# Exchange rate pass-through in emerging market economies: what has changed and why?

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## Introduction

Inflation has been fairly stable in many industrial and emerging market economies over the past few years despite wide swings in exchange rates. This development has drawn attention to the issue of the exchange rate pass-through to domestic prices and to whether and, if so, why it has declined. The last time this issue was discussed at a BIS meeting for emerging markets was in early 2001, in the aftermath of the Asian and Russian crises of 1997–98 and shortly before the onset of the most recent major emerging market crises, those in Argentina and Turkey.[2] Already at that time a decline in the exchange rate pass-through had been documented for the 1990s. However, the pass-through still seemed to be high: in countries with a history of high inflation, exchange rate changes were essentially fully passed into domestic CPI within a period of six months.

For the great majority of emerging market countries, the period since 2001 has been much more successful in terms of overall macroeconomic performance than the 1990s. Many central banks have implemented significant changes in their monetary policy frameworks. In larger economies, exchange rates were in many cases freed and inflation targeting was introduced. In a number of smaller countries, hard peg regimes were introduced in order to anchor inflation expectations. Many emerging market economies have experienced a dramatic decline in inflation partly as a result of these changes. Inflation has also declined globally as international and domestic competition has intensified since the late 1990s. In this environment, one might expect to observe a further decline in the pass-through of exchange rate changes to domestic inflation.

Against this background, this note provides estimates of the pass-through from exchange rate and foreign price changes to inflation for 14 emerging market countries for the period from 1994 to mid-2006. The main question addressed is whether the exchange rate pass-through has changed over time and, if so, what the likely determinants of this change have been. To verify whether the exchange rate pass-through has declined, estimates from this paper are compared with those for an earlier period (late 1980s to 2000) from Mihaljek and Klau (2001), using essentially the same data set and estimating framework. The paper also addresses some issues that have not been extensively analysed in the literature, such as the asymmetric and threshold effects of exchange rate changes on inflation, and the impact on the pass-through of the trend appreciation of real exchange rates in the catching-up economies.

The paper is organised as follows. Section 1 discusses recent developments in the literature and presents central banks' assessments of the exchange rate pass-through, which were provided in answers to the questionnaire prepared for this meeting. Section 2 describes the

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[2] See proceedings of a workshop on "Modelling aspects of the inflation process and the monetary transmission mechanism in emerging market countries" in *BIS Papers,* no 8, November 2001.

estimating framework and the data set used in the empirical part of the paper. Section 3 describes the estimation results. Section 4 provides tentative interpretations of possible reasons for the observed changes in the exchange rate pass-through.

## 1. Literature and central banks' assessments

The most direct way of transmitting nominal exchange rate changes into domestic inflation is by altering the domestic currency prices of imported goods. How the exchange rate affects domestic prices via import prices depends to a large extent on the pricing behaviour of exporting and importing firms.

Under so-called pricing to market, exporting firms and/or their importers/distributors fix the import price in the local currency of the market they are exporting to. Exchange rate movements therefore need not be reflected in local currency prices, implying, in an extreme case, a zero pass-through. This case is perhaps more relevant for large industrial economies such as the United States, the euro area and Japan than for smaller industrial and emerging market economies.

The other extreme is when prices of imported goods are quoted in foreign currency and are sold to consumers for local currency at the going market exchange rate. In such a case, any change in the exchange rate will be automatically transmitted to the consumer prices of the importing country, implying a complete exchange rate pass-through. This might be the case, for instance, in an environment of very high inflation or in highly dollarised economies.

The most relevant case for smaller industrial and emerging market economies would seem to be that of foreign exporters selling goods to local importers/distributors at prices quoted in foreign currency, and distributors then re-selling goods in the local market at prices quoted in local currency. If they operate in a competitive market, importers/distributors would partly absorb any effects of exchange rate changes by varying their mark-ups, so the pass-through would be incomplete.

Consistent with these theoretical considerations, a typical finding of the empirical literature for industrialised countries is that the exchange rate pass-through lies between 0 and 1 (Campa and Goldberg (2002)). The measured pass-through is usually the highest for imported goods prices, lower for producer prices and lowest for consumer prices. Several explanations have been offered for this hierarchy of pass-through effects.

- The first is that as imported goods reach consumers through wholesale and retail networks, their prices accumulate a substantial local input of services such as transportation, marketing and advertising, which partly cushions the impact of exchange rate changes on final retail prices (Burstein et al (2005)).
- The second explanation is that imports are mainly intermediate goods to which foreign currency pricing applies, so the pass-through is complete for prices "on the docks". By contrast, retail prices, as a combination of imported and local goods prices, are set in local currency and are adjusted only periodically due to menu costs (Engel (2002)). Exchange rate movements could thus be incorporated in retail prices, but only periodically, blurring the direct link between exchange rate changes and domestic inflation.
- A third explanation is that consumers in addition switch from imported goods to lower-quality, cheaper local brands when larger exchange rate depreciations occur (Burstein et al (2005)). Similarly, when the local currency strengthens, consumers might switch to higher-quality, more expensive brands, so inflation might not decline in tandem with exchange rate appreciation.

Another important finding in the literature is that the exchange rate pass-through is higher for emerging market countries and that it declines over time for both industrial and emerging market countries.[3] Three explanations have been proposed for this finding.

The first explanation focuses on shifts in the composition of imports from "high pass-through" goods to "low pass-through" goods (Campa and Goldberg (2002)). In the more developed countries, the pass-through is nearly complete for energy and raw materials and is considerably lower than unity for food and manufactured products. A shift in the composition of imports from raw materials to manufactured goods could thus lead to a decline in the measured exchange rate pass-through for both import and consumer prices.

The second explanation relates to the role of macroeconomic variables, especially inflation. Taylor (2000) conjectured that the slowdown in the pass-through – and the higher pass-through for emerging market than industrial countries – was due to changes in the macroeconomic environment, in particular in the level and variability of inflation. More precisely, monetary policy that credibly pursues a policy aimed at keeping inflation low and stable may, by anchoring inflation expectations, increase the readiness of firms to absorb exchange rate fluctuations in their profit margins. In a more stable inflationary environment, exchange rate shocks may be perceived as more temporary.

The third explanation is that the globalisation of economic activity has increased competition and the contestability of markets and reduced the pricing power of dominant firms in the tradable sector. In such an environment, firms may have to absorb temporary cost increases that are due to exchange rate movements, thereby reducing the exchange rate pass-through. To maintain profit margins, firms may outsource production to lower-cost countries, including the ones to which they are exporting, which might further reduce the pass-through.

Whether and, if so, how far the exchange rate pass-through has declined and why this has happened has been extensively discussed in the empirical literature. Frankel et al (2005), using highly disaggregated data on individual goods prices in a large sample of countries, found that the pass-through to the CPI level had decreased, but only in developing countries and not in the developed ones. They also found that the pass-through to import prices was incomplete and had increased over time. The United States was an outlier in that the pass-through to import prices was found to be considerably lower than in other developed economies. Campa and Goldberg (2006) also found that retail price sensitivity to exchange rates may have increased in industrial countries over the past decade, both for traded and for non-traded goods. They conjectured that one of the reasons might have been a large expansion of imported input use across sectors, implying greater sensitivity of the costs of imported and non-tradable goods to import prices and exchange rates.

The relationship between the monetary policy regime and the pass-through has been tested for a large number of countries by Devereux and Yetman (2003), Choudhri and Hakura (2001) and Ca'Zorzi et al (2005). These studies in general showed that high inflation was indeed conducive to perfect pass-through and was often associated with complete pass-through. Bailliu and Fujii (2004) found that for a set of 11 OECD countries the pass-through declined not just for consumer prices but also for import and producer prices during the 1990s. Other determinants of the decline in the exchange rate pass-through were found to be inflation variability (Gagnon and Ihrig (2001)) and openness and country size: the more open and the smaller a country is, the higher the pass-through seems to be (Soto and Selaive (2003)).

In addition to large cross-country studies, there have been many studies of the exchange rate pass-through focusing on individual emerging market countries and regions.[4] Research in both areas is continuing.

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[3] Sekine (2006) found that the pass-through declined over time in all major industrial countries. Campa and Goldberg (2002) argue that it could be observed only for half of the OECD countries.

## Central banks' assessments

The literature on the exchange rate pass-through does not analyse in detail the role of the exchange rate regime as a possible determinant of the pass-through. In general, the pass-through is thought to be higher for countries where the exchange rate serves as a nominal anchor to inflationary expectations. In such countries, any change in the exchange rate would be rapidly incorporated into expectations and thus prices of both tradables and non-tradables. If the exchange rate is not used as an intermediate target, inflation expectations would be less strongly associated with changes in the exchange rate. This would result in a lower exchange rate pass-through. Finally, in an inflation targeting regime with floating exchange rates, inflation expectations are mainly anchored by the central bank's inflation target, so exchange rate developments can be expected to have relatively little influence on domestic CPI.

These observations are clearly present in central banks' assessments of recent changes in the exchange rate pass-through, which were communicated in answers to the BIS questionnaire prepared for this meeting. Table 1 summarises the central banks' views.

Ten out of 15 central banks found evidence of a recent decline in the exchange rate pass-through. For those central banks that could quantify the change more precisely, the pass-through coefficient declined by about one-third (Colombia, Israel, Peru, Turkey) to one-half (Poland), or even more (the Philippines). The main reasons for the decline were identified as greater exchange rate flexibility and the decline in inflation, which has in turn been associated in several countries with the introduction of inflation targeting.[5]

However, assessments of the decline in the exchange rate pass-through are not universally shared. Four central banks out of 15 have not observed a decline in the pass-through: in Hong Kong and South Africa it was not clear that the pass-through had declined; in Malaysia the pass-through has been relatively stable; and in Thailand it increased slightly.

One should note that in these four countries the exchange rate pass-through was relatively small to begin with. In addition, the fact that the pass-through had not declined might be partly related to the role of exchange rate regimes. The Hong Kong dollar has been closely linked to the US dollar for over two decades and the Malaysian ringgit for almost a decade. Provided most imports come from the wider dollar area and are invoiced in US dollars, a certain degree of stability of the exchange rate pass-through should not come as a surprise. Thailand switched from a relatively long period of a fixed exchange rate to a floating exchange rate with inflation targeting at the start of the 1997 crisis. As economic agents learned to deal with fluctuating exchange rates in this environment, some increase in the exchange rate pass-through might have been expected, although the pass-through remains small. The case of South Africa, which has a relatively long experience with exchange rate floating and inflation targeting, might suggest that inflation expectations might have become more firmly anchored by the central bank's inflation target than by exchange rate expectations.

