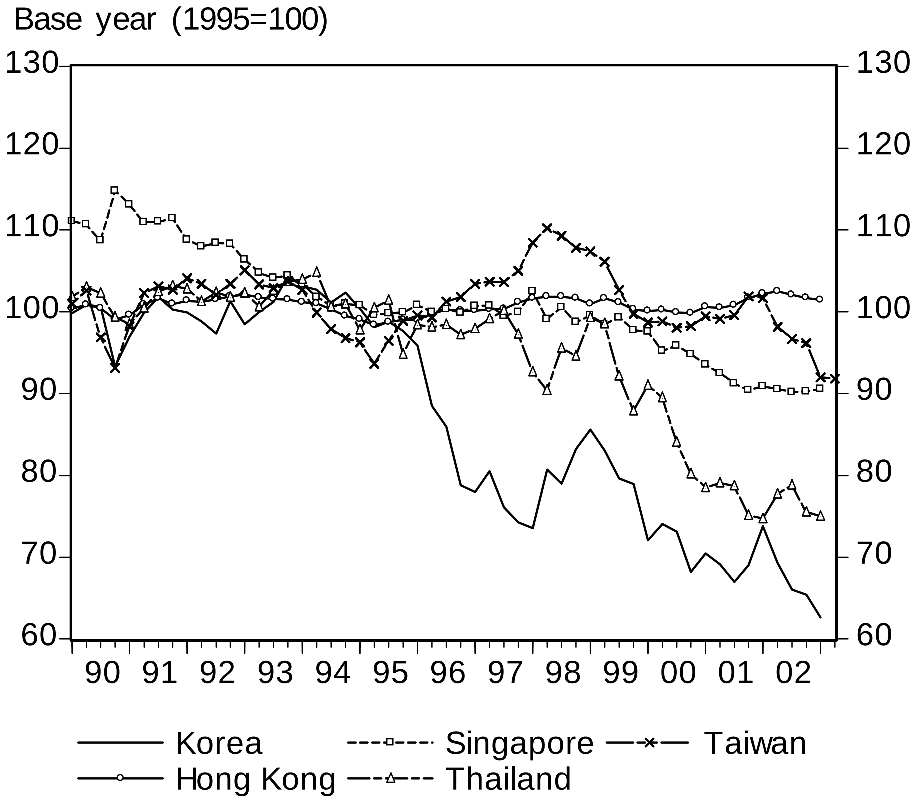
Graph 3. Trade Balance as a Percentage of Nominal GDP