Three central banks (the Czech Republic, Singapore and Thailand) reported a lower pass-through of exchange rate changes to domestic inflation than to import prices. The pass-through to import prices seems to be much faster than that to inflation; the latter takes from one year (Turkey) to two years or longer to complete (Singapore, Thailand). Finally, the central banks of Poland and South Africa found asymmetric effects of exchange rate changes on inflation, with depreciation having a larger impact than appreciation.

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[4] See for instance Bhundia (2002), Edwards (2005), Goldfajn and da Costa Werlang (2000), de Gregorio and Tokman (2004), Ito and Sato (2006), da Silva Correa and Minella (2006), Rincon et al (2005) and Rowland (2003).

[5] See the papers in this volume by the Bank of Thailand (2008), Başçi et al (2008, on Turkey), Eckstein and Soffer (2008, on Israel), Guinigundo (2008, on the Philippines), Rossini and Vega (2008, on Peru) and Sidaoui and Ramos-Francia (2008, on Mexico).

Table 1

**Central bank assessments of exchange rate pass-through**

| Country | Recent estimate of PT coefficient[1] | Has PT coefficient declined recently? | Main reason for the decline of PT | Relative size of PT to different price indices | Other |
|---|---|---|---|---|---|
| Hong Kong | | No evidence that PT declined | | | |
| India | 8–17% | Yes, since the 1990s | Decline in inflation; lower tariffs | | |
| Malaysia | | No; PT relatively stable in 1990–2006 | | | |
| Philippines | 1.2% | Yes, from 23% before 1993 | | | PT is generally very low |
| Singapore | 3% | | | $CPI^{PT}$ < $Imp.Price^{PT}$ | Complete PT after 2 yrs |
| Thailand | Small | Increased slightly | ER flexibility | $CPI^{PT}$ << $Prod.Pr.^{PT}$ << $Imp.Pr.^{PT}$ | PT to import prices full and rapid; PT to CPI not full even in the long run |
| Colombia | 3% 2006 | Yes, from 4–5% in mid-1980s | | | |
| Peru | 10% 2006 | Yes, from 10–20% in 2001–04 | | | |
| Venezuela | | Yes, during 2005–06 | FX reserves↑; oil prices↑; lower ER volatility | | |
| Czech Republic | 0–40% | Yes | Inflation targeting, ER flexibility | $CPI^{PT}$ << $Imp.Price^{PT}$ | |
| Hungary | | Yes | Widening of ER band, inflation targeting | | |
| Poland | 12% 2006 | Yes, from 24% in 2002 | Inflation targeting, ER float | | Asymmetric response of PT (ER↓ > ER↑) |
| Israel | 23% 1999–2004 | Yes, from 33% in 1991–98 | Decline in inflation, ER stabilisation | | Half of PT via rental contracts fixed to USD |
| Turkey | 42% Since 2001 | Yes, from 63% before the float | | | Full PT takes 1 year (vs 4–5 months before) |
| South Africa | 7.8% | Not clear that PT declined | | | Asymmetric, threshold effects apply |

[1] Percentage increase in the CPI following a 10% depreciation of the exchange rate (individual country definitions may differ slightly).

Sources: Central bank answers to the BIS questionnaire; central bank studies.

## 2. Estimating framework and data

The framework used to estimate the pass-through effect in this paper is a simple single equation estimated separately for each country. The dependent variable is the average quarterly change in (the log of) a country's consumer price index ($\Delta p_t$) and the explanatory variables are average quarterly changes in (the logs of) lagged CPI ($\Delta p_{t-1}$), foreign prices measured in foreign currency ($\Delta p^*_t$), the nominal exchange rate ($\Delta e_t$) and a set of control variables:[6]

$$\Delta p_t = c + \beta_{1j}\Sigma(\Delta p_{t-j}) + \beta_2 \Delta p^*_t + \beta_3 \Delta e_t + \beta_{4j} Z_{jt} + u_t \quad (1)$$

Lagged CPI ($\Delta p_{t-j}$) is included to allow the possibility of a partial adjustment of domestic inflation to the explanatory variables.[7]

Foreign prices measured in foreign currency ($\Delta p^*_t$) are included to separate the impact of exchange rate and foreign price changes (measured in foreign currency) on domestic inflation. This specification is more general than standard pass-through models, which have traditionally considered either how import prices in *domestic* currency are passed into domestic CPI, or how the exchange rate and foreign price movements that are passed into prices "at the docks" are subsequently absorbed in producer profit margins or mark-ups. In other words, in standard pass-through models the effects of exchange rate and foreign price changes are usually lumped into a single variable – import prices in domestic currency. Alternatively, it is assumed that their impact is "exhausted" on prices at the docks (ie, the first-stage pass-through is assumed to be approximately unity), and the estimation then focuses on the second-stage pass-through, which depends on the structure of competition in import-competing industries and the cost of domestic inputs (primarily labour) used in the distribution and sale of imported goods.

The first control variable used in the above specification is the domestic output gap ($y_t - y^*_t$), estimated using the Hodrick-Prescott filter. It controls for the effects of excess demand on inflation. Although it is common in studies of industrial countries, the output gap is still rarely used in studies of the pass-through in emerging market economies, partly because of incomplete data for many countries.

The second control variable is the equilibrium real exchange rate gap ($e^r_t - e^{r*}_t$), ie, the deviation of (the log of) the real effective exchange rate from its long-term equilibrium trend, which is estimated by a Hodrick-Prescott filter.[8] The rationale for including this control variable is the observed long-term tendency for real exchange rates to appreciate in the countries that are catching up with productivity levels and living standards in advanced industrial economies. The real exchange rate gap controls for the impact on inflation of the trending movement of real exchange rates and "non-equilibrium" deviations from this trend.[9] If one ignores these effects, one might underestimate the exchange rate pass-through, given

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[6] Up to four lags of each explanatory variable are used in estimation, but only one lag is specified in equation (1) to simplify notation.

[7] Thus, the short-run exchange rate elasticity is given by $\beta_3$, the long-run elasticity by $\beta_3/(1 - \beta_1)$ the short-run foreign price elasticity by the coefficient $\beta_2$, and the long-run elasticity by $\beta_2/(1 - \beta_1)$ etc.

[8] By substituting the log of the real exchange rate $e^r_t = p_t - p_t^* - e_t$ into (1) and taking lags, it can be shown that this specification effectively imposes the long-run purchasing power parity restriction on equation (1). In this specification, the coefficient $\beta_{4j}$ on the real exchange rate gap represents the instantaneous long-run exchange rate pass-through.

[9] Estimating equilibrium real exchange rates in emerging market economies is of course much more complex. For an overview of this issue in transition economies see Égert et al (2006).

the observed tendency of real exchange rates to appreciate in recent years. So far, only one study (Darvas (2001)) has explicitly modelled this aspect of the exchange rate pass-through.

The expected signs of the first three parameters in equation (1) are all positive: higher inflation persistence, an increase in foreign prices and a currency depreciation are all expected to lead to higher domestic inflation. The same is true of a positive output gap. A positive real exchange rate gap – which occurs when the real exchange rate appreciates above its trend – is expected to have a dampening effect on inflation.

Other control variables that were considered but were not included in the above specification are oil prices and regulated prices. In more advanced economies there is usually complete pass-through of oil price changes to domestic inflation, so one can expect the coefficient on oil price changes to be close to unity. In many emerging market economies the pass-through of oil price changes to domestic inflation is muted through various fiscal measures (eg, consumer subsidies). In such cases the coefficient on oil prices would be lower than unity. In the present paper we do not model these effects separately because they are subsumed in changes in foreign prices measured in foreign currency ($\Delta p^*_t$). Changes in regulated prices clearly play an important role in the dynamics of inflation in emerging markets and their inclusion would have made estimates of pass-through coefficients more precise. However, it was not possible to collect the relevant data for all the countries in the sample.

The present paper attempts to model the asymmetric effects of exchange rate changes on inflation. As noted above, exchange rate depreciation is often believed to have a larger impact on inflation than exchange rate appreciation. This issue has not often been addressed in the literature but is potentially important for assessing the size and evolution of the exchange rate pass-through. The asymmetric effects are modelled by including separate dummy variables for periods when exchange rates are depreciating and those when they are appreciating. If the size of the coefficient for depreciation is found to be significantly higher than that for appreciation, one can conclude that asymmetric effects of exchange rate changes on inflation are likely to be present.

Similarly, an attempt is made to model the threshold effects of exchange rate changes on inflation, ie, to assess whether exchange rate changes affect inflation only when they exceed a certain large enough threshold in a given period. This effect has not been modelled in the literature so far. It is assessed by defining a special dummy variable equal to 1 when exchange rate changes exceed ±5% over one quarter, ie, ±22% on an annual basis.

## Data

The analysis covers 14 emerging market countries: India, Korea, Malaysia, the Philippines and Thailand from Asia; Brazil, Chile, Mexico and Peru from Latin America; the Czech Republic, Hungary, Poland and Turkey from central and eastern Europe; and South Africa. The data series start in the first quarter of 1994 and cover the period up to the second quarter of 2006. 1994 was chosen as the initial year for the sample because of limited data for earlier years, in particular for transition economies from central and eastern Europe.

Most variables are defined in a standard way (see Data Appendix for details). The output gap is defined as a deviation of the actual growth rate of GDP from the trend growth rate, which is in turn calculated using the Hodrick-Prescott filter. Similarly, the real exchange rate gap is defined as a deviation of the actual real exchange rate from the trend real exchange rate, which is also calculated using the Hodrick-Prescott filter.

One non-standard variable is foreign price measured in foreign currency, which is derived from nominal and real effective exchange rates for each country. By construction, this variable is a multilateral foreign consumer price index, rather than the more narrow import unit value index often used in empirical literature.

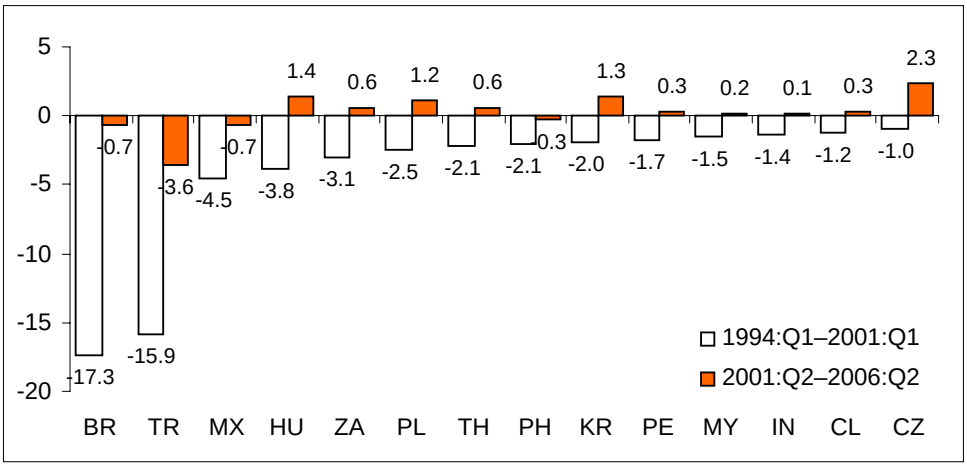
Average values and standard deviations of the main variables are shown in Appendix Table A1. They are compared in Graphs 1–3 for two illustrative sub-samples: 1994–2001:Q1 and 2001:Q2–2006:Q2. The first quarter of 2001 was chosen as a mid-point of the sample because it marks a period when the crises in Argentina and Turkey broke out. It is interesting in this regard that, despite a string of major emerging market crises from the mid-1990s up to the first quarter of 2001, the standard Chow test for in-sample structural breaks does not suggest the presence of structural breaks in the exchange rate pass-through for the majority of countries for the period from 1994 to 2001; the null hypothesis of no structural break was rejected only for the Czech Republic, Mexico and Thailand.

As can be seen from Graph 1, there was a dramatic change in the pattern of exchange rate changes between these two sub-periods. From 1994:Q1 to 2001:Q1, all countries in the sample experienced on average domestic currency depreciation, ranging from 17.3% per quarter in Brazil to 1% per quarter in the Czech Republic. By contrast, since the second quarter of 2001, only Turkey, Brazil and Mexico have on average experienced somewhat larger domestic currency depreciation; elsewhere, nominal exchange rates have appreciated by up to 2.3% per quarter on average. As noted above, this trend appreciation clearly needs to be isolated in estimates so as to avoid underestimating the exchange rate pass-through.

Graph 1

**Changes in exchange rates**

Quarterly percentage changes



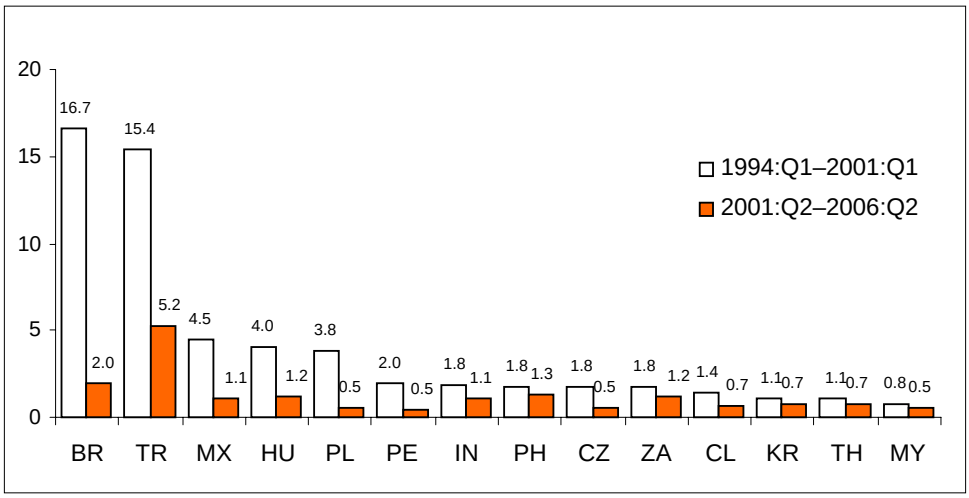

Sources: IMF; national data; BIS calculations.

Changes in inflation between the two sub-periods were in some countries no less dramatic; in others they were smaller but nonetheless visible. As shown in Graph 2, inflation declined between the two sub-periods most significantly in Brazil – from 16.7% per quarter (85% per annum) to 2% per quarter (8.2% per annum) – and Turkey, followed by Mexico, Hungary, Poland and Peru. Elsewhere, quarterly inflation rates declined by about 0.6 percentage points on average between the two periods.

Graph 2

**Changes in inflation**

Quarterly percentage changes



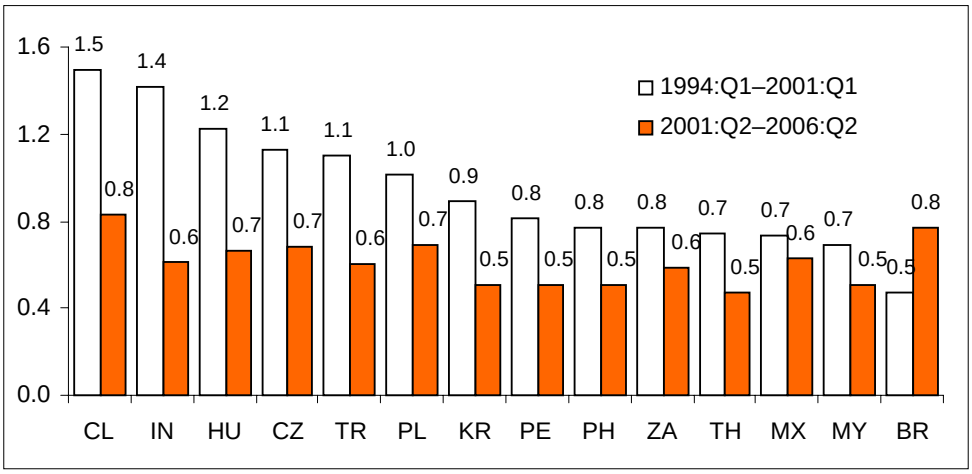

Sources: National data; BIS calculations.

Foreign prices have increased more slowly since 2001 in all the countries with the exception of Brazil (Graph 3). On average, foreign prices have increased by 0.6% per quarter since 2001:Q2, a third of a percentage point more slowly than during 1994:Q1–2001:Q1. This evidence provides support to the view that prices of imported goods have been trending down globally over the past few years, probably due to increased global competition.

Graph 3

**Changes in foreign prices**

Quarterly percentage changes




Sources: National data; BIS calculations.

## 3. Estimation results

Least squares estimates of the parameters in equation (1) are shown in Appendix Tables A2 (without the real exchange rate trend, comparable to the estimates in Mihaljek and Klau (2001))

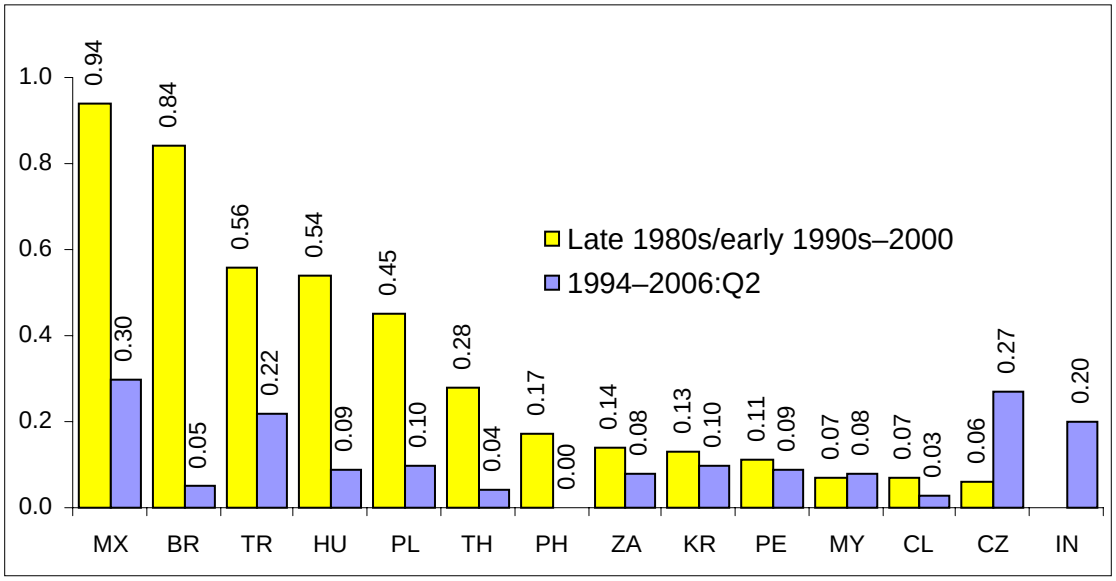
and A3 (with the real exchange rate trend).[10] All estimated coefficients are statistically highly significant; the overall fit of regressions and other standard test statistics are fairly good.

The change in pass-through coefficients over time is assessed by comparing pass-through coefficients for the period from 1994 to mid-2006 from this paper with those for the period from the late 1980s up to end-2000 presented in Mihaljek and Klau (2001). Given that the data used in these two papers are essentially the same, these comparisons over a partly non-overlapping period provide a relatively reliable indication of the direction of change in pass-through coefficients.[11]

As can be seen from Graph 4, the (short-term) **exchange rate pass-through** appears to have declined in all the countries in the sample since 2001, with the exception of the Czech Republic.[12] In Brazil and Mexico, for instance, the exchange rate pass-through was nearly complete for the period from the late 1980s to 2000. But in the period from 1994 to mid-2006, the pass-through coefficient declined to 0.3 in Mexico and just 0.1 in Brazil, meaning that the (quarterly) rate of inflation resulting from 1% nominal exchange rate depreciation increased by 0.3% and 0.1%, respectively. Hungary, the Philippines, Poland, Thailand and Turkey also seem to have experienced a substantial decline in the exchange rate pass-through. In Chile, Korea, Malaysia, Peru and South Africa, the exchange rate pass-through was already quite low before 2001 but appears to have further declined in the period since. Reasons for the small increase in the pass-through in the Czech Republic are unclear.

Graph 4

**Pass-through of changes in exchange rates to inflation**




Source: BIS calculations.