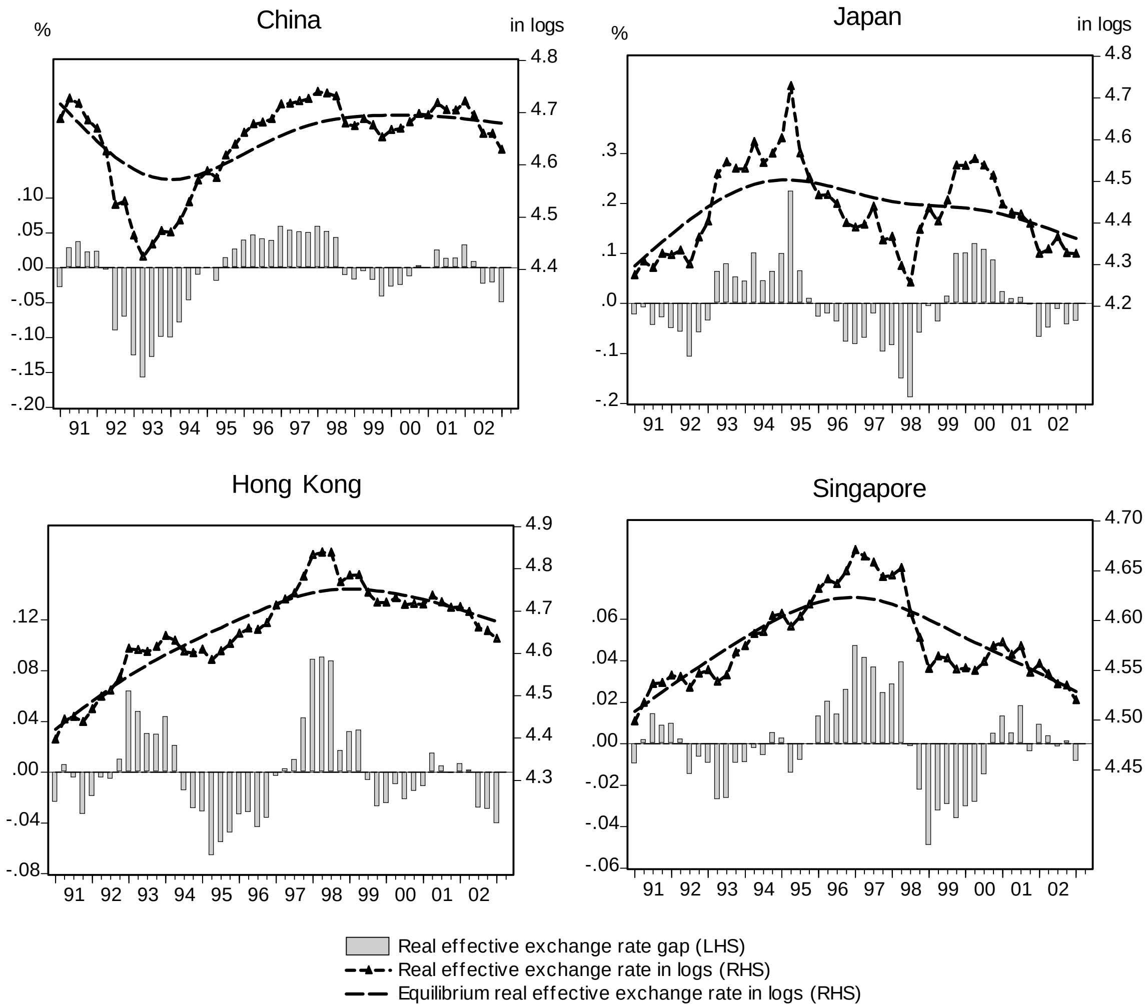
Graph 3. Trade Balance as a Percentage of Nominal GDP (Continued)