[10] For India, the results of regressions with the trend are not shown because they were generally very poor.

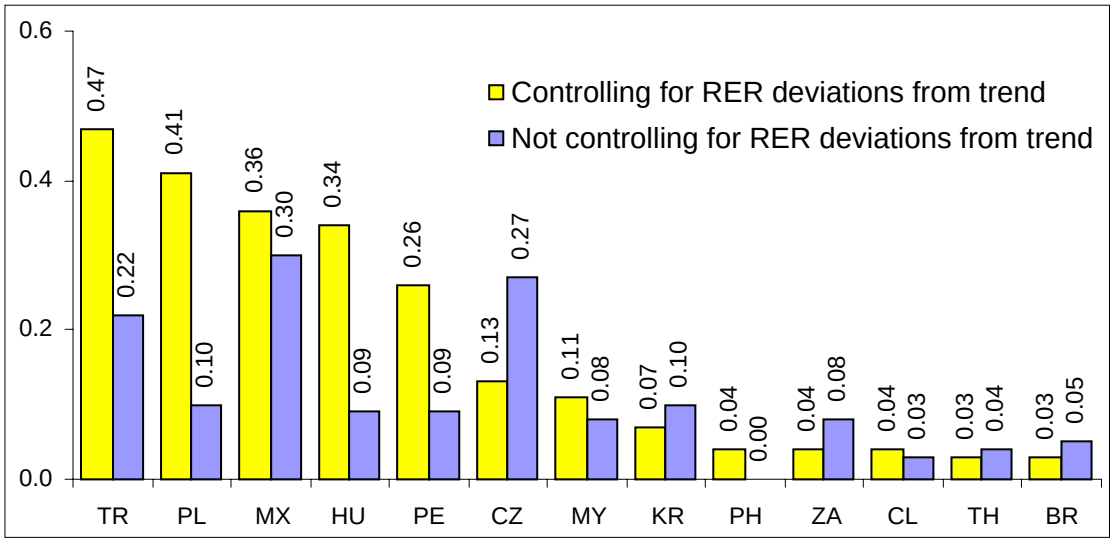
[11] The change in pass-through could have also been assessed by running separate regressions for periods before and since 2001:Q1. However, with the quarterly data used, the number of observations for the latter period (21 in total) would have been too small to allow statistically reliable conclusions to be drawn. Another possibility would have been to use the time-varying parameter approach, which was successfully applied to industrial countries by Sekine (2006). However, the shortness of individual data series and other data requirements made this approach impractical. The third possibility, yet to be explored, is rolling and recursive regressions.

[12] The pass-through coefficients shown in Graph 4 and subsequent graphs in this section represent sums of contemporaneous and lagged (up to four quarters) coefficients on the nominal exchange rate and other right-hand-side variables in equation (1) (see Appendix Table A2).

Graph 5 shows estimates of the exchange rate pass-through for the period 1994–2006:Q2 from alternative specifications of equation (1), with and without controlling for deviations of the real exchange rate from its trend. Consistent with the above remarks, controlling for real exchange rate appreciation increases the size of estimates of the short-term exchange rate pass-through for several countries that have experienced pronounced real exchange rate appreciation, such as Hungary, Mexico, Peru, Poland and Turkey.

Graph 5

**Alternative estimates of exchange rate pass-through**

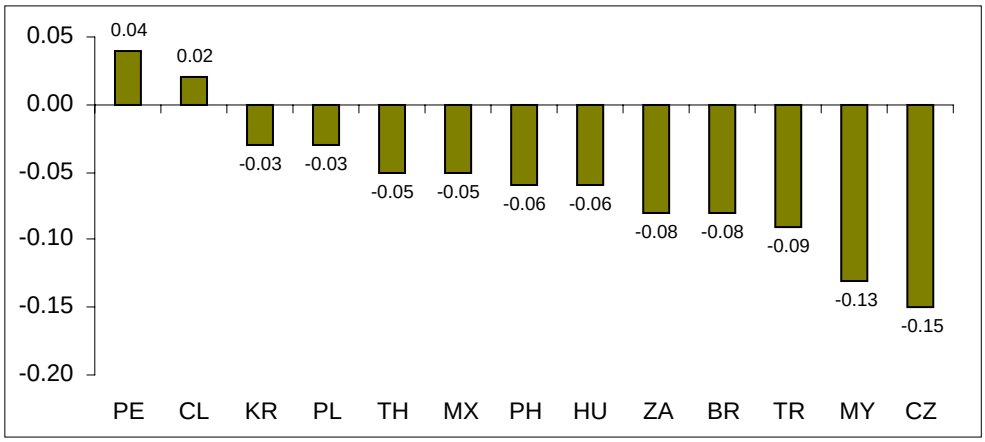



Source: BIS calculations.

In other countries that have experienced relatively strong trend appreciation (including the Czech Republic, Korea, South Africa and Thailand), controlling for this trend decreases slightly (in the case of the Czech Republic, significantly) the estimated pass-through coefficient. One reason might be that there were fewer large deviations of the real exchange rate from trend in these countries. In addition, lower initial pass-through may have played a role. For the countries where trend appreciation has not been pronounced, the difference between alternative estimates of the exchange rate pass-through is small.

Graph 6

**Real exchange rate appreciation above trend and inflation**




Source: BIS calculations.

With the exception of Chile and Peru, above-trend real exchange rate appreciation has had the predicted dampening effect on inflation. In the Czech Republic, for instance, real exchange rate appreciation of 1% above the trend reduces quarterly inflation by 0.15%, and in Malaysia by 0.13% (Graph 6).

There is also some evidence of **asymmetric effects** of exchange rate depreciation vs appreciation on domestic inflation. Exchange rate depreciation seems to have a significant and stronger effect on inflation than appreciation in Korea, Malaysia, Mexico, Poland and Turkey (Table 2). Appreciation seems to have a significant and stronger effect on inflation only in the Philippines, Brazil and Hungary. For other countries, this simple approach does not suggest the presence of asymmetric effects of exchange rate changes on inflation.

Table 2

**Asymmetric and threshold effects of exchange rate changes on inflation**

| **Depreciation**[1] | | | **Appreciation**[1] | | **Threshold effects**[2] | |
|---|---|---|---|---|---|---|
| **Significant** | **Not significant** | **Stronger effect than appreciation** | **Significant** | **Not significant** | **Significant** | **Not significant** |
| Korea | | Korea | Korea* | | Malaysia | Korea |
| Malaysia | | Malaysia | | Malaysia | Thailand | Philippines |
| | Philippines | | Philippines* | | Mexico | South Africa |
| | Thailand | | | Thailand | Hungary | Brazil |
| | South Africa | | | South Africa | Turkey | Chile |
| | Brazil | | Brazil | | | Peru |
| | Chile | | | Chile | | Poland |
| Mexico | | Mexico | | Mexico | | Czech Rep |
| | Peru | | | Peru | | |
| | Czech Rep | | | Czech Rep | | |
| | Hungary | | Hungary* | | | |
| Poland | | Poland | | Poland | | |
| Turkey | | Turkey | | Turkey | | |

* denotes borderline significance (at a 10% test level) of the corresponding dummy variable.

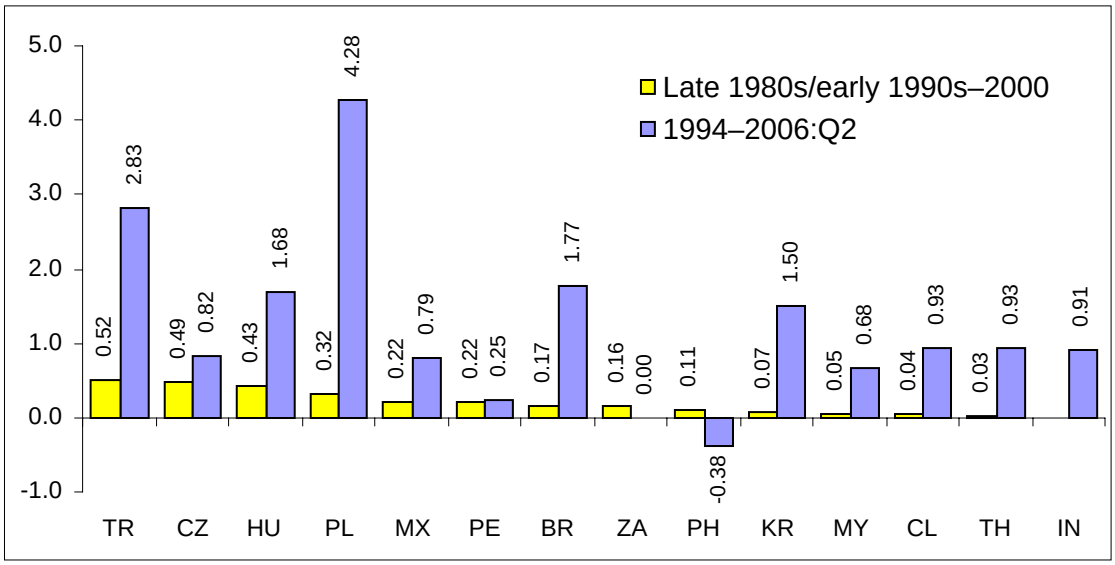
[1] Estimated using dummy variables equal to 1 when the exchange rate depreciates (appreciates), zero otherwise, for regressions specified in Appendix Table A3. [2] Defined as quarter-on-quarter changes in the average quarterly exchange rate greater than or equal to 5%.

**Threshold effects** of exchange rate changes on inflation, ie, the effects of exchange rate changes only above ±5% over a quarter (±22% over a year), seem to apply in Malaysia, Thailand, Mexico Hungary and Turkey (Table 2). Threshold effects do not seem to be significant elsewhere, including in countries such as Brazil, Poland and South Africa, which have otherwise experienced considerable volatility in nominal exchange rates. Perhaps the very fact that exchange rates have been quite volatile in these countries has dampened the pass-through of larger changes in exchange rates to inflation, as economic agents learned to expect that nominal exchange rates could move both down and up by significant amounts.