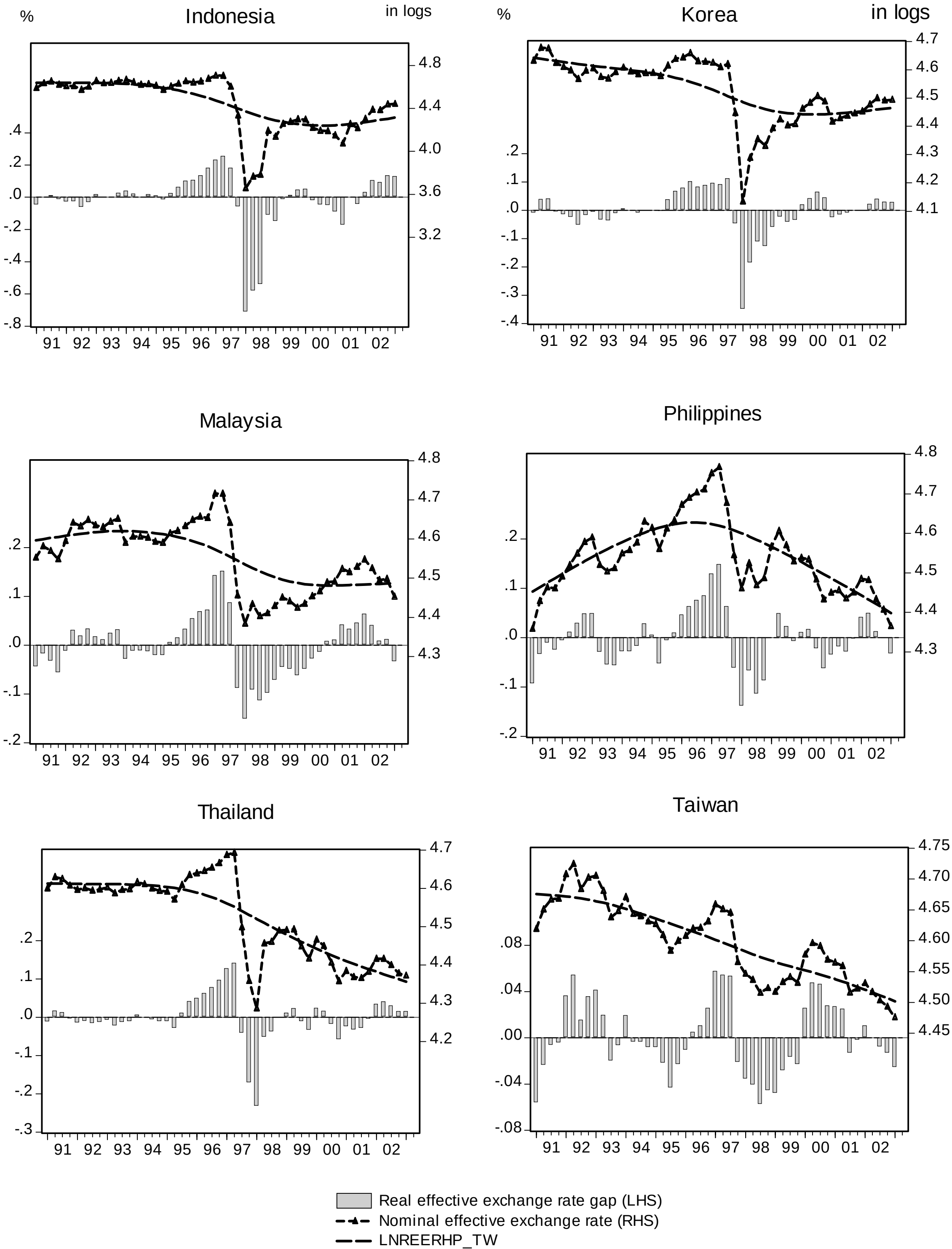
Graph 4. Terms of Trade



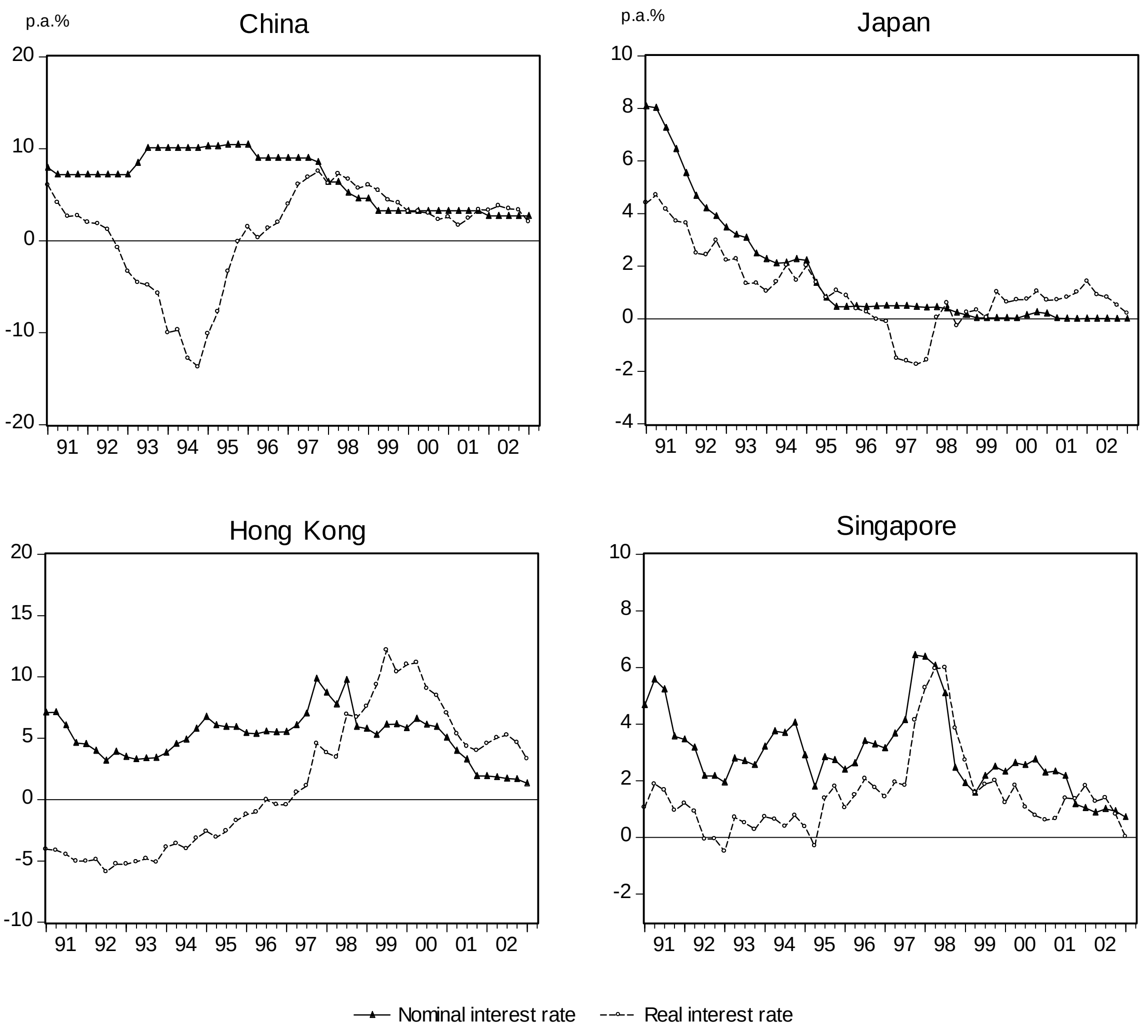
Graph 5. Actual and Equilibrium REER and Gaps



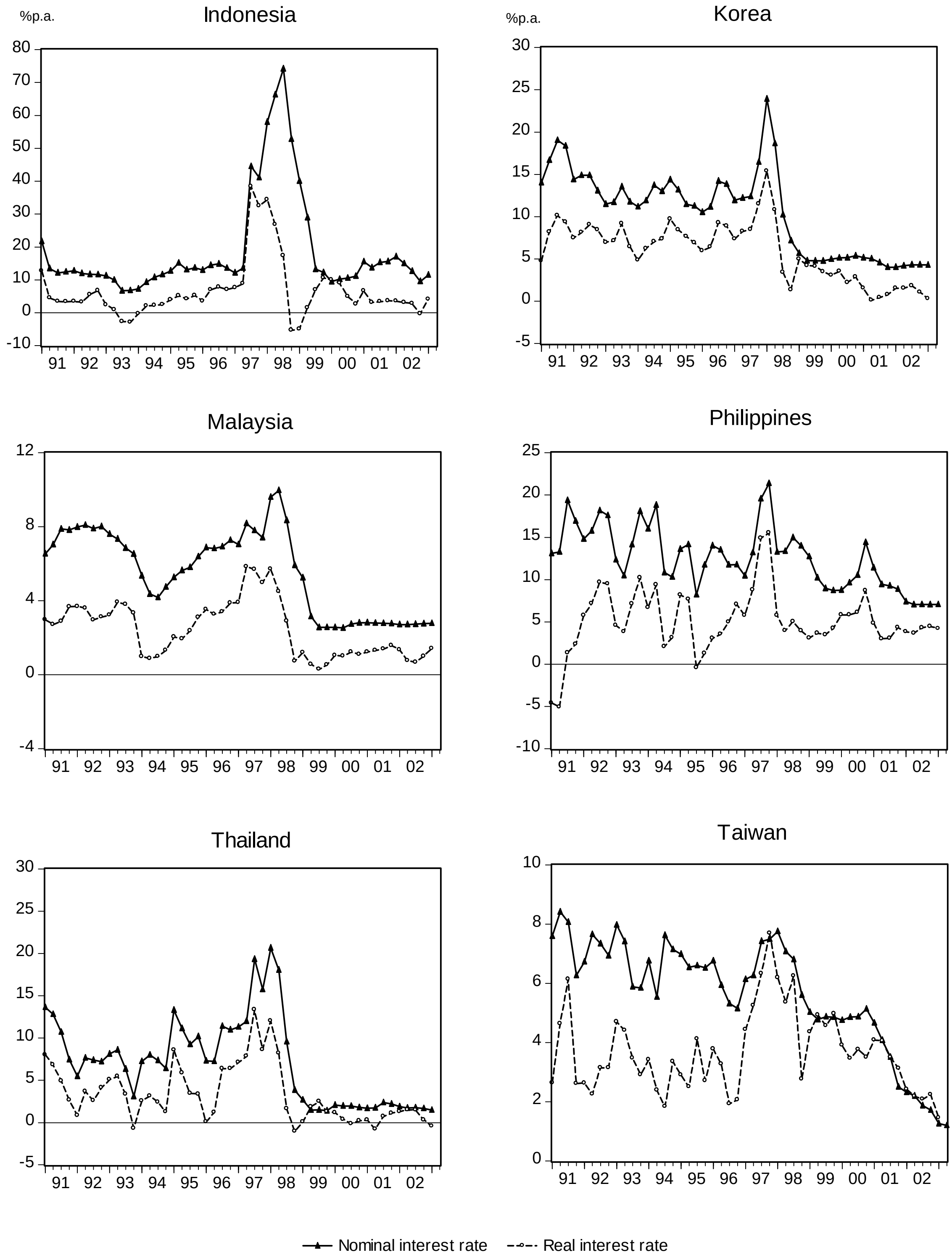
Graph 5. Actual and Equilibrium REER and Gaps (Continued)