Estimates of the **foreign price pass-through** to domestic inflation are shown in Graph 7. As noted above, this variable is a multilateral foreign consumer price index measured in foreign currency, derived from nominal and real exchange rate indices. It is interesting that despite the decline in this measure of foreign prices (Graph 3), the pass-through of changes in foreign prices to domestic inflation seems to have increased in all the countries with the exception of the Philippines. This may reflect the increased weight of foreign goods in CPI baskets of emerging market economies in the past five years, but also significantly higher prices of oil and non-oil commodities (as well as fewer energy subsidies to consumers in some countries). Why individual coefficient estimates are so high (up to 4.3 in the case of Poland, suggesting a 4.3% increase in the quarterly rate of inflation when foreign price inflation increases by 1% in a quarter) is unclear.

Graph 7

**Pass-through of foreign price changes to inflation**



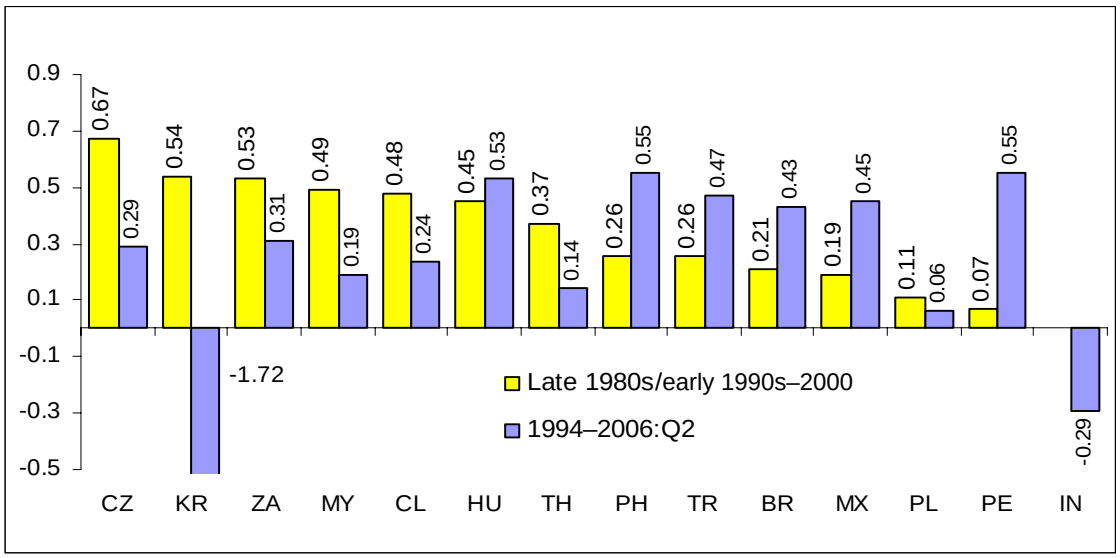

Source: BIS calculations.

Regarding **inflation persistence**, defined here as the elasticity of current inflation to changes in past inflation (cumulated over three quarters), the cross-country picture is mixed. Inflation persistence seems to have declined most significantly in Korea, followed by the Czech Republic, Chile, Malaysia, Thailand and South Africa (Graph 8). But in Peru, Mexico, the Philippines and, to a lesser extent, Brazil and Turkey, the sensitivity of current inflation to past inflationary developments seems to have increased. Moreover, inflation "inertia" remains relatively high: the cumulative increase in the quarterly rate of inflation of 1% over the past three quarters results in most countries in 0.4–0.6% higher inflation in the current quarter. The reasons for this pattern of results are unclear. Both groups of countries include some inflation targeters and in both groups inflation has declined on average since 2001 (with the exception of Turkey and, to a lesser extent, the Philippines).

The estimated relationship between the **output gap and inflation** is statistically significant for all the countries and the sign is mostly positive. With few exceptions, differences in the size of coefficients are not so large – 1 percentage point faster growth of output relative to trend is estimated to raise the quarterly rate of inflation by about 0.2% in Brazil, Mexico, the Philippines and South Africa (Graph 9). The large negative coefficient for Turkey probably reflects disinflation accompanied by a rapid recovery of growth following the 2001 crisis.

Graph 8

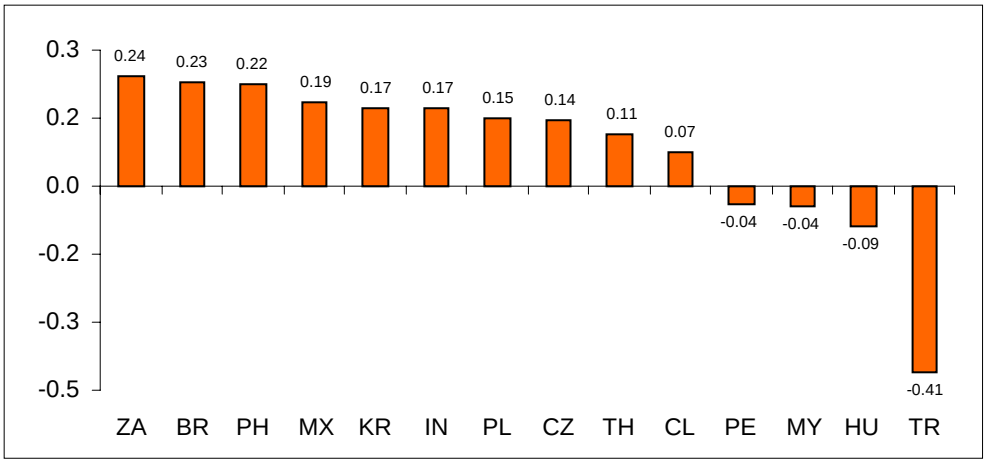
**Inflation persistence**




Source: BIS calculations.

Graph 9

**Output gap and inflation**




Source: BIS calculations.

To further assess the dynamic behaviour of the variables in equation (1), a series of Granger causality tests was performed. The results indicate that the assumption of statistical causality running from the nominal exchange rate (and deviations of the real exchange rate from trend) to consumer prices is valid for most of the countries in the sample. In particular, the null hypothesis that exchange rate changes do not cause changes in inflation is rejected for most countries; the exceptions include Chile, India, Thailand and, surprisingly, Brazil and Turkey (Table 2). The same pattern can be observed for the null that deviations of the real exchange rate from trend do not cause changes in inflation. The null that foreign prices measured in foreign currency do not cause changes in domestic inflation is rejected for Korea, Brazil, Poland and (marginally) Hungary. Finally, no causality between the output gap and inflation is rejected for Korea, the Philippines, Thailand, Chile, Peru and Hungary.

Table 3

**Granger causality tests**

| Null hypothesis | India | Korea | Malaysia | Philip-pines | Thailand | South Africa | Turkey |
|---|---|---|---|---|---|---|---|
| $\Delta \log (P^*) \rightarrow \Delta \log (P)$ | | √ | | | | | |
| $\Delta \log (E) \rightarrow \Delta \log (P)$ | | √ | √ | √ | | √ | |
| $(RERGAP) \rightarrow \Delta \log (P)$ | | √ | √ | √ | | √ | |
| $(GDPGAP) \rightarrow \Delta \log (P)$ | | √ | | √ | √ | | |
| | **Brazil** | **Chile** | **Mexico** | **Peru** | **Czech Rep** | **Hungary** | **Poland** |
| $\Delta \log (P^*) \rightarrow \Delta \log (P)$ | √ | | | | | √* | √ |
| $\Delta \log (E) \rightarrow \Delta \log (P)$ | | | √ | √ | √ | √* | √ |
| $(RERGAP) \rightarrow \Delta \log (P)$ | | | √ | | √ | √ | √ |
| $(GDPGAP) \rightarrow \Delta \log (P)$ | | √ | | √ | | √ | |

Based on quarterly data. *P* = consumer price index; *P** = import trade-weighted foreign consumer price index; *E* = nominal exchange rate (up means depreciation); *GDPGDP* = output gap; *RERGDP* = real effective exchange rate gap; Δ = quarterly change.

- The bivariate regressions are of the form: $X_t = \alpha_0 + \alpha_1 X_{t-1} + \ldots + \alpha_n X_{t-n} + \beta_1 Y_{t-1} + \ldots + \beta_n Y_{t-n}$

  $Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \ldots + \alpha_n Y_{t-n} + \beta_1 X_{t-1} + \ldots + \beta_n X_{t-n}$

  for all possible pairs of (X,Y) series in the group.

- √ means that the hypothesis that X does not cause Y is rejected at a 5% level (* at a 10% level). The results are based on an F-test for the joint hypothesis that β1 = β2 = … = βn are jointly equal to zero for each equation.

## 4. Tentative interpretations

The above results would seem to support the hypothesis that the exchange rate pass-through to domestic CPI has declined in emerging market countries in recent years. At the same time, the sensitivity of inflation to foreign price changes measured in foreign currency may have increased, even though foreign prices have on balance increased more slowly since 2001. It was shown that the trend appreciation of real exchange rates can significantly affect the measured exchange rate pass-through. Finally, there is some evidence of asymmetric and threshold effects of exchange rate changes on inflation in several countries.

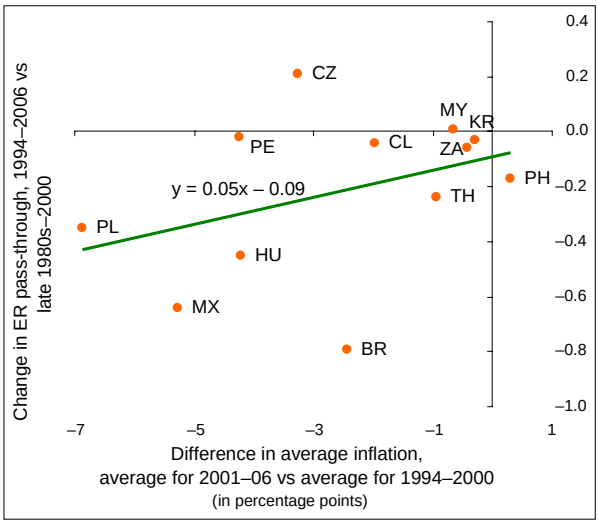
How do these findings relate to explanations for the decline in the exchange rate pass-through advanced in the literature? To assess this issue, changes in pass-through coefficients over time are plotted against some of their determinants identified in the literature.

Graph 10 shows relationships between the decline in the exchange rate pass-through and the decline in inflation and its variability. The decline in the exchange rate pass-through is measured as the difference between estimates for the period from 1994 to 2006, and those for the period from the late 1980s to 2000. As can be seen from the left-hand panel of

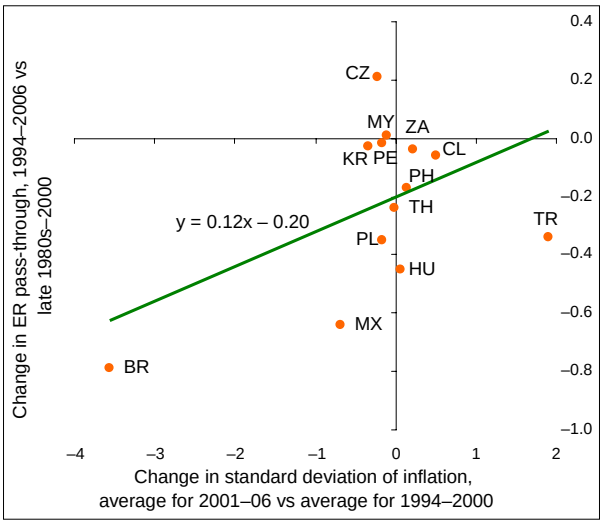
Graph 10, the exchange rate pass-through (measured along the vertical axis) has tended to decline more in those countries that have seen a larger decline in inflation in the 2000s compared to the 1990s. However, this relationship is not particularly strong. Somewhat stronger seems to be the relationship between the decline in the exchange rate pass-through and the decline in the volatility of inflation. As can be seen from the right-hand panel of Graph 10, the more the volatility of inflation has declined (ie, the more inflation has become stable), the more the exchange rate pass-through has tended to decline.

Graph 10

**ER pass-through and changes in inflation**



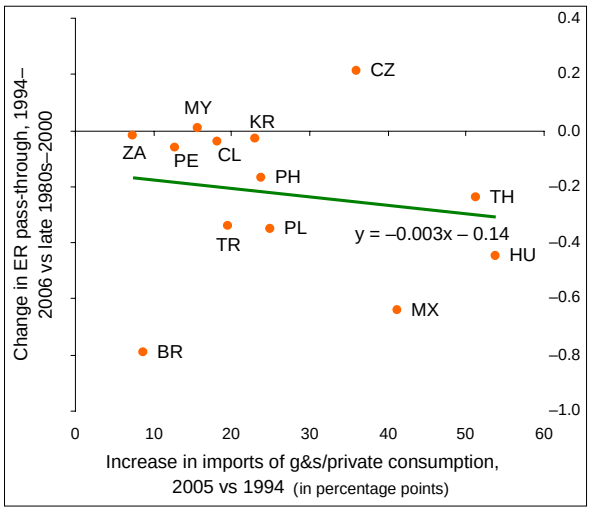

**ER pass-through and variability of inflation**



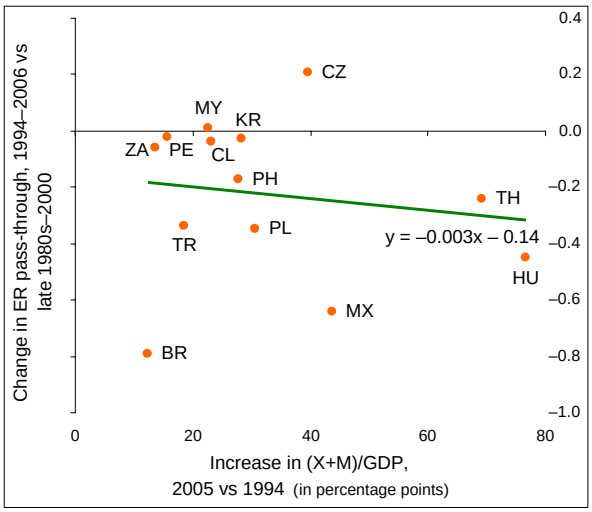

Source: BIS calculations.

Graph 11

**ER pass-through and increased share of imports in consumption**




**ER pass-through and increased openness**

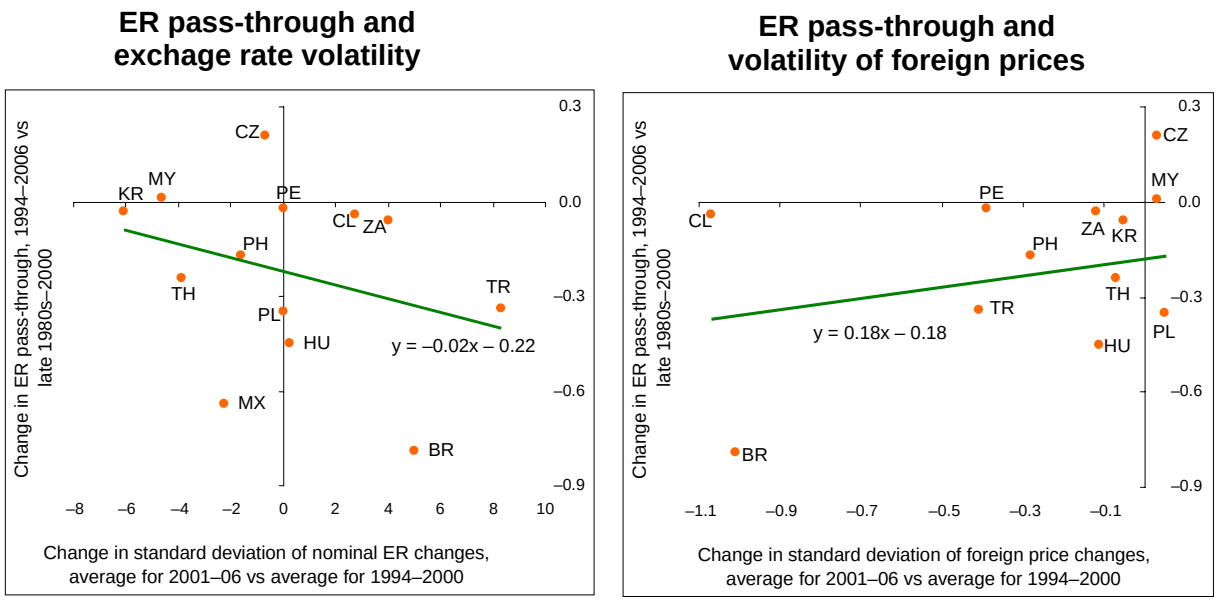



Source: BIS calculations.

Graph 11 suggests that the decline in the exchange rate pass-through has been associated with an increase in the share of imported goods in consumption (left-hand panel) and an increase in the openness of emerging market economies. The relationship is not particularly strong. Nonetheless, it indicates that, contrary to some arguments made in the literature, retail price sensitivity to exchange rates may not have necessarily increased with the greater openness and higher share of imports in the consumption of emerging market economies in recent years. On the other hand, the measured increase in the pass-through of foreign price changes to inflation has been positively correlated with the increased share of imports in consumption and greater openness of emerging market economies, although these relationships are statistically weak (graphs not shown).

Graph 12 (left-hand panel) suggests that greater volatility of nominal exchange rates has been associated – somewhat surprisingly – with the *decline* in the exchange rate pass-through. This would be consistent with earlier observation that countries such as Brazil, South Africa and Poland have experienced a decline in the exchange rate pass-through at the same time as their nominal exchange rates have become more volatile. Changes in foreign prices, on the other hand, seem to have been related to the exchange rate pass-through in an intuitively plausible way: as foreign prices have become less volatile since 2001, the exchange rate pass-through has tended to decline.

Graph 12




Source: BIS calculations.

In summary, while some of the decline in the exchange rate pass-through since 2001 seems to be related to the lower level and lower volatility of domestic inflation, as well as lower volatility of foreign prices, links to other factors identified in the literature – such as greater exchange rate volatility, increased share of imported goods in consumption and greater openness of emerging market economies – are weak or could not be established. Further research in this area will be needed to clarify these issues.

# Appendix:
# Database description

**Countries** cc:

IN = India; KR = Korea; MY = Malaysia; PH = Philippines; TH = Thailand

BR = Brazil; CL = Chile; MX = Mexico; PE = Peru

CZ = Czech Republic; HU = Hungary; PL = Poland; TR = Turkey

ZA = South Africa

**Indicators:**

CPIcc = consumer price index (base 2002 Q1)

LCPIcc = consumer price index, log

RERcc = real effective exchange rate; starting 1994 (base 2002 Q1)

NERcc = nominal effective exchange rate; starting 1994 (base 2002 Q1)

XRcc = spot exchange rate (local currency/US$)

XReurocc = spot exchange rate (local currency/euro) (for CZ, HU, PL)

GAPcc = output gap, deviation from HP-calculated trend

GAPRERcc = real effective exchange rate gap, from 1994, deviation from HP-calculated trend

MPcc = import unit value index, in local currency (base 2002 Q1)

LMPcc = import unit value index, in local currency, log

LCPFcc = log multilateral foreign CPI, from 1994, defined as
(LOG ‘CPIcc’

PLUS((LOG(‘NERcc’))MINUS(LOG(‘RERcc’)))

LCPF1cc = log multilateral foreign CPI, from 1985, defined as
(LOG ‘CPIcc’

PLUS((LOG(‘NEFcc’))MINUS(LOG(‘REFcc’)))