Graph 6. Nominal and Real 3-month Interest Rates



Graph 6. Nominal and Real 3-month Interest Rates (Continued)



Graph 7. US Real Import Demand and Non-energy Commodity Prices

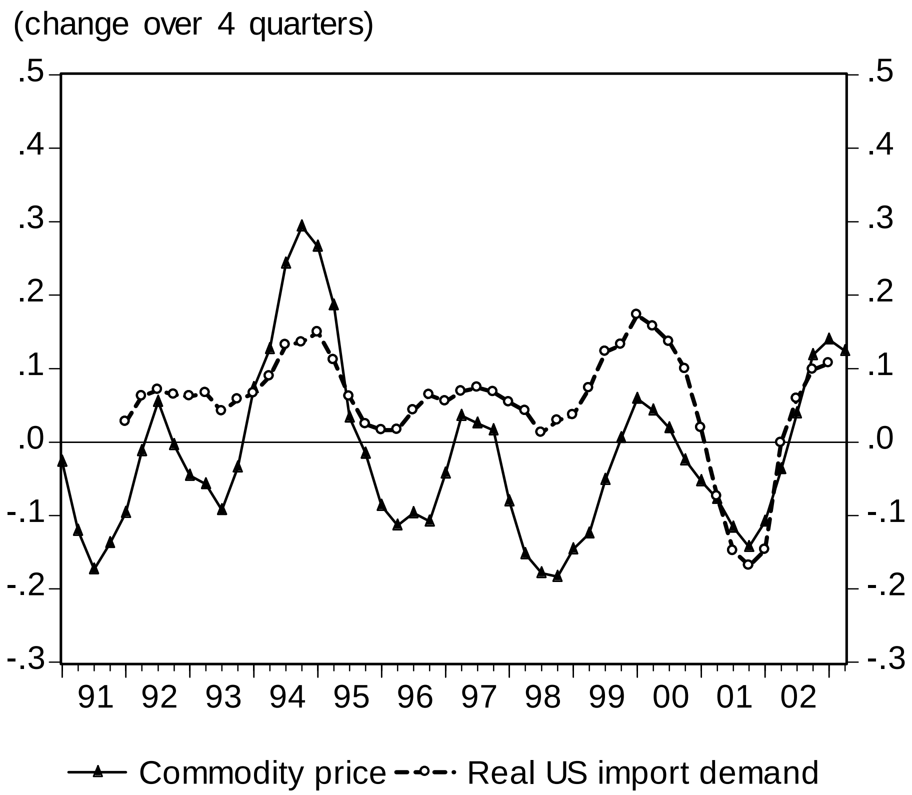


Table 1. Backward-looking Inflation Equation

Backward-looking inflation equation
Total (balanced) observations: 500
Sample period: 1990:1 to 2003:1

		Weighted 2SLS			Weighted 3SLS		
		coefficients	std. error	p-value	coefficients	std. error	p-value
A)	Lagged inflation	0.407	0.040	0.000	0.372	0.040	0.000
	Twice lagged inflation	0.238	0.039	0.000	0.206	0.037	0.000
	Expected future inflation	-	-	-	-	-	-
	Lagged output gap	0.051	0.010	0.000	0.064	0.009	0.000
	Lagged REER gap	-0.030	0.005	0.000	-0.035	0.005	0.000
	Change in NEER	-0.054	0.006	0.000	-0.057	0.005	0.000
	Change in foreign price	0.184	0.032	0.000	0.076	0.029	0.008

B)	Unit roots test on residuals	ADF test statistics	ADF test statistics
	China	-2.298	-1.932
	Hong Kong	-2.268	-1.641
	Indonesia	-4.801 *	-4.733 *
	Japan	-3.169 *	-2.868
	Korea	-3.768 *	-3.609 *
	Malaysia	-4.874 *	-3.517 *
	Phillippines	-4.796 *	-4.247 *
	Singapore	-3.210 *	-2.793
	Taiwan	-5.703 *	-4.742 *
	Thailand	-4.595 *	-4.228 *

* denotes the null hypothesis of unit root is rejected at 5% significant level.

C) Chow breakpoint test: (breakpoint introduced at 1997:3)
Null hypothesis: Coefficients are the same across entire sample period.

Restricted case: sample period from 1990:1 to 2003:1	
Restricted residual sum of squares:	0.043
Unrestricted case: two sample periods 1990:1-1997:2 and 1997:3 to 2003:1	
Unrestricted residual sum of squares:	0.029
Degrees of freedom	468
F-statistics	13.351 *

* denotes the null hypothesis is rejected at 5% significant level.

D) Structural stability test using dummy variables
Null hypothesis: Coefficients on a particular group of dummy variables are jointly zero

	Chi-squared statistics	p-value	Chi-squared statistics	p-value
Intercept dummy variables	37.636	0.000 *	56.04122	0.000 *
Interacting dummy variables	7.134	0.309	24.45757	0.000 *
All dummy variables	78.790	0.000 *	121.2409	0.000 *

Notes: Dummies are assigned the value of unity from 1997:3 to 2003:1, zero otherwise.
Intercept dummy variables refer to the group of ten dummies assigned as constants for each economy.
Interacting dummy variables refer to the group of six dummies interacting to each explanatory variable.
* denotes the null hypothesis of coefficients jointly equal to zero is rejected at 5% significant level.

Table 2. Forward-looking Inflation Equation

Forward-looking inflation equation
Total (balanced) observations: 490
Sample period: 1990:1 to 2003:1

		Weighted 2SLS			Weighted 3SLS		
		coefficients	std. error	p-value	coefficients	std. error	p-value
A)	Lagged inflation	0.196	0.045	0.000	0.299	0.043	0.000
	Twice lagged inflation	0.163	0.038	0.000	0.106	0.036	0.004
	Expected future inflation	0.558	0.050	0.000	0.527	0.041	0.000
	Lagged output gap	0.025	0.010	0.015	0.023	0.009	0.016
	Lagged REER gap	-0.024	0.005	0.000	-0.021	0.005	0.000
	Change in NEER	-0.027	0.007	0.000	-0.030	0.007	0.000
	Change in foreign price	0.086	0.033	0.009	0.078	0.027	0.005

		Weighted 2SLS	Weighted 3SLS
B)	Unit roots test on residuals	ADF test statistics	ADF test statistics
	China	-4.783 *	-4.948 *
	Hong Kong	-4.262 *	-4.682 *
	Indonesia	-5.664 *	-5.651 *
	Japan	-3.412 *	-3.613 *
	Korea	-5.752 *	-6.034 *
	Malaysia	-5.094 *	-5.068 *
	Phillippines	-5.705 *	-5.710 *
	Singapore	-4.653 *	-4.795 *
	Taiwan	-7.187 *	-7.523 *
	Thailand	-7.718 *	-7.675 *

* denotes the null hypothesis of unit root is rejected at 5% significant level.

C) Chow breakpoint test: (breakpoint introduced at 1997:3)
Null hypothesis: Coefficients are the same across entire sample period.

Restricted case: sample period from 1990:1 to 2003:1	
Restricted residual sum of squares:	0.035
Unrestricted case: two sample periods 1990:1-1997:2 and 1997:3 to 2003:1	
Unrestricted residual sum of squares:	0.033
Degrees of freedom	456
F-statistics	1.568

D) Structural stability test using dummy variables
Null hypothesis: Coefficients on a particular group of dummy variables are jointly zero

	Chi-squared statistics	p-value	Chi-squared statistics	p-value
Intercept dummy variables	5.369	0.865	4.743	0.908
Interacting dummy variables	2.006	0.960	10.508	0.162
All dummy variables	20.320	0.315	18.715	0.345

Notes: Dummies are assigned the value of unity from 1997:3 to 2003:1, zero otherwise.
Intercept dummy variables refer to the group of ten dummies assigned as constants for each economy.
Interacting dummy variables refer to the group of seven dummies interacting to each explanatory variable.