**Frequency:** Quarterly averages

Table A1

**Changes in exchange rates, domestic and foreign inflation**[1]

| | Exchange rate[2] | | | | Domestic inflation | | | | Foreign inflation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Quarterly average | | Standard deviation | | Quarterly average | | Standard deviation | | Quarterly average | | Standard deviation | |
| | 94Q1–01Q1 | 01Q2–06Q2 | 94Q1–01Q1 | 01Q2–06Q2 | 94Q1–01Q1 | 01Q2–06Q2 | 94Q1–01Q1 | 01Q2–06Q2 | 94Q1–01Q1 | 01Q2–06Q2 | 94Q1–01Q1 | 01Q2–06Q2 |
| India | –1.4 | 0.1 | 2.2 | 1.8 | 1.8 | 1.1 | 2.2 | 1.0 | 1.4 | 0.6 | 1.9 | 0.8 |
| Korea | –2.0 | 1.3 | 9.8 | 2.8 | 1.1 | 0.7 | 1.1 | 0.5 | 0.9 | 0.5 | 0.5 | 0.3 |
| Malaysia | –1.5 | 0.2 | 6.2 | 0.6 | 0.8 | 0.5 | 0.6 | 0.4 | 0.7 | 0.5 | 0.3 | 0.3 |
| Philippines | –2.1 | –0.3 | 6.0 | 2.2 | 1.8 | 1.3 | 0.9 | 0.7 | 0.8 | 0.5 | 0.7 | 0.3 |
| Thailand | –2.1 | 0.6 | 8.1 | 2.8 | 1.1 | 0.7 | 0.9 | 0.8 | 0.7 | 0.5 | 0.4 | 0.3 |
| South Africa | –3.1 | 0.6 | 5.1 | 8.1 | 1.8 | 1.2 | 0.9 | 1.1 | 0.8 | 0.6 | 0.5 | 0.3 |
| Brazil | –17.3 | –0.7 | 46.9 | 9.2 | 16.7 | 2.0 | 47.7 | 1.3 | 0.5 | 0.8 | 1.7 | 0.5 |
| Chile | –1.2 | 0.3 | 3.1 | 5.1 | 1.4 | 0.7 | 0.6 | 0.6 | 1.5 | 0.8 | 2.2 | 0.4 |
| Mexico | –4.5 | –0.7 | 12.5 | 3.1 | 4.5 | 1.1 | 3.5 | 0.5 | 0.7 | 0.6 | 0.4 | 0.4 |
| Peru | –1.7 | 0.3 | 1.9 | 1.7 | 2.0 | 0.5 | 1.3 | 0.6 | 0.8 | 0.5 | 0.8 | 0.3 |
| Czech Republic | –1.0 | 2.3 | 4.8 | 3.9 | 1.8 | 0.5 | 1.3 | 0.7 | 1.1 | 0.7 | 0.5 | 0.4 |
| Hungary | –3.8 | 1.4 | 2.8 | 3.8 | 4.0 | 1.2 | 2.2 | 1.0 | 1.2 | 0.7 | 0.7 | 0.4 |
| Poland | –2.5 | 1.2 | 3.9 | 3.9 | 3.8 | 0.5 | 2.5 | 0.9 | 1.0 | 0.7 | 0.5 | 0.4 |
| Turkey | –15.9 | –3.6 | 14.6 | 13.0 | 15.4 | 5.2 | 6.1 | 5.3 | 1.1 | 0.6 | 1.4 | 0.8 |

[1] Quarterly percentage changes (based on quarterly average data). [2] An increase indicates an appreciation.

Table A2

**Pass-through of foreign price and exchange rate changes to inflation for selected emerging market economies, 1994:Q1–2006:Q2**

| Countries | $\Delta cpi_{t-1}$ | $\Delta cpi_{t-2}$ | $\Delta cpi_{t-3}$ | $\Delta fcpi$ | $\Delta fcpi_{t-1}$ | $\Delta fcpi_{t-2}$ | $\Delta fcpi_{t-3}$ | $\Delta xr$ | $\Delta xr_{t-1}$ | $\Delta xr_{t-2}$ | $\Delta xr_{t-3}$ | gap | $gap_{t-1}$ | $gap_{t-2}$ | $gap_{t-3}$ | $R^2$ | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| India | –0.15 | –0.14 | | 0.91 | | | | 0.20 | | | | | | | –0.17 | 0.78 | 2.16 |
| | (–1.81) | (–1.70) | | (9.17) | | | | (92.57) | | | | | | | (–1.33) | | |
| Korea | –0.77 | –0.49 | –0.46 | 0.72 | 0.78 | | | | 0.06 | | 0.04 | –0.22 | 0.19 | | 0.13 | 0.75 | 1.95 |
| | (–6.44) | (–3.97) | (–3.74) | (2.64) | (3.54) | | | | (4.57) | | (2.94) | (–4.49) | (3.13) | | (2.71) | | |
| Malaysia | 0.28 | –0.35 | 0.26 | | | | 0.68 | | 0.04 | 0.04 | | | 0.07 | –0.07 | | 0.61 | 2.08 |
| | (2.12) | (–2.83) | (2.25) | | | | (4.15) | | (2.73) | (2.24) | | | (1.94) | (–1.73) | | | |
| Philippines | 0.32 | 0.46 | –0.23 | | | –0.38 | | | 0.04 | | –0.04 | | | 0.15 | | 0.44 | 1.70 |
| | (2.36) | (3.60) | (–1.91) | | | (–2.33) | | | (1.81) | | (–2.09) | | | (1.82) | | | |
| Thailand | | | 0.14* | 0.93 | | | | 0.04 | | | | –0.06 | | 0.13 | | 0.52 | 1.73 |
| | | | (1.59) | (3.70) | | | | (3.00) | | | | (–1.79) | | (4.06) | | | |
| South Africa | 0.66 | –0.35 | | | | –0.69 | 0.69 | 0.04 | | | 0.04 | | | 10.43 | | 0.51 | 2.03 |
| | (4.98) | (–2.57) | | | | (–1.74) | (2.30) | (2.64) | | | (2.38) | | | (0.84) | | | |
| Brazil | 0.37 | | 0.06* | 0.67 | | 0.61 | 0.49 | | 0.05 | | | | –0.29 | 0.35 | –0.29 | 0.76 | 2.46 |
| | (3.33) | | (3.36) | (1.93) | | (2.89) | (2.50) | | (3.81) | | | | (–2.60) | (2.60) | (–2.75) | | |
| Chile | | | 0.24* | 0.60 | | 0.58 | –0.25 | | | | 0.03* | | 0.09 | | | 0.54 | 1.80 |
| | | | (2.00) | (2.51) | | (2.92) | (–2.59) | | | | (1.68) | | (2.66) | | | | |
| Mexico | 0.31 | 0.23* | 0.14 | | | | 0.79 | 0.09 | 0.21 | | | | | | 0.12 | 0.94 | 1.93 |
| | (6.87) | (4.15) | (2.52) | | | | (2.07) | (5.53) | (14.03) | | | | | | (1.96) | | |
| Peru | 0.38 | | 0.17 | | | | 0.25 | | 0.09 | | | | | 0.15 | | 0.79 | 1.79 |
| | (3.71) | | (1.76) | | | | (1.41) | | (2.00) | | | | | (3.29) | | | |

Table A2 (cont)

**Pass-through of foreign price and exchange rate changes to inflation for selected emerging market economies, 1994:Q1–2006:Q2**

| Countries | $\Delta cpi_{t-1}$ | $\Delta cpi_{t-2}$ | $\Delta cpi_{t-3}$ | $\Delta fcpi$ | $\Delta fcpi_{t-1}$ | $\Delta fcpi_{t-2}$ | $\Delta fcpi_{t-3}$ | $\Delta xr$ | $\Delta xr_{t-1}$ | $\Delta xr_{t-2}$ | $\Delta xr_{t-3}$ | gap | $gap_{t-1}$ | $gap_{t-2}$ | $gap_{t-3}$ | $R^2$ | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Czech Republic | | 0.29 | | 0.82 | | | | | 0.16 | | 0.11 | | 0.13 | | 0.18 | 0.71 | 2.12 |
| | | (2.51) | | (2.33) | | | | | (3.94) | | (2.45) | | (2.87) | | (4.64) | | |
| Hungary | 0.49 | –0.35 | 0.39 | 1.68 | | | | | | 0.09 | | –0.14 | | | | 0.89 | 2.20 |
| | (5.37) | (–2.98) | (4.51) | (5.46) | | | | | | (1.80) | | (–3.08) | | | | | |
| Poland | 0.25 | –0.19 | | 2.69 | | | 1.59 | | 0.10 | | | 0.34 | | | 0.25 | 0.79 | 1.96 |
| | (2.55) | (–2.08) | | (5.91) | | | (4.10) | | (2.61) | | | (3.56) | | | (2.66) | | |
| Turkey | 0.24 | | 0.23 | | | 0.85 | 1.98 | 0.22 | | | | | –0.25 | 0.29 | | 0.92 | 2.05 |
| | (3.13) | | (3.66) | | | (2.77) | (7.27) | (2.96) | | | | | (–2.05) | (2.40) | | | |

* Coefficient for $_{t-4}$.

Δcpi = quarterly average change in log of consumer prices; Δfcpi = quarterly average change in log of foreign consumer prices; Δxr = quarterly average change in log of nominal exchange rate; gap = output gap (percentage deviation of actual GDP from potential); t–statistics are shown in parentheses.

Table A2

**Pass-through of foreign price and exchange rate changes to inflation for selected emerging market economies, 1994:Q1–2006:Q2**

| Countries | $\Delta cpi_{t-1}$ | $\Delta cpi_{t-2}$ | $\Delta cpi_{t-3}$ | $\Delta fcpi$ | $\Delta fcpi_{t-1}$ | $\Delta fcpi_{t-2}$ | $\Delta fcpi_{t-3}$ | $\Delta xr$ | $\Delta xr_{t-1}$ | $\Delta xr_{t-2}$ | $\Delta xr_{t-3}$ | gap | $gap_{t-1}$ | $gap_{t-2}$ | $gap_{t-3}$ | $R^2$ | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| India | –0.15 | –0.14 | | 0.91 | | | | 0.20 | | | | | | | –0.17 | 0.78 | 2.16 |
| | (–1.81) | (–1.70) | | (9.17) | | | | (92.57) | | | | | | | (–1.33) | | |
| Korea | –0.77 | –0.49 | –0.46 | 0.72 | 0.78 | | | | 0.06 | | 0.04 | –0.22 | 0.19 | | 0.13 | 0.75 | 1.95 |
| | (–6.44) | (–3.97) | (–3.74) | (2.64) | (3.54) | | | | (4.57) | | (2.94) | (–4.49) | (3.13) | | (2.71) | | |
| Malaysia | 0.28 | –0.35 | 0.26 | | | | 0.68 | | 0.04 | 0.04 | | | 0.07 | –0.07 | | 0.61 | 2.08 |
| | (2.12) | (–2.83) | (2.25) | | | | (4.15) | | (2.73) | (2.24) | | | (1.94) | (–1.73) | | | |
| Philippines | 0.32 | 0.46 | –0.23 | | | –0.38 | | | 0.04 | | –0.04 | | | 0.15 | | 0.44 | 1.70 |
| | (2.36) | (3.60) | (–1.91) | | | (–2.33) | | | (1.81) | | (–2.09) | | | (1.82) | | | |
| Thailand | | | 0.14* | 0.93 | | | | 0.04 | | | | –0.06 | | 0.13 | | 0.52 | 1.73 |
| | | | (1.59) | (3.70) | | | | (3.00) | | | | (–1.79) | | (4.06) | | | |
| South Africa | 0.66 | –0.35 | | | | –0.69 | 0.69 | 0.04 | | | 0.04 | | | 10.43 | | 0.51 | 2.03 |
| | (4.98) | (–2.57) | | | | (–1.74) | (2.30) | (2.64) | | | (2.38) | | | (0.84) | | | |
| Brazil | 0.37 | | 0.06* | 0.67 | | 0.61 | 0.49 | | 0.05 | | | | –0.29 | 0.35 | –0.29 | 0.76 | 2.46 |
| | (3.33) | | (3.36) | (1.93) | | (2.89) | (2.50) | | (3.81) | | | | (–2.60) | (2.60) | (–2.75) | | |
| Chile | | | 0.24* | 0.60 | | 0.58 | –0.25 | | | | 0.03* | | 0.09 | | | 0.54 | 1.80 |
| | | | (2.00) | (2.51) | | (2.92) | (–2.59) | | | | (1.68) | | (2.66) | | | | |
| Mexico | 0.31 | 0.23* | 0.14 | | | | 0.79 | 0.09 | 0.21 | | | | | | 0.12 | 0.94 | 1.93 |
| | (6.87) | (4.15) | (2.52) | | | | (2.07) | (5.53) | (14.03) | | | | | | (1.96) | | |
| Peru | 0.38 | | 0.17 | | | | 0.25 | | 0.09 | | | | | 0.15 | | 0.79 | 1.79 |
| | (3.71) | | (1.76) | | | | (1.41) | | (2.00) | | | | | (3.29) | | | |