Table 3. Forward-looking Inflation Equation
Test for heterogeneity and asymmetric effect of output gap

	Forward-looking inflation equation Total (balanced) observations: 490 Sample period: 1990:1 to 2003:1					
	Weighted 2SLS estimation			Weighted 3SLS estimation		
	coefficients	std. error	p-value	coefficients	std. error	p-value
Lagged inflation	0.209	0.044	0.000	0.345	0.042	0.000
Twice lagged inflation	0.183	0.037	0.000	0.091	0.036	0.011
Expected future inflation	0.454	0.047	0.000	0.479	0.038	0.000
Lagged output gap	-0.045	0.049	0.359	-0.017	0.038	0.648
Lagged REER gap	-0.021	0.005	0.000	-0.015	0.004	0.000
Change in NEER	-0.019	0.007	0.009	-0.013	0.006	0.033
Change in foreign price	0.152	0.045	0.001	0.083	0.035	0.018
Test for heterogeneity						
Quadratic terms:						
Lagged output gap	-1.197	0.644	0.064	-0.642	0.506	0.206
Lagged REER gap	0.036	0.025	0.144	0.016	0.021	0.460
Change in NEER	0.072	0.026	0.006 *	0.057	0.022	0.011 *
Change in foreign price	-0.720	0.519	0.166	-0.263	0.388	0.498
Asymmetric effect of output gap						
Dummy x Lagged output gap	0.136	0.093	0.147	0.070	0.072	0.337

* denotes the coefficient on quadratic term is significant at 5% level.

Table 4. Forward-looking Inflation Equation
Heterogeneous Effects of NEER

Forward-looking inflation equation
Total (balanced) observations: 490
Sample period: 1990:1 to 2003:1

	Weighted 2SLS estimation			Weighted 3SLS estimation		
	coefficients	std. error	p-value	coefficients	std. error	p-value
Lagged inflation	0.210	0.047	0.000	0.307	0.044	0.000
Twice lagged inflation	0.184	0.038	0.000	0.104	0.036	0.004
Expected future inflation	0.607	-	-	0.590	-	-
Lagged output gap	0.019	0.010	0.053	0.016	0.009	0.070
Lagged REER gap	-0.016	0.005	0.000	-0.014	0.004	0.001
Change in foreign price	0.078	0.034	0.024	0.061	0.029	0.037
Individual coefficients on change in NEER:						
China	-0.039	0.036	0.282	-0.010	0.030	0.727
Hong Kong	-0.022	0.041	0.602	-0.020	0.031	0.519
Indonesia	-0.046	0.021	0.026 *	-0.038	0.018	0.028 *
Japan	0.015	0.013	0.257	0.008	0.011	0.476
Korea	-0.070	0.016	0.000 *	-0.077	0.012	0.000 *
Malaysia	-0.008	0.012	0.528	0.001	0.010	0.955
Phillippines	0.011	0.022	0.628	-0.003	0.018	0.885
Singapore	-0.036	0.030	0.238	-0.016	0.028	0.568
Taiwan	0.040	0.059	0.492	-0.039	0.047	0.402
Thailand	-0.022	0.017	0.192	-0.021	0.015	0.156

* denotes the individual coefficient on NEER is significant at 5% level.

Table 5. Output Gap Equation

Output gap equation

Total (balanced) observations: 470

Sample period: 1990:1 to 2003:1

	Weighted 2SLS			Weighted 3SLS		
	coefficients	std. error	p-value	coefficients	std. error	p-value
A) Lagged output gap	1.085	0.044	0.000	0.960	0.045	0.000
Twice lagged output gap	-0.304	0.044	0.000	-0.226	0.044	0.000
Real US import demand	0.069	0.021	0.001	0.066	0.020	0.001
Real interest rate	-0.031	0.011	0.005	-0.016	0.009	0.081

B) Unit roots test on residuals

	Weighted 2SLS	Weighted 3SLS
China	-4.510*	-4.810*
Hong Kong	-3.684*	-3.196*
Indonesia	-3.720*	-3.167*
Japan	-4.553*	-3.986*
Korea	-3.308*	-3.169*
Malaysia	-3.356*	-3.168*
Phillippines	-3.308*	-3.932*
Singapore	-3.583*	-3.487*
Taiwan	-3.654*	-3.409*
Thailand	-3.401*	-3.044*

* denotes the null hypothesis of unit root is rejected at 5% significant level.

C) Chow breakpoint test (breakpoint introduced at 1997:3)
Null hypothesis: Coefficients are the same across entire sample period.

Restricted case: sample period from 1990:1 to 2003:1	0.079
Restricted residual sum of squares:	
Unrestricted case: two sample periods 1990:1-1997:2 and 1997:3 to 2003:1	0.068
Unrestricted residual sum of squares:	
Degrees of freedom	442
F-statistics	4.864*

D) Structural stability test using dummy variables
Null hypothesis: Coefficients on a particular group of dummy variables are jointly zero

	Chi-squared statistics	p-value	Chi-squared statistics	p-value
Intercept dummy variables	27.242	0.000*	53.269	0.000*
Interacting dummy variables	15.640	0.110	6.639	0.156
All dummy variables	45.137	0.000*	64.408	0.000*

Notes: Dummies are assigned the value of unity from 1997:3 to 2003:1, zero otherwise.
Intercept dummy variables refer to the group of ten dummies assigned as constants for each economy.
Interacting dummy variables refer to the group of four dummies interacting to each explanatory variable.
* denotes the null hypothesis of coefficients jointly equal to zero is rejected at 5% significant level.

Table 6. Output Gap Equation
Adjusted for Structural Instability

Output gap equation
Total (balanced) observations: 470
Sample period: 1990:1 to 2003:1

	Weighted 2SLS			Weighted 3SLS		
	coefficients	std. error	p-value	coefficients	std. error	p-value
Lagged output gap	1.056	0.044	0.000	0.792	0.046	0.000
Twice lagged output gap	-0.292	0.045	0.000	-0.138	0.045	0.002
Real US import demand	0.071	0.022	0.001	0.071	0.020	0.001
Real interest rate	-0.042	0.012	0.000	-0.018	0.009	0.052

Table 7. Output Gap Equation
Test for Heterogeneity

Output gap equation
Total (balanced) observations: 470
Sample period: 1990:1 to 2003:1

	Weighted 2SLS estimation			Weighted 3SLS estimation		
	coefficients	std. error	p-value	coefficients	std. error	p-value
Lagged output gap	1.058	0.044	0.000	0.836	0.045	0.000
Twice lagged output gap	-0.290	0.044	0.000	-0.153	0.043	0.000
Real US import demand	0.068	0.021	0.002	0.065	0.020	0.001
Real interest rate	-0.029	0.015	0.056	-0.023	0.013	0.084
Quadratic terms:						
Lagged output gap	1.861	0.739	0.012 *	1.367	0.634	0.032 *
Twice lagged output gap	-1.878	0.704	0.008 *	-0.679	0.617	0.272
Real US import demand	0.592	0.610	0.332	-0.862	0.577	0.136
Real interest rate	-0.054	0.047	0.249	0.000	0.035	0.998

* denotes the coefficient on quadratic term is significant at 5% level.

Table 8. Output Gap Equation
Heterogeneous Effects of Lagged Output Gaps

Output gap equation

Total (balanced) observations: 470

Sample period: 1990:1 to 2003:1

	Weighted 2SLS estimation			Weighted 3SLS estimation		
	coefficients	std. error	p-value	coefficients	std. error	p-value
Twice lagged output gap	-0.310	0.045	0.000	-0.219	0.044	0.000
Real US import demand	0.064	0.021	0.003	0.070	0.021	0.001
Real interest rate	-0.031	0.015	0.037	-0.023	0.013	0.083
First lag of output gap across economies						
China	0.974	0.105	0.000	0.838	0.102	0.000
Hong Kong	1.137	0.069	0.000	1.035	0.060	0.000
Indonesia	1.067	0.083	0.000	0.931	0.073	0.000
Japan	0.803	0.134	0.000	0.744	0.127	0.000
Korea	1.078	0.076	0.000	0.857	0.063	0.000
Malaysia	1.098	0.080	0.000	0.929	0.065	0.000
Phillippines	1.089	0.085	0.000	0.980	0.077	0.000
Singapore	1.069	0.081	0.000	0.937	0.073	0.000
Taiwan	0.976	0.093	0.000	0.854	0.077	0.000
Thailand	1.129	0.070	0.000	0.978	0.063	0.000