Table A2 (cont)

**Pass-through of foreign price and exchange rate changes to inflation for selected emerging market economies, 1994:Q1–2006:Q2**

| Countries | $\Delta cpi_{t-1}$ | $\Delta cpi_{t-2}$ | $\Delta cpi_{t-3}$ | $\Delta fcpi$ | $\Delta fcpi_{t-1}$ | $\Delta fcpi_{t-2}$ | $\Delta fcpi_{t-3}$ | $\Delta xr$ | $\Delta xr_{t-1}$ | $\Delta xr_{t-2}$ | $\Delta xr_{t-3}$ | gap | $gap_{t-1}$ | $gap_{t-2}$ | $gap_{t-3}$ | $R^2$ | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Czech Republic | | 0.29 | | 0.82 | | | | | 0.16 | | 0.11 | | 0.13 | | 0.18 | 0.71 | 2.12 |
| | | (2.51) | | (2.33) | | | | | (3.94) | | (2.45) | | (2.87) | | (4.64) | | |
| Hungary | 0.49 | –0.35 | 0.39 | 1.68 | | | | | | 0.09 | | –0.14 | | | | 0.89 | 2.20 |
| | (5.37) | (–2.98) | (4.51) | (5.46) | | | | | | (1.80) | | (–3.08) | | | | | |
| Poland | 0.25 | –0.19 | | 2.69 | | | 1.59 | | 0.10 | | | 0.34 | | | 0.25 | 0.79 | 1.96 |
| | (2.55) | (–2.08) | | (5.91) | | | (4.10) | | (2.61) | | | (3.56) | | | (2.66) | | |
| Turkey | 0.24 | | 0.23 | | | 0.85 | 1.98 | 0.22 | | | | | –0.25 | 0.29 | | 0.92 | 2.05 |
| | (3.13) | | (3.66) | | | (2.77) | (7.27) | (2.96) | | | | | (–2.05) | (2.40) | | | |

* Coefficient for $_{t-4}$.

Δcpi = quarterly average change in log of consumer prices; Δfcpi = quarterly average change in log of foreign consumer prices; Δxr = quarterly average change in log of nominal exchange rate; gap = output gap (percentage deviation of actual GDP from potential); t–statistics are shown in parentheses.

Table A3

**Pass-through of foreign prices and exchange rate changes to inflation for selected emerging market economies, 1994:Q1–2006:Q2**

| Countries | $\Delta cpi_{t-1}$ | $\Delta cpi_{t-2}$ | $\Delta cpi_{t-3}$ | $\Delta fcpi$ | $\Delta fcpi_{t-1}$ | $\Delta fcpi_{t-2}$ | $\Delta fcpi_{t-3}$ | $\Delta xr$ | $\Delta xr_{t-1}$ | $\Delta xr_{t-2}$ | $\Delta xr_{t-3}$ | gap | $gap_{t-1}$ | $gap_{t-2}$ | $gap_{t-3}$ | rergap | rer-gap $_{t-1}$ | rer-gap $_{t-2}$ | $R^2$ | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Korea** | –0.68 | –0.50 | –0.41 | 0.55 | 0.77 | | | | 0.04 | | 0.03 | | | | 0.17 | –0.03 | | | 0.80 | 2.00 |
| | (–6.08) | (–4.62) | (–3.65) | (2.29) | (3.94) | | | | (2.88) | | (2.40) | | | | (5.34) | (–2.14) | | | | |
| Malaysia** | 0.33 | –0.39 | | 0.54 | | | 0.58 | 0.06 | | 0.05 | | –0.04 | | | | 0.08 | –0.13 | –0.08 | 0.73 | 1.96 |
| | (2.70) | (–3.40) | | (2.82) | | | (4.11) | (2.82) | | (2.49) | | (–2.11) | | | | (3.71) | (–4.75) | (–2.99) | | |
| Philippines** | | 0.32 | | 0.41 | | | | 0.10 | | | –0.06 | | | | 0.22 | 0.10 | –0.16 | | 0.54 | 1.81 |
| | | (2.99) | | (2.59) | | | | (2.54) | | | (2.56) | | | | (2.94) | (2.41) | (–3.98) | | | |
| Thailand** | | | 0.17 | 0.82 | | | | 0.03 | | | | | | 0.11 | | | –0.05 | | 0.62 | 1.75 |
| | | | (1.70) | (3.66) | | | | (2.09) | | | | | | (4.95) | | | (3.66) | | | |
| South Africa** | | | –0.20* | 1.17 | 0.79 | | | 0.04 | | | | | | 0.24 | | | –0.08 | | 0.74 | 1.76 |
| | | | (–2.62) | (4.37) | (3.89) | | | (2.70) | | | | | | (2.92) | | | (–8.25) | | | |
| Brazil | | | 0.12 | | 0.75 | 1.13 | 0.27 | 0.03 | | | | | | 0.23 | | | –0.08 | | 0.74 | 1.79 |
| | | | (4.85) | | (2.01) | (3.92) | (2.31) | (1.95) | | | | | | (1.95) | | | (–6.33) | | | |
| Chile | | | 0.24* | 0.55 | | | | 0.09 | | –0.05 | | | 0.07 | | | 0.09 | –0.11 | 0.04 | 0.56 | 2.13 |
| | | | (2.60) | (2.69) | | | | (2.83) | | (–2.15) | | | (2.47) | | | (2.28) | (–2.48) | (1.84) | | |
| Mexico | 0.38 | | 0.21 | | –0.47 | | | 0.12 | 0.24 | | | 0.19 | | | | | | –0.05 | 0.92 | 2.02 |
| | (5.52) | | (4.27) | | (–1.24) | | | (6.88) | (11.18) | | | (2.27) | | | | | | (–1.80) | | |
| Peru | 0.81 | | –0.12 | 1.17 | –0.50 | –0.20 | –0.07 | 0.34 | 0.06 | –0.14 | | | 0.22 | –0.26 | | 0.33 | –0.29 | | 0.98 | 2.08 |
| | (8.31) | | (–2.96) | (9.10) | (–4.61) | (–2.12) | (–2.73) | (5.74) | (1.77) | (–3.18) | | | (2.45) | (–3.02) | | (8.13) | (–5.75) | | | |

Table A3 (cont)

**Pass-through of foreign prices and exchange rate changes to inflation for selected emerging market economies, 1994:Q1–2006:Q2**

| Countries | $\Delta cpi_{t-1}$ | $\Delta cpi_{t-2}$ | $\Delta cpi_{t-3}$ | $\Delta fcpi$ | $\Delta fcpi_{t-1}$ | $\Delta fcpi_{t-2}$ | $\Delta fcpi_{t-3}$ | $\Delta xr$ | $\Delta xr_{t-1}$ | $\Delta xr_{t-2}$ | $\Delta xr_{t-3}$ | gap | $gap_{t-1}$ | $gap_{t-2}$ | $gap_{t-3}$ | rergap | rer-$gap_{t-1}$ | rer-$gap_{t-2}$ | $R^2$ | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Czech Republic | | 0.48 | | 0.67 | | | | 0.13 | | | | | | | 0.14 | | –0.15 | | 0.69 | 2.16 |
| | | (5.02) | | (1.98) | | | | (2.79) | | | | | | | (3.65) | | (–4.57) | | | |
| Hungary** | 0.36 | –0.24 | 0.19 | 1.39 | | | | 0.34 | | | | –0.09 | | | | 0.32 | –0.38 | | 0.94 | 2.09 |
| | (4.75) | (–2.51) | (2.41) | (5.66) | | | | (5.19) | | | | (–2.26) | | | | (4.30) | (–4.64) | | | |
| Poland** | 0.14 | | 0.33* | 0.94 | | | | 0.41 | | | | 0.15 | | | | 0.47 | –0.50 | | 0.94 | 1.43 |
| | (2.67) | | (5.37) | (2.89) | | | | (6.05) | | | | (2.46) | | | | (6.31) | (–7.29) | | | |
| Turkey | 0.22 | | 0.13 | | | 0.58 | 1.17 | 0.47 | | | | –0.21 | –0.20 | | | 0.34 | –0.43 | | 0.94 | 2.11 |
| | (3.55) | | (2.37) | | | (2.22) | (4.22) | (8.89) | | | | (–1.91) | (1.85) | | | (4.54) | (–6.03) | | | |

* Coefficient for $_{t-4}$. ** Includes a time dummy.

Δcpi = quarterly average change in log of consumer prices; Δfcpi = quarterly average change in log of import unit value (expressed in local currency); Δxr = quarterly average change in log of nominal exchange rate; gap = output gap (percentage deviation of actual GDP from potential); rergap = real effective exchange rate gap (percentage deviation of actual rate from potential); t–statistics are shown in parentheses.

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